

SEVEN

PUBLICAÇÕES ACADÊMICAS
2025

EXPANDED SCIENCE:

**INNOVATION AND
RESEARCH**

2ND EDITION

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International Cataloguing in Publication Data (CIP)
(Brazilian Book Chamber, SP, Brazil)

S498e

Seven Editora.

Expanded Science [recurso eletrônico] : Innovation and Research / Seven Editora. – 2. ed. – São José dos Pinhais, PR: Editora Seven, 2026.

Dados eletrônicos (1 PDF).

ISBN 978-65-6109-174-9

1. Ciência. 2. Pesquisa. I. Título.

CDU 001.8

Bruna Heller - Librarian - CRB10/2348

Indexes for systematic catalog:

1 Pesquisa científica 001.8

DOI: 10.56238/sevened2025.036-

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CNPJ: 43.789.355/0001-14

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Science is a field of knowledge in which different disciplines intertwine to form a greater whole. **Expanded Science: Innovation and Research - 2° Ed** is a work that expands this interconnection, bringing 160 articles on various topics, written by experts from different areas of knowledge.

Developed by **Seven Publications**, this book presents a broad overview of the challenges, discoveries and advances in fields such as supply chain, carbon credit, kanban and much more.

SUMMARY

COLLABORATION AND INTEGRATION OF BUSINESS PROCESSES IN THE SUPPLY CHAIN: PROPOSITION OF A CONCEPTUAL MODEL

Diego Milnitz, Monica Maria Mendes Luna.

  <https://doi.org/10.56238/sevened2025.036-001>

.....32-49

REGULATORY CHALLENGES OF THE CARBON CREDIT MARKET IN BRAZIL

Gustavo Domingos Sakr Bisinoto, Valter Gustavo Danzer, Julio Cezar de Lara, Rodrigo Bruno Zanin, Ernandes Sobreira Oliveira Junior.

  <https://doi.org/10.56238/sevened2025.036-002>

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 <https://doi.org/10.56238/sevened2025.036-049>

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 <https://doi.org/10.56238/sevened2025.036-050>

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  <https://doi.org/10.56238/sevened2025.036-089>

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 <https://doi.org/10.56238/sevened2025.036-120>

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 <https://doi.org/10.56238/sevened2025.036-124>

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 <https://doi.org/10.56238/sevened2025.036-126>

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 <https://doi.org/10.56238/sevened2025.036-137>

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 <https://doi.org/10.56238/sevened2025.036-139>

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 <https://doi.org/10.56238/sevened2025.036-142>

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 <https://doi.org/10.56238/sevened2025.036-144>

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 <https://doi.org/10.56238/sevened2025.036-145>

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 <https://doi.org/10.56238/sevened2025.036-146>

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 <https://doi.org/10.56238/sevened2025.036-147>

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 <https://doi.org/10.56238/sevened2025.036-148>

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 <https://doi.org/10.56238/sevened2025.036-149>

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 <https://doi.org/10.56238/sevened2025.036-150>

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 <https://doi.org/10.56238/sevened2025.036-151>

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 <https://doi.org/10.56238/sevened2025.036-154>

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 <https://doi.org/10.56238/sevened2025.036-155>

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 <https://doi.org/10.56238/sevened2025.036-156>

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 <https://doi.org/10.56238/sevened2025.036-157>

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  <https://doi.org/10.56238/sevened2025.036-158>

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**COLLABORATION AND INTEGRATION OF BUSINESS PROCESSES IN THE
SUPPLY CHAIN: PROPOSITION OF A CONCEPTUAL MODEL**

**COLABORAÇÃO E INTEGRAÇÃO DOS PROCESSOS DE NEGÓCIO NA
CADEIA DE SUPRIMENTOS: PROPOSIÇÃO DE UM MODELO CONCEITUAL**

**COLABORACIÓN E INTEGRACIÓN DE PROCESOS DE NEGOCIO EN LA
CADENA DE SUMINISTRO: PROPUESTA DE UN MODELO CONCEPTUAL**

 <https://doi.org/10.56238/sevened2025.036-001>

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ABSTRACT

The growing complexity of supply chains has increased the need to understand how collaboration and business process integration interrelate to generate value and competitiveness. The literature shows significant progress in defining key processes and collaboration constructs, but studies that analyze the influence of these elements in an integrated manner are still scarce. This article aims to propose a conceptual model that explains how collaboration can positively affect the integration of business processes in the supply chain. The research was developed through a systematic literature review, encompassing classic models (GSCF, SCOR, Handfield & Nichols, Srivastava, and Melnyk) and recent contributions on interorganizational collaboration. As a result, eight fundamental business processes were identified (customer relationships, customer service, demand, orders, manufacturing, suppliers, product development, and returns) and four constructs that precede collaboration (internal alignment, partner trust, collaborative culture, and partnership orientation). These elements were organized into a conceptual model supported by five hypotheses that demonstrate how collaboration enhances process integration. The study's main contribution is to offer a robust theoretical framework that can guide future empirical research using quantitative methods (SEM, PLS) and support managers in implementing more effective collaborative practices. It concludes that understanding the relationship between collaboration and integration is essential to strengthening the resilience and competitiveness of supply chains, especially in a scenario marked by digital transformations, sustainability, and complex global dynamics.

Keywords: Supply Chain. Collaboration. Process Integration. Conceptual Model. Resilience.

RESUMO

A crescente complexidade das cadeias de suprimentos tem ampliado a necessidade de compreender como colaboração e integração de processos de negócio se relacionam para gerar valor e competitividade. A literatura mostra avanços importantes na definição de processos-chave e de construtos de colaboração, mas ainda são escassos os estudos que analisam de forma integrada a influência desses elementos. Este artigo tem como objetivo propor um modelo conceitual que explique como a colaboração pode afetar positivamente a integração dos processos de negócio na cadeia de suprimentos. A pesquisa foi desenvolvida

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por meio de uma revisão sistemática da literatura, contemplando modelos clássicos (GSCF, SCOR, Handfield & Nichols, Srivastava e Melnyk) e contribuições recentes sobre colaboração interorganizacional. Como resultados, foram identificados oito processos de negócio fundamentais (relacionamento com clientes, serviço ao cliente, demanda, pedidos, manufatura, fornecedores, desenvolvimento de produtos e devoluções) e quatro construtos antecedentes à colaboração (alinhamento interno, confiança no parceiro, cultura colaborativa e orientação para parceria). Esses elementos foram organizados em um modelo conceitual sustentado por cinco hipóteses que evidenciam como a colaboração potencializa a integração dos processos. A principal contribuição do estudo é oferecer uma estrutura teórica robusta, que pode orientar futuras pesquisas empíricas com métodos quantitativos (SEM, PLS) e apoiar gestores na implementação de práticas colaborativas mais eficazes. Conclui-se que compreender a relação entre colaboração e integração é essencial para fortalecer a resiliência e a competitividade das cadeias de suprimentos, sobretudo em um cenário marcado por transformações digitais, sustentabilidade e dinâmicas globais complexas.

Palavras-chave: Cadeia de Suprimentos. Colaboração. Integração de Processos. Modelo Conceitual. Resiliência.

RESUMEN

La creciente complejidad de las cadenas de suministro ha incrementado la necesidad de comprender cómo la colaboración y la integración de procesos de negocio se interrelacionan para generar valor y competitividad. La literatura muestra avances significativos en la definición de procesos clave y constructos de colaboración, pero los estudios que analizan la influencia de estos elementos de forma integrada aún son escasos. Este artículo busca proponer un modelo conceptual que explique cómo la colaboración puede afectar positivamente la integración de los procesos de negocio en la cadena de suministro. La investigación se desarrolló mediante una revisión sistemática de la literatura, que abarca modelos clásicos (GSCF, SCOR, Handfield & Nichols, Srivastava y Melnyk) y contribuciones recientes sobre colaboración interorganizacional. Como resultado, se identificaron ocho procesos de negocio fundamentales (relaciones con los clientes, servicio al cliente, demanda, pedidos, fabricación, proveedores, desarrollo de productos y devoluciones) y cuatro constructos que preceden a la colaboración (alineación interna, confianza en los socios, cultura colaborativa y orientación hacia la colaboración). Estos elementos se organizaron en un modelo conceptual sustentado en cinco hipótesis que demuestran cómo la colaboración mejora la integración de procesos. La principal contribución del estudio es ofrecer un marco teórico sólido que pueda guiar la investigación empírica futura mediante métodos cuantitativos (SEM, PLS) y apoyar a los gerentes en la implementación de prácticas colaborativas más efectivas. Se concluye que comprender la relación entre colaboración e integración es esencial para fortalecer la resiliencia y la competitividad de las cadenas de suministro, especialmente en un escenario marcado por las transformaciones digitales, la sostenibilidad y las complejas dinámicas globales.

Palabras clave: Cadena de Suministro. Colaboración. Integración de Procesos. Modelo Conceptual. Resiliencia.

1 INTRODUCTION

One of the main trends in the updated within organizations has been the change in business performance from functional structures to process structures (LAMBERT, 2008). Therefore, in the supply chain, the production of a product or service is possible by the chaining and connection of one or more processes internally and externally (DE CASTRO *et al.*, 2009). In these interconnections, the integration of processes becomes complex, since it involves the connection between different organizations, with specific cultures, at different stages of technological development and with their own management methods, thus generating the need for great synergy and collaboration between them (LAMBERT and COOPER, 2000; CROXTON *et al.*, 2001; LAMBERT and KNEMEYER, 2004; HANDFIELD and NICHOLS, 2004).

In the literature, there are several authors who have emphasized the importance of both collaboration and integration of business processes to improve the efficiency of supply chain management, among them are Lambert (2008); Bowersox *et al.* (2008); Kumar and Nath Banerjee (2014); Handfield and Nichols (2004); Lambert and Cooper (2000); Croxton *et al.* (2001), however, there are still no studies that propose to understand the relationship between these two themes.

Therefore, the main objective of this work is to propose a conceptual model that can explain how collaboration can positively affect the integration of business processes in the supply chain. In this way, the main factors of this relationship are identified through a bibliographic research of influential works in the area, then hypotheses of the model and the schematic representation that shows how the themes are related are built.

To this end, in addition to this brief introduction, the article presents in "item 2" a review of the business processes in the supply chain, where the main elements related to the subject are presented. Then in "item 3" is a review of collaboration in the supply chain. In "item 4" the propositions on the effect of collaboration on the integration of business processes are presented. And finally, in the last item, the conclusions of the research are presented, along with suggestions for future work on the theme of the article.

2 BUSINESS PROCESSES IN THE SUPPLY CHAIN

In the literature, five supply chain management models were found that have as a key component the integration of processes based on activities and tasks that must be aligned with the channel strategies, they are: (1) the GSCF model developed by the Global Supply

Chain Forum; (2) the SCOR-model, or Supply-Chain operations reference-model developed by the SCC or Supply-Chain Council; (3) the approach of Handfield and Nichols (2002); (4) the approach of Srivastava *et al.* (1999); and (5) the approach of Melnyk *et al.* (2000). The main characteristics of each model mentioned are presented below.

(1) The GSCF defines Supply Chain Management (*SCM - Supply Chain Management*) as the integration of key business processes to serve the end user (LAMBERT, 2008). In this sense, the success of SCM requires a shift from managing individual functions to integrating key activities and processes in the supply chain (LAMBERT and COOPER, 2000). In addition, according to Croxton *et al.* (2001), the main business processes defined by the members of the *Global Supply Chain Forum* are: i) customer relationship management; ii) the management of customer service; iii) demand management; iv) the fulfillment of requests; v) the management of the manufacturing flow; vi) the management of the relationship with suppliers; vii) product development; and viii) the management of returns.

According to the GSCF model, the management of partner companies in the supply chain must consider these eight processes (LAMBERT, 2008). Each of the eight processes is cross-functional and cross-organizational. At the same time, according to Lambert and Cooper (2000), the eight key processes run through the entire supply chain through companies and within the functional silos in each company. Functional silos include marketing, research and development, finance, production, purchasing, and logistics. The activities in these processes are located inside these functional silos.

(2) SCOR is a method that makes use of benchmarking and evaluations to improve supply chain performance. This is a cross-functional framework template that contains the definitions of process standards, terminologies, and metrics integrated into supply chain processes, comparing them to best practices. The model was developed to help organizations learn about internal and external processes in their segment of operation (STEWART, 1997). According to Bornia and Lorandi (2016), currently the SCOR model defines five key processes, which are: i) planning; ii) the supply; iii) manufacturing; iv) delivery; and v) the return.

The main objective of the SCOR model is to improve the alignment between the market and the strategic reaction of the supply chain, using indicators that enable the management of these five processes, in the constant search for superior efficiency of the supply chain (KIECKBUSCH, 2010).

(3) The approach of Handfield and Nichols (2002) focuses on business processes as a way to integrate actors along the supply chain, however, Santos (2008) states that the authors do not clearly define which are the main business processes that should be considered in this integration. In view of this, Bowersox *et al.* (2008) complement the model by defining eight business processes that should be considered for Supply Chain Management by the approach of Handfield and Nichols (2002).

The business processes defined were: i) demand planning and response capacity; ii) customer relationship management; iii) the fulfillment of the request and provision of the service; iv) the launch and development of products and services; v) the customization of manufacturing; vi) the management of the relationship with suppliers; vii) life cycle support; and viii) reverse logistics (BOWERSOX *et al.*, 2008).

According to Handfield and Nichols (2002), the supply chain must be a true "value system". In addition, the value results from the synergy between the organizations that make up the chain in relation to the flows of information, product, service, capital and knowledge.

(4) Srivastava *et al.* (1999) They seek in their work the identification of business processes that create value for customers and bring financial return to shareholders. The objective of the authors is to study the interferences of the marketing function in these business processes. For the authors, value creation occurs through activities such as the development of new solutions or the renewal of existing solutions, in addition, another factor that enhances this creation of value to the customer is the increase in collaboration between organizations, especially through marketing channels and customer service.

These activities are performed by three business processes, which are: i) the product development process; ii) the supply chain management process; and iii) the relationship process (collaboration) with the client.

(5) The approach of Melnyk *et al.* (2000) present eight essential business processes for Supply Chain Management, which are: i) product development; ii) the development of the process; iii) the monitoring process; (iv) the capacity management process; v) the planning process; vi) the acquisition and supply process; vii) the manufacturing process; and viii) the delivery process.

For the authors, their supply chain analysis model is concerned with understanding, explaining, predicting and changing the organizational effects related to the integration of companies and their business processes along the chain, thus ensuring the generation of

value for end customers. In other words, the emphasis of this approach is the exercise on Supply Chain Management, through collaboration.

Supply Chain Management boils down to understanding that managing the supply chain is managing the business processes that are involved and that are integrated between the organizations that make it up. In this sense, the models presented organize and guide a form of supply chain management based on business processes and their activities. In view of the models and approaches presented and taking into account other authors who comment on the importance of business processes for Supply Chain Management, Table 1 presents the business processes that are considered in the research, with a brief description and the authors who address the respective process in SCM.

The choice of these business processes was due to two important reasons, the first is related to the use of supply chain analysis models in various approaches, among them, are those mentioned in this work and the second is related to the application and validation carried out by the members of the *Global Supply Chain Forum*, based on a comprehensive research that lasted more than six years and involved 15 types of industries and nine different supply chains, with more than 90 in-depth interviews, which enabled several experts in the field to discuss, analyze and define the main business processes that should be considered in the supply chain.

Table 1

Main business processes used in Supply Chain integration

Business Process	Description	Authors
Customer relationship management	It is related to the structure of the relationship with customers. It seeks to raise customer needs and reduce demand variation and activities that do not add value to customers in the supply chain.	Lambert and Cooper (2000); Croxton <i>et al.</i> (2001); Lambert (2008); Stewart (1997); Handfield and Nichols (2002); Bowersox <i>et al.</i> (2008); Srivastava <i>et al.</i> (1999); Melnyk <i>et al.</i> (2000)
Customer service management	It is the process that shows the face of the company to the customer, providing them with real-time information, such as shipping date and availability of products with the company's functional areas such as manufacturing and logistics.	Lambert and Cooper (2000); Croxton <i>et al.</i> (2001); Lambert (2008); Stewart (1997); Handfield and Nichols (2002); Bowersox <i>et al.</i> (2008); Srivastava <i>et al.</i> (1999)
Demand management	It is about managing demand and inventories in an integrated way in all key links of the supply chain.	Lambert and Cooper (2000); Croxton <i>et al.</i> (2001); Lambert (2008); Stewart (1997); Handfield and Nichols (2002);

		Bowersox <i>et al.</i> (2008); Srivastava <i>et al.</i> (1999); Melnyk <i>et al.</i> (2000)
Order fulfillment	It provides the fulfillment of the order in the most effective way possible, seeking to meet the growing needs of customers in several dimensions (quantity, deadline and quality and others).	Lambert and Cooper (2000); Croxton <i>et al.</i> (2001); Lambert (2008); Stewart (1997); Handfield and Nichols (2002); Bowersox <i>et al.</i> (2008); Srivastava <i>et al.</i> (1999); Melnyk <i>et al.</i> (2000)
Manufacturing flow management	Manufacturing needs to be more flexible and be able to respond quickly to demand.	Lambert and Cooper (2000); Croxton <i>et al.</i> (2001); Lambert (2008); Stewart (1997); Handfield and Nichols (2002); Bowersox <i>et al.</i> (2008); Melnyk <i>et al.</i> (2000)
Supplier relationship management	It defines how the company interacts with its suppliers.	Lambert and Cooper (2000); Croxton <i>et al.</i> (2001); Lambert (2008); Stewart (1997); Handfield and Nichols (2002); Bowersox <i>et al.</i> (2008); Srivastava <i>et al.</i> (1999); Melnyk <i>et al.</i> (2000)
Product development management	It deals with the joint work between customers and suppliers for the most efficient product development.	Lambert and Cooper (2000); Croxton <i>et al.</i> (2001); Lambert (2008); Stewart (1997); Handfield and Nichols (2002); Bowersox <i>et al.</i> (2008); Srivastava <i>et al.</i> (1999); Melnyk <i>et al.</i> (2000)
Returns management	It is responsible for the destination of the products returned by customers, as well as managing the flow of materials.	Lambert and Cooper (2000); Croxton <i>et al.</i> (2001); Lambert (2008); Stewart (1997); Handfield and Nichols (2002); Bowersox <i>et al.</i> (2008); Srivastava <i>et al.</i> (1999)

Source: developed by the author.

From this brief discussion regarding the business processes that must be integrated between organizations in a supply chain, it is possible to state, according to the opinion of the authors of this research, that Table 1 presents the view of important authors who write about Supply Chain Management and that the processes contained in Table 1 are relevant, therefore, they will be used as constructs of the conceptual model.

3 SUPPLY CHAIN COLLABORATION

Over the past few years, the core strategy of Supply Chain Management has shifted from a competitive view to a collaborative view BOWERSOX *et al.* (2008). At SCM, collaboration can be an alternative for the development of value and innovation (DE MATTOS and LAURINDO, 2016), and collaboration enhances the research and development of new products and services, as well as enables the integration of processes between companies (BUENO, 2012). In addition, according to Lee; Padmanabhan and Whang (2004), collaboration helps to reduce the bullwhip effect – in which there is a distortion of demand

and a tendency for this variation to spread as it moves upstream, increasing business synergy and quality, offering flexibility and increasing joint innovation (CAO and ZHANG, 2011).

Towards Ramanathan and Gunasekaran (2014), the result of collaboration within the supply chain is cumulative. Future collaborations are significantly influenced by the level of current collaborations within the chain. Therefore, if the level of collaboration is relatively low, even if there are improvements in this practice along the supply chain, the integration of business processes between the partners in the chain will be affected (FLYNN *et al.*, 2010).

Organizations that are able to engage heavily in collaboration can achieve improvements in operational and relational outcomes, which will also lead to efficiency improvements in integrating processes with their partners (BAIHAQI and SOHAL, 2013).

Likewise, understanding your partner in the supply chain helps to increase the level of collaboration, generating trust, credibility and effectiveness in the relationship between organizations, also motivating the improvement of business results, such as: cost reduction; increased quality; Efficiency in customer service, reduction of cycle time, increase of value for the customer (ZACHARIA *et al.*, 2009).

Based on the studies found in the literature on collaboration in the supply chain, twenty factors were identified that deal with the components of collaboration (constructs), these are presented in Table 2, understood as those that are part of the nature of collaboration, being characterized as: i) elements preceding collaboration; and ii) resulting from collaboration.

i) Antecedent elements – as their name suggests, are the elements prior to the collaboration itself, that is, the factors that generate collaboration in the supply chain (MIN *et al.*, 2005). Similarly, Hair *et al.* (2009) state that the antecedent elements are defined as the predictor constructs, in this case, of collaboration.

An important point related to the antecedent elements is the construct of trust in the partner, in the literature there is no consensus on how it should be treated, whether as an antecedent or as a resultant. For some authors such as Fawcett *et al.* (2004); Kohli and Jensen (2010) and Falls *et al.* (2013), partner trust is treated as antecedents of supply chain collaboration. However, for Kanda *et al.* (2008) and Zaheer *et al.* (1998), trust in the partner is studied as a resulting element of collaboration. In this research, trust will be considered as an antecedent element of collaboration in the supply chain, as it is understood that first there must be trust and then generate collaboration.

ii) Resulting elements – these are consequences of collaboration, i.e. benefits associated with collaboration that are not likely to be immediately visualized, but generate

potential benefits in the medium and long term (MIN *et al.*, 2005; BARRATT, 2004; FAWCETT *et al.*, 2007; SIMATUPANG and SRIDHARAN, 2005; and KUMAR and NATH BANERJEE, 2014). Therefore, they can only be measured from the moment that the chain already has the practice of collaboration instituted between the partners.

Table 2

Components of collaboration in supply chains

Description of the Element		Authors														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Background	Partner trust (internal and external trust)		X	X			X		X	X				X		
	Organizational culture (collaborative culture)		X					X			X					X
	Internal alignments (personal interactions; internal and external integration)	X		X								X			X	
	Relationship orientation (partnership) - mutuality; Level of collaboration	X	X				X									
	Communication and understanding		X													
	Openness and Honesty		X													
	Selection of partners						X									
	Collaborative agreements	X														
	Joint relationship effort								X							
	Dedicated investments								X							
	Congruence of goals			X												
	Decision Synchronization				X											
Resulting	Information Sharing (exchange of information and sharing of resources)	X	X	X	X	X	X	X	X	X			X			
	Joint planning	X		X		X		X		X						
	Joint Troubleshooting	X				X		X								
	Leverage	X				X										
	Innovative processes				X											
	Incentive alignment				X											
	Collaborative performance				X											
	Performance Measures					X										
1-Min et al. (2005); 2-Barratt (2004); 3-Kohli and Jensen (2010); 4-Simatupang and Sridharan (2005) and (2008); 5-Vivaldini; De Souza and Pires (2007); 6-Doukidis et al. (2007); 7-Kumar and Nath Banerjee (2012); 8-Nyaga; Whipple and Lynch (2010); 9-Akkermans; Bogerd and Van Doremalen (2004); 10-Barney (1986); 11-Droge; Jayaram and Vickery (2004); 12-Horvath (2001); 13-Ireland and Webb (2007); 14-Prieto et al. (2009); 15-Yunus and Tadisina (2010)																

Source: developed by the author.

As the objective of the research is to evaluate how collaboration influences the integration of supply chain business processes, it is essential to measure the elements

preceding collaboration, that is, those that generate the collaborative effect. In this case, after a detailed review of the specialized literature, twelve elements were found prior to the collaboration, in view of the number of possible constructs to be used, a selection of the most relevant elements for the evaluation of collaboration in the supply chain was carried out. For this, only elements that were used in more than one approach (model) were used as a choice factor, thus, the selected elements are: i) trust in the partner; ii) collaborative culture; iii) internal alignment; iv) orientation for partnership. In addition, another important reason that motivated the choice of these factors was their validation, which occurred through the research carried out by Min *et al.* (2005) and Kumar and Banerjee (2014).

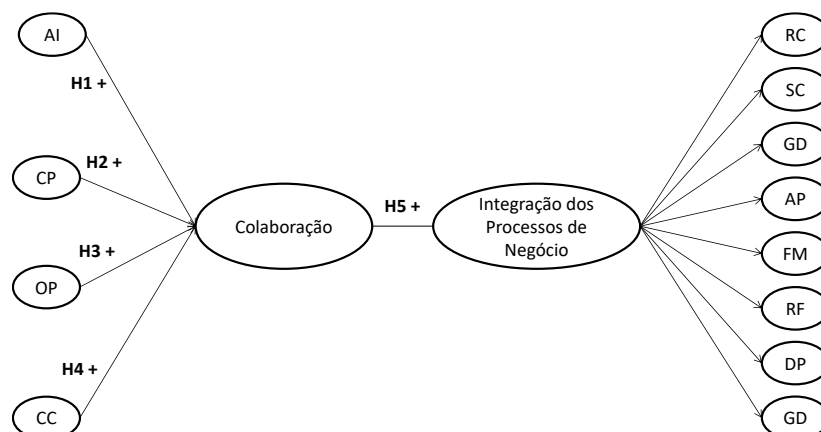
Based on the survey of the main works related to collaboration in the supply chain, it was possible to identify and select the main elements that precede collaboration and that can positively affect collaboration along the supply chain.

4 PROPOSITIONS ON THE INFLUENCE OF COLLABORATION ON THE INTEGRATION OF BUSINESS PROCESSES

From the findings found in the specialized literature and presented in this article, it is possible to build a conceptual model on the relationship between collaboration and the integration of business processes in the supply chain. This model is represented in figure 1, which shows the constructs of the model and the hypotheses of this relationship.

Figure 1

Conceptual model on the influence of collaboration on the integration of business processes in the supply chain



Model constructs: AI – internal alignment; CP – trust in the partner; OP – orientation for partnership; CC – collaborative culture; RC – customer relationship management; SC – customer service management; DG – demand management; AP – fulfillment of the request; FM – manufacturing flow management; RF – supplier relationship management; DP – product development management; and DG – returns management.

Source: prepared by the author.

According to the proposed model, all constructs related to collaboration positively influence the integration of business processes, that is, the greater their presence within organizations, the more efficient the integration of business processes with their partners along the supply chain will be.

Next, the hypotheses that guide the model presented from the constructs related to collaboration in the supply chain are developed, they are: i) internal alignment; ii) trust in the partner; iii) orientation for partnership; iv) collaborative culture; and v) effect of collaboration.

i) **Internal alignment** – this construct in an organization belonging to the supply chain suggests that there is collaboration between sectors and their teams. For Droge, Jayaram and Vickery (2004), inter-sectoral collaboration is determined as the intention of the sectors to act together, sharing information, emphasizing teamwork, presenting a common vision, sharing resources and achieving collective goals. For Baihaqi and Sohal (2013), internal alignment is a predecessor and determining aspect of collaboration in the supply chain. In addition, for the organization to have good results with external collaboration, that is, collaboration with suppliers and customers, it is essential that this practice is instituted internally through internal alignment (BARRATT, 2004). Internal alignment is an ongoing activity of supporting the needs of partners through unification of functions, standardization, simplification of processes, compliance, and structural adaptation (BOWERSOX *et al.*, 2003). In this sense, the first hypothesis of the model can be described as:

4.1 INTERNAL ALIGNMENT POSITIVELY INFLUENCES SUPPLY CHAIN COLLABORATION

ii) **Trust in the partner** -towards Daugherty *et al.* (2006), trust is a fundamental aspect for the necessary changes in a collaborative approach between organizations, because without trust none of the partners will be willing to move away from the usual comfort zone to adopt new responsibilities, such as outsourcing and integrating their business processes with other companies (FAWCETT *et al.*, 2004). Relational aspects, such as trust and credibility in the relationship between companies, are seen as the basis for collaboration in the supply chain (BAIHAQI and SOHAL, 2013). These aspects, while influencing a collaborative effort, are not inherent to a relationship, but develop over time based on experience (MIN *et al.*, 2005). These relational results are higher or lower taking into account the organization's contribution to the collaborative process. As partners share vital information and processes, work to find mutually favorable outcomes and learn together, they

increase the chances of building stronger connections and improving their ability to collaborate (ZACHARIA *et al.*, 2011).

Similarly Akkermans *et al.* (2004) They state that the more partners in the supply chain work together collaboratively, the more trust will be generated between them and the more information will be shared, therefore, it will improve the level of mutual collaboration, which further increases trust. Therefore, mutual trust can provide the basis for collaboration (MIN *et al.*, 2005). In this sense, the second hypothesis of the model can be described as:

4.2 PARTNER TRUST POSITIVELY INFLUENCES SUPPLY CHAIN COLLABORATION

iii) **Partnership orientation** – This construct is defined as an inclination of the organization to carry out cooperation actions with its partners in the supply chain, this can be simplified as the attitude of collaborating. Some research indicates that before collaborating with other actors in the supply chain, it is essential that there is a definition of which partners should be part of this process, seeking to collaborate exclusively with those strategically relevant to the chain (BARRATT, 2004; LAMBERT and KNEMEYER, 2004; MATOPOULOS *et al.*, 2007; MIN *et al.*, 2005). According to authors such as Barratt (2004); Matopoulos *et al.* (2007) and Min *et al.* (2005), there must be a direction towards the development of a relationship and the understanding of the business of each partner in the chain. For instance Lambert and Knemeyer (2004) In their research, they identified companies that separated their partners between high-value and low-value collaboration. This strategic differentiation between business partners is an aspect that characterizes the company's orientation to establish partnerships with other organizations (JAYARAM and PATHAK, 2013), signaling the predisposition or need to develop an external collaborative relationship (MIN *et al.*, 2005). Towards Liker and Choi (2004) Companies can only create the basis for partnership guidance if they know as much about their suppliers and customers as they know about themselves. In this sense, the third hypothesis of the model can be described as:

4.3 PARTNERSHIP ORIENTATION POSITIVELY INFLUENCES SUPPLY CHAIN COLLABORATION

iv) **Collaborative culture** - Collaboration is a relationship-oriented strategy, and its long-term viability depends heavily on the environment in which collaboration is practiced. Culture is an important enabler or even an essential element of collaboration that can make or break the relationship between organizations (FRIEDLI *et al.*, 2006), because working

together and sharing knowledge, skills, risks, communication and processes is difficult without a collaborative culture (FAWCETT *et al.*, 2007; BARRATT, 2004; IRELAND and BRUCE, 2000). The culture in a collaborative network reflects the way companies and people think, work, interact, and behave, and therefore provides a basic protocol for performing all other activities, making collaboration a reality (KUMAR and NATH BANERJEE, 2012). Collaborative culture comprises the attitudes, behavior, and the way individuals and organizations in a collaborative process perceive other partners (KUMAR and NATH BANERJEE, 2012). Both individuals and organizations can experience this culture in terms of the characteristics of individuals and groups, which reflects in openness to communication, knowledge, skill sharing and learning attitude, which, for example, is related to the processes that are integrated between supply chain partners, and the strength of relationships (NYAGA *et al.*, 2010; BARRATT, 2004; ELLINGER, 2000; HADAYA and CASSIVI, 2007). In this sense, the fourth hypothesis of the model can be described as:

4.4 COLLABORATIVE CULTURE POSITIVELY INFLUENCES COLLABORATION IN THE SUPPLY CHAIN

v) **Effect of collaboration** – The effect of collaboration on the integration of business processes is related to the positive effects generated by its previous constructs, i.e., the more significant the internal alignments, trust in partners, the orientation towards partnership and the collaborative culture, the greater the positive effect between collaboration and integration of processes in the supply chain. For example, for Min *et al.* (2005), internal alignment provides additional results, helping to simplify and integrate business processes in basic areas, such as manufacturing flow, demand forecasting, customer service, sales, logistics, and information systems (MIN *et al.*, 2005). In addition, organizations with high levels of internal alignments tend to engage in external collaboration with other actors in the supply chain and thus integrate their business processes. Trust in the partner for Akkermans *et al.* (2004) It generates collaboration that facilitates the sharing of information and resources, thus generating greater ease in the integration of business processes. Regarding the orientation for partnership Liker and Choi (2004) In their research, they state that many companies defend the idea and encourage their managers at all levels to study their partners to understand them and thus facilitate the process of integrating business processes between organizations throughout the supply chain. The collaborative culture is related to the attitudes and behaviors of the organization and its employees and produces a favorable environment

for the integration of business processes (KUMAR and NATH BANERJEE, 2012). In this sense, the fifth hypothesis of the model can be described as:

4.5 COLLABORATION POSITIVELY INFLUENCES THE INTEGRATION OF BUSINESS PROCESSES IN THE SUPPLY CHAIN

From the development of the hypotheses that support the conceptual model on the effect of collaboration on the integration of business processes along the supply chain, it is possible to understand how collaboration and the integration of business processes are interrelated. The construction of the model as well as its hypotheses were defined from an in-depth review of the literature and the consideration of the most important authors in the area, which makes this conceptual model robust and reliable, as it is anchored in results and placements of renowned authors in the area of Supply Chain Management.

5 CONCLUSIONS

The new criteria of competition in the markets have led organizations to develop new capabilities to remain competitive. One of these capabilities is the formation of stronger and more lasting partnerships with its customers and suppliers, in order to establish a chain capable of facing these new criteria and obtaining advantages for all participants in the supply chain.

This research sought to discover how collaboration is related to the integration of business processes in the supply chain. For this, a review of the existing bibliography on the topic of Supply Chain Management related to the integration of business processes and collaboration in the chain was carried out, with the objective of identifying the main and most influential works and enabling the development of a conceptual model that can represent the influence of the constructs presented.

The evidence obtained in the bibliographic research allowed us to verify that the main business processes in the supply chain are: i) customer relationship management; ii) the management of customer service; iii) demand management; iv) the fulfillment of requests; v) the management of the manufacturing flow; vi) the management of the relationship with suppliers; vii) the management of product development; and viii) the management of returns. As well as the constructs that precede collaboration in the supply chain, which are: i) internal alignment; ii) trust in the partner; iii) the orientation towards partnership; and iv) collaborative culture.

From these findings and the conceptual model developed, it is concluded that collaboration, based on the defined constructs, positively influences the integration of business processes in the supply chain, that is, the greater the presence of the collaboration constructs, the more efficient the integration of the processes will be. Thus contributing to increasing competitiveness in the chain and strengthening relationships between partners.

With this, the researchers believe that this research fully achieved its objectives, contributing to the improvement of knowledge on the topics discussed and to the construction of theory about collaboration and integration of processes in supply chains, in addition to providing a conceptual model that can be used in other situations.

As a suggestion for future work, the researchers suggest that the model be tested in practical applications that allow the hypotheses constructed to be tested and the model presented here can be validated.

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REGULATORY CHALLENGES OF THE CARBON CREDIT MARKET IN BRAZIL
DESAFIOS REGULATÓRIOS DO MERCADO DE CRÉDITOS DE CARBONO NO BRASIL

DESAFÍOS REGULATORIOS DEL MERCADO DE CRÉDITOS DE CARBONO EN BRASIL



<https://doi.org/10.56238/sevened2025.036-002>

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ABSTRACT

The growing relevance of the carbon market in the international arena places Brazil before the challenge of structuring a regulated system capable of reconciling economic competitiveness with environmental protection. In this context, the enactment of Law No. 15,042/2024, which establishes the Brazilian Greenhouse Gas Emissions Trading System (SBCE), constitutes a regulatory milestone, while raising doubts about its sufficiency to consolidate a robust and effective market. This study aimed to assess the law's capacity to enable a regulated carbon market in Brazil, considering its historical and legal trajectory, the distinctions between voluntary and regulated markets, the main technical and institutional challenges, as well as its merits and limitations. Methodologically, the research is exploratory, with a qualitative approach, based on bibliographic and documentary review across scientific databases (Scielo, Scopus, Google Scholar) and legislative records. From an initial corpus of 303 documents, 90 were selected for in-depth analysis and organized into thematic categories (regulatory frameworks, market design, infrastructure, socio-environmental justice, and methodological gaps). The results indicate that, although the law advances by creating a mandatory system with phased implementation and benefit-sharing mechanisms, significant gaps persist. These include the exclusion of agribusiness from emission limits, the absence of clear sectoral reduction targets, weaknesses in monitoring, reporting, and verification (MRV), and the risk of speculative dynamics. In conclusion, Law No. 15,042/2024 constitutes an important step but remains insufficient. Regulatory and institutional refinements are required to ensure an environmentally effective, legally stable, and socially just carbon market. Ongoing research and careful monitoring of its implementation will be essential for aligning the system with Brazil's climate goals.

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Keywords: Emissions Trading System. Climate Policies. Market Regulation. Sustainable Development. Environmental Governance.

RESUMO

A crescente relevância do mercado de carbono no cenário internacional coloca o Brasil diante do desafio de estruturar um sistema regulado capaz de alinhar competitividade econômica e proteção ambiental. Nesse contexto, a promulgação da Lei nº 15.042/2024, que institui o Sistema Brasileiro de Comércio de Emissões (SBCE), representa um marco normativo, mas levanta dúvidas quanto à sua suficiência para consolidar um mercado robusto e efetivo. Este estudo teve como objetivo avaliar a capacidade da lei em viabilizar o mercado regulado de carbono no Brasil, considerando sua trajetória histórica e jurídica, as distinções entre os mercados voluntário e regulado, os principais desafios técnicos e institucionais, além de seus méritos e limitações. Metodologicamente, a pesquisa caracteriza-se como exploratória, de abordagem qualitativa, baseada em revisão bibliográfica e documental em bases científicas (Scielo, Scopus, Google Scholar) e registros legislativos. Dos 303 documentos inicialmente identificados, 90 foram selecionados para análise integral, organizados em categorias temáticas (marcos regulatórios, desenho de mercado, infraestrutura, justiça socioambiental e lacunas metodológicas). Os resultados indicam que, embora a lei avance ao criar um sistema obrigatório, com fases de implementação progressiva e mecanismos de repartição de benefícios, persistem lacunas regulatórias e setoriais - como a exclusão do agronegócio, ausência de metas claras por setor, fragilidades em monitoramento, relato e verificação (MRV) e risco de especulação. Conclui-se que a Lei nº 15.042/2024 constitui um avanço importante, mas ainda insuficiente, demandando aperfeiçoamentos regulatórios e institucionais para garantir um mercado ambientalmente efetivo, juridicamente seguro e socialmente justo. Pesquisas contínuas e o monitoramento de sua implementação serão cruciais para adequação às metas climáticas brasileiras.

Palavras-chave: Sistemas de Comércio de Emissões. Políticas Climáticas. Regulação de Mercado. Desenvolvimento Sustentável. Governança Ambiental.

RESUMEN

La creciente relevancia del mercado de carbono en el escenario internacional presenta a Brasil el desafío de estructurar un sistema regulado capaz de alinear la competitividad económica y la protección ambiental. En este contexto, la promulgación de la Ley N.º 15.042/2024, que establece el Sistema Brasileño de Comercio de Emisiones (SBCE), representa un hito regulatorio, pero plantea interrogantes sobre su suficiencia para consolidar un mercado robusto y efectivo. Este estudio tuvo como objetivo evaluar la capacidad de la ley para habilitar un mercado regulado de carbono en Brasil, considerando su trayectoria histórica y legal, las distinciones entre los mercados voluntarios y regulados, los principales desafíos técnicos e institucionales, y sus méritos y limitaciones. Metodológicamente, la investigación es exploratoria, con un enfoque cualitativo, basada en una revisión bibliográfica y documental de bases de datos científicas (Scielo, Scopus, Google Scholar) y registros legislativos. De los 303 documentos identificados inicialmente, se seleccionaron 90 para un análisis completo, organizados en categorías temáticas (marcos regulatorios, diseño de mercado, infraestructura, justicia socioambiental y brechas metodológicas). Los resultados indican que, si bien la ley avanza al crear un sistema obligatorio con fases de implementación progresivas y mecanismos de distribución de beneficios, persisten brechas regulatorias y sectoriales, como la exclusión de la

agroindustria, la falta de objetivos sectoriales claros, las deficiencias en el monitoreo, reporte y verificación (MRV) y el riesgo de especulación. La conclusión es que la Ley N.º 15.042/2024 representa un avance importante, pero sigue siendo insuficiente, requiriendo mejoras regulatorias e institucionales para garantizar un mercado ambientalmente eficaz, jurídicamente seguro y socialmente justo. La investigación y el monitoreo continuos de su implementación serán cruciales para el cumplimiento de los objetivos climáticos de Brasil.

Palabras clave: Sistemas de Comercio de Emisiones. Políticas Climáticas. Regulación del Mercado. Desarrollo Sostenible. Gobernanza Ambiental.

1 INTRODUCTION

The Earth's atmosphere consists of various gases and particles, with nitrogen and oxygen in greater quantities, as well as other gases that form what is known as the greenhouse effect. Among these gases, carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) stand out as the main ones. CO₂ is the most significant of these gases (IPCC AR6 WG3, 2022) and contributes substantially to climate change, such as the rise in global average temperatures (Hansen *et al.* 2006). This is due to its long residence time in the atmosphere and its gradual yet significant increase year after year.

Humanity is convinced that reducing CO₂ emissions is essential, particularly to curb the rise in global temperatures. Several alternatives have been proposed, including the preservation of carbon stocks in soils, forests, and other types of vegetation (Smith *et al.*, 2016).

Among the alternatives studied for mitigating climate change, the knowledge of carbon dynamics is of great relevance. The process carried out by plants, which capture CO₂ through photosynthesis and store it in their biomass, is widely recognized (Dias-Filho, 2006; Viana *et al.*, 2023), as well as the process carried out by the soil (Lal and Cerri, 2006; Pinheiro-Junior *et al.*, 2024), which stores it in the form of carbon. It is also known that carbon is stored in areas with large amounts of dense forests (Soepadmo, 1993; Pan *et al.*, 2011). In this context, Brazil stands out as a powerhouse in forest carbon stocks, particularly in dense forests, due to its vast forested areas and the diversity of biomes with varying capacities for carbon sequestration and storage, especially in the Amazon (Heinrichi *et al.*, 2021).

In addition to environmental preservation, carbon stockpile can generate credits, especially through the reduction of emissions due to deforestation and forestry manipulation (REDD+). Carbon credits correspond to a type of financial tool used to mitigate greenhouse gas emissions into the atmosphere, thus contributing to reducing the impact of climate change. The fundamental idea is to assign a financial value to verified reductions in carbon emissions, in order to encourage the reduction of greenhouse gas emissions in a more efficient and economical way (Ribeiro, 2007; Souza, Alvarez and Andrade, 2014; Souza *et al.*, 2023).

The regulation of Brazil's carbon credit market faces complex and multifaceted challenges. This emerging market, which plays a crucial role in combating climate change, involves the trading of credits, with each credit representing one ton of CO₂ either avoided or removed from the atmosphere (Fisher, 2010; Mendes, 2013).

The establishment of a robust regulatory framework is considered decisive to ensure the integrity and transparency of the carbon credit market. This regulation must set clear guidelines for the quantification, reporting, and verification of emissions, as well as define strict standards for emission reduction projects (Vilar, 2022). Studies suggest that such regulation is requirement to guarantee that carbon credits genuinely represent effective, measurable, and permanent reductions in greenhouse gas emissions (Cames *et al.*, 2016). However, if it is widely acknowledged that the implementation of a carbon credit market brings both economic and environmental benefits, the question arises: is Law No. 15,042/2024 sufficient to enable a robust carbon market in Brazil, or do its regulatory and sectoral gaps undermine the environmental effectiveness and legal stability of the proposed system?

Projects on carbon credits often occur in areas with a significant presence of traditional communities, whose ways of life may be impacted (Alvarez, Elfying and Andrade, 2016; Schroeder 2010). Therefore, it is essential that these communities are effectively involved in the decision-making process and that part of the benefits generated by carbon projects are reverted towards the sustainable development of these communities (Alkmin, 2023; Souza *et al.*, 2023).

The overarching purpose of this study is to examine the capacity of Law No. 15,042/2024 to structure a regulated carbon market in Brazil, assessed in light of its normative advances, regulatory and sectoral shortcomings, as well as the multifaceted challenges posed to environmental effectiveness, legal certainty, and socio-environmental inclusion.

In pursuing this goal, the research further intends to scrutinize the historical and legal trajectory of the principal international conferences, agreements, and legislative initiatives that have shaped the carbon market within the Brazilian context; to delineate the distinctions between voluntary and regulated carbon markets by emphasizing their legal, economic, and operational underpinnings; to identify and categorize the principal technical, institutional, and regulatory barriers to the effective implementation of the Brazilian Emissions Trading System (SBCE); and to critically assess the merits and limitations of Law No. 15,042/2024 through reference to the scientific literature and antecedent legislative proposals that informed its enactment. Finally, the study seeks to formulate complementary guidelines and policy recommendations designed to strengthen the effectiveness and resilience of the Brazilian carbon market, informed by comparative international experiences.

2 MATERIAL AND METHOD

In this work, a narrative literature review was used, which involved a detailed study of publications related to the topic under discussion. The research is characterized as exploratory, with a qualitative approach, and bibliographic procedures. Data collection was carried out through consultation of the Scielo, Scopus, and Google Scholar databases, selecting journals classified as Qualis “A” or “B” or with an H-index greater than two, as well as undergraduate and postgraduate works (dissertations or theses). Documents such as Bills and Opinions were also gathered from federal legislative bodies (Federal Senate and Chamber of Deputies). According to Dourado and Ribeiro (2023), this type of literature review is a solid and reliable source of information, as it compiles knowledge from various selected publications, facilitating the identification of gaps in existing research.

The search strategy used the descriptors: “CARBON CREDIT” OR “CARBON CREDITS” AND BRAZIL OR BRASIL AND REGULAÇÃO OR REGULATION OR “PROJETO DE LEI” OR “PROJECT OF LAW”, in All Fields. The timeframe considered was the last six years (2019–2024), with the inclusion of classic or pioneering works beyond this period based on relevance and citation volume.

Initially, 303 documents were retrieved. After removing duplicates and applying relevance filters based on title and abstract screening, 90 documents were selected for full-text analysis. Figure 1 illustrates the methodological flow used for selection, based on adapted PRISMA guidelines.

Figure 1

Methodological flow used for selection of documents



Source: elaborated by the authors.

Subsequently, the selected publications were classified into thematic categories, following an inductive coding process derived from content analysis. The categories reflect the dominant axes of discussion present in the carbon credit regulatory debate in Brazil:

- Regulatory Frameworks and Legal Instruments** (e.g., PLs, decrees, SBCE, SINARE);
- Market Design and Economic Mechanisms** (e.g., cap-and-trade, voluntary vs. regulated systems);
- Infrastructure and Implementation Challenges** (e.g., MRV systems, institutional gaps);
- Social and Environmental Justice** (e.g., REDD+, indigenous participation, benefit sharing);
- Technical Proposals and Methodological Gaps** (e.g., additionality, leakage, double counting).

These categories are detailed in Table 1, which also lists representative references for each cluster. This analytical classification supported a more structured discussion of results, allowing comparisons between international experiences and the Brazilian context, with emphasis on gaps in current legislation (Law 15.042/2024) and potential areas for improvement.

Table 1

List of quantities by thematic categories and relevant works

Thematic Category	Nº of Articles	Representative Works
Regulatory Frameworks	24	Lima (2023); Souza <i>et al.</i> (2020); BRASIL (2024)
Market Design and Economic Mechanisms	18	Cames <i>et al.</i> (2016); Reisch (2022)
Infrastructure and Implementation	12	Vilar (2022); Rocha (2019); Rocha, Álvarez and Silveira (2014)
Social/Environmental Justice	20	Alkmin (2023); Alvarez; Elfving and Andrade (2016); Brito and Pozzetti (2021)
Methodological Gaps and Proposals	16	Poyer, Silveira and Oliveira (2020); Montovanelli (2023)

Source: elaborated by the authors.

Given the established objectives, the study was developed along the following topics: Historical Context of Carbon Market Regulations; Carbon Market: Voluntary vs Regulated; Challenges, Brazilian Potentials in the Regulated Market and Conclusions, presented below. The data was analyzed descriptively and demonstrated in boxes to better demonstrate the results obtained.

3 RESULTS AND DISCUSSIONS

3.1 HISTORICAL CONTEXT OF CARBON MARKET REGULATIONS

The inception and evolution of the carbon credit concept is situated in the broader context of global concerns about climate change and the role of greenhouse gas emissions. This idea originated from the growing awareness of the need to establish for efficient and scalable mechanisms to reduce global carbon emissions and mitigate global warming. In the initial phase, the notion of crediting emerged as an innovative tool to incentivize the reduction of emissions in a cost-effective manner (Guimarães, 2023).

The initial discussions started indirectly at the Stockholm Conference (1972), when the interdependence of human beings and the environment was recognized. At the Vienna Convention (1985) there was an international agreement to protect the stratospheric ozone layer. Its aim was to prevent the production and consumption of ozone-depleting substances such as chlorofluorocarbons (CFCs).

The Montreal Protocol (1987) was a complement to the Vienna Convention and established specific targets for the progressive elimination of the use of substances that cause the depletion of the ozone layer. At ECO-92 (1992) there was a significant milestone in promoting global awareness of environmental issues and establishing commitments in the search for more sustainable development.

These events did not directly debate the creation of the carbon credit market, but their ideals contributed to highlighting the problems the modern world was experiencing. Table 2 summarizes the historical evolution of the carbon credit market.

Table 2

Summary of the historical evolution of the regulation of the Carbon Credit Market

Year	Event	Action
1972	Stockholm Conference	Declaration on the Human Environment "To inspire and guide the peoples of the world to preserve and improve the human environment". Emergence of the concept of Sustainability.
1985 / 1987	Vienna Convention and Montreal Protocol	Protecting the ozone layer and restricting CFC emissions for the sake of protecting the ozone layer.
1992	ECO-92	Agenda 21 for sustainable development. Creation of the Convention on Diversity and the Framework Convention on Climate Change.
1997	Kyoto Protocol - COP III of the United Nations Framework Convention on Climate Change	Establishment of targets and market mechanisms for the reduction of greenhouse gases. The reduction of greenhouse gases could be financially compensated through CERs - Certified Emission Reductions.

Year	Event	Action
2012	RIO+20	Creation of the SDGs and institutional commitment by States Parties to structure a green economy and eradicate poverty.
2015	Paris Agreement COP 21 of the United Nations Framework Convention on Climate Change	Establishment of iNDCs (Intended Nationally Determined Contribution) to reduce GHG.
2024	Law 15,042 approved	Establishes the Brazilian Greenhouse Gas Emissions Trading System (SBCE)

Source: elaborated by the authors.

An analysis of the main international conferences, such as Kyoto and Paris, reveals the progressive evolution of global understanding and response to climate change, particularly in the context of the carbon credit market. These conferences, milestones in the history of climate negotiations, have outlined paths and established fundamental commitments for the global management of greenhouse gas emissions (Lima, 2023).

In order to look for options to promote sustainable development, the 3rd Conference of the Parties (COP-3) generated documents of intents. These documents were signed by the countries that, at the time, were responsible for 55% of global emissions. The agreement set targets for the developed countries, which were members of the Organization for Economic Cooperation and Development (OECD), included in Annex I of the agreement. In addition, Russia signed the agreement in 2004, and Eastern European countries also became signatories (Seiffert, 2009; Delpupo, 2009).

The Kyoto Protocol established emission reduction targets of around 5.2% in relation to 1990 levels for developed countries, which at the time were considered to be the main contributors to emissions. These targets were projected for the first period of the agreement, between 2008 and 2012 (Souza *et al.*, 2012).

This agreement established both conditions and targets to reduce the continuous increase in greenhouse gas emissions resulting from the growing volume of global production (Lombardi, 2008). A significant contribution of the Kyoto Protocol was the incorporation of three forms of flexibility mechanisms to achieve the stipulated targets. Through these mechanisms, emission reduction efforts from different countries, projects and initiatives can be considered to meet local targets. These mechanisms include:

- a) Emissions Trading System (ETS),
- b) Joint Implementation Mechanism (JI) and
- c) Clean Development Mechanism (CDM).

The CDM is the only mechanism that allows developing countries (like Brazil) to carry out emission reduction and removal projects in order to generate carbon credits, by allowing carbon credits to be traded with Annex I countries that need to reduce their excess emissions. This mechanism is considered an economic instrument that gave rise to the regulated carbon market worldwide. The regulated carbon market consists of an institutional environment where participants are subject to national or global legislation and standards, which establish criteria and rules for designing projects and trading Certified Emission Reductions (CERs) from CDM projects (Souza *et al.*, 2012).

With the replacement of the Kyoto Protocol by the Paris Agreement, there was a new look at the world, letting countries express how much they could contribute to reducing their emissions through NDCs, which must pass through the congresses and parliaments of each country (Hamilton *et al.*, 2021). In its NDC, presented in 2015, Brazil set out its goals for mitigating climate change. Officially, Brazil has committed to reducing its emissions by 37% by 2025 and 50% by 2030, based on its 2005 emissions, through mitigation and adaptation measures (UNFCCC, 2023). At COP29 in November 2024, Brazil set a new target by proposing to reduce net greenhouse gas emissions by 59% to 67% by 2035, relative to 2005 levels. Table 3 shows a summary of the main commitments ratified in the Paris Agreement by the five countries with the highest CO₂ emissions, which accounted for 61% of emissions in 2022.

Through these conferences, there has also been a progressive increase in the global ambition to reduce emissions. While the Kyoto Protocol focused on short-term targets and a more quantitative approach, the Paris Agreement introduced a long-term vision aimed at limiting the increase in global temperature to values below 2°C above pre-industrial levels (Brito and Pozzetti, 2021).

Table 3

Summary of the main commitments ratified in the Paris Agreement by the top 5 CO₂ emitting countries

Country	Treaties signed	Global CO ₂ emissions (2022)	
		%	MtCO ₂
1° China	• peak CO₂ emissions by 2030; • reduce energy intensity by 2030; • increase the share of non-fossil sources by 20% by 2030; • expand areas of afforestation and reforestation;	32%	11.900
2° USA	• reduce greenhouse gas emissions by 26% to 28% below 2005 levels by 2025; • increase renewable energy sources; • improve energy efficiency in various economic sectors; • Implement policies and initiatives to promote sustainability and resilience to climate change, including the preservation of forests and natural ecosystems; • contribute to the financing of climate initiatives in developing countries;	13,7%	5.080
3° India	• reduce the greenhouse gas emissions intensity of its GDP by 33% to 35% by 2030, compared to 2005 levels; • increase the installed capacity of non-fossil energy to 40% of the total by 2030; • create an additional carbon sink of 2.5 to 3 billion tons of carbon dioxide equivalent by increasing forest cover and improving the quality of forests by 2030; • invest in clean technologies and promote technology transfer to support their sustainable growth; • implement measures to increase the country's resilience to the impacts of climate change, including the protection of vulnerable communities and the development of resilient infrastructure;	7,4%	2.760
4° Russia	• reduce their greenhouse gas emissions by 25% to 30% below 1990 levels by 2030; • maintain current forests as a carbon sink; • promote energy efficiency in sectors such as transportation, industry and construction, with the aim of reducing total energy consumption and associated emissions; • increase the use of renewable energy sources;	4,3%	1.600
5° Japan	• reduce its greenhouse gas emissions by 26% by 2030, compared to 2013 levels; • significantly improve energy efficiency in sectors such as transportation, industry and buildings to reduce energy consumption and associated emissions; • increase the share of renewable energy sources; • implement adaptation measures to increase the country's resilience to the impacts of climate change;	2,9%	1.060
TOTAL		60,3%	22.400

Source: Elaborated by the author based on data from Climate Watch - PIK (2024) – CO₂ Emissions excluding Land Use Change and Forests.

International conferences have increasingly become critical forums for discussions on integrity and effectiveness. Consequently, issues such as transparency, accounting, and the prevention of “double counting” of emissions have become central topics, reflecting the

ongoing effort to enhance and strengthen market mechanisms in the context of climate change (Oliveira, 2022).

In the early stages, carbon market policies focused mainly on creating cap-and-trade systems, in which limits or caps were set on total allowable emissions, and companies or countries could trade emission permits. These systems sought to incorporate the environmental cost of carbon emissions into economic decisions, encouraging investments in cleaner and more efficient technologies (Chagas, Ferreira and Feitosa, 2022).

With the growing understanding of the impacts of climate change, there has also been a greater emphasis on the need for inclusive and fair approaches. Public policies have begun to recognize and integrate sustainable development considerations, including the protection of biodiversity, the promotion of social equity and the involvement of local and indigenous communities in carbon credit projects (Montovanelli, 2023; Alkmin, 2023).

A comparison of global regulations surrounding carbon credit markets highlights the diversity of approaches adopted by different nations and economic blocks, reflecting the varied economic, environmental and political contexts. This comparison reveals the differences in regulatory frameworks and the similarities in fundamental objectives and challenges faced (Stevanato, 2022).

In the European Union, for example, the Emissions Trading System (EU ETS) represents one of the oldest and most sophisticated carbon markets in the world. It is characterized by a strict cap-and-trade regime, where a ceiling for emissions is set and emission rights are traded. This system has been instrumental in reducing greenhouse gas emissions in the region, demonstrating the effectiveness of a well-structured and coherent regulatory approach (Oliveira, 2021).

In contrast to the European model, the carbon credit regime in the United States is marked by a decentralized approach based on state initiatives, such as the California Cap-and-Trade Program. This program, specific to the state of California, illustrates how sub-national regulations can be effective in managing emissions, offering flexibility and adaptability to local contexts (Maldaner, 2022).

On the Asian continent, particularly in China, the approach has been to gradually implement emissions trading systems. Initially launched as pilot projects in various cities and provinces, these systems are evolving into a national scheme, reflecting China's growing importance on the climate change scene and its pragmatic, phased approach to implementing environmental policies (Fonseca, 2022).

In regions with established emissions trading systems, such as the European Union, there has been a clear boost in the adoption of low-carbon technologies, demonstrating the potential of these markets to stimulate changes in industrial and energy practices (Delgado, 2022). However, challenges have also been identified, such as the need to set emission ceilings that are both ambitious and achievable. Experience has shown that caps that are too high can fail to promote significant emission reductions, while caps that are too low can impose excessive economic challenges, especially for industries in transition (Nicoletti, 2022).

The integrity of carbon credit markets depends heavily on confidence in the accuracy of emissions data and the effectiveness of reported reductions. Challenges related to double counting and quality have driven efforts to improve monitoring systems and international regulation (Souza, 2020).

An emerging understanding is the importance of climate justice and social inclusion in markets. Initiatives must consider the environmental and economic aspects and the social impact and involvement of local communities. International experience has shown that the most successful projects are those that combine emission reductions with local social and environmental benefits (Oliveira, 2021).

3.2 CARBON MARKET: VOLUNTARY VS REGULATED

The structure and operation of the voluntary carbon credit market has distinct characteristics that differentiate it from regulated markets. The former is characterized by the trading of carbon credits outside of a mandatory regulatory framework, where the buying and selling of credits is driven by the will of interested parties to contribute to the reduction of greenhouse gas emissions, in addition to achieving corporate or personal sustainability goals. In the voluntary market, companies, governments or individuals can buy credits to offset their own emissions, with the aim of becoming neutral or achieving other environmental goals. They are generated by projects that reduce, avoid or capture greenhouse gas emissions. Common examples include reforestation projects, renewable energy, carbon capture and storage, and energy efficiency improvements (Montovanelli, 2023).

Unlike regulated ones, where they are often traded within parameters set by government policies, voluntary ones offer greater freedom in terms of how and where credits can be generated and sold. This provides a breeding ground for innovation and experimentation in reduction projects (Silveira and Oliveira 2021).

Although it is not regulated by a specific legal framework, the market relies heavily on credibility and transparency. Therefore, carbon credits are often validated and verified by independent third parties, according to internationally recognized standards and protocols. This ensures that the emission reductions are real, measurable and permanent (Delgado, 2022).

The regulated market is structured under guidelines and standards established by governmental or intergovernmental authorities, differing substantially from the voluntary market in terms of regulation and supervision. This form of market is often based on international agreements, such as the Kyoto Protocol, or on national legislation that sets emission reduction targets for entire sectors or countries (Souza, 2020).

In this system, they are used as a tool to meet regulatory obligations to reduce emissions. Generally, a cap is set on the total emissions allowed within a jurisdiction or sector. Companies or entities that emit greenhouse gases are then obliged to hold an amount of carbon credits equivalent to their emissions, encouraging them to reduce their emissions or buy additional credits on the market if they exceed their allocated limits (Anis, Carducci and Ruviaro, 2022).

A distinctive feature of the regulated market is the existence of a cap-and-trade mechanism. This system allows companies that reduce their emissions below the established limits to sell surplus credits to others that are struggling to meet their targets. This creates an economic incentive to reduce emissions and promotes efficiency in the allocation of resources to where emissions reductions can be achieved at the lowest cost (Inácio Filho, 2022).

Integrity and effectiveness depend heavily on a rigorous emissions Monitoring, Reporting, and Verification (MRV) system. Such systems are key to ensuring that emissions reductions are real, measurable and verifiable, sustaining trust in the market and ensuring that emissions reduction targets are effectively achieved (Vercillo, 2023).

The economic and procedural differences are striking and significantly influence the dynamics and effectiveness of each system. In the economic sphere, the main distinction lies in the way carbon credit prices are set and the nature of the incentives for reducing emissions (Maldaner, 2022).

In the markets, carbon credit prices are generally influenced by factors such as emission targets set by the government, supply and demand within the cap-and-trade system, and penalties for non-compliance with quotas. This system tends to create a more stable and

predictable price for carbon, reflecting environmental policies and objectives defined in a regulatory manner. It provides a direct incentive to reduce emissions, as companies look for ways to cut their costs by buying credits (Reisch, 2022).

On the other hand, in the voluntary market, prices are more influenced by market supply and demand, without the imposition of government limits or penalties. In many cases, companies acquire carbon credits voluntarily to meet corporate sustainability, social responsibility or marketing objectives. In this context, the price of credits can be more variable (and generally lower than in the regulated market), reflecting a diverse range of projects and their perceived environmental and social quality (Fonseca, 2022).

In terms of procedures, regulated markets require a robust system to ensure that emissions and reductions are accurately quantified and verified. This process often involves regulatory or certification bodies that ensure compliance with established standards. In addition, participation in a regulated market usually implies stricter legal and compliance requirements for companies (Souza, 2020).

Another challenge is the issue of “carbon leakage”, where companies can transfer production to countries with less stringent regulations, resulting in emissions not being reduced globally. To combat this, some jurisdictions have implemented measures such as free allocation of permits to sectors at risk of carbon leakage, seeking a balance between environmental protection and economic competitiveness (Moreira and Silva 2022).

3.3 BRAZIL'S CHALLENGES AND POTENTIAL IN THE REGULATED MARKET

In the context of the Brazilian carbon credit market, several current barriers can be identified, reflecting challenges at both structural and operational levels. One of the main barriers is the absence of a specific and comprehensive regulatory framework. This legal gap creates uncertainty about the rules of operation, discouraging potential investors and participants due to the lack of clarity about the rights and duties involved, and can even lead to fraud, as reported by CNN Brasil in the article entitled “PF carries out mega operation against fraud in granting carbon credits to multinationals” (Maia, 2024).

There are currently four rules in force in Brazil that legitimize the trading of carbon credits: the National Policy for Payment for Environmental Services (Law N°. 14.119/21), the Cédula de Produto Rural - CPR-Verde (Decree N°. 10.828/21); the National System for Reducing Greenhouse Gas Emissions - SINARE (Decree N°. 11.075/22 amended by Decree

Nº. 11.550/2023) and the Law 15.042/2024 which establishes the Brazilian Greenhouse Gas Emissions Trading System (SBCE).

However, it is important to note that these legal frameworks do not establish guidelines or regulations for this market. The approval of Law 15,042/2024 alone is not sufficient to ensure the operationalization of the market, as the law itself sets a timeline for the implementation of the SBCE, which will be gradual and divided into five main phases, as shown in table 4. This aims to ensure predictability and legal certainty for regulated companies, in addition to attracting international investments and positioning Brazil as a global leader in the carbon market.

Table 4

Phases for implementing the Brazilian Greenhouse Gas Emissions Trading System

Phase	Time – Months	Action - Objectives
1	12 to 24	Initial regulation, creation of the governing body, and definition of the sectors to be regulated. At this stage, the operational details of the system and the legal framework for market functioning will be established.
2	12	Operationalization of the monitoring, reporting, and verification (MRV) system for emissions. Companies will be required to report their emissions in a standardized manner, creating a database that will enable market oversight.
3	24	Start of the obligation to submit emissions reports and monitoring plans, providing the necessary data for the first National Allocation Plan (PNA).
4	Approximately 12 to 24	Start of the first allocation cycle of Carbon-Based Emission Allowances (CBEs) and the operationalization of the first auctions. The PNA will be published, defining the rules for quota distribution and the initial volume available to the market. During this phase, the first CBEs will begin to be issued and traded, involving regulated companies.
5	Approximately 12	Full implementation of the market, with the first CBE auction and the launch of the secondary market, allowing transactions between companies.

Source: prepared by the authors based on Law No. 15,042/2024.

Law No. 15,042/2024 establishes the Brazilian Greenhouse Gas Emissions Trading System (SBCE), defining emission caps, setting rules for the commercialization of offset credits, and creating standards for the functioning of the trading system. Its purpose is to reconcile economic competitiveness with environmental protection. By instituting the legal

framework for the carbon credit market in Brazil, the law aligns national regulation with international standards and the commitments assumed under the United Nations Framework Convention on Climate Change and the Paris Agreement. In practice, this means the establishment of a mandatory system that imposes progressive emission reduction targets on regulated sectors and integrates Brazil's national reduction commitments under UN monitoring mechanisms.

Before being enacted as Law 15,042/2024, the text was processed under Bill 182/2024, which consolidated the following bills addressing various issues related to emissions and carbon credit trading:

- Bill 10.073/2018: Establishes an IPI reduction for products suitable for the low-carbon green economy;
- Bill 290/2020: Provides for environmental compensation for electricity generation and the certification of carbon credits for generation projects using alternative sources;
- Bill 3.606/2021: Proposes the establishment of a regulatory framework for MBRE;
- Bill 2.122/2021: Proposes the definition of rules for financial assets related to the mitigation of greenhouse gas emissions;
- Bill 4.028/2021: Proposes the creation of general guidelines for the regulation of the carbon market in Brazil;
- Bill 412/2022: Regulates the Brazilian Emissions Reduction Market (MBRE), provided for by Law 12.187, of December 29, 2009, and amends Laws 11.284, of March 2, 2006; 12,187, of December 29, 2009; and 13,493, of October 17, 2017;
- Bills No. 7.578/2017, 5.710/2019, 528/2021, 4.290/2023, 4.088/2021, 5.157/2023 and 155/2023, which deal with similar matters and were therefore joined as substitutes to Bill 182/2024;

It is important to mention these bills, as each emerged within a specific political and social context, reflecting distinct economic, political, environmental, and social interests. Law No. 15,042/2024 ultimately consolidated nearly all of them, except for the exclusion of obligations requiring the agribusiness sector to comply with emission limits.

Although Brazil has great potential for generating carbon credits, especially due to its vast forest cover and renewable energy opportunities, it still lacks a mature market infrastructure that can effectively manage the supply and demand for credits, as well as ensure the integrity and transparency of transactions (Maldaner, 2022). In both the public and private sectors, there is a lack of specialized knowledge, its potential and its operational

mechanisms. This lack of knowledge and experience can result in mistrust or the adoption of inefficient practices (Poyer, Silveira and Oliveira, 2020).

The law 15,042/2024 lists a series of actions that can generate carbon credits, including restoration, maintenance and conservation of permanent preservation areas (APPs), legal reserves or restricted use areas, and conservation units; integral or sustainable use conservation units with a management plan; land reform settlement projects; indigenous peoples and traditional communities are allowed to participate in the market through associations. A preliminary analysis of the draft laws was carried out in December 2024, where the following positive and negative points can be seen in table 05.

Table 5

Analysis of the Positive and Negative Points of the Bills Regulating Carbon Credits in Brazil

 Pros	 Cons
• It will provide competitive advantages for the Brazilian economy. • It will encourage changes in production and consumption patterns, promoting greater demand for clean technologies. • Regulating the carbon market could become an effective way of reducing greenhouse gas (GHG) emissions, aligning the sustainability tripod: economically viable, socially fair and ecologically correct. • Implementing carbon pricing will help mitigate climate change by creating economic incentives for companies to adopt sustainable practices, as well as stimulating investment in research and innovation. • It increases the mix of compensation possibilities, creating rules and methodologies for certifications, through CBEs (Brazilian Emission Quotas) and CRVEs (Certificates of Verified Emission Reduction or Removal).	• Carbon pricing alone will not be enough to mitigate the environmental impacts needed to reduce the effects of climate change. • Many carbon offset projects do not result in significant emission reductions, serving merely as a way for companies to offset their pollution without modifying their production processes. • There are concerns about climate justice, as local communities in developing countries, where many offsets occur, may suffer socio-environmental impacts without receiving direct benefits. • They do not explicitly address methane credits, which were included in Decree 11.003/2022 by Decree 11.075/2022. It would be pertinent to include such a reference in the legislation, especially considering the global commitment made by Brazil at COP 26 to reduce methane gas emissions by 30%. • They do not directly address the issue of reducing deforestation.

 Pros	 Cons
• Establishes control of activities that emit more than 10,000 tons of CO₂ per year. Companies with emissions of between 10,000 and 25,000 tons per year will have to submit an emissions monitoring plan to the SBCE management body, including the submission of an annual emissions and removals report. For activities with emissions of more than 25,000 tons per year, it will be compulsory to submit an annual report on the periodic reconciliation of obligations, which is not currently done. • The issuance of carbon bonds will be validated and regulated by the Brazilian state, which could be important in providing more technical and legal security for both generators and purchasers of decarbonization bonds. • This is a significant step forward in terms of legal certainty, considering that, currently, with the deregulated and voluntary market, negotiations can lead to various risks and legal consequences for those who acquire carbon credits and use them as proof of reductions and compensations at a global level. • It guarantees traditional and indigenous communities the right to receive and participate in the management of financial resources generated by carbon credit projects carried out in their territories. They will be entitled to 50% of the credits in the case of conventional greenhouse gas removal initiatives, and 70% of the credits in the case of avoided deforestation and forest degradation projects, conservation, and forest management (REDD+).	Even after the signing of the Glasgow declaration on forests and land use at COP 26, this action does not entail formal obligations. • Although the main focus is on regulating financial transactions in the context of a market structure, it would be beneficial to highlight the importance of meeting the targets set in the Paris Agreement, especially by reducing deforestation. • The creation of an Emissions Trading System (ETS) could result in carbon emissions becoming yet another commodity for the international market, without generating significant impacts for Brazil's economic growth. There is concern that the ETS could be concentrated in the hands of large corporations or volatile on the speculative market. • Agriculture, forestry and alternative land use were excluded in the vote by the Senate (Bill 412/2022) and the House (PL 2.148/2015) under the pretext that Brazilian agriculture is low-impact, with a vast area of the country still preserved and increasingly, environmental barriers are being established globally for agricultural products and commodities, which is already causing the Agribusiness sector to organize itself to reduce emissions. • Emission levels can be increased (made more flexible), taking into account the cost-benefit ratio of regulation and compliance with Brazil's commitments to the United Nations Framework Convention on Climate Change.

Source: elaborated by the authors based on Law No. 15,042/2024.

The complexity and diversity of the Brazilian environmental scenario also pose challenges. The country has a wide range of biomes and great socio-environmental diversity, which makes the implementation of carbon credit projects and the measurement of their emission reductions particularly challenging (Vercillo, 2023). This complexity requires customized and well-founded approaches that take into account the peculiarities of each region and community (Munhoz, 2023).

From a social point of view, the carbon credit market has the potential to generate tangible benefits for local communities, especially those located in rural areas or in regions of great ecological importance, although the viability of this depends on areas of at least 20,000 hectares, due to the high fixed costs of auditing and certifying projects (Credcarbo, 2024; Carbonext, 2024); through consortium contracts or partnerships, it is possible to unite areas of 4,000 hectares or more in order to reach the break-even point of economic viability.

Well-structured projects can create jobs, foster sustainable local development and improve people's quality of life, in line with the United Nations Sustainable Development Goals. However, it is essential that these projects are developed in a participatory and inclusive manner, ensuring that the benefits are shared with local communities and that their rights and ways of life are respected (Brito and Pozzetti, 2021).

An important strategy is also investment in infrastructure and technical capacity. This involves, for example, developing systems that minimize carbon emissions, as well as training qualified professionals to manage and operate these systems (Rocha, 2019).

The awareness and involvement of all stakeholders must be promoted, including the private sector, the government, local communities and civil society. This can be achieved through educational campaigns, participatory dialogues and collaboration with non-governmental organizations and academic institutions. The inclusion of diverse perspectives and the dissemination of information about the benefits and functioning of the carbon credit market can foster broader and more effective uptake (Vargas, Delazeri and Ferreira, 2022).

Another fundamental aspect is the integration of credit policies with other environmental and economic initiatives. This includes aligning credit policies with national strategies for sustainable development, forest conservation, renewable energy and poverty reduction. An integrated approach can maximize environmental and social benefits while contributing to the low-carbon economy (Brito and Pozzetti, 2021).

This framework must establish clear guidelines on the issuing, marketing and monitoring of carbon credits, guaranteeing transparency, reliability and compliance with

international standards. This regulation in phases should also include inspection mechanisms and penalties for non-compliance with the established standards (Baeta, 2020).

4 CLOSING REMARKS

Law No. 15,042/2024 represents a relevant advancement by establishing the Brazilian Greenhouse Gas Emissions Trading System (SBCE) and aligning the country with international climate mitigation commitments. However, the findings of this study indicate that the law is not yet sufficient to enable a robust carbon market, as it contains regulatory, operational, and sectoral gaps that compromise both environmental effectiveness and legal certainty.

The analysis of the historical and legal trajectory of the carbon market shows that the law is the result of a long process of legislative maturation, influenced by international agreements (such as the Kyoto Protocol and the Paris Agreement) and the consolidation of several previous legislative proposals. While the text incorporates important regulatory elements, it failed to fully include crucial sectors such as agribusiness, based on fragile justifications. This omission weakens the scope of national climate policy.

The comparison between voluntary and regulated carbon markets reinforces the importance of transitioning to a state-managed system with binding targets, emissions control, and environmental integrity. While the voluntary market operated with variable credibility and lacked legal obligations, the regulated market imposes emission caps and trading rules grounded in monitoring, reporting, and verification (MRV) methodologies. Law 15,042/2024 advances in this direction, but its effective implementation will depend on complementary regulations and the creation of robust institutional structures.

Among the main technical and institutional challenges identified are: the absence of a fully operational governing body; the need for a reliable MRV system; the technical unpreparedness of many public and private actors; and the complexity of implementing projects in diverse socio-environmental contexts. Additionally, the economic viability of carbon projects, according to international standards, is still limited to large areas (>20,000 hectares), potentially excluding small rural producers and traditional communities unless consortia are formed.

The critical analysis of the law also reveals strategic limitations. There are no clearly defined emission reduction targets by sector; methane credits and effective deforestation control mechanisms are omitted; and the compensation system may allow companies to

merely “buy the right to pollute” without being encouraged to change their production processes. Furthermore, there is a risk that the market could become a speculative commodity with no real climate benefit.

Despite these issues, Law 15,042/2024 contains important merits: it guarantees benefit-sharing with Indigenous and traditional communities; proposes the issuance of regulated carbon quotas (CBEs and CRVEs); and promotes predictability through a five-phase implementation model. Its existence already constitutes a legal milestone that can be improved and expanded.

Based on successful international experiences, the following recommendations are made for subsequent regulatory phases and possible revisions to the law: (a) include all economic sectors, especially agriculture and land use; (b) impose limitations on the use of offset mechanisms to prevent misuse; (c) improve MRV methodologies to avoid double counting; (d) set ambitious and progressive emission reduction targets; (e) integrate SBCE with other environmental and climate public policies; and (f) ensure participatory governance with transparency, oversight, and social inclusion in all technical working groups and regulatory bodies involved in the law’s implementation.

In conclusion, although it is an important step, Law No. 15,042/2024 still requires regulatory and operational refinements to guarantee the establishment of an environmentally effective, legally stable, and socially just carbon market in Brazil. Ongoing research and rigorous monitoring of the law’s implementation will be crucial to ensure its success and alignment with the country’s climate goals.

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BATUQUES À MINA: TERREIRO EDUCATION AND MUSICAL TRANSMISSION PROCESSES

BATUQUES À MINA: EDUCAÇÃO DE TERREIRO E PROCESSOS DE TRANSMISSÃO MUSICAL

BATUQUES À MINHA: EDUCACIÓN TERREIRO Y PROCESOS DE TRANSMISIÓN MUSICAL

 <https://doi.org/10.56238/sevened2025.036-003>

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ABSTRACT

This article presents a study on the origins and processes of musical transmission in a Mina Jeje Nagô terreiro in Belém do Pará. Mina is a typically Afro-Amazonian religion that is most widespread in the state of Pará. In this context, music is an inseparable element, performing a communicative function, present in its rituals, as well as being closely related to extramusical elements, such as dance and the mythology of the orixás, the African and Afro-Brazilian deities. Aiming to go beyond everyday content, research the musical activities of the Mina terreiros to encourage reflection on traditional and contemporary educational practices. Understanding the religious universe of Tambor de Mina was considered appropriate to review the concepts of culture and education and assist in understanding this system that involves music. Therefore, based on bibliographic and field research, where dialogue was established with musicians from the terreiros, a bibliographic review was conducted with theoretical support from authors in the fields of education, music education, and ethnomusicology, as well as specific works on culture and music in the terreiro, in addition to interviews with the Yalorixá and the lead drummer of Kuênãbossizô – Casa do vento no caminho do fogo (House of the Wind on the Path of Fire) located in the Pedro Teixeira complex. These are some of the authors. Therefore, through a global view of the cultural environment of Tambor de Mina, we aim to bring it and its contributions to Afrocentric music education.

Keywords: Afro-Brazilian Music. Tambor de Mina. Transmission Processes. Afrocentric Music Education.

RESUMO

O presente artigo apresenta um estudo sobre as origens e os processos de transmissão musical num terreiro de Mina Jeje Nagô em Belém do Pará, a Mina é uma religião tipicamente Afro-Amazônica mais difundida no estado do Pará. Nesse contexto, a música é um elemento indissociável, exerce função comunicativa, presente em seus rituais, bem como está intimamente relacionada com elementos extramusicais, como a dança e a mitologia dos orixás, as divindades africanas e afrobrasileiras. Visando extrapolar os conteúdos cotidianos,

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pesquisar as atividades musicais dos terreiros de Mina para fomentar uma reflexão sobre as práticas educacionais tradicionais e contemporâneas. Entender o universo religioso do Tambor de Mina, foi considerado oportuno, para revisar os conceitos de cultura e educação e auxiliar na compreensão desse sistema que envolve a música. Sendo assim, contando com a pesquisa bibliográfica e de campo onde foi estabelecido o diálogo com os músicos dos terreiros assim como, foi realizada uma revisão bibliográfica tendo como suporte teórico autores das áreas da educação, da educação musical, da etnomusicologia, bem como, obras específicas sobre cultura e a respeito da música no terreiro, além da entrevista com a Yalorixá e o tambor guia da Kuênãbossizô – Casa do vento no caminho do fogo localizada no conjunto Pedro Teixeira, estes são alguns dos autores. Portanto, mediante uma visão global do ambiente cultural do Tambor de Mina, almejamos trazer da mesma e suas contribuições para uma educação musical afrocentrada.

Palavras-chave: Música Afro-Brasileira. Tambor de Mina. Processos de Transmissão. Educação Musical Afrocentrada.

RESUMEN

El presente artículo presenta un estudio sobre los orígenes y los procesos de transmisión musical en un terreiro de Mina Jeje Nagô en Belém do Pará. La Mina es una religión típicamente afroamazónica muy extendida en el estado de Pará. En este contexto, la música es un elemento indisoluble, ejerce una función comunicativa, está presente en sus rituales y está íntimamente relacionada con elementos extramusicales, como la danza y la mitología de los orixás, las deidades africanas y afrobrasileñas. Con el objetivo de extrapolar los contenidos cotidianos, investigar las actividades musicales de los terreiros de Mina para fomentar una reflexión sobre las prácticas educativas tradicionales y contemporáneas. Se consideró oportuno comprender el universo religioso del Tambor de Mina para revisar los conceptos de cultura y educación y ayudar a comprender este sistema que involucra la música. Así pues, basándonos en la investigación bibliográfica y de campo, en la que se estableció un diálogo con los músicos de los terreiros, se llevó a cabo una revisión bibliográfica con el apoyo teórico de autores de las áreas de la educación, la educación musical y la etnomusicología, así como de obras específicas sobre la cultura y la música del terreiro, además de la entrevista con la Yalorixá y el tambor guía de Kuênãbossizô – Casa del viento en el camino del fuego, situada en el conjunto Pedro Teixeira, estos son algunos de los autores. Por lo tanto, mediante una visión global del entorno cultural del Tambor de Mina, aspiramos a aportar sus contribuciones a una educación musical afrocentrada.

Palabras clave: Música Afrobrasileña. Tambor de Mina. Procesos de Transmisión. Educación Musical Afrocentrada.

1 INTRODUCTION

In Brazil, since the arrival of blacks in the colonial period, from the seventeenth to the nineteenth centuries, batuques, as a religious practice, have always been present in Pará and established in the Amazon as a result of the transposition of African knowledge. Practices conducted by the sound of drums are important communication tools for African societies, in this way, several drums with healing rituals were constituted in Brazil - Indigenous Shamanism, Mina, Catimbós, Umbanda and Candomblés.

This musical language makes up the religiosity applied initially in healing rituals and, later, in other rituals. Over time, Pará became a force for the diffusion of black and indigenous religiosity in the Amazon, musicologist Sonia Chada, in her research *The Music of the Caboclos in the Candomblés of Bahia*, highlights the importance of music in religious practices. She points out: "The musical system thus reflecting the cognitive system of its practitioners, their feelings, their cultural experiences, in addition to their social, intellectual and musical activities" (Chada, 2007, p. 14). In this vein, Flávio Pessoa de Barros, in his book *The King's Banquet - Olubajé: An introduction to Afro-Brazilian sacred music* of 2006, makes significant contributions to the study of the music of the Candomblés of Bahia and Rio de Janeiro.

In the terreiro communities, the processes of knowledge transmission present, as their main characteristics, the traditional methodology of orality, the processes of repetition and memorization and their forms of Africanized sociability. The teaching of music, specifically, adopts an Afro-centered musical education, in which its main subjects - today, black Brazilians, indigenous people, caboclos and white people - remain in ritual and community interaction, ensuring the permanence of this Africanized education. As a consequence, Mina consolidates itself as an Afro-Brazilian religion that establishes an important black cultural heritage, deserving to be studied and disseminated as an important tool for the dissemination of Afro-Brazilian culture in the Amazon and for the formation of an Afro-centered education.

In this way, *'Ilù ñ ké, ará ñ jó, orí ñ àlàfià'* - *The Music of the Terreiros de Mina Jêje Nagô do Maranhão in Belém do Pará* stands out for its unprecedented character when approaching music in the Afro-Amazonian religion, the research will seek to analyze, describe, point out and understand the importance of the resistance of the black people in their occupation in the Amazon, having the batuques as a guiding thread of cultural practices in the city of Belém.

Data were collected through bibliographic field research, in which sound, visual and audiovisual records were collected. Other interaction and collection procedures were used, such as interviews with Yalorixá Mãe Claudia and Gujalonã Lucas Eduardo from *Kuênãbossizô – Casa do vento no caminho do fogo*, telephone calls, recordings, Figuregraphs, among others, which serve the elaboration and production of artistic and educational products.

In this context, it is worth understanding: What are the musical knowledge present in the Mina Jêje Nagô terreiros in Belém? How does the transmission of musical knowledge take place in the way of teaching and learning in the terreiros? Who are the guardians of this musical knowledge? How to insert Afro-religious music in the school context, in a process of building an Afro-centered anti-racist education? By exploring these issues, research will greatly contribute to the strengthening of Afro-Brazilian history and culture, as well as play an important role in the area of education.

2 A BRIEF REFLECTION ON AFRO-BRAZILIAN MUSICALITIES

In the Americas, the influence of African peoples contributed to the constitution of the culture of the various countries that were crossed by the inhumanity of enslavement, but despite all the ills of this for the African people in diaspora, the survival of identity is proof of the resistance and cultural resilience guaranteed through various artistic expressions, popular brought by blacks, thus making an important and relevant part of the diversity of musical genres and styles in the Americas by the musicality inherited from their ancestors.

In port cities in the Caribbean, the Americas, as well as West Africa, vats for transporting goods, available at port docks and warehouses, were widely used for drum construction. Also adopted and adapted in the modes of playing, were Etheric string instruments and percussion and wind instruments of military bands. (Markl, 2011, p. 57)

In Brazil, African and Afro-Brazilian music is fundamental in the constitution of national identity, we can see this through its influence in the first creation of genuinely Brazilian artistic expression, samba. The samba born in batuques as well as in terreiros in Bahia and Rio de Janeiro, as an Afro-Brazilian expression is a heritage that has spread throughout Brazil.

"When the first samba with a samba rhythm appeared in Tia Ciata's house as a collective work of a group of old Bahian revelers and people from the modern lower class of Rio de Janeiro" (Tinhorão, 1973, p. 123). Making an analogy between terreiros and samba,

we understand the proximity of musicality applied to religiosity and leisure that originates in the batuques in the terreiros, which these practices also influenced several expressions of popular culture and Brazilian music, such as carimbó, maracatu, bois bumbá, among many other sambas and batuques that cross and remain alive in the country, because, like in Rio de Janeiro, several of these houses also maintained religious artistic activities.

Brazilian music and other cultural expressions have a deep relationship with the processes of socialization and accommodation of blacks who were first enslaved, but also when they were free, they had a great influence on the urbanization processes of large and small cities in Brazil, where the rhythmic and sound presence guaranteed the identity of Brazilian music in its various forms and expressions, A music of blacks in diaspora, indigenous and Europeans originated several styles these styles composed of elements of the diverse ethnic, with characteristics that over time merged. This process of fusion I will call here accommodation also defined by other researchers as "creolization" or miscegenation.

The creolization or miscegenation of customs made the batuques less ostentatious, forcing blacks to new tactics of preservation and continuity of their cultural manifestations. The batuques were modified, sometimes to incorporate popular festivals of white origin, sometimes to adapt to urban life. African music and dances were transformed, losing some elements and acquiring others, depending on the social environment. Thus, since the second half of the nineteenth century, the traces of a Brazilian urban music began to appear in Rio de Janeiro, the seat of the Imperial Court – the modinha, the maxixe, the lundu, the samba. Despite its mestizo characteristics (a mixture of African and European influences), this music was really fermenting among the black population, especially after Abolition, when blacks began to seek new modes of communication adaptable to a hostile urban framework. (Sodré, 1998, p. 13)

This path leads us straight to samba, as well as other genres and musical styles that have become popular in Brazil and throughout America, the music that also transmits the characteristics of miscegenation, this miscegenation as well as syncretism were widely used resources as well as accommodated that allowed to disguise and even acclimatize various cultural practices that were on the margins repressed mainly by the practice of racism, but that in times of modernity also allows us to understand the participation of these subjects, music and dances such as carimbós, lundus, bois, maxixes as well as a variety of sambas.

The lundu, like the batuque or the samba, also included in its choreography a circle of spectators, a soloist pair, violent swaying of the hips and umbigada, with the accompaniment of violas. But lundu is already fully urban: it is the first black music

accepted by whites. In fact, she is the first to become a creolized, to become a mulatto. (Sodré, 1998, p. 30)

This mulatice or miscegenation made these cultural expressions more accepted, in this way this ended up strengthening the insertion of oxen, coconuts, frevos and carimbós and others by accommodating in their music or dances European influences that also introduced the presence of the white, in the Amazon also the presence of the caboclo consolidates this idea of miscegenation on the enslaved peoples and the native peoples who began to have gestures and sonorities as a strategy of social approximation between blacks, indigenous people and whites.

However, and despite a history of repression yesterday and today, the African contribution and influence is already described in research that accounts for the religious and leisure practice of blacks since Belém do Grão Pará, with records of popular expressions and occurrences of gatherings of blacks frequently recorded in police records and other documents that account for social and cultural activities. There are references to various drums promoted by enslaved people in moments of leisure after hard work.

But batuque, associated with religious practices, only became known in Pará in the middle of the last century. The Germanic scientists Spix & Martius, around 1820, speaking of the mestizos of Pará and the leisurely spirit of the blacks, noted the unbridled batuque and the lascivious lundu as their dances. (Salles, 1969, p. 106).

With regard to religiosity and leisure, the music and dance so important to African peoples is fully established in the way of life of various peoples, these creations, treated pejoratively have their cultural activities stereotyped, forbidden and thus pointed out as something minor and evil associated with primitivism. Primitivism as applied here in the sense of associating origin with a dimension of inferiority. According to Tinhorão (1972, p. 33) "While in primitive human groups music and dance, invariably associated, fulfill a religious function, linking their origins to tribal rites, in modern societies music and dance constitute creations included in the organization of leisure". On the other hand, starting from the idea of Africa:

In some African languages (Kimeru, for example, spoken in a region of Kenya), the word for "music" has the same meaning as singing and dancing. Something strongly vital happens in dance in its origin. First, the re-actualization of the knowledge of the cult simultaneous to the inscription of the individual's body in a territory, so that the cosmic force, that is, the power of belonging to an integrated totality, is realized. In addition, thanks to the intensification of the dancer's movements at the party – a whole

complex that encompasses action, voice, gestures, songs and affections – space and time become a single value (that of sacralization) and, thus, become autonomous, becoming independent of the one who individually occupies the space. (Sodré, 1998, p. 166)

In the religious practices of blacks, the music in the terreiros is the connection with Africa; It is established as an immanent link to the performance of rituals, celebrations and trance (incorporation) in these sacred houses. The ringtones and doctrines existing within the Tambor de Mina are forms of praise to the sacred, which are played and sung with devotion to Voduns, Orixás, and Caboclos present in the giras and rodas in the Mina and other entities present in Umbanda or Candomblé. The repertoire of the houses of saints "is very numerically expressive and in its symbolic contents at the same time it is functional because music plays an important role in the maintenance of the customs of religious groups" (Berrague, 1976, p. 131).

Thus, we can see that the Africans, when they arrived in Brazil, had, in music and dances, not only the opportunity for rare relaxation, but also a form of reconnection and reinvention of their cultural practices that were already happening in Africa, an approximation with practices that already consisted of their ways of life. Mina, Candomblé and other religions of African origin went through a process of syncretization, which appears in the changes in the practices in the rituals and celebrations of the blacks where music took place. These gatherings, which took place in different spaces, over time were established in specific spaces such as terreiros or religious houses.

In this research, the ethnography of the musical records in the rituals and festivities of the Tambor de Mina was made with the objective of contributing to the study and debate of Afro-Brazilian religious practices, from the perspective of valuing the culture of the traditional communities of the Jêje Nagô terreiros of Maranhão in Belém, capital of Pará, as well as for the recognition of the sacredness of the processes related to religious practices. The methodology used was participant research, based on observation and participation, in which an emic approach to sociocultural aspects was made, with various bibliographic reference materials that supported the research.

"The term emic is used to describe the reference system of forms and objects that are used in a specific cultural tradition. This word was coined by Pike (1954, 1957, 1966) and later elaborated by French (1963)" (Roazzi, 1987, p. 37). In this study, the author deals with the music in the terreiros in its ritualistic and musical aspects, and its modes of transmission.

The adoption of the emic approach is a determining factor for the researcher to describe the phenomena in a meaningful and traditional way for the researched community. Thus, fieldwork was carried out with the heads of the houses of Mina and musical groups, with the following objectives: to study the behavior of the group within the established system, to examine the cultural aspects, to structure the discoveries made, to observe and record the musical knowledge object of research. The criteria refer to the internal characteristics of cultural practice.

The concept of culture is an abstraction sketched to describe all patterns of thought and interaction, "an organized system of signifying symbols" (Geertz, 1975, 46), which persists in communities over time. Musical instruments and the transcriptions or scores of the music played on them are not the culture of their creators, but the manifestations of this culture, the products of social and cultural processes, the material result of the "capacities and habits acquired by man as a member of society". We cannot "see" a culture: we can only infer it from the regularities in the form and distribution of the things we observe. Every musical performance is, in a system of social interaction, a standardized event whose meaning cannot be understood or analyzed in isolation from the other events in the system (Blacking, 2007, p. 204).

Thus, having defined the aspects related to the methodology of ethnographic research, the study of terreiro music was divided into two stages: 1- Historical and bibliographic research; 2- Field research. Both processes deal with the trajectory, history and memory in cultural and religious practices; Afrocentric musical education and its processes of transmission of ritual music; the formal structure of this sacred music; and the pedagogy of the terreiro. Thus, it is possible to understand the role of music as a representation of the strength of this community, in which sounds and rhythms establish access to a symbolic universe motivated by the strength of Axé.

In a dynamic governed by axé, as is the case of the Afro liturgy, music is primarily vibratory, guided by the modalities of rhythmic execution, singing and dance, in which percussion is fundamental. In Europe, scholarly music, governed by the ascendant universe of writing since sounds of the Middle Ages, was guided by melody and harmony, leaving in a secondary plane the timbre and rhythm, which predominate in the mythical universe of orality. If the rite is the bodily and affective expression of the myth, the rhythm is a rite capable of feeding back the existential power of the group. Body and time appear in the rhythmic apprehension in various modulations of existence. (Sodré, 2017, p.164)

On the issue of the fundamentals of music in the terreiros, it is necessary to understand them, to prioritize them from the African conception, obeying the spiritual dimension, where the foundation applied is related to the music, the points, also called doctrines, songs that facilitate the transcendental moment of trance, these fundamentals are elements that enable the sound link with spirituality, a way so close to African and Afro-Brazilian peoples. However, those fundamentals that deal with the technical dimension of music, which involve rhythm, dynamics, intensity and pitch of sound, are also evident in the practices of the musical group even if these fundamentals have another meaning related to musical technique.

Rhythm thus creates a space of its own and gives rise to a specific imaginary, which implies a practical, bodily reflection on duration. This means that it is not just a technical artifice in the context of musicality, but a symbolic configuration of the lived time that, combined with dance, constitutes itself a context, a kind of "place", or synesthetic and synergetic scenario, where ritualistically something happens (Sodré, 2017, p. 165).

It is understood that the music present in the terreiros goes far beyond their formal structures, also involving affection, bonding with the community and, above all, a transcendental aspect. Its fundamental elements - timbre, pitch and rhythm - assume a central role and predominate in the mythical universe inherent to the ritual. "If the rite is the bodily and affective expression of the myth, the rhythm is a rite susceptible of feeding back the existential power of the group. Body and time appear in the rhythmic apprehension in various modulations of existence" (Sodré, 2017, p. 165). Thus, one can conclude the importance of music in the connection between earthly bodies and spirituality. "Rhythm in African music is often a social and spiritual language, which tells stories, communicates across distances, and reflects the cycles of life" (Alsup, 2024).

Another aspect inherent to the fundamentals and musical practice is related to the performance of the musicians, who in the ritual find themselves as participants completely involved in the worship, where they reproduce essentially musical elements and fundamentals, both are structuring, these are preserved from the traditional processes of musical transmission present in the terreiros. Where the members of the musical group such as the Tambor Guia who develops specific roles as an assistant conductor of the musical group, and influences the rhythm of the drums at parties and celebrations. The contribution of this subject is important in the ritual, although it does not supplant the symbolism linked to the transcendence of the religious event.

The ethnography of musical performance [...] gives up the focus on music as a 'product' to adopt a broader concept, in which music acts as a 'process' of social meaning, capable of generating structures that go beyond its merely sound aspects. Thus, the ethnomusicological study of performance deals with all musical activities, their opportunities and their functions within a larger community or social group, adopting a processual perspective of the cultural event. (Oliveira Pinto, 2001, p. 227-228).

In this way, musical performance associated with the fundamentals of music understood as a process of social signification. In the touch and vibration present in the sacred beats of atabaques, gourds, maracas and irons, the music of the abatazeiros that are an inseparable part of the Tambor de Mina in Belém do Pará through music is guaranteed.

3 THE STRUCTURE OF MUSICAL GROUPS AND CELEBRATIONS

Regarding the structuring of music and musicians in the terreiros, it is important to note that it has a role in the daily life of the community and is structuring in the rituals. In the house, positions and functions are established through hierarchy. There are musicians with a position and function in the house; They are the guardians of sounds, an important African and Afro-Brazilian cultural and religious heritage. In this culture, the processes of transmission of knowledge are linked to labels related to the seniority of the performance of the children of the house, the support for the dynamics of musical practice is also directed by those who exercise leadership in the group.

Learning is the product of experience and an initiatory process that is materialized through the oral transmission of knowledge. It is common, however, for the youngest initiates to have notebooks where they write down what is observed by them: the songs, prayers and other treasures collected in daily life; yet they never cease to perceive their existence, keeping them in absolute secrecy. (Barros, 1999 p. 30-31)

The musical group is divided between the following musicians: Abatazeiros, Cabaceiros and Ferreira. This is the basic formation of musical groups in the Mina drum, but it may, however, occasionally present the numerical participation of more people in the group – but a function that cannot be duplicated is that of Ferreira. The leadership and making of the members of the musical group is exercised by the Abatazeiro Guia or Alabê, according to Lucas Peniche or Gujálonã Abatazeiro Guia da Casa do Vento e do Fogo *Kuênãbossizô* in an interview given on August 10, 2025.

Regarding the identification of the drums present in the Tambor de Mina, Lucas Peniche in his interview clarifies that the nomenclature of these is not fixed as in other religions of Brazilian African origin, according to the abatazeiro guide Lucas Peniche "These drums have no fixed name, they are named and baptized in an obligation and receive a name according to what the conch defines", that is, there is also an initiation process that is what defines the name of the drums, but in the structure of the group they are called Tambor Guia, drum against guide and the drum that stands call the drum of the forest.

It is also important to note that because some festivals and ceremonies can be long, group members take turns during the time of the doctrines. The musical practice follows the logic of the group's structure: the ferreira (woman), guide drum, second drum and the gourds, successively.

Below, Figuregraphs of the instruments of the musical groups belonging to the terreiros: 1- *Kuênãbossizô – House of the wind on the path of fire*; 2- *Casa Grande de Mina Jeje Nagô de Toy Lissá and Abe Manja Huevy*.

Figure 1

Tambor da Mata



Source: Record of the author researcher.

Figure 2

Gán. Ilê Axé Kuênãbossizô



Source: Author's record.

The music in the terreiros is associated with the establishment of rituals, celebrations and trance (incorporation) in these sacred houses. To transcend is to connect to the spirits and cultivate them, so the music in the terreiros carries symbolic aspects that go beyond the fundamentals of music according to a Western logic.

On the other hand, in ritual practice, music presents structures and formal organization, with regard to the conduct of the musical group in traditional behaviors in ritual. Musical performance in the perfect execution of doctrines or points is learned traditionally where the processes are repeated in a community that lives the secret and the sacred. In practice, the performance of musicians also goes through the traditional processes of musical transmission. Below, a table that presents the structure of the music in a Mina ritual. The existence of a specific musical repertoire aimed at the entities in worship is verified (see table 1). This repertoire is distinct and dedicated to each entity, in this case, Voduns, Orixás and Caboclos.

Table 1

Ritual music

Entities	Doctrines	Touch	Directory
Orisha	Oya- Ogumgum lanaô, o Ní o nissé naô, aê naô Oyá Nissé naô Oyá tetê, Oyá tetê, Oyá Oyá oyá, cararô jotá (repeats)	Folded Run	Jêje Nagô
Vodun	Toy Lissá - Oh Lissá is Vodun maó, Tóy Lissá is Vodun maó (repeats) Ebo babá, eborum alá Vodun Lissá, ta no obiriô, ebô	Waltz Waltz	Jêje Nagô
Caboclos	Cabocla Ita- She went for a walk, on a steam trip, Oh on the island of the crabs, cabocla Ita was enchanted She walked walked, my lord But here it arrived	3x1	Jêje Nagô
	Antônio Légua- My St. Anthony cowboy, you tell me, who are you...	Run	Jêje Nagô

Source: Prepared by the authors based on the paintings of Chada (2006) and information collected from the community of the terreiro.

It is analyzed, here, the development of the repertoire of the houses, focused on the reality of this traditional hierarchical community, in which the interaction between the various spirits and entities involved in the cult - known as Pantheon - aggregate Voduns, Orixás and Caboclos. This interaction has specific characteristics and aspects, such as languages, dialects, and deities, which are important to know. The musicologist from Pará Sonia Chada (2001, p. 121) states that there is a certain flexibility in the cult of the Caboclo that allows the creation or alteration of the structure of the rituals and results in the adaptation of the same musical repertoire to different contexts. These changes are attributed to the will of each Caboclo, consequently affecting the musical repertoire that has to be adapted to new contexts, entities and subjects, producing differential changes in the cult of the Caboclo in the Bahian candomblé houses that start to build their own history, although there is a basic structure common to all of them. later spread throughout Brazil.

Table 2

Ritual comparison

	Vodun	Orisha	Vodun Gentil	Caboclo
Deities	African	African	European nobles	Brazilians, indigenous people
Type of communication	African dialects (more than one)	African dialects (Yoruba, others)	Portuguese	Portuguese, indigenous dialects
\	African deities	African deities + Catholic saints	European/noble deities	Brazilian, indigenous entities.

Ritualistic	Parties/Drum, cute	Parties/Drum, cute	Parties/Drum	Parties/Drums, giras, mediumistic tables, others
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Source: Prepared by the authors based on the paintings of Chada (2006) and information collected from the community of the terreiro.

In the Mine, the touches and doctrines, which are touched and directed to the deities and entities, perform 4 touches: 3x1, Folded, Leaked, Run. They are linked to the pantheon that is present in the houses. The musical group is formed by the following musicians: Abatazeiros (2), Cabaceiros (2), Ferreira (1). During the festivals and celebrations that last long, often more than 3 hours, the musicians take turns among themselves. Another important aspect refers to the modal scale used most of the time, with the exception of some caboclo repertoires that are more Brazilianized, sometimes referring to samba.

Still on the rhythms and touches that we find in the various terreiros of the country, it is important to highlight that referring to candomblé due to this presence of the caboclo in candomblés according to Barros (1999 p 52) "18 rhythms performed in the liturgy of the terreiro communities, belonging to the Jeje Nagô cultural complex of Rio de Janeiro, were identified".

In the African-based religion, music is an essential communication instrument for religious ceremonies. In the interculturality of the musical practices of the terreiros de Mina – in Belém do Pará, in the Amazon – Afro-religious music still presents itself as a field that is little researched and explored, despite its importance. The musical change generated by the processes of hybridization of music originating from African drums also reinforces the need for further studies on the subject, even to provide its understanding and popularization.

The chants, doctrines or points as they are popularly defined have a praiseworthy character, they are performed to honor a certain entity, Vodun, orixá or caboclo, although the music of the mine has a consolidated modal system, the music of the caboclos promotes changes that bring new sounds closer to the sounds of Brazil.

Ritual chants have very specific characteristics that denote their uniqueness as a musical form. These specificities can be noted as melodic patterns and syncopated rhythms, that is, where we perceive the displacement of the strong tempo in the rhythm marking. Also marks of this musical form are the singing in responsorial style, with the support of the tonality proposed by the soloist Alabê or Italabexê (Barros, 2006, p. 53).

Table 3

Musicality

Touches	3x1	Folded	Leaked	Run
Instruments	Guide Drum, Drum; drum of the forest / Gan / Gourds	Guide Drum, Drum; drum of the forest / Gan / Gourds	Guide Drum, Drum; drum of the forest / Gan / Gourds	Guide Drum, Drum; drum of the forest / Gan / Gourds
Dialect	Various African languages	Various African languages	Portuguese	Portuguese
Dance	Predominant	Predominant	Predominant	Predominant

Source: Prepared by the authors based on the paintings of Chada (2006) and information collected from the community of the terreiro.

The rituals can be private or public and are deeply linked to the line adopted in religious action: "In the Tambor de Mina the spiritual entities received by the filhos-de-santo are classified in various ways, among them: by category, by family, by lineage or 'nation', by position in the head of the medium in which they incorporate and by position in the terreiro" (Ferretti, 2000, p. 73).

The rituals of private order, in the Mine, are linked to the owner of the house, that is, to Vodun, they are ceremonies and celebrations that involve a lot of secrecy. The one who receives Vodun has many obligations, among them, those involving the killing of animals and the making. A very popular Vodun in the house is Oxalá, in the Casa Grande de Mina Jêje Nagô de Toy Lissá and Abe Manja Huevy this is the celebration that opens the festivities of the year, one of the main ones in the house.

Table 4

Structure of the ritual

	Vodun	Orisha	Gentle Vodun	Caboclo
Secret Ceremony	Liabilities/ Kills	Liabilities/ Kills	Liabilities/ Kills	Liabilities/ Kills
Public Ceremony	Drums: Imbarabô or opening corresponding to the ritual; Songs for the Vodun of the party; Corresponding vodun songs. Drum Closure - Oxalá	Drums: Imbarabô or opening corresponding to the ritual; Songs for the Vodun of the party; Corresponding vodun songs. Drum Closure - Oxalá	Drums: Opening and closing corresponding to the ritual	Drums: Opening and closing correspond to the ritual. Parties and other daily activities.

Source: Prepared by the authors based on the paintings of Chada (2006) and information collected from the community of the terreiro.

Below, three examples of doctrines chanted and danced at the Oxalá party at the Casa Grande de Mina Jêje Nagô de Toy Lissá and Abe Manja Huevy on January 6, 2024:

Nanã (Vodun doctrine)

Oh dance, oricô
Give me sequere, ah a deum
Nanã ah icó, ah Grandma Misan wanting is
Oh sister zakaô, Orisha oke adeô and arocô
Toy Lissá is Mina deô

Oyá (doctrine of Orixá)

Ogungum nanaô
Oni Onissé, no
Yay noô Oyá miss noô

Chica Baiana (Caboclo Doctrine)

Oh in the woods there is a grove
In the grove, a nightingale
At the foot of the palm tree where the thrush sings
Here in the terreiro Chica Baiana comes to baia.

Rituals, festivities and celebrations can take place in private ceremonies that involve all entities - vodun, orixá, caboclo. The exact date of when caboclos began to interact in the terreiros of Minas Gerais is not known, but it is known that caboclos have been seen since the first batuques, acclimatizing indigenous people and other national subjects.

In the Maranhão Mine, although COSTA EDUARDO made reference in 1948 (in a work published in English, not yet translated) to the presence of caboclos in the oldest and most traditional Yoruban terreiro in São Luiz and of terreiros derived from and spoken about caboclos received in the interior of Maranhão (Codó) (Ferretti, 2000, p. 54).

This presence in Mina's houses, even if not dated, promotes variations in the repertoire of ceremonies and celebrations. "The cult of the Caboclo, due to the emphasis it gives to the individualism of the Caboclos, an aspect of the religious system, is an open door, within limits, to individual variations that may or may not constitute musical change" (Chada, 2006, p. 109-110). The researcher points out that, like other sociabilities, religion is in a constant process of change, which affects culture. In this way, the cult of caboclos and orixás is subject to the same changes.

It is observed that, in the case of Mina, the musical change is assimilated with the alteration of the repertoire. However, it is important to highlight that, even with the presence of the caboclo in ceremonies, solemnities and celebrations, the same four musical touches are still maintained, with the inclusion of the specific doctrines of caboclos. In this case, the

formation of the group differs with the introduction of a drum of excavated wood and leather played standing on the Tambor da Mata, a typically caboclo drumming.

Table 5

Type of ritual

	Vodun	Orisha	Gentle Vodun	Caboclo
Secret Ceremony	Liabilities/ Kills	Liabilities/ Kills	Liabilities/ Kills	Liabilities/ Kills
Public Ceremony	Drums	Drums	Drums	Drumming, parties and other daily activities.

Source: Prepared by the authors based on the paintings of Chada (2006) and information collected from the community of the terreiro.

In the Tambor de Mina, the cult of the vodun, the orixá and the caboclo has, in its musical practice, the permanence of 4 specific touches that are altered by the doctrines, however, they are linked to all the entities and spirits present in the practice of the Mina. As for the rituals of the entities that make up the Pantheon, each one has a specific type of solemnity. These solemnities are very important, as they consolidate hybridization as a phenomenon present in the Mine, allowing a variety of rituals that accommodate and acclimatize, in a very symbolic way, all the entities and cultures that made the Mine such a diverse religion. Below are some different models of rituals:

Table 6

Vodun Ritual

Vodun Festival – Solemnity
Xirê drum
Enchanted family that has a foundation with vodun

Source: Prepared by the authors based on the paintings of Chada (2006) and information collected from the community of the terreiro.

Table 7

Orisha Ritual

Vodun Festival – Solemnity
Xirê drum
Xirê Nagô
Enchanted family that has a foundation with vodun

Source: Prepared by the authors based on the paintings of Chada (2006) and information collected from the community of the terreiro.

Table 8

Caboclo Ritual

Caboclo Festival - Solemnity
Some Orixás corresponding to the honored family are played
Songs for caboclos and their family

Source: Prepared by the authors based on the paintings of Chada (2006) and information collected from the community of the terreiro.

The tables allow us to see a simplified overview of how the music present in parties, rituals and celebrations is structured, what they play, how they play and for whom. All this dynamic is a system that transmits here too, the results of an Afro-centered musical education.

4 THE PROCESSES OF MUSIC TRANSMISSION: AN AFROCENTRIC MUSICAL EDUCATION

The musical knowledge present in Mina's houses are non-formal processes, which promote an education based on memories, knowledge and cultural traditions that permeate knowledge through the orality of repetition. These processes promote a non-formal musical education in the daily life of the casas de santo, however, they are part of the already established pedagogy of the terreiro.

The processes of acquisition and learning of music, construction of knowledge and development of musical perception take place socially, through participation in rituals, through interaction and joint action between the subjects involved in the collective construction, in addition to the coordination of individual actions in the distribution and sharing of social cognition. The context, of fundamental importance, shapes musical practice, at the same time that it is modeled by it (Chada, 2007, p. 1).

With regard to the definitions and concepts adopted by the non-formal education present in traditional communities or houses, what we have most symbolic is the intention of those who teach. It is the children of the houses - actors endowed with knowledge and skills - who, in view of their responsibilities in the terreiro, carry with them the function of transmission. It is important to highlight that this task is not defined by the formal structures of education, since the transmission of knowledge is based on its own system, which has its specific form of organization established by the dynamics of the functioning of sacred spaces. Thus: "non-formal education would be those activities that have an intentional character, but

are poorly structured and systematized, where pedagogical relationships occur, but which are not formalized (Wille, 2025, p. 41).

We highlight the importance of presenting the processes related to music and its educational processes in the terreiro; and the memories related to this knowledge and its processes, understanding who its actors are and their role. Because, as Molina (2006, p. 53) states, "The resignification of knowledge cannot be a one-way line, but rather a one-way street, but rather a function of the context in which it is produced, and this context includes both what is produced scientifically and what is produced by non-academic knowledge, in different ways and situations". However, it is important to highlight the main differences between the terms formal, non-formal or informal education, in order to define, more precisely, the field of study of this research on the musical knowledge of the terreiros of Mina Jêje Nagô do Maranhão, in Belém do Pará, with emphasis on the "batusques à mina: processes of musical transmission".

It is up to me to say that education as axé that I claim is not necessarily a model of experiences/learning codified strictly in contexts of Afro-religious cultural practices. What is commonly called by communities the axé education terreiro is understood as the educational processes experienced in the daily lives of these populations, a kind of habitus experienced in the time/space of Afro-religious contexts. These forms of education practiced in these educational contexts resize the educational problem in relation to diversity, revealing modes of education as culture (Rufino, 2019, p. 66).

In this sense, and in order to recognize the importance of Africa in the history of the formation of the Brazilian people and to strengthen the teaching of Afro-Brazilian culture, this thesis also proposes the cataloguing, analysis and creation of a musical collection. This collection will serve as material aimed at formal education, thus reducing the scarcity of didactic materials that explore the issue of Afro-Brazilian identity, but above all, understanding and using the system of musical transmission experienced in the terreiros makes it possible to admit other epistemologies.

The research of the musical memory of the terreiros of Mina emerges, therefore, as an important tool for safeguarding and disseminating Afro-Brazilian culture in the Amazon. The elaboration of relevant educational material will have the function of disseminating and demystifying African-based religions, combating racism in society.

Research in the area of music, ethnomusicology, has much to contribute with regard to the musical knowledge of the terreiros of Mina. It presents itself with the challenge of

establishing a parallel between the music and the cultural system of the terreiros de Mina in Pará. It also seeks to understand and establish the meaning of music in the reality of the terreiro and its expressions as religiosity. The need to implement affirmative and evaluative policies that express in the daily lives of these traditional and religious communities.

Music, in its sociabilities, is present in the most diverse human expressions. Through it, we are led to variables between the profane and the religious, we can transcend between the earthly and the spiritual. Its foundations are decisive for the interaction of the bodies that dance as an expression of axé. Thus, in this microcosm that is the terreiros, music is an inseparable element that composes a system in religious practice – whether in the terreiros of Mina, or in the terreiros of Candomblé.

The processes of transmitting the songs, even in Yoruba, depend on the status of the child made in the house, who will have more and more access to information due to the advancement of traditional learning, as well as the functions developed according to his seniority in the house – the child goes through several initiations, which the ogãs also go through, inside the terreiro. It is important to highlight that all members of the terreiro go through initiatory processes, regardless of whether they have the function of rodante, ekedi or other.

In an interview given on June 24, 2023, to Oyárumbá Claudia Peniche from Keenãnbossizo - Casa do Vento no Caminho do Fogo, located in Conjunto Pedro Teixeira, Coqueiro neighborhood, defines musical organization as a ritual element in Mina's terreiro:

The ritual music that is constituted in the Mina is a process where, when entering a terreiro, those who come from outside can visualize a whole organization that allows the best enjoyment and execution of the works or celebrations, where you also express the hierarchy of the house, by having as main participants the leaders and authorities of the house: Yalorixás; Babalorixás; the guide abatazeiro; other authorities and caboclos when authorized by the Babalorixá. (Interview with Oyárumbá Claudia Peniche, 2023)

This organization shows the unity of the group, as it involves many of the subjects inherent to the terreiro – its community. In this ritualistic space, music is part of a system of non-formal knowledge, which is fundamental to the existence of ritual. In the terreiro, the guide sings and evokes the entities. He also calls the children of the house to experience the sacred, evoking their gods in the mythical universe of the terreiro. The Abatazeiros have the function of giving the sound of the drums, which make all the magic or enchantment happen

in a terreiro de Mina. The ritual is initially opened with the use of iron, brought and played by Ferreira, fulfilling the stage of beginning the work preceding the use of drums.

Musical knowledge reflects and expresses the dynamics and pedagogy of the terreiro. This pedagogy is a system of informal education, which enables the transfer of knowledge, between generations, through processes symbolically established by the community itself. Memories are activated and stories are constituted through orality, imitation and other traditional practices, which make up the elements of preservation of cultural memory and musical memory. According to Luneli (2015, p. 8-9), "Most of those interested in learning the rituals had, in their genealogies, family members who participated in the ceremonies. The process occurs with socialization and with the insertion of apprentices in the universe of rituals and drums".

In the terreiro, the musical instruments also maintain a relationship of sacredness. They are consecrated, for they establish the connection between man and divinity. Oyárumbá Claudia Peniche (2023), explains how these instruments are used and their functions:

The atabaques are the instruments that call the orixás, in the Tambor de Mina it is important that there are two drums lying down, the tambor de mina is differentiated by that, encased on two sides, they are not hollow like the curimbó for example. And the drums of the forest can be placed upright, unlike Candomblé where all the drums are standing. Generally in a house it must have two drums lying down, or two drums standing and a gourd and an iron, which is an instrument of the Mina drum mostly played by women, being the instrument that calls the orixás, it enters before any other instrument, and then the atabaques and gourds enter. The instruments in this case can be called batas or abatás and the players abatazeiros. (Interview with Oyárumbá Claudia Peniche, 2023).

As for the informal knowledge systems, which are educational knowledges closely linked to the pedagogy of the terreiro, there is an epistemology recognized by the results traditionally achieved by all those who are children of the terreiros and who constitute educational spaces. Arroyo (2000, p. 89) suggests the use of new practices that move between school and non-school spaces, aiming to "account for the diversity of musical experiences that people are experiencing in today's society".

The transmission of this knowledge is effective in the interaction, in the exchange of experiences between the authorities and the members of the house. This conviviality comes as a principle of exchange, which, within the pedagogy of the terreiros, brings the teachings that form the filhos de santo. The ways and practices – such as the ways of playing and

singing – constitute specific forms, timbres, intensity and movements for all those who, linked to the ritual, will evoke and interact. These touches are initially taught by the babalorixá, but the guide drum also exercises this function of teaching the touches through a lot of repetition. Nowadays, technological resources such as recordings for musical transmission are already used, but initially the process is always traditional, through orality and repetition.

The Toque, for example, in the Tambor de Mina, it has several ringtones. There is the corrido, there is the dobrado. According to what the pai de santo and the mãe de santo (Babalorixá and lalorixá in this case) are singing. The cadence is determined by the one who pulls the corner. And the pitch of the drums (Intensity), they are always played in a tone that the whole house can hear, we cannot determine a music system with a speaker and other equipment. It's all live, it's all done to the sound of the voices, in the tambor de Mina I have not yet seen as in other houses the lalorixá who use a microphone (Interview with Cláudia Peniche, held on June 24, 2023).

Singing is presented as another fundamental element of the ritual in Tambor de Mina. It merges in its dynamics to evoke and honor the entities, as well as to identify the families. This relationship is linked to the hierarchy of houses, as Claudia Peniche (2023) explains to Oyáorumbá:

The Songs of the Minas drum are all sung both in Portuguese, especially when the Tambor de Mina arrives here in Pará, because there is a mixture with the Pajelança, but I am talking about the Tambor de Mina Jeje Nagô of Maranhão, where the Songs are sung in Portuguese and Yoruba, which is the African language. I am not talking about Mina do Pará, because Mina do Pará and Umbanda are the same thing. The Points sung in the drum of Mina they are according to the families. The Tambor de Mina is hierarchical, it has several families, so the chants are directed to these families, the same thing is the Songs of the caboclos, they sing points that have reference to the caboclos with the entities with the name of these entities, especially the orixás. (Interview with Oyáorumbá Claudia Peniche, 2023)

The processes of transmission of musical knowledge in the Tambor de Mina Jêje Nagô of Maranhão, established in the terreiros of the capital of Pará, need to be recognized as an educational practice, resulting from a traditional pedagogy of the terreiro, as this system is already a fact. The system has its foundations based on faith, in the ways and dynamics of the functioning of these houses, which constitute true Afro-religious communities. The transmission of traditional knowledge constitutes educational and formative processes for all children who adopt religious practices in the daily life of the terreiros of Mina.

Like education, religion is a territory for the exchange of goods, services and meanings between people. Like those of education, the cultural agencies of religious work involve hierarchies, unequal distribution of power, inclusions and exclusions, routines, programs of serial training of personnel and different styles of daily work (Brandão, 2002, p. 152).

In this way, within the hierarchy and daily life of the houses of Mina Jêje Nagô in Maranhão in Pará, musical knowledge is taught to the children, as dancing and singing are part of the process and dynamics of the rituals. These songs, with their forms, dynamics, rhythms, intensities and songs, are sacred instruments and repertoires. They carry the importance of entities and all the vibration necessary for the interaction between body and spirits in the incorporation. Music serves as a vibratory and conductive line, dynamic and evocative, for the performance of the ritual in celebrations, works and festivities.

Thus, religion, in its meanders, mechanisms and ways of acting in the world, acts as education. More than that: the religious temple is an educational place, given that inside the terreiro there is a series of transmissions of knowledge that open up possibilities for the establishment of a set of pedagogical relationships (Silva and Costa Junior, 2020, p. 3).

By observing and analyzing the experiences lived by the children of the terreiros, it is found that the communities or peoples who experience the terreiros do not traditionally resort to formal or official mechanisms, such as schools. These religious practices have educational systems that transmit knowledge to the community of the terreiro. As Albuquerque (2011, p. 26) points out, there is no direct or exclusive need to consult "school, books, television, the internet or teachers in their human form".

Afrocentric musical education is not formal, but a natural, symbolic and popular process that generated the musicality of the revelries and sambas. In the terreiros of Mina Jêje Nagô do Maranhão in Belém do Pará, the education necessary to form the son of the house (the son of the terreiro) is based on Pensar Nagô - the recognition of the Tambor de Mina as the main religion of African origin practiced in the State of Pará, showing a new political configuration among all the subjects who, In their diversity and multiculturalism, they live these religious practices.

African culture, transformed by the effects of the diaspora on our society, emerges in the Amazon through religious practices. Thus, the Tambor de Mina is established as the African-based religion of the Amazon. From the Amazon, why? Because it was exactly here,

in the universe of enchantment, that syncretism took place and a religion was given life with unique subjects and entities that reflect all those who are in society.

It is clear that the Tambor de Mina is the religion of the new pact of forces, it is a religion of fission and syncretism. Thus, in Mina's houses in Belém do Pará, we see the members of the house as subjects who produce education, materializing the assimilation of these teachings. Sociability and intelligibility, in the relationships existing in the terreiro and in the community, are the facilitators that allow us to give life to the dynamics and belonging of all those who are in these spaces. In this way, by understanding the existence, origin, teachings and life in these spaces, the way of life is built through an African and Afro-Brazilian philosophy.

5 FINAL CONSIDERATIONS

Colonization in the Americas unfortunately consolidated an unequal and hierarchical social structure where the traditional knowledge of black peoples in diaspora as well as native peoples was born. In a society that establishes roles and divides bodies and subjectivities based on racial and cultural criteria that are structuring in Brazilian society. Afro-Brazilian religiosity is the expression of Afrocentric knowledge, which established dialogue with indigenous and European people, occupying inferior spaces, pressuring the acceptance of non-European cultures in social relations.

The research of music in the terreiros of Mina Jêje Nagô do Maranhão in Belém do Pará presents and analyzes the various liturgical repertoires, which consist of songs sung in the giras, festivals, rituals, ceremonies and celebrations in two terreiros in the capital of Pará. These songs are the doctrines or points that make the connection and transcendence of the participants in the rituals or celebrations.

Regarding their modes of transmission, the instrumentalists who are children of the house go through traditional terreiro training and education, which has an Afrocentric character, often based on orality. The music of the terreiro maintains its essence in African traditions, musicality and sound, despite the changes arising from socialization processes and the historical transformations that occurred in the configuration of the Pantheons that today make up the Pará Mine.

Finally, terreiro education and the transmission of musical knowledge is proof of the existence of other epistemologies that enabled the diffusion of Afro-Brazilian musical

expressions throughout all regions, an example of the implementation of traditional Afrocentric systems representative of Afro-Amazonian religiosity and identity.

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**FREEDOM AND DEVELOPMENT: THEORETICAL, INSTITUTIONAL AND
SOCIO-ENVIRONMENTAL PERSPECTIVES**

**LIBERDADE E DESENVOLVIMENTO: PERSPECTIVAS TEÓRICAS,
INSTITUCIONAIS E SOCIOAMBIENTAIS**

**LIBERTAD Y DESARROLLO: PERSPECTIVAS TEÓRICAS, INSTITUCIONALES
Y SOCIOAMBIENTALES**

 <https://doi.org/10.56238/sevened2025.036-004>

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ABSTRACT

This article critically analyzes the relationship between development and freedom, understanding freedom as a constitutive element of an emancipatory and sustainable development model. Based on a transdisciplinary approach, the study is structured in three analytical axes: theoretical foundations of freedom, the role of institutions in guaranteeing substantive rights, and the environmental limits of economic growth. The first axis discusses the transition from negative to substantive freedom, emphasizing justice and autonomy. The second explores how structural inequalities restrict real freedoms and highlights the importance of inclusive and equitable institutions. The third addresses sustainability as a condition for intergenerational freedom, integrating ecological balance, ethical responsibility, and the rights of nature. The article concludes that true development is not measured only by economic indicators, but by the expansion of real freedoms, the democratization of opportunities, and the preservation of the ecological foundations that sustain human dignity and coexistence.

Keywords: Freedom. Development. Sustainability.

RESUMO

Este artigo analisa criticamente a relação entre desenvolvimento e liberdade, compreendendo a liberdade como componente essencial e estruturante do processo desenvolvimentista. Por meio de uma abordagem transdisciplinar, são examinadas três dimensões fundamentais: a concepção teórica da liberdade, o papel das instituições na efetivação das liberdades substantivas e os limites socioambientais ao crescimento econômico. No primeiro eixo, discute-se a transição da liberdade negativa para uma liberdade substantiva, vinculada à justiça social. Em seguida, investiga-se a influência das desigualdades estruturais sobre o acesso efetivo à liberdade, ressaltando a necessidade de instituições comprometidas com a equidade. Por fim, aborda-se a sustentabilidade como condição para a liberdade intergeracional, defendendo-se a integração entre justiça ambiental e direitos da natureza. Conclui-se que o desenvolvimento só pode ser considerado

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pleno quando articulado à ampliação concreta das liberdades reais, à redistribuição de oportunidades e à preservação das condições ecológicas que tornam possível a vida digna.

Palavras-chave: Liberdade. Desenvolvimento. Sustentabilidade.

RESUMEN

Este artículo analiza críticamente la relación entre desarrollo y libertad, entendiendo esta última como un componente esencial y estructurante del proceso de desarrollo. Mediante un enfoque transdisciplinario, se examinan tres dimensiones fundamentales: la concepción teórica de la libertad, el papel de las instituciones en la realización de las libertades sustantivas y los límites socioambientales al crecimiento económico. El primer eje aborda la transición de la libertad negativa a la libertad sustantiva, vinculada a la justicia social. A continuación, se investiga la influencia de las desigualdades estructurales en el acceso efectivo a la libertad, destacando la necesidad de instituciones comprometidas con la equidad. Finalmente, se aborda la sostenibilidad como condición para la libertad intergeneracional, defendiendo la integración de la justicia ambiental y los derechos de la naturaleza. La conclusión es que el desarrollo solo puede considerarse completo cuando se articula con la expansión concreta de las libertades reales, la redistribución de oportunidades y la preservación de las condiciones ecológicas que posibilitan una vida digna.

Palabras clave: Libertad. Desarrollo. Sostenibilidad.

1 INTRODUCTION

The binomial development and freedom emerges as one of the most instigating and complex debates in the contemporary human sciences, articulating ethical, economic, legal and political dimensions. Traditionally linked to economic advancement and institutional modernization, development has come to be analyzed in a critical and multidimensional way, incorporating factors such as quality of life, democratic participation, environmental sustainability, and social justice. In this new scenario, freedom ceases to occupy a peripheral place in the developmental debate and assumes a central role in the formulation of public policies and strategies for social transformation.

From a broader perspective, development can no longer be understood as simple material growth or economic efficiency. True progress is measured, above all, by the ability of societies to expand the real freedoms of their members — the freedom to live with dignity, to choose, to express oneself, to participate politically and to access fundamental goods. This conception resignifies the role of legal institutions, the State and the market, emphasizing not only the absence of coercion, but the effective presence of conditions for the exercise of individual and collective autonomy.

In the face of this paradigmatic shift, a deep reflection on the multiple meanings of freedom in the context of development is required. Freedom can be conceived as a universal value, as a subjective right, as an instrument of social emancipation or as a condition of economic efficiency. Each of these approaches carries with it different normative implications and different political orientations, especially with regard to state intervention, the protection of fundamental rights and the equitable distribution of social resources.

It is not too much to emphasize, at this point, that Brazilian art, especially Brazilian Popular Music (MPB), has always played (and why not say still plays) a relevant role in the construction of social consciousness and in the reflection on freedom and development. Poetry and music function as instruments of collective sensitization, capable of translating abstract concepts into experiential experiences that directly touch human subjectivity.

Vinícius de Moraes, in his famous poem "The Worker in Construction", for example, offers a poetic synthesis of the dialectic between development and freedom that permeates this entire study. The poet from Rio de Janeiro manages to poetize the dynamics of the construction of the worker's consciousness, demonstrating how awareness is simultaneously an individual and collective process of emancipation. The worker who "climbed with the houses that sprouted from his hand" but "did not know everything about his great mission"

represents the condition of alienation that prevents the full realization of substantive freedom (CALIBAN, 2020).

Furthermore, the transformation of the worker from "class in itself" to "class for itself" narrated in the poem echoes Sen's (2000) theoretical reflections on real capacities and freedoms. When the worker finally says "No!", the moment materializes when freedom ceases to be just formal and becomes substantive, capable of confronting structures of power and inequality. This time, it is clear that this artistic dimension of social consciousness reveals how Brazilian popular culture anticipated, in poetic language, many of the contemporary debates on human development and social justice.

This article aims to critically examine the conceptual entanglement between development and freedom, considering its philosophical foundations, institutional implications, and contemporary challenges. It is intended, therefore, to investigate how freedom can be understood as a constitutive element of development, and not only as its consequence. The analysis will be conducted based on a transdisciplinary approach, which articulates elements of law, economics, political science and social theory.

The central problem of the research lies in the tension between different models of freedom and their consequences for the design of development policies. On the one hand, there is a liberal conception, which values individual autonomy and the limitation of state power; on the other, more substantive views, which demand affirmative action by the State to guarantee minimum conditions of existence and equal opportunities. This tension reverberates directly on the structure of institutions and on the normative efficacy of fundamental rights.

As a general objective, it seeks to critically analyze the relationship between development and freedom, with emphasis on its theoretical and legal implications. Specific objectives include: i) examining the philosophical-political foundations that sustain different conceptions of freedom; ii) to identify the role of legal institutions in the realization of substantive freedoms; and iii) to discuss the contemporary limits of freedom in contexts of structural inequality and environmental crisis.

Methodologically, the research adopts a qualitative approach, of a theoretical-conceptual nature, based on critical literature review, documentary analysis and interdisciplinary articulation. The work will be structured in three chapters, corresponding to the theoretical foundation, institutional analysis and contemporary challenges. At the end,

conclusions and recommendations will be presented, aiming to contribute to the construction of a development model that, in fact, promotes freedom in the full sense.

2 THEORETICAL FOUNDATIONS OF DEVELOPMENT AND FREEDOM

In recent decades, reflection on development has gone beyond the limits of economic growth and material productivity. By replacing purely quantitative indicators with broader criteria of well-being, authors propose that true progress should be measured by the expansion of the real freedoms available to individuals. Such a paradigm shift shifts the focus from accumulation to emancipation, articulating social, political and legal dimensions around the promotion of human dignity (SEN, 2000).

Amartya Sen's work inaugurates an innovative perspective by conceiving freedom as both a means and an end of development. In this approach, freedom is not limited to the absence of coercion, but implies effective access to capacities that allow subjects to live lives that they value. Education, health, food security and political participation, for example, are essential components of substantive freedom, and must be guaranteed by institutional structures and public policies that correct structural inequalities (SEN, 2000).

In this scenario, the analysis of freedom as a structuring element of development requires considering the multiple factors that condition access to real opportunities. The existence of historical, social and economic barriers often limits the possibility of choice and self-determination of individuals, making any definition of freedom that is restricted to the formal level insufficient. It is necessary to recognize that the full realization of freedom requires the elimination of legal obstacles, but also the creation of material and symbolic conditions that allow the flourishing of diverse life projects.

Thus, the contemporary debate on development shifts the focus from the simple absence of coercion to the effective promotion of capacities, considering the plurality of contexts and the complexity of social demands. By incorporating these variables, the understanding of the role of the State and institutions is expanded, which come to be seen as fundamental agents in the equalization of opportunities and in the construction of a fairer and more inclusive society.

This conception is significantly different from the classical formulations of economic liberalism, which understand freedom from a negative perspective, that is, as the absence of external interference. Friedrich Hayek, one of the main exponents of this tradition, argues that any attempt to plan or economically control society inevitably leads to serfdom. For him,

individual freedom resides in protection against arbitrariness, and the State must limit itself to guaranteeing the minimum legal order so that individuals can act autonomously in the market (HAYEK, 1990).

Milton Friedman, in line with Hayek, reinforces the idea that economic freedom constitutes the necessary basis for political freedom. His analysis is based on the principle that State intervention in the economy tends to restrict individual choices, compromising efficiency and personal autonomy. Friedman defends free choice as a fundamental right and proposes that systems based on competition and individual responsibility are more efficient in promoting social welfare than interventionist policies (FRIEDMAN; FRIEDMAN, 2015).

The contrast between Sen's perspectives and those of classical liberals evidences an epistemological tension regarding the role of the State and institutions in the construction of freedom. While Sen proposes a proactive role of the public power in the creation of equitable conditions, Hayek and Friedman attribute to the market the capacity for self-regulation and to economic freedom the status of the basic premise of a just society. This dichotomy is not merely theoretical: it reflects different conceptions of justice, citizenship and social responsibility (SEN, 2000; HAYEK, 1990; FRIEDMAN; FRIEDMAN, 2015).

The growing complexity of contemporary societies requires, however, an overcoming of these traditional dichotomies. Edgar Morin proposes a transdisciplinary and systemic approach, in which development should be understood as a multidimensional, dynamic and interdependent process. From this perspective, freedom cannot be thought of in isolation or linearly, but as part of a network of relationships between culture, nature, economy, technology and spirituality, whose effects are unpredictable and often contradictory (MORIN, 2013).

For Morin, the challenge is to integrate knowledge and recognize that humanity's problems cannot be solved within watertight disciplinary compartments. Freedom, in this context, must be reconceptualized not only as an individual right, but as a collective responsibility for the sustainability of life on the planet. This implies recognizing that there are freedoms that, when absolutized, can compromise the social fabric, the ecological balance and the very survival of future generations (MORIN, 2013).

The tropicalist movement, led by Caetano Veloso and Gilberto Gil, offers a unique perspective on the tension between tradition and modernity in the Brazilian development process (DAVINO; FERREIRA, 2020). Tropicália represented an anthropophagic synthesis

that combined "the old and the new, the national and the global", establishing a creative dialogue with the country's cultural contradictions (LEORNE, 2025).

Caetano Veloso, in "Coração Civil", poetically expresses many of the ideals that permeate the substantive conception of freedom: "I want utopia, I want everything and more / I want happiness in the eyes of a father / I want joy for many happy people / I want justice to reign in my country". There is no denying that such verses articulate, in accessible language, the inseparable relationship between individual freedom and collective well-being, between personal development and social justice.

Therefore, the tropicalist vision anticipated, in the cultural field, many of the contemporary reflections on sustainable and inclusive development. By rejecting both retrograde nationalism and uncritical modernization, the movement proposed a third way that recognized the complexity of peripheral societies and the need for their own paths to development. This stance is echoed in Morin's (2013) reflections on the need to overcome simplifying dichotomies and embrace complexity as a fundamental characteristic of contemporary social processes.

The recognition of culture as a strategic dimension of development shows that freedom and progress cannot be dissociated from the collective identities and symbolic expressions of a people. Valuing cultural diversity, creativity, and intangible heritage contributes to the construction of a social environment that is more open to innovation and plurality of perspectives.

In this sense, public policies aimed at strengthening culture and education play a central role in the democratization of opportunities, promoting social inclusion and respect for differences. By integrating cultural and social aspects into the debate on development, the horizon of possibilities for the realization of a freedom that is, in fact, substantive and universal, capable of responding to the challenges imposed by historical inequalities and the accelerated dynamics of contemporary transformations, is expanded.

Thus, understanding the theoretical foundations of freedom in the context of development requires a critical reading, which considers both the values of individual autonomy and the imperatives of social justice and environmental preservation. The articulation between these dimensions points to a development model that is not limited to economic efficiency, but that is realized in the concrete expansion of human possibilities, in the reduction of inequalities and in the construction of a legal order guided by solidarity, diversity and sustainability.

3 FREEDOM IN THE STRUCTURE OF INSTITUTIONS AND THE REDUCTION OF INEQUALITIES

The realization of freedom as a substantive vector of development depends directly on the structure and functioning of political, legal and economic institutions. Freedom, in this context, is not limited to mere individual autonomy or the absence of coercion, but manifests itself concretely when the legal-institutional system guarantees equal conditions for the exercise of rights. In this way, it is possible to argue that the institutional architecture plays a decisive role in the construction of real freedoms, overcoming the liberal vision restricted to formal freedom (BERCOVICI, 2005).

The effectiveness of political, juridical and economic institutions in promoting substantive freedom depends on their formal existence, but above all on the quality of their operation and the ability to adapt to social demands. Institutions that are inclusive, transparent and responsive are essential to ensure that the rights provided for in the legal system are translated into concrete practices of equality and participation. In addition, the dynamic interaction between the State and civil society is fundamental for the construction of an environment in which freedom is not a privilege of a few, but a condition accessible to all.

Thus, institutional strengthening should be thought of as a continuous process of improvement, which articulates mechanisms of social control, transparency, and distributive justice, ensuring that political and economic structures regulate, but effectively promote, human and social development.

In the Brazilian case, the 1988 Constitution enshrined an economic order based on social justice, the social function of property and the reduction of inequalities. This normative arrangement, called the Economic Constitution, imposes limits on the logic of the market and legitimizes the State's action as an agent that promotes development. For Bercovici, this constitutional framework is not neutral, but guided by the search for a more just society, in which institutions are called upon to operate in favor of substantive freedom and citizen inclusion (BERCOVICI, 2005).

By shifting the focus to the issue of economic inequality, it is found that the concentration of income and wealth constitutes one of the main obstacles to the realization of freedom in its material dimension. Excessive inequality erodes social cohesion, undermines intergenerational mobility and distorts the democratic functioning of institutions. Thomas Piketty shows that, over the last decades, there has been a widening of wealth

disparities, with profound implications for access to opportunities, political voice and fundamental rights (PIKETTY, 2014).

Moreover, the persistence of economic inequality limits access to material resources, but also compromises the effectiveness of political participation, creating an environment in which disadvantaged voices are systematically marginalized. This asymmetry of economic power translates into inequality in access to information, influence over public decisions, and capacity for social mobilization, weakening democratic mechanisms and representativeness.

Furthermore, the structural imbalance between social groups generates a concentration of power that hinders the implementation of inclusive public policies and perpetuates the exclusion of significant portions of the population. In this way, economic inequality becomes a central factor in the reproduction of cycles of political exclusion, eroding the basis of citizenship and compromising the construction of fairer and more democratic societies.

Political freedom, in this context, becomes vulnerable to institutional capture by economic elites, who shape public policies according to narrow interests. This dynamic produces a vicious cycle in which inequality fuels exclusion, and exclusion reinforces inequality, undermining the foundations of democratic citizenship. Piketty argues that, without effective mechanisms of redistribution and fiscal control, institutions begin to operate in a regressive manner, privileging the maintenance of historical privileges and restricting the possibilities of social transformation (PIKETTY, 2014).

Joseph Stiglitz reinforces this perspective by analyzing the structural impacts of inequality on the institutional and economic performance of countries. For the author, societies marked by extreme asymmetries face difficulties in establishing equitable, transparent and effective institutions. Freedom, under such conditions, becomes the privilege of the few, while the majority remains imprisoned in contexts of economic exclusion, educational precariousness and low political representation. Thus, the poor distribution of income not only compromises development, but sabotages the very idea of freedom in its socially relevant expression (STIGLITZ, 2012).

In the midst of this scenario, it is possible to highlight that MPB played a relevant role during the Brazilian military dictatorship, functioning as a channel of expression and cultural resistance in a period of institutional repression. Artists such as Chico Buarque have developed sophisticated poetic strategies to circumvent censorship and keep social criticism

alive, demonstrating how art can preserve spaces of freedom even in authoritarian contexts (PLAGGE, 2025).

The experience of Brazilian cultural resistance concretely illustrates how democratic institutions depend on formal structures, but also on a political culture that values plurality and public debate. The protest songs denounced injustices, but politically educated an entire generation, contributing to the formation of a democratic consciousness that would be fundamental in the process of redemocratization (PLAGGE, 2025).

Milton Nascimento and Clube da Esquina exemplify how art can articulate political resistance with aesthetic innovation. Combining MPB, rock, jazz, and folk influences, the movement created a unique musical language that challenged both repression and dominant aesthetic standards. Songs like "Coração de Estudante" became symbols of struggle and hope, demonstrating the power of art to sustain utopia even in the darkest moments (PLAGGE, 2025).

Thus, this cultural dimension of resistance highlights fundamental aspects about the nature of democratic institutions. They are not sustained only through legal norms, but need a cultural substrate that values diversity, creativity and citizen participation. The Brazilian experience demonstrates how popular culture can function as a guardian of democratic memory and as an instrument of political education.

In this sense, it becomes evident that the strengthening of institutions cannot be dissociated from public policies oriented to equity. It is not enough for the norms to recognize rights; there must be structures capable of making them feasible and accessible to all citizens. State action must be redesigned in order to reverse historical inequalities and guarantee objective conditions for the full exercise of freedom. This process requires institutional reconstruction based on principles of distributive justice, social responsibility and substantive inclusion (BERCOVICI, 2005; STIGLITZ, 2012; PIKETTY, 2014).

The idea of freedom is often associated with the expansion of individual choices and the ability to consume goods and services in an increasingly diverse market. However, this conception is limited in the face of the environmental and social impacts of the continuous growth model. The depletion of natural resources, the climate crisis and global inequality demonstrate that the unrestricted exercise of freedom of consumption can paradoxically compromise the conditions that sustain the very life and freedom of future generations (LATOUCHE, 2009).

The imperative of economic growth, widely naturalized as synonymous with progress, needs to be critically reassessed. Overcoming this logic requires a transition to a more conscious development model, which values collective well-being, responsible autonomy, and reconnection with ecological limits. Such an approach proposes an inversion of values, replacing the cult of excess with a culture of sufficiency, sobriety and solidarity (LATOUCHE, 2009).

Freedom, in this context, should not be confused with the mere absence of restrictions or with the unlimited possibility of individual choices. It is materialized when there are material, social and ecological conditions that allow subjects to carry out their life projects in balance with others and with the natural environment. The expansion of real freedoms is necessarily conditioned to the preservation of common goods and the construction of a sustainable and equitable coexistence (LATOUCHE, 2009).

This vision demands the incorporation of intergenerational responsibility as a structuring element of public policies and legal institutions. The protection of the environment and the rational management of resources cannot be seen as programmatic options, but as binding duties of the State and society. Freedom, in order to be fully realized, requires the guarantee of a viable future, with minimum conditions for human flourishing in all its dimensions (FREITAS, 2012).

The normative structure must therefore transcend the short-term logic of exploitation and assume ethical commitments over time. This means recognizing that contemporary freedom implies conscious choices that respect the precautionary principle, intergenerational equity, and the intrinsic value of ecosystems. Sustainability is no longer just a political guideline to become the legal basis of a new institutional rationality (FREITAS, 2012).

The global ecological crisis cannot be understood solely as a result of the deterioration of natural resources. It expresses, in a deeper way, a civilizational and subjective crisis, in which the fragmentation of relationships, the trivialization of life and the commodification of social bonds have eroded collective sensibility. Freedom, in this scenario, requires not only structural transformation, but also the reconstruction of meanings, affections and ways of being in the world (GUATTARI, 1990).

It is necessary to break with the notion that nature and humanity occupy separate and hierarchical spheres. Freedom acquires full meaning when recognized as a relational experience, permeated by bonds of respect, interdependence and care for all forms of life. This understanding challenges the normative structures centered on anthropocentrism and

establishes an ethics of coexistence, in which the natural environment ceases to be an object and becomes a subject of rights (GUATTARI, 1990).

In the face of this conceptual reconstruction, the challenge of the twenty-first century lies in articulating freedom, justice and sustainability in the same normative horizon. Development, in order to be effectively liberating, needs to operate with new ethical, political and legal parameters, capable of guaranteeing not only immediate well-being, but the continuity of life in its diversity. Only with the integration between human rights, rights of nature and intergenerational justice will it be possible to consolidate a truly emancipatory model of coexistence.

4 FREEDOM, SUSTAINABILITY AND THE RIGHTS OF NATURE: CONTEMPORARY LIMITS TO GROWTH

The contemporary conception of freedom is tensioned in the face of the environmental, social and civilizational challenges imposed by the dominant model of development. The association between freedom and the expansion of consumption, which permeates hegemonic political and economic discourses, begins to reveal profound contradictions when confronted with the reality of ecological collapse and structural inequality. Freedom understood as the unlimited multiplication of individual choices, especially in the field of consumption, ignores the physical limits of the planet and compromises the possibilities of a dignified existence for future generations (LATOUCHE, 2009).

The environmental crisis is not limited to the scarcity of natural resources, but represents a crisis of meaning, in which the values that sustained the modern ideal of progress have become instruments of destruction. The expansion of production and material wealth, detached from ethical and ecological parameters, compromises the very foundations of human freedom. The notion of linear and cumulative progress needs to be reviewed in the light of an alternative rationality, guided by principles of sufficiency, reciprocity and balance (LATOUCHE, 2009).

Freedom, in this new horizon, is no longer understood as the simple absence of external interference and is now linked to the ability to live consciously and responsibly in relation to others and the environment. Its implementation requires not only guaranteed rights, but also collective and structural conditions that preserve the common good. Environmental justice and the recognition of planetary limits thus become inseparable elements of the free human experience (LATOUCHE, 2009).

From a legal point of view, sustainability is presented as a structuring principle of the new conception of freedom. The requirement to preserve the environment for future generations does not stem only from a technical or environmental concern, but from an ethical and constitutional commitment to the continuity of life in its multiple forms. Freedom is not fully realized when dissociated from intergenerational responsibility, the duty of precaution and respect for the natural cycles that sustain human existence (FREITAS, 2012).

This responsibility transcends the scope of individual decisions and imposes a profound institutional reconfiguration. The legal system must be able to incorporate the temporal dimension of freedom, recognizing that the present use of natural resources directly impacts the collective future. In this context, the role of public policies and legal institutions is to ensure the balance between development and conservation, ensuring that today's rights do not make tomorrow's rights unfeasible (FREITAS, 2012).

The reductionist approach to freedom as an isolated subjective right is incompatible with the complexity of contemporary social and ecological relations. Freedom should be thought of as the result of dynamic interactions between individuals, collectivities and nature, which implies its reconceptualization as a relational, situated and ecological value. This understanding requires the displacement of a paradigm centered on the individual to another oriented by cohabitation and interdependence (GUATTARI, 1990).

Environmental deterioration, in this sense, should also be understood as a deterioration of social and subjective relations. The ecological imbalance reflects a broader crisis, marked by the fragmentation of bonds, the reduction of sensitivity and the instrumentalization of human relationships. Freedom, when limited to the logic of the market and the reproduction of consumption patterns, loses its emancipatory power and becomes a vector of alienation and destruction (GUATTARI, 1990).

The relationship between art and environmental awareness in MPB offers unique perspectives on the contemporary challenges of sustainability. Maria Bethânia, in "Purificar o Subaé", articulates in a poetic way the criticism of the predatory development model and the need for a new relationship with nature. The song denounces the "empty progress that brings environmental destruction" and invokes the protection of Iemanjá, integrating spiritual, cultural and ecological dimensions.

Gilberto Gil, especially in "Refloresta", offers an urgent poetic appeal to environmental preservation: "Keeping what remains standing is not enough", reinforcing the need for proactive ecological restoration actions. The song highlights the insufficiency of palliative

measures in the face of the magnitude of environmental destruction, echoing theoretical reflections on the limits of economic growth.

The environmental poetry of MPB anticipated, in accessible language, many of the contemporary debates on sustainability and the rights of nature, works that demonstrate how artistic sensibility can capture social trends and contradictions even before they are systematized by academic thought (FERNANDES, 2021). The reference to the orishas and Afro-Brazilian spirituality, present in several compositions, suggests alternative ways to think about the relationship between humanity and nature, overcoming the Western dichotomy between culture and environment.

Thinking about freedom from the perspective of ecology requires an integration between the environmental, social and mental dimensions. The reestablishment of an ethical relationship with nature, with the other and with oneself becomes a condition for the construction of a more just, plural and sustainable society. In this scenario, the law assumes the task not only of regulating conduct, but of stimulating the reconstruction of an ecological sensibility capable of sustaining new forms of coexistence and freedom (GUATTARI, 1990).

The protection of freedom in its substantive dimension cannot dispense with the action of institutions capable of guaranteeing material equity and ecological balance. The contemporary institutional structure, historically shaped by short-term interests and economistic orientations, demonstrates a low capacity to deal with the challenges of sustainability and environmental justice. In order for freedom to be broadly guaranteed, it is necessary for the normative apparatus to recognize the centrality of the environment as an existential and legal support for human dignity (FREITAS, 2012; BERCOVICI, 2005).

The disconnect between economic development and distributive justice accentuates the fragility of societies in the face of the climate and institutional crisis. The accumulation of wealth in the hands of a few compromises equal access to essential environmental goods, such as clean water, clean air, and arable land. Environmental inequality adds to economic inequality, restricting the real freedoms of the majority and transferring the ecological costs of consumption to the most vulnerable populations (PIKETTY, 2014; STIGLITZ, 2012).

By adopting economic growth as the main measure of success, many public policies neglect the ecological and social impacts of their decisions. This reductionist logic obscures the fact that full freedom is not sustained on degraded material bases. The concept of freedom requires structural and institutional conditions that are not only formal, but that

ensure that all people have the opportunity to choose lifestyles compatible with mutual respect and the conservation of life support systems (SEN, 2000; LATOUCHE, 2009).

Law, in this context, plays a fundamental role in mediating between immediate interests and long-term commitments. It is a matter of rethinking the very purpose of the legal norm, shifting it from a merely regulatory function to a function that promotes sustainability and intertemporal freedom. This implies incorporating intergenerational justice as a vector for the interpretation of fundamental rights, demanding from public institutions a new ethos aimed at the preservation of life in a broader sense (FREITAS, 2012; BERCOVICI, 2005).

The articulation between freedom and sustainability also requires an epistemological rupture. The modern paradigm, centered on the fragmentation of knowledge and the supremacy of instrumental rationality, limits the understanding of ecological complexity and the interdependencies that characterize social and natural systems. A more integrated approach requires recognizing that environmental, economic and social crises are interconnected and that isolated solutions tend to reinforce the problems they intend to solve (GUATTARI, 1990; MORIN, 2013).

In this sense, thinking about freedom in ecological terms implies accepting the existence of limits. These limits should not be seen as obstacles, but as conditions for human survival and flourishing. A truly free society is one that recognizes its insertion in a web of relationships that includes the environment and other living beings, adopting ethical attitudes that prioritize coexistence and care as the foundations of autonomy (LATOUCHE, 2009; GUATTARI, 1990).

Sustainability-driven freedom cannot be captured by technocratic discourse or the promise that technological innovation alone will solve environmental problems. Although technology is a strategic ally, it is in the political and legal field that regulatory frameworks capable of guaranteeing climate justice, the equitable distribution of responsibilities, and the recognition of the rights of nature must be established. The challenge is to build institutional models that integrate science, ethics and democratic participation (STIGLITZ, 2012; FREITAS, 2012).

The contemporary reformulation of the idea of freedom requires overcoming its reduction to an abstract and formal concept, detached from the concrete structures that sustain it. When freed from the material, institutional and ecological conditions that make it possible, freedom becomes the privilege of the few and a discursive façade for the

maintenance of inequalities. The modern challenge is to reroot it in the field of environmental justice, collective responsibility and intergenerational solidarity (SEN, 2000; FREITAS, 2012).

The effects of climate change, resource scarcity and environmental degradation already impact millions of people around the world, especially marginalized communities, who have historically had restricted access to the commons. Freedom, in these contexts, becomes unattainable. The liberal discourse that celebrates individual autonomy without considering structural barriers proves to be insufficient in the face of the urgency of building a model of coexistence that is simultaneously fair, viable and sustainable (PIKETTY, 2014; STIGLITZ, 2012).

In this scenario, the concept of environmental justice gains centrality by integrating the ecological dimension with social and institutional struggles for freedom. This perspective allows us to understand that the forms of oppression and exclusion are not limited to the economic or legal field, but include the unequal distribution of environmental damage and access to natural resources. Freedom, therefore, also depends on justice in the distribution of environmental goods essential to life (LATOUCHE, 2009; GUATTARI, 1990).

The very notion of development must be reconfigured based on these parameters. Instead of the incessant search for growth, it is necessary to build an idea of development that privileges collective well-being, the balance of ecosystems, and the preservation of human rights and the rights of nature (GODOY, 2025). Such a perspective requires the adoption of public policies based on the ethics of sufficiency, the mitigation of damage and the prevention of socio-environmental risks (FREITAS, 2012; LATOUCHE, 2009).

The modern conception of law needs to keep up with this transformation. Traditional law, centered on property, consumption and autonomy detached from the collectivity, is limited in the face of the complexity of contemporary problems. The guarantee of freedom requires the reinterpretation of fundamental rights in the light of sustainability, considering nature as a legal subject and not only as an object of use and exploitation (GUATTARI, 1990; BERCOVICI, 2005).

In this sense, rethinking freedom in times of environmental crisis implies repositioning human beings within the web of life, recognizing their dependence on natural conditions and their responsibility towards them. This repositioning requires ruptures with dominant paradigms and the construction of a new model of rationality, which values plurality, interdependence and care as the foundations of democratic and ecological coexistence (MORIN, 2013; GUATTARI, 1990).

Institutions, in turn, must be reformulated to play an active role in the construction of socially and ecologically committed freedom. The State's action cannot be restricted to regulatory neutrality, but must incorporate a redistributive, sustainable and participatory logic, promoting inclusive policies that guarantee equitable access to environmental goods, information and democratic deliberation (BERCOVICI, 2005; STIGLITZ, 2012).

Consolidating a libertarian vision of development implies overcoming the false dichotomy between individual freedom and the collective good. Contrary to what classical liberal currents advocate, the protection of the common good – especially with regard to the environment – does not represent a threat to freedom, but its condition. The freedom of each person can only be realized in a livable, socially just and environmentally balanced world. Thus, real freedoms become inseparable from environmental justice and harmonious cohabitation with nature.

The contribution of Brazilian art to the debate on freedom and development transcends aesthetic value and takes on fundamental epistemological and political dimensions. Poetry and music work as mediators between theoretical reflection and lived experience, making complex concepts accessible and mobilizing affections necessary for social transformation.

Vinícius de Moraes' "Hiroshima Rose" exemplifies how art can address global issues with local sensitivity, connecting the struggle for world peace with the search for social justice in Brazil (VERSOS..., 2023). The poem uses constructivist techniques that reinforce its political message, demonstrating how form and content are articulated in the construction of a poetics committed to social transformation.

The Brazilian cultural experience suggests that authentic development cannot do without the artistic and symbolic dimension. The cities sung by Vinícius de Moraes, the utopias dreamed of by Caetano Veloso, the resistances narrated by Chico Buarque and the ecologies invoked by Bethânia and Gil make up a collective imaginary that guides aspirations and projects for the future.

This time, this synthesis between art and social consciousness points out that substantive freedom is not only realized through public policies and institutional arrangements, but also through the construction of new meanings, affections and imaginaries. Brazilian social poetry, from Castro Alves to the present day, demonstrates how art can function as an "instrument of revolution", capable of awakening consciences and mobilizing transformative energies (GETENS; MONTOVANI, 2023).

Closing this chapter means recognizing that the debate on freedom and development can no longer ignore the limits of the planet or the ethical requirements of coexistence. Freedom is not achieved in isolation, but in the relationship with others and with the environment in which one lives. Incorporating sustainability as a constitutive value of freedom is, at the same time, a gesture of historical lucidity and a civilizing imperative. The future of freedom depends, to a large extent, on our ability to reconfigure the horizons of development, guiding them by criteria of justice, balance and interdependence.

5 CONCLUSION

The present investigation started from the proposal to understand freedom as a constitutive element — and not just a result — of development, going beyond the traditional paradigms centered on economic expansion. The theoretical path made it possible to show that the concept of freedom, when detached from the material, social and ecological conditions that sustain it, becomes abstract and inoperative in the face of contemporary inequalities and crises. Development, in order to be effectively liberating, requires the recognition of freedom as a relational value, situated and conditioned by historical and environmental reality.

The initial analysis demonstrated that the substantive conception of freedom involves not only the absence of coercion, but the presence of real capacities for individuals to carry out their life projects. This approach shifts the focus from formal freedom to effective freedom, incorporating variables such as access to essential services, political participation, and distributive justice. Thus, development ceases to be an end in itself and is conceived as a means to the full realization of human autonomy.

When analyzing the role of institutions, it was found that they constitute the normative and organizational foundation for the construction of freedom. Legal and political structures must guarantee not only declaratory rights, but objective conditions for their universal exercise. When institutions become refractory to equity or captured by concentrated interests, freedom is emptied of meaning and development begins to reproduce historical inequalities. Therefore, institutional effectiveness must be permanently guided by the principles of social justice, substantive democracy, and pluralism.

On the socioeconomic level, it has become evident that freedom finds serious limits when confronted with the persistence of extreme inequalities. The concentration of income, power, and opportunities reduces access to full citizenship, compromises democratic

legitimacy, and weakens the mechanisms of collective deliberation. In addition, the overlap between economic inequality and environmental degradation increases the vulnerability of marginalized populations, demonstrating that freedom cannot be thought of in isolation from the distributive and ecological issue.

Sustainability, in turn, proved to be an indispensable dimension of freedom. In times of climate emergency, the preservation of the environment ceases to be a peripheral ethical imperative and becomes a precondition for the continuity of human and non-human life. Future freedom depends directly on the current ability to responsibly manage natural resources, mitigate ecological damage, and institute legal mechanisms capable of protecting the rights of nature and ensuring intergenerational justice.

The articulation between freedom and the environment requires, therefore, a paradigm shift. It is about replacing the logic of exploitation with the principle of care, recognizing the interdependence between all forms of life. Freedom can no longer be conceived as an unrestricted license for action, but as a conscious commitment to the limits of the planet and to the maintenance of equitable conditions of existence for present and future generations. This imposes on law and public policies the task of incorporating ecological ethics as a normative foundation.

In addition, the notion of freedom needs to be reinterpreted in the light of contemporary complexity, which integrates economic, cultural, institutional, subjective and environmental dimensions. The idea that freedom can be guaranteed without profoundly transforming the modes of production, consumption and coexistence is unsustainable. The challenge is to build a shared, inclusive and responsible freedom, supported by structures that recognize the value of diversity and life in common as the foundations of democratic coexistence.

It follows from this that there is no genuine development without real freedom, and there is no real freedom without justice, equity, and sustainability. The construction of a truly free society depends on institutions committed to social transformation, the overcoming of structural inequalities and the incorporation of the environment as a subject of rights. Only through the integration of these dimensions will it be possible to move towards a development model that does not exclude, does not destroy, and that is capable of sustaining freedom as a collective, enduring, and fully realizable value.

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FROM STORAGE TO E-LOGISTICS: LOGISTICS SERVICES AND THEIR APPLICATION IN THE TEXTILE AND APPAREL INDUSTRY

DA ARMAZENAGEM À E-LOGÍSTICA: SERVIÇOS LOGÍSTICOS E SUA APLICAÇÃO NA INDÚSTRIA TÊXTIL E DE CONFECÇÃO

DEL ALMACENAMIENTO A LA LOGÍSTICA ELECTRÓNICA: SERVICIOS LOGÍSTICOS Y SU APLICACIÓN EN LA INDUSTRIA TEXTIL Y DE LA CONFECCIÓN

 <https://doi.org/10.56238/sevened2025.036-007>

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ABSTRACT

Logistics plays a strategic role in the competitiveness of supply chains, especially in global sectors such as textiles and apparel, which face growing demands for efficiency, traceability, customization, and sustainability. In this context, logistics services are becoming increasingly important not only as operational support but also as instruments of differentiation and value creation. This article aims to analyze, through a structured literature review, the main types of logistics services available and their potential applications in the textile and apparel industry. The research was conducted using Scopus and Web of Science databases, using analysis and selection procedures that resulted in a portfolio of 20 core articles. The results indicate that, in addition to the traditional areas of storage and transportation, there is an expansion of value-added services such as customer support, information technology, security, and e-logistics. The growing role of outsourcing was also highlighted, allowing companies to focus on strategic activities and establish more collaborative partnerships throughout the supply chain. The analysis reveals that the integration of logistics services and collaborative practices enhances competitiveness and resilience gains, but also highlights gaps in performance measurement and the incorporation of green and digital practices. As a contribution, the study provides an integrated view of logistics services, highlighting their importance for strengthening the textile and apparel supply chain and signaling opportunities for future research on emerging topics such as sustainability, Logistics 4.0, and the circular economy.

Keywords: Logistics Services. Textile and Apparel Industry. Supply Chain. Outsourcing. E-Logistics.

RESUMO

A logística desempenha papel estratégico na competitividade das cadeias de suprimentos, especialmente em setores globais como o têxtil e de confecção, que enfrentam demandas crescentes por eficiência, rastreabilidade, personalização e sustentabilidade. Nesse contexto, os serviços logísticos assumem relevância não apenas como suporte operacional, mas também como instrumentos de diferenciação e geração de valor. Este artigo tem como objetivo analisar, por meio de uma revisão bibliográfica estruturada, os principais tipos de

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serviços logísticos disponíveis e suas potenciais aplicações na indústria têxtil e de confecção. A pesquisa foi conduzida a partir das bases Scopus e Web of Science, utilizando procedimentos de análise e seleção que resultaram em um portfólio de 20 artigos centrais. Os resultados indicam que, além das áreas tradicionais de armazenagem e transporte, observa-se a expansão de serviços de valor agregado, como apoio ao cliente, tecnologia da informação, segurança e e-logística. Evidenciou-se ainda o papel crescente da terceirização, que permite às empresas focar em atividades estratégicas e estabelecer parcerias mais colaborativas ao longo da cadeia. A análise revela que a integração entre serviços logísticos e práticas colaborativas potencializa ganhos de competitividade e resiliência, mas também aponta lacunas quanto à mensuração de desempenho e incorporação de práticas verdes e digitais. Como contribuição, o estudo fornece uma visão integrada dos serviços logísticos, destacando sua importância para o fortalecimento da cadeia de suprimentos têxtil e de confecção e sinalizando oportunidades de pesquisa futura em temas emergentes como sustentabilidade, logística 4.0 e economia circular.

Palavras-chave: Serviços Logísticos. Indústria Têxtil e de Confecção. Cadeia de Suprimentos. Terceirização. E-Logística.

RESUMEN

La logística desempeña un papel estratégico en la competitividad de las cadenas de suministro, especialmente en sectores globales como el textil y la confección, que se enfrentan a crecientes demandas de eficiencia, trazabilidad, personalización y sostenibilidad. En este contexto, los servicios logísticos adquieren cada vez mayor importancia no solo como apoyo operativo, sino también como instrumentos de diferenciación y creación de valor. Este artículo busca analizar, mediante una revisión bibliográfica estructurada, los principales tipos de servicios logísticos disponibles y sus posibles aplicaciones en la industria textil y de la confección. La investigación se realizó utilizando las bases de datos Scopus y Web of Science, mediante procedimientos de análisis y selección que dieron como resultado una cartera de 20 artículos principales. Los resultados indican que, además de las áreas tradicionales de almacenamiento y transporte, existe una expansión de servicios de valor añadido como la atención al cliente, las tecnologías de la información, la seguridad y la logística electrónica. También se destacó el creciente papel de la externalización, que permite a las empresas centrarse en actividades estratégicas y establecer alianzas más colaborativas a lo largo de la cadena de suministro. El análisis revela que la integración de servicios logísticos y prácticas colaborativas mejora la competitividad y la resiliencia, pero también destaca las deficiencias en la medición del rendimiento y la incorporación de prácticas ecológicas y digitales. Como contribución, el estudio ofrece una visión integral de los servicios logísticos, destacando su importancia para fortalecer la cadena de suministro textil y de la confección y señalando oportunidades para futuras investigaciones en temas emergentes como la sostenibilidad, la Logística 4.0 y la economía circular.

Palabras clave: Servicios Logísticos. Industria Textil y de la Confección. Cadena de Suministro. Subcontratación. Logística Electrónica.

1 INTRODUCTION

There are a number of changes that have taken place in the textile and apparel industry in relation to its functions, activities, and strategies. For example, demand and supply are no longer restricted to nations or regions, they have become global processes (ERYURUK; KALAOĞLU; BASKAK, 2011). In addition, product assortments have expanded significantly and market demands on product quality, traceability, delivery services and sustainability continue to increase (HSIAO *et al.*, 2010). One of the innovations in logistics is to specialize in its core activities and outsource non-essential activities to service providers. Outsourcing is an elegant way to solve organizational problems, in the literature there are numerous reports of its growing use (ANDERSSON and NORRMAN, 2002).

Most publications on logistics services discuss the use of traditional logistics processes, such as transportation and warehousing (DAIM; UDBYE; BALASUBRAMANIAN, 2012; VAN LAARHOVEN; BERGLUND; PETERS, 2000; STEFANSSON, 2006), advantages and risks of outsourcing (RAZZAQUE and SHENG, 1998; NOREK and POHLEN, 2001; SOHAIL and SOHAL, 2003), or the service provider selection process (DAIM; UDBYE; BALASUBRAMANIAN, 2012; AGHAZADEH, 2003). However, very little is known about the various types of logistics services that exist, whether basic or value-added, that involve logistics planning and control activities specifically in the textile and apparel supply chain.

In this sense, this article aims to analyze, through a theoretical study about logistics services, which are possible to be explored by the textile and apparel industry. As it is an updated literature review, the study tends to present a vision of the logistics service that is more integrated with the collaborative concepts of the supply chain. In this way, the structure and activities in the traditional areas of logistics, such as storage and transport, as well as in the areas that have been incorporated in recent years, such as customer service, information technology, safety and security, and e-logistics, are discussed.

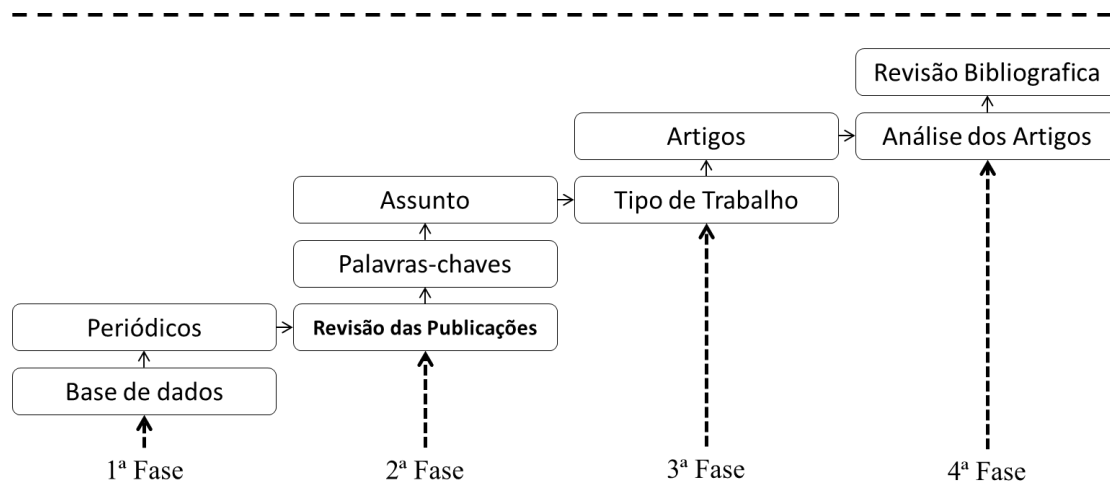
For this, this work was divided into five sections, in addition to this brief introduction, there is section two that presents the methodological procedures, section three discusses logistics services in the textile and apparel industry, section four presents the types of logistics services offered and, finally, in section five, the final considerations of the article and some recommendations for future research are made.

2 METHODOLOGICAL PROCEDURES

This research can be considered conceptual theoretical, focused on the bibliographic analysis to be carried out through a structured literature review (MARASCO, 2008), with the objective of analyzing the theme of logistics service. To this end, the literature review method with four different phases will be used, as illustrated in Figure 1.

Figure 1

FlowTable of the Methodology to be applied in the research



Source: Based on the methodology employed by Marasco (2008).

2.1 PHASE 1: DEFINITION OF DATABASES AND JOURNALS

In the first phase for the composition of the bibliographic portfolio, the *Web of Science* and *Scopus* databases were defined. The choice of the *Scopus database* is due to the fact that it encompasses the journals that publish the most in Production Engineering and Logistics (MARASCO, 2008). In the case of choosing *the Web of Science*, it is due to the fact that the main journals in the area of Production Engineering are indexed.

The research was carried out by searching for publications in journals without time limit to verify the evolution of the theme over the years. The total number of papers found in these databases was the result of searching for the researched theme in the titles, abstracts and keywords of the articles.

2.2 2ND PHASE: DEFINITION OF KEYWORDS AND READING OF ABSTRACTS

In the second phase, the following keywords were defined for the literature review: "*Logistics and Service*".

The works found with this combination of keywords were mostly book chapters, standards, conference papers, among others, giving a total of 3,107 works. However, the present research focused on international articles, with the aim of giving greater credibility and also delimiting the research. Thus, in the two journals researched, 1,469 articles were obtained.

2.3 3RD PHASE: SELECTION OF ARTICLES

After reading the titles of the 1,469 articles, only the articles that had a strong relationship with the logistics service were selected, thus accounting for 243 publications in the *Scopus and Web of Science databases*.

Another filter used to verify the scientific relevance of the articles was the number of citations, which was used as a criterion for their permanence in the research publication database. The search for this criterion was carried out with the help of the *Google Scholar tool*, which presents the number of citations of each article through the title of the article. Finally, the abstracts, introduction, and conclusions of the articles were read. Of the 243 articles, only 20 were aligned with the two research themes, and were selected for full reading, as illustrated in Table 1.

Table 1

Selected articles in the bibliographic portfolio

N o.	Authors	Article Title	Year of Publication	No. of Citations
1	Aghazadeh	How to choose an effective third party logistics provider.	2003	106
2	Alkhatib; Darlington; Nguyen	Logistics Service Providers (LSPs) evaluation and selection: Literature review and framework development.	2015	1
3	Andersson; Norrman	Procurement of logistics services - a minutes work or a multi-year project?	2002	239
4	Caputo; Pelagagge; Scacchia	Integrating Transport Systems in Supply Chain Management Software Tools.	2003	42
5	Chapman; Soosay; Kandampully	Innovation in logistic services and the new business model: a conceptual framework.	2003	361
6	Daim; Udbye; Balasubramanian	Use of analytic hierarchy process (AHP) for selection of 3PL providers.	2012	23
7	Eryuruk; Kalaoğlu; Baskak	Logistics as a Competitive Strategy Analysis of the Clothing Industry in Terms of Logistics.	2011	9

8	Esper; Williams	The Value of Collaborative Transportations Management (CTM): Its Relationship to CPFR and Information Technology.	2003	187
9	Griffis; Cooper; Goldsby; Closs	Performance measurement: measure selection based upon firm goals and information reporting needs.	2004	85
10	Hendricks; Singhal	The effect of supply chain glitches on shareholder wealth.	2003	627
11	Hsiao; Van der Vorst; Kemp; Omta	Developing a decision-making framework for levels of logistics outsourcing in food supply chain networks.	2010	36
12	Jahre; Johan	Packages and physical distribution: implications for integration and standardisation.	2004	54
13	Knemeyer; Zinn; Eroglu	Proactive planning for catastrophic events in supply chains.	2009	240
14	Lieb	The 3PL industry: where it's been, where it's going.	2005	45
15	Morash; Lynch	Public policy and global supply chain capabilities and performance: a resource-based view.	2002	93
16	Ovalle; Marquez	The effectiveness of using e-collaboration tools in the supply chain: an assessment study with system dynamics.	2003	139
17	Patterson; Grimm; Corsi	Diffusion of supply chain technologies.	2004	72
18	Power; Sharafali; Bhakoo	Adding value through outsourcing: Contribution of 3PL services to customer performance.	2007	76
19	Stefansson	Collaborative logistics management and the role of third-party service providers.	2006	180
20	Van Laarhoven; Berglund; Peters	Third-party logistics in Europe-five years later.	2000	328

Source: Authors.

2.4 4TH PHASE: ANALYSIS OF ARTICLES

After the construction of the bibliographic portfolio, a literature review was carried out. From this analysis it was possible to understand the subject and build knowledge about the objective proposed for the research. The results of this review are presented in the following items of the article.

3 LOGISTICS SERVICES IN THE TEXTILE AND CLOTHING INDUSTRY

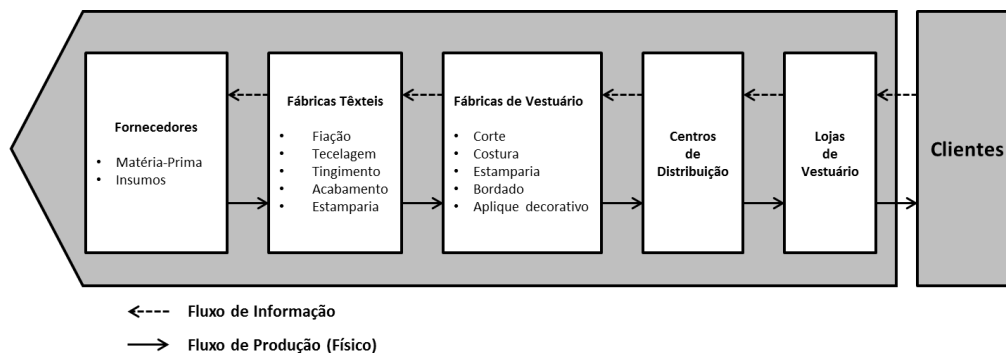
Logistics, in its basic definition, is the efficient flow and storage of goods from their point of origin to the point of consumption. It is the part of the process in the supply chain that plans, schedules, and controls the flow of goods. It can also be seen as inventory management, of products in stock or in motion (ERYURUK; KALAOGLU; BASKAK, 2011). It is also defined as a business planning framework for the management of materials, services, information, and capital flows. It includes the increasingly complex information,

communication, and control systems required in today's business environment (ERYURUK; KALAOGLU; BASKAK, 2011).

The textile and apparel sector can be seen as a supply chain that encompasses a series of distinct activities, such as the supply of raw materials and inputs, the development of products and their production, distribution, and marketing. Figure 2 shows an illustration of this chain, with the dotted lines representing the flow of information, while the solid lines represent the flow of goods. Information flows from the customer providing production needs and delivery dates. In many cases, information flows directly from retailers to textile mills. The links that manufacture the product are formed by several companies that, in order to produce goods and services that make the information flow smoothly, need a series of logistical and business services. Depending on the size of the companies and the development of the economy, such services may be provided by the leading company in the supply chain or by service providers (ABERNATHY *et al.*, 1999).

Figure 2

Supply chain in the textile and apparel sector



Source: Adapted from Abernathy *et al.*, 1999.

Currently, large textile and apparel companies use logistics as a globalization strategy and have been outsourcing some operations, such as *inbound* and *outbound* logistics, which can be carried out at any stage of the chain. In addition, some processes in the apparel industry have also been outsourced, such as inventory and inventory management, repairs, stain removal, quality control, reprinting, counting, barcode application, labeling, packaging, placement of accessories, manuals and warranty documents, separation and classification of products, order management and assembly of product sets.

As a result, companies have obtained important advantages, such as time and cost reductions, being able to focus on their strategic activities in a more professional way.

4 TYPES OF LOGISTICS SERVICES

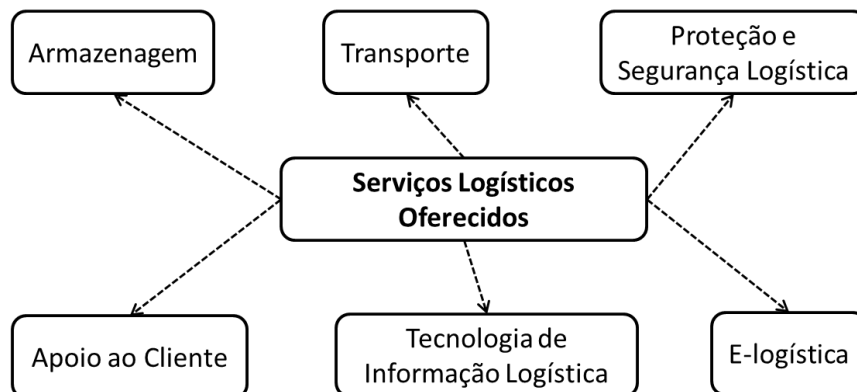
Logistics service can be called any activity that supports the processes of purchase, manufacture, sale, distribution and marketing, and they are generally outsourced because they do not constitute activities that are the company's business, in addition to collaborating to reduce costs, investments, obtaining expertise, etc. (LIEB, 2005; STEFANSSON, 2006).

Over time, many activities have been incorporated by logistics service providers, promoting the consolidation of partnerships. With this, it was possible to structure logistics services as an integral part of the client's business (GRIFFIS *et al.*, 2004).

In view of the literature review carried out, it was possible to elucidate several types of services that make up the logistics portfolio. These services can be divided into the most basic ones linked to the needs of moving products and their storage, as well as those with higher added value, which provide an appreciation of the product in relation to the logistical aspects involved. In each service category there is a series of specific activities and processes that complete its portfolio. Figure 3 presents a summary of the types of logistics services available in the market today.

Figure 3

Structure of Logistics Services available for Supply Chain



Source: Authors.

In the next items of the study, the details of each service are presented along with its specific portfolio. In addition, in each item, the possibilities of using these services by textile and clothing companies are presented and how this impacts the performance of the chain as a whole.

4.1 WAREHOUSING SERVICES

Inventory management of raw materials and finished products is necessary in all activities of the textile and apparel supply chain to obtain adequate production cycles and to supply the services demanded by the market. The physical operation of inventory management is usually carried out by distribution centers or warehouses, whose main activities are: receiving, storage, inventory control, product separation and loading (GUIMARÃES, 2008).

In addition to the basic services that are linked to storage both in warehouses and distribution centers, there are some types of value-added services that can be contracted by companies such as: *Cross-Docking*, product assembly, quality testing, product preparation, packaging, labeling, product rework, *Recall*.

For example, it is common for clothing companies to outsource some production processes to reduce operating costs, so it could hire others that add value to the product along with the storage service, passing on to the outsourced the responsibility for quality tests on the products received, labeling, packaging of products and availability in stock. As this type of service is usually hired in strategic locations as a way to speed up deliveries and reduce transportation costs, it is also possible to transfer steps in the after-sales process, such as rework and *recall*. Thus, administrative activities related to complaints and the rework or exchange of products could also be carried out.

Table 2 shows a summary of the main value-added activities and services that are related to warehousing.

Table 2

Types of logistics storage services offered by outsourcing companies

Basic Services in Warehousing		
	Description of Service Activities	Authors

Type of Service Offered		Power; Sharafali; Bhakoo (2007)	Hsiao <i>et al.</i> (2010)	Aghazadeh (2003)	Van Laarhoven; Berglund; Peters (2000)	Daim; Udbye; Balasubramanian (2002)	Stefansson (2006)	Guimarães (2008)
Receipt of products	All products that are stored, whether in warehouses or Distribution Centers, go through a receiving process, which consists of checking product characteristics with pre-established information.					X		X
Product storage	It is the product stored for later shipment. It requires a specific technique to locate the products according to the characteristics of the product itself and the form of storage.	X	X		X	X	X	
Inventory Control	Some products are sent for storage and there they are tested according to criteria established by the manufacturer	X	X	X	X	X	X	X
Order Picking	It consists of the separation of products by order. There are several picking techniques depending on the product and the type of order.		X		X		X	X
Loading orders	It consists of the shipment of products for subsequent transport. The form of loading must suit the mode used for loading.			X	X			X
Value-Added Services in Warehousing								
Cross-Docking	The cargo arrives at the terminal in a consolidated way and is dispatched fractionally, without generating storage, there is only one passage. The process requires synchronization in the receiving and dispatch processes.						X	
Product assembly	It consists of the final formation of products that are assembled when the order is confirmed for dispatch.	X	X	X	X	X		
Quality Control	Some products are sent for storage and there they are tested according to criteria established by the manufacturer			X	X	X	X	
Product preparation	There are products that require specific formatting and packaging before being shipped, or even specific packaging for dispatch.	X	X				X	
Product Packaging	You receive the consolidated product and then pack it when it is sold (or the type of sale)		X	X			X	
Product labeling	According to the type of sale, there is personalized or specific labeling.		X	X	X		X	

Rework and Recall	Products that return and allow reuse can be worked on in warehouses or distribution centers, avoiding going back to the factories.			X			X	
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Source: Authors.

4.2 TRANSPORTATION SERVICES

The transportation service is one of the main logistics functions. In addition to representing the largest portion of logistics costs in most organizations, it plays a fundamental role in the performance of several dimensions of customer service. Even with the advancement of technologies, which allow the exchange of information in real time, transport continues to be fundamental to achieve the logistical objective: the right product, in the right quantity, at the right time, in the right place, at the lowest possible cost. With an increasingly demanding and globalized market, companies feel the need to find partners that ensure not only the entire logistics service, but also the transport service of their products at more affordable costs (GUIMARÃES, 2008).

In order to improve the performance of services, especially by speeding up deliveries, many companies have sought alternatives by increasing new transportation systems, such as the system of loading in standardized carts used for loading and unloading, or standard packaging that tends to facilitate operations. However, these systems must be well studied according to the needs of each chain and the involvement of its agents (JAHRE and JOHAN, 2004). Alternatives that involve the handling of cargo linked to transport, such as *merge-in-transit*, are also an option for seeking results and improving services (HSIAO *et al.*, 2010; STEFANSSON, 2006)

Another aspect that has transformed transportation services has been the use of management tools supported by software capable of analyzing distribution networks, synchronizing and simulating the best alternatives, in addition to providing agility to the system. Geographic location systems also support these services (CAPUTO *et al.*, 2003; ESPER and WILLIAMS, 2003). For the textile industry, this type of value-added service in transportation reduces the risk of theft in the transfer of product loads, especially the loading of yarns or fabrics on rolls.

An important point in transport services is the growing demand from the textile and apparel chain for value-added services. An example is the distribution of clothing items to some retail companies that require products to be delivered on hangers, with the customer's price and labels. This type of personalized service is usually carried out by the clothing

companies themselves, but it is a process that can clearly be absorbed by transport service providers.

Table 3 presents a summary of the main transport services offered by transport companies.

Table 3

Types of transport logistics services offered by outsourcing companies

Basic Services in Transportation								
Type of Service Offered	Description of Service Activities	Authors						
		Power; Sharafali; Bhakoo (2007)	Hsiao et al. (2010)	Aghazadeh (2003)	Van Laarhoven; Berglund; Peters	Daim; Udbye; Balasubramanian	Stefansson (2006)	Hannon (2005) Lieb (2005)
Transportation (Outbound)	It groups a series of storage, handling, order picking and loading functions, until the cargo is delivered. In a market view, it consists of delivering the product to the customer or point of sale.	X				X		X
Transportation (Inbound)	Its purpose is to search for the distribution or manufacturing product to be delivered to the manufacturing or assembly customer.	X						X
Merge-in-Transit	The main logic is to coordinate the meeting of several supplies or vehicles so that compounds in another vehicle can form the cargo planned for dispatch.				X			X
Transit-Point	It consists of sending consolidated loads in larger vehicles, which will be passed on in a pre-defined location to smaller vehicles that operate regionally, for example.		X				X	
Value-Added Services in Transportation								
Fleet Management	Manage the processes involving the various types of vehicles, with the intention of providing decision-makers with information on the performance of these assets.	X	X	X				X
Fleet Location	Supported by GPS-type systems, the software allows companies to track where their cargo is.	X			X			X
Scripting	Through the use of specific software, it is possible to program loads according to the type of vehicle, organize routes according to the best route and according to the variables imposed by customers and the route.							X

Definition of Modals	The study of the possible modes to be used for the transportation of cargo, according to requirements specified by customers.							X	
Freight Selection Quote	It is a system of organization of several carriers that allows the service provider to seek the best freight options, as well as to have flexibility and agility in serving their customer.	X							X
Broker Service	It consists of brokering carriers for other companies.							X	X

Source: Authors.

4.3 CUSTOMER SUPPORT SERVICES

Customer service is the component that differentiates modern logistics from the traditional approach, since currently the importance lies not only in the search for operational efficiency, but also in meeting the needs of customers (MARCHESINI and ALCÂNTARA, 2012). Logistics processes seek to provide superior quality and low-cost customer service, adding value to customers. Thus, logistics services have great potential as an instrument of differentiation of a company. Morash and Lynch (2002) found that customer service is the most important training in the search for better performance. In addition, it is related to the generation of revenues and, thus, the basis for the elaboration of a strategy in a supply chain aimed at generating a certain level of logistics service to the customer (MARCHESINI and ALCÂNTARA, 2012).

In the textile and apparel supply chain, customer service can generate more logistical integration between the various actors, reducing costs by sharing activities with service providers and improving the performance of the entire chain. For example, call-center services can be directed to logistics operators who manage the information in this channel and also relate to complaint services where they record information, monitor actions, and rework or exchange textile or clothing products.

These services serve as complements to traditional logistics processes, generating greater value for the customer and the company that offers it. The apparel industry often needs to transport small volumes of semi-finished and finished products between the various partners in the supply chain. Therefore, support services such as simulations and logistics studies are essential to improve routes and reduce transport times for these products.

In addition to the examples mentioned, there are several other possibilities for using the customer support logistics service in the textile and clothing industry. Table 4 presents a summary of the main customer support services offered by logistics companies.

Table 4

Types of logistics services to support customers offered by outsourcing companies

Type of Service Offered	Description of Service Activities	Authors					
		Power; Sharafali; Bhakoo (2007)	Aghazadeh (2003)	Daim; Udbye; Balasubramanian (2004a)	Stefansson (2006)	Hannon (2005)	Lieb (2005)
Order fulfillment and fulfillment	It consists of receiving the order from customers and covers the documents necessary for the registration of the order and its circulation among the various partners involved, including the customer himself.				X		X
Complaints	Management of complaints, involving the entire process of registration, transmission, follow-up and feedback.				X		
Call-center operation	It supports the service of the end customer, working according to strategies defined by the contractor.	X					
Customer inventory management	It involves the management of the volumes of inventory needed for sale (outbound) and for supply (inbound)	X			X		
Demand Management	It is related to the management of information that allows you to better meet market demand.				X		
Order management at suppliers	Management of orders with suppliers in order to control flows and stock levels in the supply chain.				X		X
Customs Administration (import and export)	To offer all the services inherent to the import and export process.		X	X			
Logistics collection management	To speed up the financial process and reduce wear and tear in the commercial relationship between the service provider and the customer.	X			X		
Reverse Logistics	It is the management of the return of products or inputs after the life cycle.	X	X		X		X
Development of Logistics Projects	These are specific solutions that can be offered by logistics companies to help the customer's processes.	X					X
Simulations and Logistics Studies	With the help of software, it is to generate specific solutions to streamline decision-making in logistics activities.					X	
Product Development Support	It aims to streamline the development process and generate improvements in the product design that facilitate logistics activities.					X	
Information and Logistics History	Have a database with information and histories about the logistics operations carried out by the customer, especially in relation to the market and suppliers.				X		

Source: Authors.

4.4 LOGISTICS INFORMATION TECHNOLOGY SERVICES

Information technology in support of the logistics process has been used as a great partner for the optimization of flows and improvement of the level of service (PATTERSON; GRIMM; CORSI, 2004). This innovation is essential for logistics companies to serve the market, since it contributes to the efficiency and integration of the operation in the supply chain (CHAPMAN; SOOSAY; KANDAMPULLY, 2003).

In addition, the necessary structure is summarized in equipment (hardware) and applications (Software Solutions), such as satellite transmission, web-based orders, electronic data transmission, bar codes, systems for order entry, routing, inventory systems and stock replenishment, among others (OVALLE and MARQUEZ, 2003).

The development of information technology in the logistics flow, from production operations to distribution, with systems of cooperation and information sharing between manufacturer-retailer and between manufacturer-supplier, contribute to demand management and more efficient decision-making (STEFANSSON, 2006). Considering that these processes are integrated with the management of the supply chain, it is essential for the service provider to have these technologies, thus being able to offer its contractor the opportunity to count on an increase in the processes and technology used (SAUVAGE, 2003).

For example, the textile and apparel supply chain increasingly needs its processes to be fast and efficient, especially among links closest to consumers. In retailers, when a purchase is made, this information can feed a database of a logistics company that manages the customer's inventories and can automatically articulate the various logistics processes so that the stores are replenished with products and, in addition, can generate production needs for the companies in this chain.

Another example of the importance of this type of service in the textile and apparel industry can be the management of customer complaints that can be carried out by logistics companies that can automatically record the information, evaluate this complaint and exchange or rework the product, returning the feedback to the customer.

Given the importance of information technology services, Table 5 presents some types of logistics systems that are available to companies. These technological applications support the various activities of companies that provide services to their customers, remembering that all these applications must be accompanied by the necessary physical structure (assets and space), as well as software.

Table 5

Types of logistics information technology services offered by outsourcing companies

Type of Service Offered	Description of Service Activities	Authors				
		Power; Sharafali; Bhakoo (2007)	Aghazadeh (2003)	Alkhatib; Darlington; Nguyen (2015)	Van Laarhoven; Berglund; Peters (2006)	Stefansson (2006)
WMS - Warehousing Management System	Warehouse Management System provides directed stock rotation, intelligent picking directives, automatic cross-docking consolidation to maximize the use of storage spaces.	X	X			
RFID - Radio-Frequency Identification	It is a method of automatic identification through radio signals, retrieving and storing data remotely through devices called RFID tags.	X				
TMS - Transportation Management System	Transportation Management System or Transportation and Logistics Management System, this system allows you to control the entire operation and management of transportation in an integrated way.	X	X		X	X
EDI - Electronic Data Interchange	It can be defined as the electronic movement of standard business documents between, or within, companies. EDI uses a self-collapsing structured data format that allows data to be transformed without being re-entered.	X	X			X
ECR - Efficient Consumer Response	It is a voluntary movement, based on change and continuous improvement, which affects the entire production and distribution chain of consumer products. It aims to establish a consistent flow of information and products that are included bidirectionally in the supply logistics chain					X
VMI - Vendor Managed Inventory	It is a system to optimize the performance of the supply chain, in which the supplier is responsible for managing the inventory levels at the customers.	X				X
CR - Continuous Replenishment	Continuous supply between trading partners, with information related to the actual sales given by the scanners, with supply adjusted to what is necessary, with the maintenance of minimum stocks and with information compared with the demand forecast previously agreed between the trading partners.					X
CPFR - Collaborative Planning, Forecasting, and Replenishment	It is a collaborative program between the different actors in the supply chain, which establishes coordination between production, planning, sales forecasting and replenishment.		X		X	

ERP - Enterprise Resource Planning	They are systems developed to control various departments and processes of a company.			X		
Data Warehousing	It is a digital data warehouse that serves to store detailed information about a company, creating and organizing reports through histories that help in decision-making.		X	X		
BI - Business Intelligence	It is a set of techniques and tools to assist in the transformation of raw data into meaningful and useful information in order to analyze the business.	X				X

Source: Authors.

4.5 LOGISTICS SAFETY AND SECURITY SERVICES

In response to the growing risk profile faced by companies around the world, logistics security services have been gaining attention from various industrial segments, especially those with higher value-added products HENDRICKS and SINGHAL (2003).

The increase in interest in this topic is due to the growth in the level of efficiency and integration within the chains. For Knemeyer; Zinn; According to Eroglu (2009), highly effective supply chains typically do not work with excess resources, nor do they have enough teams to collaborate on recovery after an unexpected event occurs. Additionally, due to global markets and operations, local events can have repercussions and impact in various parts of the world. Sheffi (2005) suggests that the probability that some link in the chain will suffer a rupture is high, even if the chances of each facility being affected individually are small, so in some logistical activities it is important that safety procedures are adopted.

Transportation is the main component of the logistics system, and one of the most important decisions in the management of logistics operations involves the safety of the transported cargo. For example, in the spinning industry, it is a link in the textile supply chain that has great exposure to safety risks, due to the value of cargoes. In view of this situation, whenever possible, companies end up moving cargo with monitoring, either with escort or GPS.

Table 6 presents a summary of the main logistics protection and security services offered by logistics companies.

Table 6

Types of logistics protection and security services offered by outsourcing companies

Type of Service Offered	Description of Service Activities	Authors		
		Power; Sharafali; Bhakoo (2007)	Alkhatib; Darlington; Nguyen (2015)	Daim; Udbye; Balasubramanian (2012)
Embedded Intelligence	Responsible for the real-time monitoring of carriers' and shippers' loads on a continuous basis through security and logistical support programs, which allow the visualization of vehicles, the exchange of messages and the sending of commands that enable the taking of preventive or corrective measures from the monitoring center.		X	X
Risk Analysis	These are Risk Management Plans that are prepared through the customization of each stage of the trip, taking into account cargo monitoring histories and other parameters such as insurance policy.		X	
Employee Profile Assessment	It is a quick and effective analysis of the driver's and vehicle's history, identifying if there is any divergence for the service. This evaluation significantly increases safety in the shipment and transport of cargo.		X	X
Cargo Escort	They are Armed Escort teams that monitor the cargo, further increasing transport safety, especially on roads considered high risk.	X		
Prompt Answer	It is the tactical and ostensive support service. By activating the Prompt Response team, the company receives immediate support from specialized teams in any region to locate the vehicle, at points with no signal of the tracking equipment or suspected accident.	X		
Logistics safety training	These are training sessions on the monitoring of cargo vehicles, adapting the procedures to the necessary safety conditions, guiding and minimizing operational failures. Contributing to increase safety, reduce costs, protect the lives and property of companies.			

Source: Authors.

4.6 E-LOGISTICS SERVICES

The evolution of information and communication technologies, consolidated in new equipment and software, has enabled a new model of commerce: the so-called electronic commerce or e-commerce, which is the acquisition of products without the need for physical presence at the place of purchase, allowing the transaction to be carried out electronically,

usually via the internet. Organizations seek to follow this evolution resulting from the business model created by the internet, developing skills to act and maintain themselves in this new market (NORDSTRON and RIDDESTRALE, 2001).

The logistics to serve e-commerce presents itself with a perspective of growth and challenge for new ventures, consequently the transport and distribution operation needs to be agile. In e-logistics services, practically the same tools are applied as in logistics related to traditional commerce, paying attention to the fact that they must be adapted to make virtual commerce viable, they are: the postponement of logistics; dematerialization and exchange of resources; leveraged boarding and CAM service (LEE and WHANG, 2002).

The clothing industry is one of the oldest sectors to conduct its business with the help of e-commerce, having started in the mid-1990s. Clothing products are one of the favorite and best-selling types through the internet. Therefore, the logistics infrastructure to serve this market is very important. Table 7 presents a summary of the main e-logistics services offered by service providers.

Table 7
Types of e-logistics services offered by outsourcing companies

Type of Service Offered	Description of Service Activities	Authors		
		Alkhatib; Darlington; Nguyen (2015)	Nordstron and Riddestrale (2001)	Lee and Whang (2002)
Logistical postponement	It is the condition of delaying production as much as possible, aiming to deliver on order as close as possible to the order, in order to minimize the margin of error of sales forecasts, in some cases, storage may involve activities of assembling, packaging and moving the product.	X	X	
Warehouse in Motion	The idea is not to specify quantities in advance, the products are not previously designated on the truck, this decision is postponed from the time of loading to the time of unloading, which thus becomes a warehouse in motion, to meet any changes in orders and especially on long distances.	X		

Dematerialization	It is the transformation of the flow of materials by flow of information, such as stamps, receipts, financial statements, etc.	X		
Exchange of Resources	It is the sharing of resources that can be: internet servers, information systems, communications capacity, warehouses, transport equipment or logistics experience.	X		
Leveraged shipments	It is the process of concentrating orders from customers located close to each other or the considerable appreciation of the order, that is, the better the ratio of the invoiced value transported per km traveled, the better the delivery performance.	X		X

Source: Authors.

5 FINAL CONSIDERATIONS

There is currently a growing demand for logistics services in developed markets, where customers are relatively sophisticated, resulting in a great deal of competitive pressure. Customer requirements for faster delivery, continuous shipment tracking, and electronic information transfer reflect a desire to minimize wasted time.

In view of the need to improve the performance of logistics operations inside and outside organizations, it is essential that each company focuses its activities on the main processes and has adequate services available that meet its needs. However, the vast majority of publications on the subject address a set of solutions without consensus or uniformity, probably due to the contemporaneity of logistics attributions in the supply chain.

In this aspect, the article contributed to the development of a current picture of the main types of existing logistics services, as well as their integration with the other existing logistics processes. In addition, the results of this study make a useful contribution to the textile and apparel industry and to academia, as well as to analyze the various logistical possibilities in these industrial sectors.

For future work, it is interesting to understand more specifically how the various logistics services have been used by the textile and apparel industry and how they can be optimized to improve the overall performance of the supply chain in this sector.

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**COMPARISON OF SOLARIMETRIC DATABASES FOR PHOTOVOLTAIC
ENERGY PLANNING IN SERGIPE**

**COMPARAÇÃO ENTRE BASES SOLARIMÉTRICAS PARA PLANEJAMENTO
ENERGÉTICO FOTOVOLTAICO EM SERGIPE**

**COMPARACIÓN ENTRE LAS BASES DE SOLARIMETRÍA PARA LA
PLANIFICACIÓN DE LA ENERGÍA FOTOVOLTAICA EN SERGIPE**

 <https://doi.org/10.56238/sevened2025.036-012>

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ABSTRACT

This study performs a comparative analysis of solar irradiation data provided by the Brazilian Solar Energy Atlas and the Global Solar Atlas for the state of Sergipe. It was identified that the data provided by the databases present relevant differences in the solar irradiation estimate, in which the values of the Global Solar Atlas are systematically higher with an average difference of 1.8% in relation to the Brazilian Atlas. These variations can be attributed mainly to the different data collection and modeling methodologies, spatial resolution and analysis periods adopted by each database. These divergences have relevant practical implications for the technical and economic planning of photovoltaic systems, reinforcing the importance of local measurements to increase the reliability of solar projects. The study provides important subsidies for strategic decisions about solar energy in Sergipe, contributing to energy efficiency and local sustainability.

Keywords: Solar Irradiation. Photovoltaic Planning. Sergipe.

RESUMO

Este estudo realiza uma análise comparativa dos dados de irradiação solar disponibilizados pelo Atlas Brasileiro de Energia Solar e pelo Global Solar Atlas para o estado de Sergipe. Foi identificado que os dados disponibilizados pelas bases apresentam diferenças relevantes na estimativa de irradiação solar, em que os valores do Global Solar Atlas são sistematicamente mais elevados com uma diferença média de 1.8% em relação ao Atlas Brasileiro. Essas variações podem ser atribuídas principalmente às metodologias distintas de coleta e modelagem dos dados, resolução espacial e períodos de análise adotados por cada base. Essas divergências têm implicações práticas relevantes para o planejamento técnico e

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econômico de sistemas fotovoltaicos, reforçando a importância de medições locais para aumentar a confiabilidade dos projetos solares. O estudo fornece subsídios importantes para decisões estratégicas sobre energia solar em Sergipe, contribuindo para a eficiência energética e sustentabilidade local.

Palavras-chave: Irradiação Solar. Planejamento Fotovoltaico. Sergipe.

RESUMEN

Este estudio realiza un análisis comparativo de los datos de irradiación solar proporcionados por el Atlas Brasileño de Energía Solar y el Atlas Solar Global para el estado de Sergipe. Se identificó que los datos de estas bases de datos presentan diferencias significativas en las estimaciones de irradiación solar, siendo los valores del Atlas Solar Global sistemáticamente superiores, con una diferencia promedio del 1,8 %, en comparación con el Atlas Brasileño. Estas variaciones se atribuyen principalmente a las distintas metodologías de recopilación y modelado de datos, la resolución espacial y los periodos de análisis adoptados por cada base de datos. Estas discrepancias tienen importantes implicaciones prácticas para la planificación técnica y económica de los sistemas fotovoltaicos, lo que refuerza la importancia de las mediciones locales para aumentar la fiabilidad de los proyectos solares. El estudio proporciona información importante para la toma de decisiones estratégicas en materia de energía solar en Sergipe, contribuyendo a la eficiencia energética y la sostenibilidad local.

Palabras clave: Irradiación Solar. Planificación Fotovoltaica. Sergipe.

1 INTRODUCTION

The growing global demand for clean and renewable energy sources has driven investments and research focused on solar energy, considered one of the most promising alternatives due to its abundance, technical feasibility, and contribution to climate change mitigation. In the Brazilian context, the highlight is even greater: the country has one of the highest solar incidences on the planet, with the Northeast being one of the regions with the greatest potential for photovoltaic generation (Moreira Júnior & Souza, 2020; Bursztyn, 2020).

In the state of Sergipe, the climatic conditions are especially favorable to the use of this resource, justifying the expansion of the energy matrix through solar systems. However, the effective use of this potential depends fundamentally on the accuracy and reliability of the solarimetric data used in the planning and dimensioning of photovoltaic plants (Morais et al., 2021; Rocha et al., 2022; Araújo et al., 2024).

Several databases are used for this purpose, the main ones being the Brazilian Atlas of Solar Energy, prepared by the National Institute for Space Research (INPE), and the Global Solar Atlas, maintained by the World Bank and operated by the company Solargis. Both provide estimates of Global Horizontal Irradiation (GHI) and Normal Direct Irradiation (DNI), among other variables. However, recent studies show that these bases may present significant discrepancies in the estimated values, which directly impact the technical and financial feasibility of photovoltaic projects (Porfirio et al., 2020; Uchôa, 2022; Reis et al., 2023).

In addition, the Brazilian Atlas, despite its technical detail and history of local validations through the SONDA network, has been outdated since 2017, which may compromise its accuracy in the face of recent climate change (Martins et al., 2019; INPE, 2025a). On the other hand, the Global Solar Atlas updates its data periodically based on multi-satellite imagery, but its global semi-empirical model may not capture regional nuances, such as microclimates or superirradiance events common in the northeastern semi-arid region (Freitas, 2023; Araújo, 2024).

In this scenario, analyses that critically compare these bases, pointing out their limitations and practical impacts, become increasingly relevant. The wrong choice of a database can lead to errors in sizing, under- or over-sizing systems, and negatively influencing the financial return of solar projects (Tiba, Azevêdo, 2023).

Therefore, this study aims to perform a detailed comparative analysis between the Global Solar Atlas and the Brazilian Atlas of Solar Energy in the state of Sergipe, evaluating their GHI estimates and discussing the technical, economic and strategic implications of these differences for local energy planning.

2 METHODOLOGY

2.1 FIELD OF STUDY

The study adopted the geographic division of the State of Sergipe based on the definition of mesoregions and microregions established by the Brazilian Institute of Geography and Statistics (IBGE). Sergipe is composed of three mesoregions, which, in turn, encompass a total of 13 microregions, as shown in Table 1. Aiming at a better understanding, throughout the present work, each micro-region was represented by a prominent municipality, considering its relevance in terms of installed power of Distributed Generation (DG) with photovoltaic systems. Data collection required the definition of geographic coordinates for each location. Considering that most of the systems are concentrated in urban areas, the points were defined in the central region of the reference cities, aiming to reflect real installation conditions.

Table 1

List of Municipalities and Coordinates chosen

Mesoregion	Microregion	Reference Municipality	Geographic coordinates
Sergipe Sertão	Sergipe from the Sertão do São Francisco	Canindé do São Francisco	-9.657751, -37.794373
	Carira	Carira	-10.358032, -37.704920
	Our Lady of Sorrows	Our Lady of Sorrows	-10.480661, -37.220805
Agreste Sergipano	Agreste de Itabaiana	Itabaiana	-10.689492, -37.431162
	Tobias Barreto	Tobias Barreto	-11.181965, -38.000390
	Agreste de Lagarto	Lizard	-10.893367, -37.662981
East Sergipe	Propriá	Propriá	-10.218359, -36.838090
	Cotinguiba	Chapel	-10.475648, -37.031843
	Japaratuba	Japaratuba	-10.592197, -36.944591
	Lower Cotinguiba	Orange trees	-10.803993, -37.166900
	Aracaju	Aracaju	-10.951906, -37.078516
	Bobby	Bobby	-11.146917, -37.620025
	Resort	Resort	-11.261429, -37.438354

Source: Prepared by the authors (2025).

2.2 DATABASES USED

The Brazilian Atlas of Solar Energy – 2nd Edition (2017), produced by the National Institute for Space Research (INPE) (Pereira et al. 2017), and the Global Solar Atlas,

developed by the World Bank in partnership with the International Finance Corporation (IFC) and operated by Solargis (World Bank, 2019), provide essential data on solar radiation and photovoltaic potential. This information helps planners, investors, and researchers assess the feasibility of solar projects in Brazil and around the world.

Although both atlases provide detailed information on solar radiation and meteorological variables, they differ in scope and methodology. The Brazilian Atlas of Solar Energy focuses on the national territory, while the Global Solar Atlas offers a comprehensive view of the availability of solar energy on a global scale, allowing for comparative analysis between different regions.

Despite these differences, both share the objective of quantifying the solar potential, using different approaches that will be analyzed in the "Results and Discussion" section.

2.3 DATA AVAILABLE IN THE DATABASES

The databases provide information on solar radiation, photovoltaic generation, and environmental and geographic factors, each with its own data coverage (Table 2). With regard to solar radiation, the following are available:

- Diffuse Irradiation: Portion of solar radiation dispersed in the atmosphere before it reaches the surface.
- Horizontal Diffuse Irradiation: A component of solar radiation dispersed before it reaches the ground.
- Normal Direct Irradiation (DNI): A direct component of solar radiation incident perpendicular to the direction of the sun.
- Global Horizontal Irradiation (GHI): Total solar radiation incident on a horizontal surface.
- Irradiation on the Inclined Plane: Solar radiation received on an inclined surface, considering different angles of inclination.
- Irradiation Photosynthetically Active Radiation (PAR): Range of solar radiation used in the process of photosynthesis by plants.

With regard to data related to photovoltaic generation, the following are available:

- Specific Photovoltaic Power Output (PVOUT): Estimated energy that a photovoltaic system can generate in a given location.
- Optimal Inclination of Photovoltaic Modules: Best inclination angle for installing solar panels in a given location.

- Optimal Global Inclined Plane Irradiation: Radiation received on a surface inclined at the optimal angle to maximize uptake.

With regard to environmental and geographical factors, the following are available:

- Terrain Elevation: Altitude of the site, which can influence the radiation received.
- Air Temperature: Climatic information relevant to the efficiency of photovoltaic systems.

Table 2

Data available for each database

Group	Available Data	Brazilian Atlas	Global Solar Atlas
Solar radiation	Diffuse Irradiation	Yes	No
	Horizontal Diffuse Irradiation	No	Yes
	Normal Direct Irradiation (DNI)	Yes	Yes
	Global Horizontal Irradiation (GHI)	Yes	Yes
	Irradiation on the Inclined Plane	Yes	No
	Irradiation Photosynthetically Active Radiation (PAR)	Yes	No
	Specific Photovoltaic Generation Potential (PVOUT)	No	Yes
Photovoltaic generation	Optimal Inclination of Photovoltaic Modules	No	Yes
	Global Irradiance in the Optimal Inclined Plane	No	Yes
Environmental and geographical factors	Air Temperature	No	Yes
	Land Elevation	No	Yes

Source: Prepared by the authors (2025).

Considering the scope of the information provided by the two databases, the Brazilian Atlas of Solar Energy stands out for offering more detailed data on specific components of solar radiation, such as diffuse irradiation, irradiation on the inclined plane and photosynthetically active radiation (PAR). The Global Solar Atlas provides useful data for the sizing of photovoltaic plants, providing the data of Generation Potential (PVOUT), Optimal Inclination and Irradiation in the Optimal Plan. In addition, this base includes environmental variables such as air temperature and terrain elevation, which are not provided by the Brazilian Atlas.

2.4 COMPARATIVE ANALYSIS OF THE DATA PROVIDED BY THE DATABASES

To compare the data provided by the Brazilian Atlas of Solar Energy (2017) and the Global Solar Atlas (2024), the parameter of Global Horizontal Irradiation (GHI) was selected. The choice of GHI as the main metric is due to the fact that it is the variable present in both databases and expressed in the same unit of measurement: kWh/m² per day. Although

Normal Direct Irradiation (NID) is also present in both databases and is a relevant variable for projects that use solar tracking systems, the focus of this study is on the general energy planning of the State of Sergipe. Thus, the GHI was considered more suitable to represent the availability of solar energy for photovoltaic generation in different scenarios.

The values referring to the GHI parameter were collected from the databases and recorded in a Microsoft Excel spreadsheet.

GHI values were compared directly, without temporal adjustments, considering that both sources provide estimates based on the annual average.

Then, the following statistical measures were calculated, each with a complementary role in the evaluation of the discrepancies between the solar irradiation data:

- **Average Error (ME):** It was chosen because it allows the identification of whether there is a systematic bias, that is, whether one database consistently tends to provide higher or lower values in relation to the other.
- **Mean Absolute Error (MAE):** Selected because it provides a clear measure of the average magnitude of deviations, without negative and positive errors canceling each other out, offering a direct view of the average accuracy between data sets.
- **Mean Square Error (RMSE):** Essential to detect and penalize larger discrepancies, being especially useful to evaluate extreme cases or significantly discrepant values, ensuring a detailed perception of the existence of relevant errors that may compromise more detailed studies.
- **Standard Deviation of Differences:** Fundamental to understand the variability of the observed differences, helping to identify consistencies or inconsistencies in the divergences between the bases.
- **Pearson's correlation:** Chosen to evaluate the intensity and direction of the linear association between the sets, crucial to determine if there is a common trend in the variations of the databases.
- **Coefficient of Determination (R^2):** Indispensable to quantify how much the variations in one database explain the variations observed in the other, providing a deeper understanding of the predictive relationship between the sets.

These combined metrics provide a comprehensive and detailed assessment, which is essential to ensure informed decisions in selecting the most appropriate data sources for energy planning.

Equation (1) - Mean Error (ME): The mean error measures the mean difference between the observed values (y_i) and the estimated values ($\hat{y}_i$):

$$ME = \frac{1}{n} \sum_{i=1}^n (y_i - \hat{y}_i) \quad (1)$$

Equation (2) - Mean Absolute Error (MAE): The MAE calculates the average of the absolute values of the differences between the observed and estimated values:

$$MAE = \frac{1}{n} \sum_{i=1}^n |y_i - \hat{y}_i| \quad (2)$$

Equation (3) - Root Mean Squared Error (RMSE): The RMSE measures the mean squared error, penalizing larger errors due to squared:

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (y_i - \hat{y}_i)^2} \quad (3)$$

Equation (4) - Standard Deviation of Differences: The standard deviation of differences measures the dispersion of differences between the observed and estimated values:

$$\sigma_d = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (d_i - \bar{d})^2} \quad (4)$$

Where:

$d_i = y_i - \hat{y}_i$ represents the differences between the observed and estimated values.

$\bar{d}$ is the average of the differences divided by semicolons.

Equation (5) - Pearson's correlation: Pearson's correlation measures the strength of the linear relationship between two variables:

$$r = \frac{Cov(X, Y)}{\sigma_X \sigma_Y} \quad (5)$$

Where:

σ_X and σ_Y are the standard deviations of the variables X and Y.

Equation (6) - Coefficient of Determination (R^2): The coefficient of determination measures the proportion of variability of the observed values explained by the model:

$$R^2 = 1 - \frac{\sum_{i=1}^n (y_i - \hat{y}_i)^2}{\sum_{i=1}^n (y_i - \bar{y})^2} \quad (6)$$

Where:

$\bar{y}$ It is the average of the values observed in Y_i .

3 RESULTS

3.1 ANALYSIS OF THE METHODOLOGICAL DIFFERENCES OF THE DATABASES

To analyze the differences between the values provided by the databases, it is necessary to understand their methodological distinctions, which explain the variations in the results. Table 3 presents the main comparative characteristics between the atlases, highlighting that the Brazilian Atlas of Solar Energy, developed by INPE, uses the BRASIL-SR radiative transfer model, focusing exclusively on the Brazilian territory and without updates since its second edition in 2017. In contrast, the Global Solar Atlas, maintained by the World Bank in partnership with Solargis, employs a semi-empirical satellite-based model, with global coverage, including oceans, and undergoing monthly recalibrations that incorporate recent atmospheric data. In addition, Global Solar Atlas undergoes frequent improvements and updates with its latest version made available in May 2024 (version 2.11).

Table 3

Comparison of database characteristics

Column 1	Column 2	Column 3
Accountable	LABREN/INPE	World Bank/Solargis
Geographic focus	Brazil	Global (including oceans)
Base model	BRASIL-SR radiative transfer model	Semi-empirical satellite-based Solargis model
Primary source	SONDA network (ground stations) + GOES satellite	Multi-satellites (Meteosat, GOES and Himawari) + global ground stations
Last updated	2017 (2nd edition)	May/2024 (v2.11)
Recalibration	There is no	Monthly, including recent atmospheric data
Interface	Digital book	Interactive maps and monthly/yearly time series

Source: Prepared by the authors (2025).

3.1.1 Brazilian Atlas of Solar Energy

In the Brazilian Atlas, obtaining the data that underlie the Atlas is based on the integration of in situ measurements and advanced computational modeling. The measurements were carried out by the Brazilian Network of Solarimetric Monitoring Stations (SONDA), a program that maintains meteorological stations equipped with sensors for monitoring solar radiation in different regions of Brazil. These sensors include pyranometers for measuring global irradiance and radiometers for direct and diffuse components of solar radiation (INPE, 2025b).

In addition to the measured data, the Atlas incorporates numerical modeling based on images from geostationary satellites, such as those operated by the GOES (Geostationary Operational Environmental Satellites) program. The modeling uses algorithms to estimate solar irradiance on the Earth's surface, combining atmospheric information, such as aerosols and cloud cover, with calibration techniques from data from SONDA stations. This approach allows a high spatial and temporal resolution estimate of the availability of solar energy in the Brazilian territory (INPE, 2025a).

The result of this process is a comprehensive database that subsidizes scientific research, photovoltaic energy generation projects and the formulation of public policies for the energy sector.

3.1.2 Global solar atlas

The Global Solar Atlas data is obtained from advanced numerical modeling, combining measurements from geostationary satellites and ground-based sensors. The methodology uses images from meteorological satellites, such as those from the Meteosat and GOES

programs, to estimate solar irradiance on the Earth's surface. This estimate is improved through atmospheric models that consider factors such as cloud cover, aerosols, and water vapor (World Bank, 2024a).

In addition to satellite-based modeling, the Global Solar Atlas incorporates calibration data from solarimetric measuring stations in various regions of the world. The company Solargis performs systematic validations to ensure the accuracy of the data, comparing the model estimates with the actual solar irradiance measurements. The platform provides interactive maps and time series of parameters such as horizontal global radiation (GHI), direct normal radiation (DNI) and photovoltaic generation potential, with a spatial resolution of up to 1 km (World Bank, 2024b).

The integration of numerical modeling and terrestrial measurements allows Global Solar Atlas to provide highly reliable information, being an essential tool for feasibility studies and global energy planning.

3.2 ANALYSIS OF THE METHODOLOGICAL DIFFERENCES OF THE DATABASES

Initially, a detailed comparative analysis of the data provided by the Brazilian Atlas of Solar Energy and the Global Solar Atlas for the state of Sergipe was carried out.

As presented in the study area, 13 reference municipalities were used, covering all micro-regions of Sergipe. Table 4 shows the annual average values of Global Horizontal Irradiation (GHI) in kWh/m² per day.

Table 4

Tables should have their titles at the top

Reference Municipality	Geographic coordinates	Average annual GHI (kWh/m ² per day)	
		Brazilian Atlas	Global Solar Atlas
Canindé do São Francisco	-9.657751, -37.794373	5,41	5,539
Carira	-10.358032, -37.704920	5,28	5,355
Our Lady of Sorrows	-10.480661, -37.220805	5,28	5,471
Itabaiana	-10.689492, -37.431162	5,28	5,463
Tobias Barreto	-11.181965, -38.000390	5,22	5,312
Lizard	-10.893367, -37.662981	5,22	5,301
Propriá	-10.218359, -36.838090	5,43	5,592
Chapel	-10.475648, -37.031843	5,26	5,352
Japaratuba	-10.592197, -36.944591	5,41	5,555
Orange trees	-10.803993, -37.166900	5,39	5,590
Aracaju	-10.951906, -37.078516	5,50	5,912
Bobby	-11.146917, -37.620025	6,20	5,441
Resort	-11.261429, -37.438354	5,42	5,558

Source: Research data - Prepared by the authors (2025).

Notable differences are observed in the estimates of global horizontal solar irradiance (GHI). These differences result from the different methods employed in each Atlas, considering historical series, data acquisition periods, and different spatial resolutions.

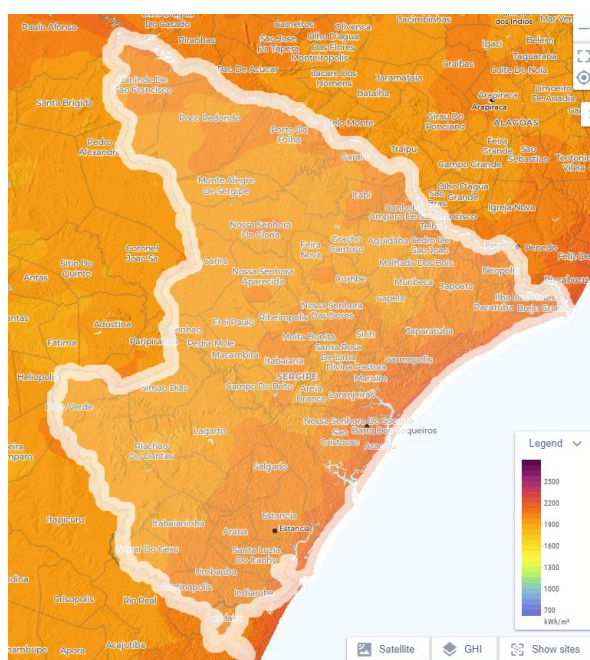
There is also a difference in the way the data is presented, depending on the platform used, the consolidated data for the state of Sergipe are presented below.

3.2.1 GHI in Sergipe – Global solar atlas

In Sergipe, the global horizontal solar irradiation (GHI) varies between 5.26 and 5.98 kWh/m² per day, with an average of 5.51 kWh/m².

Figure 1

GHI (Global horizontal irradiation) in Sergipe



Source: Global Solar Atlas (2025).

These values are considered favorable for photovoltaic energy generation, surpassing the average of many regions of the world that invest in this type of energy. The distribution of GHI in the state reveals that 5.5% of the area has values above 5.80 kWh/m², while 15.1% registers between 5.80 and 5.60 kWh/m². Most of the territory (61.3%) has irradiation between 5.60 and 5.40 kWh/m², and the remaining 18.2% have values below 5.40 kWh/m².

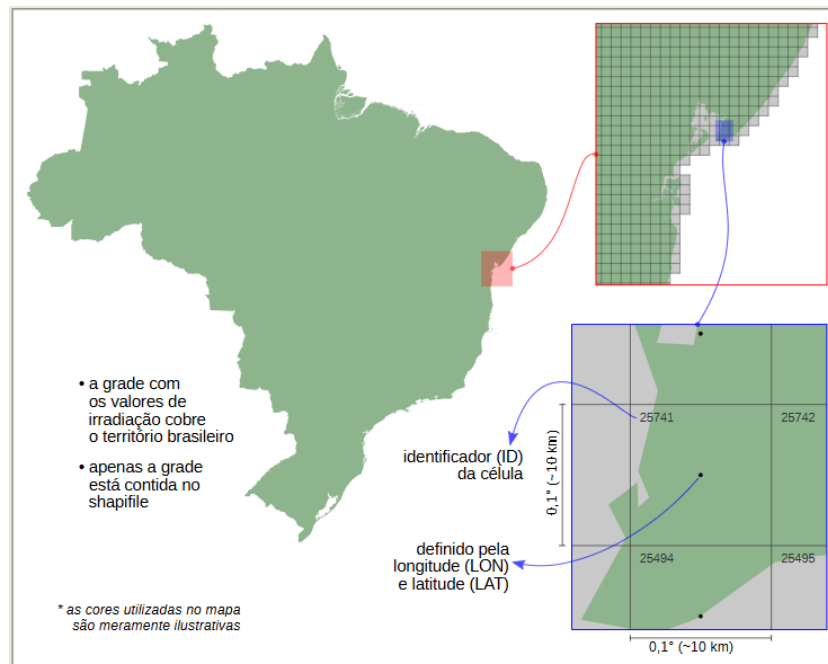
3.2.2 GHI in Sergipe – Brazilian Atlas

The Global Horizontal Irradiation in the Brazilian Atlas is presented indirectly, to obtain the data, it is necessary to fill out a form with the Geographic Coordinates (Latitude and Longitude) on the Solar Potential - SunData v 3.0 platform, made available by CRESEB (Reference Center for Solar and Wind Energy Sérgio de S. Brito).

This is because, in the Brazilian Atlas, the database is composed of 72,272 records containing the annual and monthly averages of the total daily Global Horizontal, Diffuse, Direct Normal, Inclined Plane and PAR irradiation in Wh/m².day. Spatial resolution of 0.1° x 0.1° (approximately 10 km x 10 km). Longitude and latitude define the centroid of the entities, or cells, of 0.1° x 0.1°.

Figure 2

Representation of 1 block of record

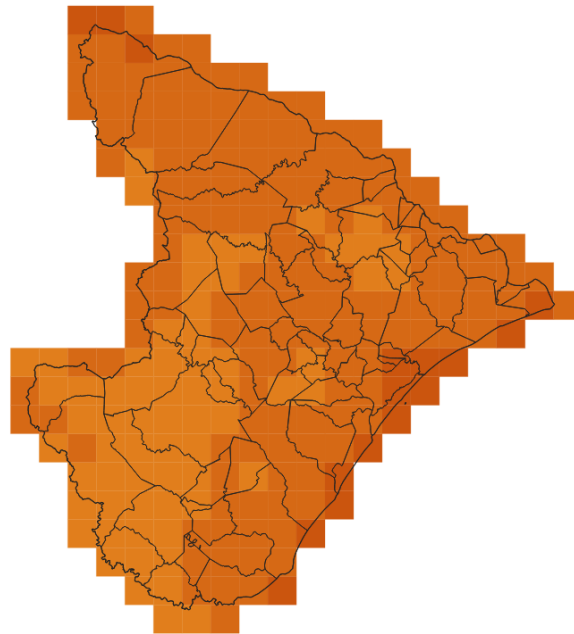


Source: Brazilian Atlas (2025).

Thus, as shown in Figure 3, the blocks of the state of Sergipe are represented in the Brazilian Atlas.

Figure 3

GHI (Global horizontal irradiation) in Sergipe



Source: Brazilian Atlas (2025).

Applying the equations to the data in the spreadsheet, here are the results of the statistical metrics calculated based on the differences between the Global Horizontal Irradiance (GHI) values, expressed in kWh/m² per day, from the two sources:

- Mean Error (ME): 0.088
- Mean Absolute Error (MAE): 0.205
- Mean Square Error (RMSE): 0.273
- Standard Deviation of Differences: 0.269
- Pearson's correlation: 0.230
- Coefficient of Determination (R²): 0.053

4 DISCUSSION

4.1 INTERPRETATION OF STATISTICAL METRICS

The results indicate that there are considerable differences between the Global Horizontal Irradiation (GHI) values provided by the Brazilian Atlas of Solar Energy and the Global Solar Atlas. Some analyses can be done to better understand these differences and their impacts.

The results of the statistical analyses indicate considerable differences between the databases of the Brazilian Atlas of Solar Energy and the Global Solar Atlas, with important implications for energy planning in Sergipe.

- **Mean Error (ME = 0.088):** The positive value indicates that, on average, the Global Solar Atlas presents values slightly higher than those of the Brazilian Atlas. This suggests a slight systematic bias between the two bases.
- **Mean Absolute Error (MAE = 0.205) and Mean Square Error (RMSE = 0.273):** These values confirm that there are differences of relevant magnitude between the data sets, especially the RMSE, which emphasizes that some divergences can be significant and need to be considered in the planning phase.
- **Standard Deviation of Differences (0.269):** This value shows a significant variability in the differences between the bases, indicating that the divergences are not constant, varying according to the location studied.
- **Pearson's correlation (0.230) and Coefficient of Determination ($R^2 = 0.053$):** The low correlation and the low value of R^2 indicate that the bases have a weak linear relationship with each other, highlighting that the differences observed do not follow a consistent pattern. The low coefficient of determination reinforces that one database does not satisfactorily explain the variations observed in the other, suggesting that local and methodological factors significantly influence the results.

4.2 POSSIBLE CAUSES OF DIFFERENCES

The divergences found between the analyzed databases can be attributed to different methodological and technical factors used by each source. The Brazilian Atlas of Solar Energy is predominantly based on local measurements obtained through the solarimetric stations of the SONDA network, complemented by specific modeling that uses geostationary satellite images calibrated to the local atmospheric conditions of Brazil. The Global Solar Atlas, on the other hand, uses a global numerical modeling methodology, based on data from international satellites and calibrated through global terrestrial measurements. Thus, it may not fully capture regional particularities, such as specific microclimates, small topographic variations, or local atmospheric conditions, including cloud cover and relative humidity levels.

Another significant factor is the differentiated spatial resolution. The Brazilian Atlas has a more detailed spatial resolution, adapted specifically for the national territory, while the Global Solar Atlas presents a global approach with less detailed spatial resolution, which can generate less precision in smaller regions. In addition, temporal differences in the periods analyzed may also contribute to the divergences, since the Brazilian Atlas is based on historical data up to 2017, while the Global Solar Atlas uses data from 2024, in which climate change or atmospheric variations can influence the availability of solar radiation. As the historical series used by each atlas belong to different periods, 2017 in the case of the Brazilian Atlas and 2024 in the Global Solar Atlas, the differences found may be associated not only with modeling methodologies, but also with climate change and atmospheric variations over time.

4.3 POSSIBLE CAUSES OF DIFFERENCES

The divergences between the two databases have important implications for the energy and technical planning of photovoltaic systems in Sergipe. Small variations in solar irradiance values can have a significant impact on the sizing and efficiency of solar systems. Underestimated values can lead to oversizing of systems, resulting in unnecessary additional costs, while overestimated values can result in undersized systems that do not achieve the expected results in terms of energy generation.

These differences also have important strategic consequences for the development of public policies and investment decisions in energy infrastructure. The use of databases that do not adequately represent the regional reality can negatively affect the economic and technical viability of solar projects, harming both investors and end consumers. From an academic and scientific point of view, such divergences can also negatively influence the results of environmental and climate studies, highlighting the need for greater caution and complementation with local measurements in the analysis and interpretation of solar data.

5 CONCLUSION

This study performed an in-depth comparative analysis between the solar irradiation data provided by the Brazilian Atlas of Solar Energy and the Global Solar Atlas, with a specific focus on the state of Sergipe. The results indicated significant differences between the two databases, with the Global Solar Atlas presenting

systematically higher GHI values, on average, 1.8% higher than those of the Brazilian Atlas. Although this difference seems modest, statistical analyses revealed a low degree of linear correlation ($R^2 = 0.053$), indicating an inconsistent relationship between the bases.

The divergences observed are due to relevant methodological factors, such as the collection and calibration model, spatial resolution, and the reference period adopted by each database. The Brazilian Atlas, despite offering specific data for the national territory with relevant technical detail, is outdated (last edition in 2017), not reflecting recent climatic variations. On the other hand, the Global Solar Atlas, with monthly updates and global coverage, may not accurately capture local climatic particularities, as evidenced by Araújo (2024) and Porfirio *et al.* (2020).

These differences are not merely academic: they have substantial practical implications for the design of photovoltaic systems. Underestimated irradiation values can lead to oversizing and increased costs, while overestimated values can lead to failures in meeting projected demand, compromising the economic viability of solar projects (Rocha *et al.*, 2022; Uchôa, 2022; Araújo *et al.*, 2024).

In addition, the study reinforces the importance of complementary strategies to mitigate the limitations of each database. This includes the use of local measurements whenever possible, and, more recently, the use of hybrid modeling with the support of machine learning algorithms (Reis *et al.*, 2023), which have shown potential to significantly reduce prediction errors.

Therefore, it is recommended that technical, strategic, or political decisions related to solar energy in Sergipe be based on the critical integration of different data sources, with local validations and sensitivity analyses. This multidimensional approach contributes to increasing the robustness of feasibility studies, minimizing financial risks, and promoting the sustainable development of the state's energy matrix.

This work also signals the urgency of updating and modernizing the Brazilian Atlas of Solar Energy, in order to ensure its continuity as a technical reference for the national energy sector, especially in a scenario of energy transition and growth of distributed generation in Brazil.

ACKNOWLEDGMENT

Special thanks to Sergipe Technological Park (SergipeTec) and the State Secretariat for Economic Development and Science and Technology (SEDETEC) for the support granted during the development of this research.

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**TOUCH-SENSITIVE JACQUARD FABRIC FOR HOME INTERFACES: A
TECHNICAL STUDY WITH A MULTIDISCIPLINARY APPROACH**

**TECIDO JACQUARD SENSÍVEL AO TOQUE PARA INTERFACES
RESIDENCIAIS: UM ESTUDO TÉCNICO COM ENFOQUE MULTIDISCIPLINAR**

**TEJIDO JACQUARD SENSIBLE AL TACTO PARA INTERFACES
DOMÉSTICAS: UN ESTUDIO TÉCNICO CON UN ENFOQUE
MULTIDISCIPLINARIO**

 <https://doi.org/10.56238/sevened2025.036-013>

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ABSTRACT

This article discusses the design and functional analysis of a touch-sensitive fabric, created with Litz conductive yarns and woven on a Jacquard loom, for home automation applications. The study begins with the following research question: is it possible to design a fabric that maintains its textile properties but functions as a tactile sensor in a smart home system? The hypotheses tested were: (1) the fabric will exhibit electrical conductivity after the weaving process; (2) it can be integrated into electronic systems with efficient Bluetooth response. The methodology consisted of the production of the conductive fabric, its integration with an FPGA board, conductivity testing, practical simulations with electrical circuits, and an interface with a mobile application. The results indicated technical feasibility, good tactile response, and stable functional integration, confirming the potential of e-textiles as active components of environmental automation systems. Furthermore, the study reports on an interdisciplinary learning experience of a Textile Engineering student, who was challenged to acquire skills in electronics, sensors, and digital communication, demonstrating the importance of integrated approaches in higher education technology. Further research is recommended to further explore durability, washability, ergonomics, and energy integration testing to consolidate the system's applicability in real-world contexts.

Keywords: Smart Fabric. E-Textiles. Conductivity. Jacquard. Interdisciplinary Training.

RESUMO

Este artigo trata do projeto e da análise funcional de um tecido sensível ao toque, criado com fios condutores do tipo Litz e confeccionado em tear Jacquard, voltado para aplicações em automação residencial. O estudo parte da seguinte questão de pesquisa: é possível projetar um tecido que mantenha suas propriedades têxteis, mas funcione como sensor tátil em um sistema de casa inteligente? As hipóteses testadas foram: (1) o tecido apresentará condutividade elétrica após o processo de tecelagem; (2) poderá ser integrado a sistemas eletrônicos com resposta eficiente via Bluetooth. A metodologia consistiu na produção do tecido condutor, sua integração com uma placa FPGA, testes de condutividade, simulações

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práticas com circuitos elétricos e interface com aplicativo móvel. Os resultados indicaram viabilidade técnica, boa resposta tátil e integração funcional estável, confirmando o potencial dos e-têxteis como componentes ativos de sistemas de automação ambiental. Além disso, o estudo relata uma experiência de aprendizagem interdisciplinar de uma estudante do curso de Engenharia Têxtil, que foi desafiada a adquirir competências em eletrônica, sensores e comunicação digital, demonstrando a importância de abordagens integradas no ensino superior tecnológico. Como continuidade, recomenda-se o aprofundamento em testes de durabilidade, lavabilidade, ergonomia e integração energética, a fim de consolidar a aplicabilidade do sistema em contextos reais.

Palavras-chave: Tecido Inteligente. E-Textiles. Condutividade. Jacquard. Formação Interdisciplinar.

RESUMEN

Este artículo aborda el diseño y el análisis funcional de un tejido sensible al tacto, creado con hilos conductores Litz y tejido en un telar Jacquard, para aplicaciones de domótica. El estudio parte de la siguiente pregunta de investigación: ¿es posible diseñar un tejido que mantenga sus propiedades textiles, pero que funcione como sensor táctil en un sistema de domótica? Las hipótesis probadas fueron: (1) el tejido exhibirá conductividad eléctrica tras el proceso de tejido; (2) podrá integrarse en sistemas electrónicos con una respuesta Bluetooth eficiente. La metodología consistió en la producción del tejido conductor, su integración con una placa FPGA, pruebas de conductividad, simulaciones prácticas con circuitos eléctricos y una interfaz con una aplicación móvil. Los resultados indicaron viabilidad técnica, buena respuesta táctil e integración funcional estable, lo que confirma el potencial de los textiles electrónicos como componentes activos de sistemas de automatización ambiental. Además, el estudio informa sobre la experiencia de aprendizaje interdisciplinaria de un estudiante de Ingeniería Textil, quien se enfrentó al reto de adquirir habilidades en electrónica, sensores y comunicación digital, lo que demuestra la importancia de los enfoques integrados en la tecnología de la educación superior. Se recomienda realizar más investigaciones para explorar más a fondo la durabilidad, la lavabilidad, la ergonomía y las pruebas de integración energética para consolidar la aplicabilidad del sistema en contextos del mundo real.

Palabras clave: Tejidos Inteligentes. Textiles Electrónicos. Conductividad. Jacquard. Formación Interdisciplinaria.

1 INTRODUCTION

The presence of digital technologies in everyday life has profoundly transformed the way we live and relate to the spaces around us. What was once a traditional house, designed only to house and organize basic functions, is now configured as an intelligent environment, where comfort, practicality and efficiency are amplified by devices that communicate with each other. In this new context of connectivity, e-textiles — fabrics that integrate electronic circuits and functionalities — emerge as innovative solutions, capable of going beyond fashion or technical clothing and assuming interactive, sensory, and even communicational roles.

Initially restricted to academia, e-textiles have been consolidated, in recent decades, as a strategic area of development, where knowledge of textile engineering, embedded electronics and information technology converge. According to Skyrme (2023), in the report *E-textiles and smart clothing markets 2023–2033: technologies, players, and applications*, by the IDTechEx consultancy, there are already more than 200 organizations involved in the creation of smart textile-based products. These products range from heated garments and sensor dressings to touch-sensitive interfaces embedded in vehicle and home interiors. This advance has been made possible by factors such as the miniaturization of components, the evolution of conductive fibers, and the strengthening of connections with mobile devices and the Internet of Things (IoT).

In the field of home automation, this trend gains even more relevance. Houses began to incorporate elements of environmental intelligence that integrate aesthetics, functionality, and technology (Freitas et al., 2012; Muratori, 2015). In this scenario, the so-called smart textiles, also known as *smart textiles*, play an important role in expanding the possibilities of interaction between people and automated systems, as pointed out by Tao (2001) and Van Langenhove & Hertleer (2004). By connecting traditional textile materials with digital solutions, new forms of interface are created that combine design, comfort and technology in a discreet and efficient way.

This article addresses the construction of a conductive fabric responsive to touch, developed with Litz-type copper conductive wires covered by polyester, structured on a Jacquard loom. The fabric is used in the manufacture of a decorative and functional cushion, with a Bluetooth interface aimed at home automation. The research is guided by the following question: is it possible to develop a conductive fabric that maintains aesthetic and structural properties suitable for decorative use?

As a hypothesis, it is assumed that the fabric will maintain electrical conductivity after weaving, be integrated with stability to mobile electronic systems and preserve conventional textile attributes.

In addition to the technical application of the project, this study also represents an interdisciplinary learning experience in the context of training in Textile Engineering. The development of the solution required the author to deepen the contents of basic electronics, conductivity, sensors and digital integration, themes that go beyond the traditional training of the textile area, promoting a practical articulation between different technical knowledge.

General objective: to develop a touch-sensitive fabric applied to residential decoration.

Specific objectives: a) to integrate the fabric with electronic components via Bluetooth;
b) test its electrical conductivity and functionality as a tactile interface.

2 THEORETICAL FRAMEWORK

The integration of electronic functions into textile substrates has been the subject of intensive studies in recent decades, driven by the demand for wearable technologies, flexible interfaces, and integrated solutions for environmental automation. The so-called smart textiles can be classified into three categories: passive, active, and very intelligent, based on their ability to respond and adapt to external stimuli (Wen, 1992; Tao, 2001). This classification guides the development of applications ranging from body sensors to interactive textile panels for device control in smart homes.

E-textiles or electronic textiles are a subcategory of technical fabrics, characterized by built-in electronic functionalities. They integrate electronic components into conventional textile structures, enabling applications ranging from physiological monitoring to interfaces for environmental control (Post; Margaret, 1997; Lind et al., 1997; Rossi; Paradiso, 2011). According to Blecha et al. (2024), this integration can occur superficially — by sewing or printing — or structurally, with the insertion of conductive threads during weaving. The ASTM D8248-20 standard, a reference for classification and standardization of e-textiles, recognizes different levels of complexity and establishes criteria for their validation as functional systems.

From a technical point of view, fundamentals on textile structures and Jacquard weaving processes are well described in classic works such as Araújo (1986), Castelli et al. (2000) and Marks & Robinson (1976). These authors discuss aspects such as warp density, ligaments, and structural parameters that influence the malleability, resistance, and

aesthetics of the final fabric, being essential for planning the insertion of functional threads without compromising textile integrity.

Among the most used functional elements are conductive metal wires, such as copper, silver, and stainless steel. Litz yarn, in particular, stands out for its multifilament composition and flexibility, being widely applied in projects that require good conductivity and malleability. Kuzubaşoğlu et al. (2023) point out that the association between metallic yarns and conventional fibers (cotton, viscose, polyester) allows obtaining comfortable and functional substrates, while maintaining desired characteristics such as soft touch, good mechanical strength, and dimensional stability.

Several studies analyze the mechanical and electrical properties of conductive wires. Ashgar et al. (2016) demonstrate that the orientation and type of metallic filament directly impact the tensile strength and conductivity of hybrid yarns. Rajendrakumar and Thilagavathi (2012) complement this, showing how variations in the construction parameters of fabrics with metallic threads interfere with electromagnetic performance. Lou (2012) describes industrial processes for the production of core-spun conductive yarns with application in functional fabrics.

In addition to metals, conductive polymers have also been widely used as viable alternatives. Ding et al. (2010) investigated the behavior of fabrics impregnated with PEDOT:PSS, relating conductivity with electrochromic stability. Varesano et al. (2005), in turn, examined the degradation of electrical conductivity in fabrics impregnated with polypyrrole, highlighting the challenges related to the durability of these materials in the face of continuous use and washing.

As far as practical applications are concerned, smart fabrics have been used in functional clothing, biometric sensors, and touch-sensitive interfaces. Bae and Hong (2013) researched the use of conductive fabrics as substitutes in the control of contact surface screens. Ferreira et al. (2011) demonstrated the application of carbon nanotubes in monofilaments for the development of sensors integrated into technical fabrics.

Andrade, Borelli and Giacomini (2014) developed wide-area textile sensors applicable to clothing, reinforcing the feasibility of integration into large-area garments. Zhang et al. (2021) conducted a review on advances in the engineering of multifunctional fibers, which can simultaneously act as sensors, emitters, actuators, and energy conductors. Materials such as graphene, carbon nanotubes (CNTs) and metallic nanowires have been applied in textile architecture, allowing the incorporation of circuits directly into the fibrous mesh and its

integration with Internet of Things (IoT) systems. Sánchez (2006.) contributes with a broad vision of the European textile sector, highlighting the advancement of functional fabrics and the industrial perspectives for e-textiles in technical and decorative contexts. This international vision complements the understanding of the challenges and opportunities of applying smart textile technologies in the contemporary context.

In the context of home automation, the use of functional fabrics represents an innovative approach to creating discreet and comfortable interfaces, replacing or complementing conventional rigid surfaces. The literature indicates that these fabrics can be used to control lighting, temperature, sound, or household appliances through touch or proximity detection. Kirstein et al. (2005) highlight that wearable systems and textile interfaces must combine functionality with essential characteristics such as comfort, washability, mechanical durability and low perceptible interference for the user.

The evolution of manufacturing techniques has contributed to the consolidation of these systems. According to Kuzubaşoğlu et al. (2023), methods such as weaving with hybrid threads, computerized embroidery of conductive tracks, printing circuits with functional inks, and soldering flexible electronic components make it possible to produce e-textiles at scale while maintaining control over physical and electrical properties. Structures are often used to encapsulate the lead wires and protect the circuit from wear, bending, or shorting.

However, the main barriers to large-scale commercial adoption still include:

- (1) the degradation of conductive materials in the face of daily use and washing;
- (2) the absence of widely accepted technical standards that regulate performance, safety and durability; and
- (3) the need for compact and integrable energy sources to the fabric. Strategies such as polymeric encapsulation, development of self-sufficient sensors with triboelectric nanogenerators, and integration with textile solar cells have been proposed as viable solutions (Kuzubaşoğlu et al., 2023).

In view of this panorama, the present work is anchored in the understanding of smart fabrics as hybrid platforms, which combine traditional textile properties with the capacity for digital performance and communication. The proposal for an interactive touch-sensitive cushion, connected to mobile systems via Bluetooth, represents a concrete application of this convergence between textile engineering, functional materials and automation technologies.

3 METHODOLOGY

The methodology adopted in the present study is in line with similar proposals already documented in the literature, such as the research conducted by Guedes, Borelli and Giacomini (2017), who also explored the incorporation of tactile sensors in textile materials with interest in applications aimed at the Internet of Things (IoT), highlighting the challenges related to the integration between textile properties and electronic functionalities.

This study is characterized as an investigation of applied and experimental nature, with a projectual objective, presenting the design, synthesis and functional analysis of an intelligent touch screen fabric for use in home automation systems.

The project was developed based on a project-based learning (*PBL*) approach, which allowed the student to articulate knowledge from different areas in a practical and applied way, as discussed by the active methodologies in technological higher education (Markham, 2008).

The development process involved four main steps:

- (1) design and manufacture of conductive fabric;
- (2) integration with electronic systems;
- (3) performance of physical-functional tests; and
- (4) Application of the fabric in a functional decorative item.

3.1 DEVELOPMENT OF TOUCH-SENSITIVE FABRIC

The first stage comprised the structural construction of the touch-sensitive fabric, based on Jacquard technology, which allows precise control of complex ligaments and planned insertion of functional elements. Figure 1 illustrates the structure of the fabric, which was made on a Jacquard loom of the Howa do Brasil brand, using continuous carded cotton threads in the warp, in ecru color, with Ne 20/2 title, and in the weft 90% viscose and 10% metallic yarns, in burgundy color, with 6/2 title.

Figure 1

Jacquard touch-sensitive fabric



Source: authors.

The fabric also has a conductive thread (Litz thread), composed of 4 copper filaments covered by textured polyester, inserted every 2 cm in the direction of the weft and warp. Finally, in the warp, the conductive threads were inserted approximately every 30 cotton threads, and in the weft, a conductive thread was passed for every 14 strokes of the metallized thread, approximately. The wires are shown in figure 2.

Figure 2

Cotton, Litz and metallized yarns



Source: authors.

Electrical functionality was ensured by the insertion of Litz-type conductive wires, composed of four copper filaments covered with textured polyester. In the warp, the conductive threads were positioned every 30 cotton threads, and in the weft, a Litz thread was inserted every 14 passes of the metallized yarn, resulting in a functional distribution

pattern every 2 cm in both directions. The chosen pattern was aimed at residential decoration, aiming at the use of fabric as a visual and interactive component of a cushion. The objective was to ensure that the fabric maintained the appearance and texture of a conventional fabric, respecting criteria of comfort, flexibility and aesthetics.

3.2 TESTING AND EXPERIMENTAL DESIGN

With the system assembled, it was planned to carry out technical-functional tests with the objective of validating the effectiveness of the fabric as a capacitive tactile sensor. The tests were divided into three categories:

(a) verification of electrical conductivity of Litz wires: A Minipa ET-2231 digital multimeter was used to measure the resistance between two points of the conductive wire inserted in the fabric. Due to the enamelled coating of the copper wires, it was necessary to carefully scrape the enamel with tin solder to ensure proper electrical contact.

(b) functional test with mini lamp: An acrylic set containing batteries, cables and a mini lamp, illustrated in figure 3, was used to simulate an electrical circuit. The cables were connected to the fabric conductor wires and, upon touch, the mini lamp was activated, confirming the presence of efficient electrical continuity in the fabric.

Figure 3

Set for the Fabric Conductivity Test



Source: authors.

(c) tactile response tests and communication via Bluetooth with mobile device: After assembling the system, the tissue was subjected to tactile stimuli with real-time response monitoring in the Android application. Communication latency, signal reading accuracy, and

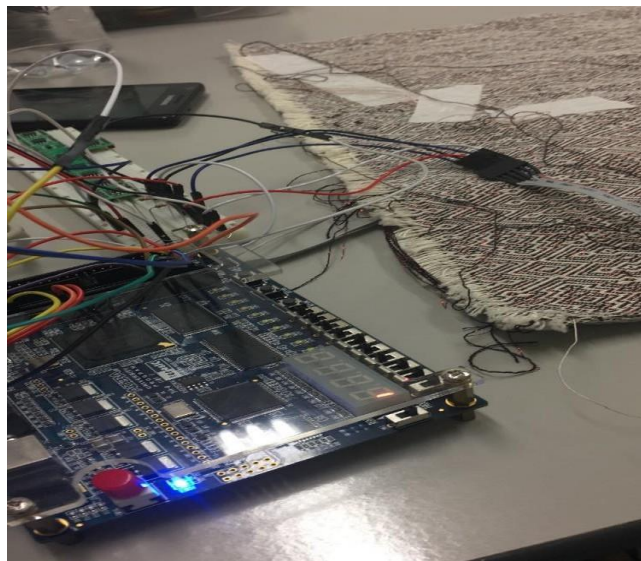
interface stability during prolonged operation were evaluated.

3.3 ELECTRONIC INTEGRATION AND INTERACTIVE SYSTEM DEVELOPMENT

In the second stage, the fabric was integrated into a responsive electronic system, based on an Altera DE0 (Terasic) development board, equipped with FPGA (Field Programmable Gate Array) architecture, programmed to interpret touch signals (Figure 4). To make the electrical connection viable, the Litz wires had their coating removed at strategic points with the help of heated tin, exposing the copper filaments for later soldering to flat cables. These cables were connected directly to the DE0 board, ensuring the reading of tactile signals in an individualized way (Figure 5).

Figure 4

Electronic board system connected to the touch-sensitive fabric



Source: authors.

Figure 5

DE0 electronic board and cell phone, integrated via Bluetooth



Source: authors.

The circuit was powered by a PowerBank, offering mobility and energy independence of the system in relation to the conventional power grid. Data transmission between the fabric and the mobile device was carried out through a Bluetooth module integrated into the board. The interface application was developed using the Bluetooth Electronics platform, compatible with Android devices, allowing the creation of configurable responsive input buttons. Each button in the app was linked to a conductive thread of the fabric, simulating different touch-sensitive activation channels.

3.4 MAKING THE DECORATIVE ITEM

The final stage consisted of the practical application of the developed tissue. A piece was sewn, in the form of a decorative cushion, as shown in figure 6, with dimensions of 40 x 40 cm, allowing the insertion of the electronic components and their integrated operation. Thinking about maintaining the aesthetic and functional character of the article, the piece was filled with textile fibers.

Figure 6

Jacquard touch-sensitive fabric sewn in the shape of a cushion



Source: authors.

4 RESULTS AND DISCUSSIONS

The evaluation of the developed fabric was carried out based on the planned tests, focusing on functional validation and the feasibility of using the material in home automation contexts.

4.1 CONDUCTIVE PROPERTIES OF TOUCH SENSITIVE FABRIC

The electrical conductivity tests, performed with a Minipa ET-2231 digital multimeter illustrated in figure 7, indicated an average resistance of less than 2 ohms per tested segment of the Litz type conductive wires. Due to the insulating enamel of the wires, it was necessary to manually remove the coating in specific areas to ensure direct contact of the multimeter terminals with the copper filaments. The electrical continuity was maintained even after the weaving process and the manipulation of the fabric, proving that the yarns preserved their functional properties in the Jacquard structure.

Figure 7

Results regarding tissue measurement with the multimeter



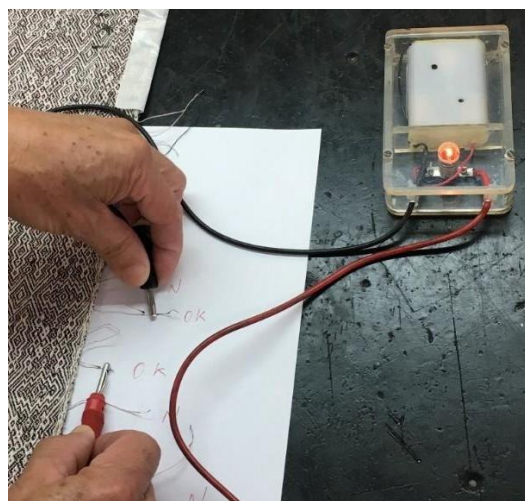
Source: authors.

4.2 PRACTICAL TESTS WITH ELECTRICAL CIRCUIT

In the test with a mini lamp connected to batteries, all 20 tests performed showed immediate activation on the conductive wires, evidencing the ability of the fabric to act as a circuit closing element. Figure 8, with the device's light on, confirms its operation as a practical and direct tactile interface.

Figure 8

Electrical circuit with the mini lamp lit through the conductive wires of the touch-sensitive fabric



Source: authors.

4.3 CONNECTIVITY AND INTEGRATION VIA BLUETOOTH

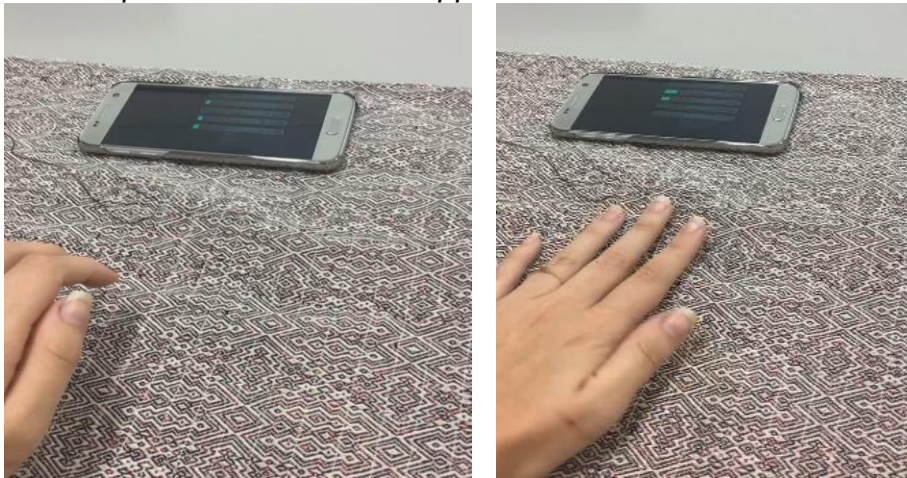
During the testing phase with the mobile application, the system's immediate response to tactile interactions was observed. The signals were read by the DE0 board and transmitted via Bluetooth, with latency of less than 200 milliseconds and stability for 10 consecutive cycles.

This result proves that the developed touch-sensitive fabric is functional as a capacitive contact sensor and that its integration into mobile digital systems is technically feasible. This extends the potential of its application in home automation solutions, where the activation of devices by touch can be done discreetly, without the need for rigid interfaces.

In addition, the visual response offered by the app enables an intuitive and accessible user experience, paving the way for applications that involve accessibility, comfort, and smart interior design.

Figure 9

Touch-sensitive Jacquard fabric – mobile app demo



Source: authors.

In addition to the functional performance, the fabric has retained its flexibility and aesthetic appearance after the insertion of the conductive threads and the assembly procedures. The regular distribution of the Litz wires, with a spacing of 2 cm, was effective both to ensure capacitive activation and to maintain the aesthetics of the product. The developed cushion operated as a sensitive, discreet and comfortable interface, demonstrating practical applicability for interior design and accessibility and automation solutions.

Although the developed fabric does not use cutting-edge materials such as graphene

or printed sensors, it represents a technically feasible and affordable solution for tactile automation in homes. The simplicity of the system and the possibility of customization in conventional textile structures expand its application potential. However, the absence of washability, mechanical durability and ergonomics tests limit its commercial validation.

From a pedagogical point of view, the development of this interactive fabric provided a practical and interdisciplinary experience to the author, an undergraduate student in Textile Engineering. The project required not only the mastery of textile and structural aspects, but also the active search for knowledge of electronics, capacitive sensors, wireless communication and FPGA board programming. This experience demonstrates the potential of project-based approaches (*Project based learning*) to promote integration between areas of technical knowledge and prepare the student for real challenges.

5 CONCLUSION

The present study aimed at the development and functional evaluation of a touch-sensitive fabric, made on a Jacquard loom with Litz-type conductive threads, applied to home automation systems. The results obtained demonstrated the technical feasibility of the proposal: the fabric preserved its essential textile properties, such as flexibility and aesthetics, even after the insertion of conductive threads, in addition to presenting stable electrical conductivity and functional integration with electronic systems via Bluetooth.

The practical application in the form of a decorative cushion reinforces the potential of smart fabrics as discreet and functional interfaces for residential environments. Communication with mobile devices occurred responsively and without noticeable latency, validating the system as an integrated capacitive tactile sensor.

In addition to its technical character, this work also stands out as a significant pedagogical experience. Developed by a Textile Engineering student, the project required the articulation of knowledge from different areas — such as electronics, sensors, programming, and wireless communication — traditionally absent in conventional textile training. It is, therefore, an example of active and interdisciplinary learning, in which knowledge is built from real and complex challenges, in line with pedagogical proposals such as project-based teaching and integrated technological education.

It is concluded that the developed touch fabric is a promising solution for applications in home automation and smart interior design, and a powerful training tool. For future research, it is recommended to carry out durability tests (washability, abrasion, use cycles),

usability analysis with different user profiles, and the study of integration with autonomous energy sources. Such actions can expand the practical and educational applicability of e-textiles in multiple contexts of contemporary society.

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FABRIC ART: REPORT OF A SUCCESSFUL PRACTICE IN SPECIAL EDUCATION

ARTE EM TECIDO: RELATO DE PRÁTICA EXITOSA NA EDUCAÇÃO ESPECIAL

ARTE EN TELA: INFORME DE UNA PRÁCTICA EXITOSA EN EDUCACIÓN ESPECIAL

 <https://doi.org/10.56238/sevened2025.036-014>

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ABSTRACT

This article describes a pedagogical practice carried out in the Multifunctional Resource Room (SRM) of the Capitão Silvio de Farias State Full-Time High School in Rondônia, aimed at students with special needs. The activity consisted of creating a toiletry bag using cutting and sewing techniques, with the goal of promoting the development of motor, cognitive, social, and emotional skills. Analysis of the results, based on theoretical frameworks on integrative methodologies and inclusive education, revealed significant improvements in the participants' autonomy, motor coordination, and social interaction, reinforcing the importance of manual practices in the inclusive educational process.

Keywords: Special Education. Integrative Practices. Sewing. Motor Skills. School Inclusion.

RESUMO

Este artigo descreve uma prática pedagógica realizada na Sala de Recursos Multifuncionais (SRM) da Escola Estadual de Ensino Médio em Tempo Integral Capitão Silvio de Farias, em Rondônia, voltada para estudantes da Educação Especial. A atividade consistiu na produção de um nécessaire por meio de técnicas de corte e costura, com o objetivo de promover o desenvolvimento de habilidades motoras, cognitivas, sociais e emocionais. A análise dos resultados, à luz de referenciais teóricos sobre metodologias integrativas e educação inclusiva, evidenciou avanços significativos na autonomia, coordenação motora e interação social dos participantes, reforçando a relevância de práticas manuais no processo educativo inclusivo.

Palavras-chave: Educação Especial. Práticas Integrativas. Costura. Habilidades Motoras. Inclusão Escolar.

RESUMEN

Este artículo describe una práctica pedagógica llevada a cabo en el Aula de Recursos Multifuncionales (ARM) del Liceo Estatal de Tiempo Completo Capitão Silvio de Farias en Rondônia, dirigida a estudiantes con necesidades educativas especiales. La actividad consistió en la creación de un neceser mediante técnicas de corte y costura, con el objetivo

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de promover el desarrollo de habilidades motoras, cognitivas, sociales y emocionales. El análisis de los resultados, basado en marcos teóricos sobre metodologías integrativas y educación inclusiva, reveló mejoras significativas en la autonomía, la coordinación motora y la interacción social de los participantes, lo que refuerza la importancia de las prácticas manuales en el proceso educativo inclusivo.

Palabras clave: Educación Especial. Prácticas Integrativas. Costura. Habilidades Motoras. Inclusión Escolar.

1 INTRODUCTION

In contemporary society, marked by rapid and constant changes, it is essential to promote the inclusion and belonging of people with Special Educational Needs (SEN) to the various social and educational spaces. In this scenario, the Capitão Silvio de Farias Integral School, through the Multifunctional Resource Room (SRM), develops actions aimed at strengthening students' skills and abilities, seeking to achieve educational inclusion in a broad and meaningful way.

According to the National Policy on Special Education in the Perspective of Inclusive Education (MEC, 2008), Special Education aims to ensure access, participation and learning for students with disabilities, global developmental disorders and high abilities/giftedness. To this end, the adoption of integrative methodologies has gained prominence, since it favors educational experiences that transcend the limits of traditional curricular content.

Among these methodologies, manual practices, such as sewing, stand out for articulating cognitive, motor, affective and social aspects, favoring the overall development of students (Santos; Oliveira, 2021). In addition, such practices promote autonomy and self-esteem, which are fundamental for the integral formation and construction of the identity of individuals.

In this context, this article aims to report the experience developed in SRM through the making of a toiletry bag, analyzing how this activity contributed to the development of motor, cognitive, social and emotional skills of the participating students. The study also dialogues with the literature that discusses integrative methodologies and inclusive practices in education.

2 THEORETICAL FOUNDATION

2.1 MULTIFUNCTIONAL RESOURCE ROOM

The implementation of Multifunctional Resource Rooms (SRM) in Brazil represents a milestone in public policies for Special Education and school inclusion, especially after the enactment of the National Policy on Special Education in the Perspective of Inclusive Education (BRASIL, 2008). This advance reflects the commitment of the Brazilian State to guarantee Specialized Educational Service (SES) as a right guaranteed to students with disabilities, global developmental disorders and high abilities/giftedness, reinforcing the concept of education for all.

However, the analysis of recent studies, such as those by Mendes (2019) and Bueno (2021), reveals that resource rooms, although expanded in number and scope, still face significant challenges in their consolidation as effective pedagogical spaces. Among them, the need for continuing education of teachers, the curricular integration of SEA with regular education and the adequacy of material and technological resources that meet the specificities of students stand out. Without these elements, there is a risk that the resource room will be seen only as a space for school reinforcement, and not as an environment for the construction of autonomy and global development.

Another central issue raised by researchers such as Carvalho (2020) is the articulation between educational policies and pedagogical practices. Although the legislation establishes inclusion as a guiding principle, the realization of this right requires that the resource room transcends the welfare character and starts to act in an integrated way with the school's political-pedagogical project. This implies collaborative action between SEA teachers, common room teachers, managers and families, in order to ensure pedagogical coherence and continuity in the learning process.

In addition, contemporary literature points to the urgency of producing and disseminating knowledge about successful experiences in resource rooms (SANTOS; OLIVEIRA, 2021). Case studies, action research, and reports of successful practices can support more effective public policies, guiding teacher training and the definition of innovative methodologies that promote meaningful learning.

However, when considering the resource room as a pedagogical device, it is understood that its role goes beyond individualized care. It is a space that should dialogue with the school curriculum, articulating strategies that develop students' cognitive, motor, social, and emotional skills, as advocated by authors such as Pletsch and Glat (2019). In this sense, the current challenges lie not only in the expansion of the number of classrooms, but in the qualification of their performance, in order to consolidate school inclusion as a daily and effective practice.

2.2 FINE AND GROSS MOTOR COORDINATION

Motor coordination, as highlighted by authors such as Gallahue and Ozmun (2005), is one of the pillars of child development, since it is directly associated with the child's ability to interact actively and independently with the environment around him. The division between gross motor coordination — responsible for broad and wide-ranging movements — and fine

motor coordination — focused on delicate and precise movements — allows us to understand how different motor skills are interconnected throughout growth, forming the basis for the acquisition of cognitive, social and academic skills.

The work of Rodrigues (2024) contributes significantly to this field by proposing the creation of a transportable kit with devices aimed at the development of fine motor skills. The proposal dialogues with research such as those by Santos and Ferreira (2018), which highlight the importance of manipulative materials to stimulate dexterity, bilateral coordination and precision of movements, especially during early childhood education, a critical phase for neuromotor development.

In addition, the results obtained reinforce the notes of Case-Smith (2013), who highlights how planned and playful interventions can enhance essential skills for daily activities, such as tying shoes, writing and handling objects safely. The use of a portable kit becomes even more relevant when considering educational inclusion, allowing children with special educational needs to also be contemplated with strategies adapted to their specific demands.

Another relevant point is the association between fine motor skills and cognitive and emotional aspects. Research by Cameron et al. (2016) shows that children with greater fine motor skills tend to have better performances in reading, writing, and problem solving, in addition to having greater autonomy and self-esteem. Thus, projects that involve practical activities, such as the one described in this work, not only favor motor coordination, but also contribute to the child's overall development.

In view of the above, it is noteworthy that the analysis stage of similar products and the generation of project requirements follow principles of user-centered design, as defended by Norman (2013), which guarantees the functionality and pedagogical effectiveness of the devices created. This alignment between theory, practice, and applicability demonstrates the project's potential to be incorporated into diverse educational contexts, strengthening active and meaningful learning.

3 REPORT OF PRACTICE

The experience took place with students who are the target audience of Special Education, involving the use of a sewing machine to produce a toiletry bag in honor of Mother's Day. The steps included:

3.1 FAMILIARIZATION WITH THE MACHINE: LEARN HOW TO RUN THE LINE AND CONTROL THE FOOT PEDAL

In this stage, the students Before starting to use the sewing machine, the students received simple instructions on how to pass the thread through the machine's cursors. It was not a challenge to teach students how to run the line through the machine. This process involves several steps, from the top thread guide to threading the needle. Using sewing thread of the shade of the chosen fabric and guidance on how to guide the thread on the cursors and it was possible to make the process more visual and accessible. The student was instructed to follow the steps sequentially, which worked not only on manual skill, but also on attention and sequential memory. When the student was able to pass the line through all the cursors independently, it was a significant victory, evidencing the evolution of perseverance and attention to detail.

The next step was how to position your feet on the pedal and your hands on the fabric. With the machine's pedal placed under the dominant foot, the student was instructed to press it gently to adjust the speed of the sewing. The pressure on the pedal was gradual, according to the motor control of each student, but before starting the pedal movement, the pressure that should be exerted on the pedal with their hands was worked on so that they had a sense of strength and pressure.

The importance of correct posture was highlighted, ensuring that students felt stability, without haste, observing the movement of the machine with maximum concentration. The hands were positioned on the fabric, the left hand guiding lightly, while the right hand kept the fabric aligned. This initial gesture helped improve hand-eye coordination.

With the previous stage finished, it was started how to position the hands on the machine, often complex, it was approached slowly and repetitively, to create an environment of trust and patience, as it involves a piercing object that is the needle and some students showed fear of getting hurt, to lose the fear the needle was removed from the machine and worked on the position of the hands through a sewing exercise on sulfite sheet.

Figure 1

Students in the initial phase of positioning their hands on the sewing machine



Source: From the Authors

3.2 MOTOR SKILLS: CUTTING FABRICS, ALIGNING PIECES, SEWING WITH PRECISION

Once the stages of the sewing machine operation were completed, we started the project with the choice of fabric, where some fabrics of varied colors and prints were made available and the student was guided to choose the one he liked best, having chosen the fabric, the measurements of the main fabric, lining and acrylic mat were passed, items necessary to make the toiletry bag, The student was instructed how the measurements would be marked on the fabrics and after the measurements were scratched and demarcated on the fabric, the cut was made following the markings, some students had difficulties in being able to cut the fabric, because they did not apply adequate pressure with scissors, which made it difficult to make the cut. After the fabric was cut, it was time to make the marking for the metalassê that would have on the piece, this was used as a detail and also to fix the acrylic blanket. Once the demarcations of the metalassê were finished, the students put into

practice the skills previously worked on when we started the presentation of the project, such as positioning the hands and foot on the pedal. When starting to sew the fabric, the students were anxious, but attentive to the teacher's guidelines.

Figure 2

Demonstration of motor skills development



Source: From the Authors

3.3 COGNITIVE SKILLS: FOLLOWING SEQUENCES, SOLVING TECHNICAL PROBLEMS

Some seams came out crooked, but for some who had never had contact with the machine before, it was already expected that this would happen. A seam was made around the piece, fixing the sides of the blanket to the fabric and then the students were guided by the markings previously made on the main fabric. Finishing sewing this step, the students went to the next step, sewing the zipper to close the piece and after placing the lining and closing the sides of the fabric to finish the piece.

Figure 3

Demonstration of cognitive skills in solving technical problems



Source: From the Authors

Emotional and social skills were also developed: working in groups, dealing with frustrations, persisting in the face of difficulties.

The project adopted a practical and adaptive methodology, respecting the individual rhythm and valuing each achievement of the students.

4 DISCUSSION

The results corroborate the findings of Rocha and Pereira (2021), who highlight how manual practices favor the integral development of students, especially in Special Education. Sewing required attention, patience and precision, aspects that, according to Gonçalves (2018), contribute to emotional self-regulation and strengthening self-confidence.

In addition, group work enabled social interaction and cooperation, in line with Vygotsky's (1991) perspective on the importance of the social context in learning.

Studies by Vygotsky (1991) emphasize that learning occurs in interaction with the social environment and that practical activities help in the construction of higher psychological functions, such as attention and memory.

The practice showed significant gains in **fine and gross motor coordination**, as observed by Carvalho, Souza and Almeida (2019), who highlight how handicraft activities contribute to the refinement of movements, both fine and wide. For Rodrigues (2024), The development of fine motor coordination is important at all stages of life, but when we are children this improvement has greater impacts on our interaction with the environment and other people

The process required clear **planning and problem-solving**, in line with Ferreira and Silva's (2020) considerations about the importance of sequencing steps in a logical and adaptable way to the needs of students.

The activity also promoted **creativity and aesthetic expression**, consistent with what Rocha and Pereira (2021) discuss about the potential of manual practices to stimulate aesthetic appreciation and artistic creation.

Finally, it was possible to observe the strengthening of **autonomy and emotional self-regulation**, especially in challenging situations, reinforcing Gonçalves' (2018) statements about the ability of manual activities to promote emotional control and independence in the learning process.

Authors such as Papert (1994), when discussing constructionism, reinforce the importance of "learning by doing", defending practices that provide the student with protagonism in the learning process.

5 FINAL CONSIDERATIONS

The present study showed that the practice of sewing, developed in the Multifunctional Resource Room, proved to be an extremely effective pedagogical strategy for the integral development of Special Education students. The execution of the project allowed not only the acquisition of technical skills related to sewing, but also favored the development of cognitive, motor, social and emotional skills, demonstrating the importance of pedagogical practices that promote meaningful and contextualized learning.

From the motor point of view, a substantial improvement in fine and gross motor coordination was observed, which is essential for the performance of daily and academic activities. The students had the opportunity to manipulate fabrics, operate the sewing machine, adjust the pedal and coordinate hands and eyes, experiences that consolidate not only manual skills, but also spatial perception, motor precision and functional autonomy. This practical learning reinforces the relevance of educational interventions that articulate theory and practice, allowing the student to be the protagonist of their own learning (RODRIGUES, 2024; CASE-SMITH, 2013; CAMERON et al., 2016).

In the cognitive aspect, the practice required attention, sequential memory, planning and problem solving. The students had to follow structured steps, interpret instructions, take measurements, cut fabrics with precision and apply sewing techniques, developing logical reasoning and organizational skills. This articulation between practical action and cognitive

processes reinforces constructionism, according to Papert (1994), showing that learning is enhanced when the student "learns by doing" and experiences the concepts taught in a concrete way.

From a socio-emotional perspective, the project provided significant opportunities for interaction, cooperation, and strengthening of self-esteem. By working in groups, students shared responsibilities, exchanged experiences, helped each other and experienced the importance of empathy and collaboration. In addition, overcoming fears and challenges, such as the fear of the sewing machine needle, showed emotional growth, the ability to deal with frustration and the development of perseverance. Such elements are essential for the formation of autonomous and confident individuals, prepared to face both academic and everyday challenges (GONÇALVES, 2018; ROCK; PEREIRA, 2021; VYGOTSKY, 1991).

Another relevant aspect was the appreciation of aesthetics and creativity. The project encouraged students to choose fabrics, define colors, apply decorative techniques and customize their products, promoting artistic expression and identity construction through manual art. This aesthetic and creative dimension contributes not only to cognitive and motor development, but also to emotional well-being, stimulating the perception of personal achievements and reinforcing the student's role in the learning process.

In addition to individual impacts, the project highlighted the importance of inclusive and integrative pedagogical practices in the school context. The Multifunctional Resource Room proved to be a strategic space for the promotion of effective inclusion, articulating with the school curriculum and strengthening the relationship between Specialized Educational Service and regular education. The experience reinforces the need for public policies that guarantee resources, continuous teacher training and innovative methodologies, enabling each student with SEN to have access to meaningful learning and experiences of full development (BRASIL, 2008; PLETSCH; GLAT, 2019; SAINTS; OLIVEIRA, 2021).

In summary, the practice of sewing has become a multifaceted pedagogical tool, capable of integrating cognitive, motor, social and emotional aspects, promoting not only technical learning, but also the integral formation of students. It is recommended the continuity and expansion of similar projects, incorporating other areas of knowledge and involving the school community, in order to consolidate inclusive education as a daily, meaningful and transformative practice. In this way, it is possible not only to meet specific educational needs, but also to form autonomous, creative, socially engaged and emotionally resilient citizens.

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**CHEMICAL CHARACTERIZATION AND DETERMINATION OF CONTAMINANT
ELEMENTS IN LOW-GRADE CASSITERITE FROM THE BOM FUTURO MINE (RO),
WESTERN AMAZON**

**CARACTERIZAÇÃO QUÍMICA E DETERMINAÇÃO DE ELEMENTOS
CONTAMINANTES EM CASSITERITA DE BAIXO TEOR PROVENIENTE DO GARIMPO
BOM FUTURO (RO), AMAZÔNIA OCIDENTAL**

**CARACTERIZACIÓN QUÍMICA Y DETERMINACIÓN DE ELEMENTOS
CONTAMINANTES EN CASITERITA DE BAJO TENOR PROVENIENTE DEL GARIMPO
BOM FUTURO (RO), AMAZONÍA OCCIDENTAL**

 <https://doi.org/10.56238/sevened2025.036-015>

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ABSTRACT

The present study aimed to perform the chemical characterization and determination of contaminant elements in low-grade cassiterite samples from the Bom Futuro Mine, located in the Western Amazon (RO), Brazil. The research sought to assess the elemental composition of the ore, identify potentially toxic metals, and provide technical support for discussions on mineral utilization and environmental risks associated with its exploitation. Representative samples were collected from different mining fronts and tailings piles, following geological and mineral exploration criteria. The samples were prepared according to standardized protocols for drying, grinding, and homogenization, and subsequently analyzed using X-Ray Fluorescence (XRF) and Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). The results revealed that tin (Sn) is the main element in the samples, with average contents ranging from 45% to 46%, characteristic values of secondary alluvial deposits in the region. Moderate concentrations of iron (Fe) and tungsten (WO₃) were observed, as well as low levels of potentially toxic metals such as lead (Pb), arsenic (As), cadmium (Cd), and zinc (Zn), all below environmental reference limits. The compositional homogeneity and low moisture contents (0.17–0.23%) reinforce the representativeness of the samples and the analytical reliability of the results. Thus, it was verified that the low-grade cassiterite from the Bom Futuro Mine presents a composition favorable to mineral recovery and low geoenvironmental risk, demonstrating economic potential and sustainability for regional mining.

Keywords: Cassiterite. XRF. ICP-OES. Heavy Metals. Western Amazon.

RESUMO

O presente estudo teve como objetivo realizar a caracterização química e a determinação de elementos contaminantes em amostras de cassiterita de baixo teor provenientes do Garimpo Bom Futuro, localizado na Amazônia Ocidental (RO). A pesquisa buscou avaliar a composição elementar do minério, identificar metais potencialmente tóxicos e subsidiar

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discussões sobre o aproveitamento mineral e os riscos ambientais associados à sua exploração. Para isso, foram coletadas amostras representativas em diferentes frentes de lavra e pilhas de rejeitos, seguindo critérios geológicos e de exploração mineral. As amostras foram preparadas segundo protocolos padronizados de secagem, moagem e homogeneização, e posteriormente analisadas pelas técnicas de Fluorescência de Raios X (FRX) e Espectrometria de Emissão Óptica com Plasma Indutivamente Acoplado (ICP-OES). Os resultados obtidos revelaram que o estanho (Sn) constitui o principal elemento nas amostras, com teores médios entre 45% e 46%, valores característicos de depósitos secundários aluvionares da região. Foram observados teores moderados de ferro (Fe) e tungstênio (WO_3), além de baixas concentrações de metais potencialmente tóxicos, como chumbo (Pb), arsênio (As), cádmio (Cd) e zinco (Zn), todos abaixo dos limites de referência ambientais. A homogeneidade composicional e os baixos teores de umidade (0,17–0,23%) reforçam a representatividade das amostras e a qualidade analítica dos resultados. Dessa forma verificou-se que a cassiterita de baixo teor do Garimpo Bom Futuro apresenta composição favorável ao reaproveitamento mineral e reduzido risco geoambiental, evidenciando potencial econômico e sustentabilidade para a mineração regional.

Palavras-chave: Cassiterita. FRX. ICP-OES. Metais Pesados. Amazônia Ocidental.

RESUMEN

El presente estudio tuvo como objetivo realizar la caracterización química y la determinación de elementos contaminantes en muestras de casiterita de bajo tenor provenientes del Garimpo Bom Futuro, ubicado en la Amazonia Occidental (RO), Brasil. La investigación buscó evaluar la composición elemental del mineral, identificar metales potencialmente tóxicos y ofrecer fundamentos técnicos para las discusiones sobre el aprovechamiento mineral y los riesgos ambientales asociados con su explotación. Se recolectaron muestras representativas en diferentes frentes de extracción y pilas de relaves, siguiendo criterios geológicos y de exploración minera. Las muestras fueron preparadas según protocolos estandarizados de secado, molienda y homogeneización, y posteriormente analizadas mediante las técnicas de Fluorescencia de Rayos X (FRX) y Espectrometría de Emisión Óptica con Plasma Acoplado Inductivamente (ICP-OES). Los resultados obtenidos revelaron que el estaño (Sn) constituye el elemento principal de las muestras, con contenidos medios entre 45% y 46%, valores característicos de depósitos secundarios aluviales de la región. Se observaron concentraciones moderadas de hierro (Fe) y tungsteno (WO_3), además de bajos niveles de metales potencialmente tóxicos, como plomo (Pb), arsénico (As), cadmio (Cd) y zinc (Zn), todos por debajo de los límites de referencia ambiental. La homogeneidad composicional y los bajos niveles de humedad (0,17–0,23%) refuerzan la representatividad de las muestras y la calidad analítica de los resultados. De esta manera, se verificó que la casiterita de bajo tenor del Garimpo Bom Futuro presenta una composición favorable para el reaprovechamiento mineral y un riesgo geoambiental reducido, evidenciando potencial económico y sostenibilidad para la minería regional.

Palabras clave: Cassiterita. FRX. ICP-OES. Metales Pesados. Amazonia Occidental.

1 INTRODUCTION

Cassiterite (SnO_2) is the main tin ore mined worldwide, being a strategic resource for several production chains, especially the electronics, metallurgical and chemical industries (Mitchell *et al.*, 2019). In Brazil, tin production is prominent in the North Region, with historical relevance in the state of Rondônia, where the Bom Futuro Mine, one of the largest cassiterite deposits in South America, is located (Silva; Oliveira, 2020). In recent years, interest in low-grade deposits has grown due to the progressive depletion of high-purity ores, requiring the improvement of analytical and processing techniques capable of identifying and quantifying impurities and contaminants at trace concentrations (De la Roche *et al.*, 2018).

Chemical characterization of low-grade ores is essential to understand their mineralogical composition and the geochemical behavior of trace elements that can act as environmental contaminants (Costa *et al.*, 2021). Elements such as lead (Pb), arsenic (As), cadmium (Cd), chromium (Cr) and manganese (Mn) may be present in small proportions in the crystalline structure or in associated phases, and, when released into the environment during mining and processing processes, represent significant risks to biota and human health (Guimarães; Rezende, 2022). Thus, the detailed analysis of the elemental composition of low-grade cassiterite allows not only to assess the economic potential of the ore, but also to identify possible sources of contamination associated with artisanal and semi-industrial mining in the Western Amazon.

In the Amazonian context, mineral exploration has a relevant socioeconomic role, but it is also associated with environmental impacts resulting from the inadequate disposal of tailings and the contamination of water bodies (Santos; Almeida; Souza, 2020). The absence of strict technical control in mining operations favors the accumulation of heavy metals in the soil and water, requiring regional geochemical investigations to help diagnose and mitigate these impacts (Ferreira *et al.*, 2023). In this way, the characterization of samples from the Bom Futuro mine contributes to the knowledge of local geoenvironmental conditions and to the sustainable management of Amazonian mineral resources.

The application of analytical techniques such as X-ray Fluorescence (XRF) and Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) has been shown to be effective in the identification and quantification of principal and trace elements in complex mineral matrices (Mendes; Rodrigues; Soares, 2021). These methodologies allow the chemical composition to be determined with high precision and provide subsidies for geochemical correlations that indicate the origin of the contaminants and the degree of

alteration of the samples (Brito *et al.*, 2022). Such information is fundamental for the development of mineral reuse strategies and for the reduction of environmental liabilities in the Amazon region.

In view of this scenario, the present study aimed to carry out the chemical characterization and determination of the contaminant elements present in samples of low-grade cassiterite from the Bom Futuro Mine (RO), in order to evaluate its elemental composition, identify potentially toxic metals and subsidize research on mineral use and environmental risks related to its exploitation. The results obtained can contribute to the advancement of technical-scientific knowledge about tin ores from the Western Amazon, as well as to the development of more sustainable practices in regional mining.

2 THEORETICAL FRAMEWORK

2.1 THE ECONOMIC AND GEOLOGICAL IMPORTANCE OF CASSITERITE IN WESTERN AMAZONIA

Cassiterite (SnO_2) is the main tin mineral mined on a global scale, representing the main source of this metal for the metallurgical and electronics industries. In the Brazilian context, its extraction has significant economic relevance, especially in the Western Amazon, where the state of Rondônia stands out as one of the largest national producers. In this region, the Bom Futuro mining emerges as one of the most important secondary occurrences of cassiterite, the result of weathering processes that favored the residual concentration of the ore in alluvial and eluvial deposits (Souza *et al.*, 2019).

The exploration of cassiterite in the Bom Futuro Mine not only boosted local economic development, but also consolidated Rondônia as a strategic hub for tin production in Brazil. This activity generates direct and indirect jobs, fosters associated production chains, and contributes to the collection of taxes and regional investments (Mitchell *et al.*, 2018). However, the intensive mining dynamics and the advance of the exploration of low-grade ores require a more judicious technical approach, based on responsible mining practices and the control of environmental impacts.

In this context, it is essential to develop studies aimed at the chemical and geochemical characterization of low-grade cassiterite samples, since such analyses provide subsidies to evaluate the economic potential of the ore and identify possible environmental risks associated with the presence of contaminating elements. The integration between geological knowledge, instrumental analysis and sustainable environmental management is essential to

ensure the rational use of the mineral resources of the Western Amazon, reconciling productivity, socio-environmental responsibility and preservation of local ecosystems.

2.2 SECONDARY DEPOSITS AND MINERALOGICAL CHARACTERISTICS OF LOW-GRADE CASSITERITE

The low-grade cassiterite deposits present in the Western Amazon are characterized by their predominantly secondary nature, resulting from intense chemical weathering processes and residual concentration of heavy minerals from tin-enriched granitic rocks (De la Roche *et al.*, 2020). These processes act over long geological periods, promoting the disaggregation of primary rocks and the selective accumulation of resistant minerals, including cassiterite (SnO_2), the main source of economically exploitable tin.

The mineralogy associated with these deposits is diversified and includes accessory minerals of high economic importance, such as ilmenite (FeTiO_3), wolframite ($(\text{Fe}, \text{Mn})\text{WO}_4$), columbite-tantalite ($(\text{Fe}, \text{Mn})(\text{Nb}, \text{Ta})_2\text{O}_6$) and zircon (ZrSiO_4). The presence of these minerals confers added value to the ore and represents a significant potential for the use of strategic elements, such as tantalum (Ta) and tungsten (W), widely used in cutting-edge technologies and in the electronics industry (Costa *et al.*, 2022). Thus, the study of these complementary minerals becomes relevant not only from an economic point of view, but also from a scientific and technological point of view.

The detailed investigation of the mineralogy and geochemistry of these deposits allows us to understand the behavior of the elements during the processes of natural concentration and industrial processing. The chemical and structural characterization of these minerals helps in the definition of more efficient processing routes, reducing metallurgical losses and environmental impacts. Thus, in-depth knowledge of the composition and geochemical behavior of cassiterite and its associated minerals is an essential tool for the improvement of extraction techniques and the development of sustainable mining practices in the Western Amazon.

2.3 RELEVANCE OF CHEMICAL AND MINERALOGICAL CHARACTERIZATION IN GEOENVIRONMENTAL STUDIES

Chemical and mineralogical characterization is a fundamental step in geoenvironmental studies aimed at the evaluation of mineral resources and the management of impacts resulting from mining activity. Through this approach, it is possible to identify the

elemental composition of ores, determine the contents of main oxides and trace elements, and understand the geochemical interactions that occur in different formation and exploration environments (Silva; Oliveira, 2021). In low-grade cassiterite deposits, such as those at Garimpo Bom Futuro, such analyses are indispensable for assessing the quality of the ore, diagnosing the presence of contaminants, and establishing strategies for processing and economic use.

In addition to supporting technical decisions on mineral use, geochemical characterization plays a crucial role in the assessment of environmental risks associated with mining. Potentially toxic elements, such as lead (Pb), arsenic (As), cadmium (Cd), and chromium (Cr), may be present in small amounts in the minerals associated with cassiterite, becoming potential sources of soil and groundwater contamination (*World Health Organization*, 2022). In this context, detailed characterization allows not only to identify these contaminants, but also to understand their mechanisms of release and mobility in the environment, contributing to the monitoring and mitigation of environmental impacts.

2.4 APPLIED ANALYTICAL TECHNIQUES: X-RAY FLUORESCENCE (XRF) AND ICP-OES

Modern instrumental techniques, such as X-ray Fluorescence (XRF) and Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES), represent essential tools for the geochemical analysis of ores and soils. XRF is widely used for the determination of major oxides and trace elements in solid samples, allowing fast, non-destructive analyses with excellent accuracy (Cetem, 2020). ICP-OES, on the other hand, enables the quantification of several metals simultaneously in solutions obtained by total acid digestion, with high sensitivity and reproducibility (Santos; Lima, 2023).

The combined application of these techniques provides a comprehensive view of the elemental composition of the samples, favoring the correlation between mineralogical, geochemical and environmental aspects. In addition, the use of standardized preparation protocols, analytical quality control, and calibration with certified reference materials ensures the reliability of the results (Oliveira *et al.*, 2021). Thus, the use of XRF and ICP-OES in low-grade cassiterite studies contributes significantly to the advancement of scientific knowledge about the mineral deposits of the Western Amazon and to the development of sustainable mining strategies.

2.5 RELEVANCE OF CHEMICAL AND MINERALOGICAL CHARACTERIZATION IN GEOENVIRONMENTAL STUDIES AND APPLIED ANALYTICAL TECHNIQUES (FRX AND ICP-OES)

Chemical and mineralogical characterization represents one of the fundamental pillars for understanding the geological, environmental and technological processes that involve the exploration and use of mineral resources. In geoenvironmental studies, this approach provides essential information about the elemental composition of ores, their crystalline phases, and the geochemical interactions between the elements present. In the context of the Western Amazon, particularly in the Bom Futuro Mine, the detailed characterization of low-grade cassiterite is indispensable to assess both the economic potential of the ore and the environmental risks associated with its extraction (Silva; Oliveira, 2021).

Chemical analysis allows determining the levels of main oxides and trace elements, making it possible to identify impurities and contaminants that can interfere with processing and generate environmental impacts. Elements such as iron (Fe), lead (Pb), arsenic (As), cadmium (Cd), and chromium (Cr), when present in high concentrations, pose potential risks to environmental quality and human health (World health organization, 2022). Thus, the geochemical study of mineral samples not only guides the technological use of the ore, but also constitutes a preventive tool for environmental diagnosis, allowing the monitoring of areas impacted by mining.

From a mineralogical point of view, knowledge of the crystalline phases associated with cassiterite, such as ilmenite, wolframite, columbite-tantalite, and zircon, is fundamental to understand the geochemical behavior of the elements during weathering and residual concentration processes. This information helps in the definition of more efficient and environmentally safe processing routes, reducing metallurgical losses and avoiding the release of toxic metals into the environment (Costa *et al.*, 2022). Therefore, the integration between mineralogy and geochemistry is indispensable for the development of sustainable mining practices, especially in ecologically sensitive regions such as the Amazon.

Among the analytical methodologies used in the characterization of ores, X-ray Fluorescence (XRF) and Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) stand out, widely recognized for their accuracy and versatility (Cetem, 2020). XRF is a non-destructive technique that allows the identification and quantification of chemical elements in solid samples, being especially effective in the determination of major oxides and trace elements. ICP-OES, on the other hand, offers high sensitivity and multi-element

capacity, enabling the simultaneous quantification of metals in solutions obtained by total acid digestion, as in the case of low-grade cassiterite samples (Santos; Lima, 2023).

The integrated application of XRF and ICP-OES in geochemical studies of minerals ensures a more comprehensive and reliable analysis, allowing to correlate chemical, mineralogical and environmental aspects. The use of rigorous preparation protocols, calibration with certified reference materials, and instrumental quality control ensures the accuracy of the results (Oliveira *et al.*, 2021). Thus, the chemical and mineralogical characterization based on modern techniques of instrumental analysis is an essential instrument for the evaluation of the potential for the use of low-grade cassiterite and for the monitoring of the environmental impacts of mining, contributing to a rational and sustainable exploration of the mineral resources of the Western Amazon.

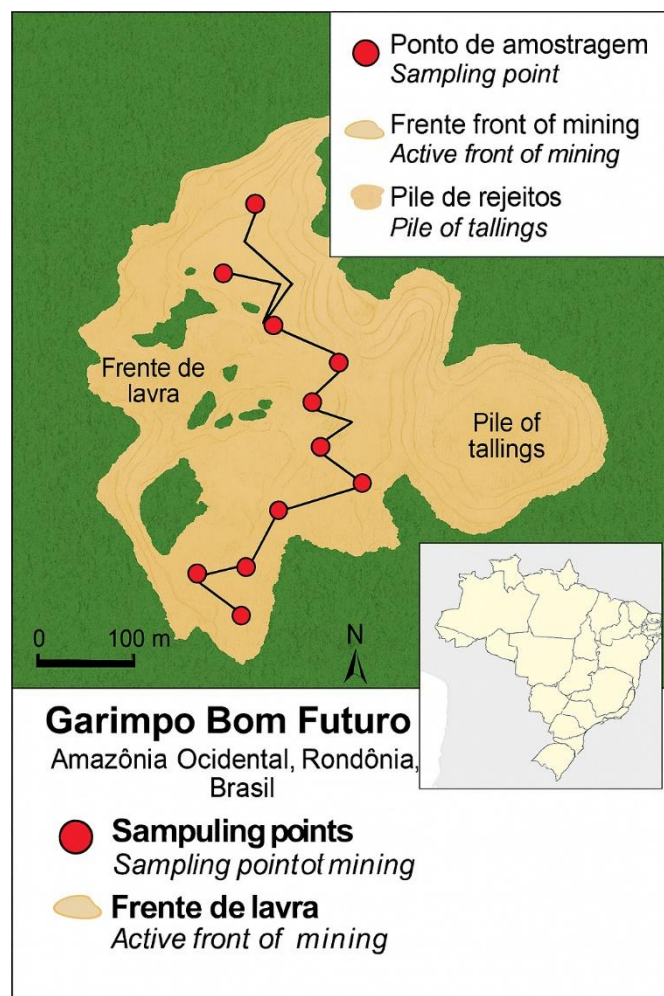
3 METHODOLOGY

3.1 STUDY AREA AND SAMPLE DESIGN

The research was conducted at the Bom Futuro mine, located in the Western Amazon, state of Rondônia, one of the main regions of cassiterite extraction in the country. The samples were collected at different points in the mine, covering active mining fronts and tailings piles. The selection of sampling sites considered the geological representativeness and the history of mineral exploration in the area, as represented in figure 1.

Figure 1

Sampling points of low-grade cassiterite in the Bom Futuro Mine, Western Amazonia, Rondônia (Brazil)



Source: Prepared by the authors themselves (2025)

Each sampling point was georeferenced using a Global Positioning System (GPS) and characterized according to the type of substrate, stage of exploration and local geological context. At each point, subsamples were collected systematically, in a zigzag pattern, composing representative composite samples of each environment studied. The raw samples were packed in previously sanitized polyethylene bags, properly identified and sealed for safe transport to the laboratory.

3.2 SAMPLE PREPARATION

In the laboratory of the coopersanta company, the samples went through a carefully standardized preparation process to ensure the analytical integrity and reproducibility of the results. Initially, the material was dried in an oven at 105 ± 2 °C for 24 hours to remove

moisture. Then, mechanical disaggregation and quartering were carried out by means of riffle dividers, ensuring the homogenization of the material.

The fractions obtained were ground in an agate mill until they reached a particle size of less than 75 μm , ensuring uniformity for the instrumental analyses. An aliquot of each sample was reserved for the determination of the loss to fire (PAF), performed at 1000 ± 50 $^{\circ}\text{C}$ for 1 hour. The entire procedure was conducted on a clean bench and with properly decontaminated equipment, using an acid bath (HNO_3 10%) and ultrapure water ($18 \text{ M}\Omega\cdot\text{cm}$), minimizing the possibility of cross-contamination.

3.3 PREPARATION FOR XRF ANALYSIS

For elemental determination by X-ray Fluorescence (XRF), two types of preparation were adopted: pressed wafers and molten beads, according to the type of element to be quantified.

Pressed pellets (trace elements): 6.0 g of the dry powder was homogenized with approximately 10% w/w boric acid, used as a binding agent and mechanical support. The mixture was pressed under pressure from 20 to 30 tons for 60 seconds, obtaining uniform and stable pellets.

Molten pearls (major oxides): 0.60 g of the sample was fused with 6.0 g of lithium borate ($\text{Li}_2\text{B}_4\text{O}_7/\text{LiBO}_2$, 66:34) in platinum crucibles, at a temperature of approximately 1050 $^{\circ}\text{C}$. Cooling was carried out in a controlled manner in preheated molds, ensuring the homogeneity of the vitreous matrix.

After preparation, all lozenges and pearls were carefully inspected for the presence of bubbles, cracks or segregation, being disapproved and remade when necessary.

3.4 PREPARATION FOR ANALYSIS BY ICP-OES

For multielemental quantification, the samples were subjected to total acid digestion, suitable for minerals rich in tin dioxide (SnO_2). Approximately 100 to 150 mg of sample were weighed in Teflon® (PTFE) vessels, to which 5 mL of HF (48–50%) and 2 mL of HNO_3 (65%) were added. The mixture was initially reacted cold, under fume hood, and was subsequently heated in a closed digester block to 120–140 $^{\circ}\text{C}$ until almost dry.

The process was repeated until complete solubilization. Then, 10–15 mL of boric acid (H_3BO_3 4–5% w/v) were added for complexation of the residual fluorides, and the final volume was adjusted with 2% HCl. The resulting solutions were quantitatively transferred to

volumetric flasks, applying the same dilution factor to blanks, duplicates and certified reference materials.

Safety: The handling of HF was carried out with the strict use of Personal Protective Equipment (compatible gloves, apron and face shield), in an exhaust hood, with immediate availability of calcium gluconate, following the biosafety protocols of the laboratory.

3.5 INSTRUMENTAL ANALYSIS

3.5.1 X-ray Fluorescence (XRF)

The analyses were performed in an XRF spectrometer by energy and/or wavelength dispersion, calibrated with multielement standards and matrix corrections by the fundamental parameter method (FP). Contents of major oxides (Sn, Fe, Ti, Si, Al) and trace elements (Pb, As, Cd, Mn, Cr, Zn) were determined. Instrumental parameters, such as acquisition time and collimation, were adjusted by spectral region to maximize the signal-to-noise ratio (S/N).

3.5.2 Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES)

The quantification of potentially toxic metals (Fe, Pb, As, Cd, Mn, Cr, Zn, among others) was performed in an ICP-OES equipment with an axial torch, concentric nebulizer and cyclonic chamber. Multielemental external standards in a compatible acid matrix and independent verification standards were used every 10 samples. For instrumental control, an internal standard (yttrium or scandium) was applied, correcting for any variations in nebulization or signal drift.

3.5.3 Statistical Treatment and Interpretation

The data obtained were submitted to robust statistical treatment, involving descriptive analyses — mean, median, standard deviation and interquartile range — with the objective of characterizing the distribution and variability of the determined parameters. Then, linear correlation analysis (Pearson and Spearman) was applied to identify possible associations between chemical elements, notably between pairs such as Pb–Zn and Cr–Fe, which may indicate mineralogical cooccurrence or common geochemical origin.

When appropriate, Principal Component Analysis (PCA) was used, after a self-scaling procedure, in order to reduce the dimensionality of the data and to evidence clustering patterns between samples from different mining fronts. This multivariate approach allowed us to infer geochemical affinities and potential sources of compositional variation.

For the interpretation of the results, the local geological and mineralogical context was considered, enabling an integrated discussion between the geochemical characteristics observed, the potential for economic use of low-grade cassiterite and the possible environmental risks arising from its exploitation in the Bom Futuro mining region.

4 RESULTS AND DISCUSSIONS

The samples differ in terms of batch and date of receipt, but have similar characteristics in relation to moisture, ranging between **0.17% and 0.23%**, values that reflect good conservation and low residual water content – a favorable condition for chemical analysis and processing processes. The clear identification of batches and collection dates reinforces the traceability and reliability of analytical data, essential aspects for quality control and the evaluation of the economic potential of low-grade cassiterites in the region.

Table 1

General information on the certificates of analysis of low-grade cassiterite samples from the Bom Futuro (RO) mine, issued to the company traxys europa sa

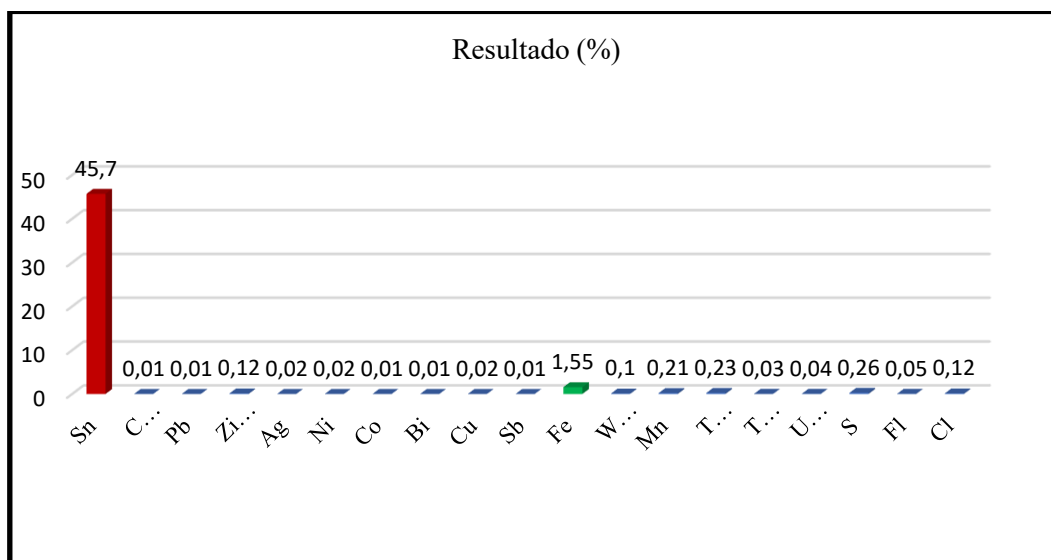
Parameter Our reference	Certificate 1 M20238791	Certificate 2 M20238188
Certificate date	August 6, 2025	June 5, 2025
Customer	Traxys sa europa	Traxys sa europa
Material	Cassiterite	Cassiterite (low grade)
Lot No.	156380-1	Bra (good future)
Date of receipt of the sample	August 4, 2025	May 30, 2025
Moisture	0,17%	0,23%

Source: Prepared by the authors themselves (2025)

Table 1 presents the general information of the certificates of analysis referring to the samples of low-grade cassiterite from the Bom Futuro Mine (RO), issued to the company **Traxys Europa SA**. It is observed that both samples were analyzed in close periods, between May and August 2025, indicating continuity in the monitoring and mineral characterization activities. Figure 2 shows the results obtained from the percentage levels of the elements determined in a sample of low-grade cassiterite.

Figure 2

Result of the percentage contents of the elements determined in a sample of low-grade cassiterite Lot no. 156380-1



Source: Prepared by the authors themselves (2025)

The results obtained reveal that tin (Sn) is the main element of the sample of low-grade cassiterite from the Bom Futuro mine, with a content of 45.7%, a value consistent with average concentrations reported in alluvial and eluvial deposits in the Western Amazon. According to Souza *et al.* (2019), cassiterite samples collected in mines near the region of Ariquemes-RO showed levels ranging between 40% and 55% of Sn, reflecting the presence of economically viable minerals, even if associated with metallic and non-metallic impurities. The moderate iron content (Fe = 1.55%) and the low presence of oxides such as WO_3 (1.55%) and Mn (0.21%) corroborate the secondary nature of mineralization, typical of deposits formed by weathering processes and residual concentration.

When compared to studies carried out in other tin provinces, such as those by Mitchell *et al.* (2018) and De La Roche *et al.* (2020), the results of cassiterite from Garimpo Bom Futuro indicate a composition similar to that of secondary deposits, with a predominance of SnO_2 and low levels of potentially toxic elements, such as Pb (0.01%), As (0.02%) and Cd (0.01%). These values are significantly lower than those observed by Silva and Oliveira (2021) in samples from the northeast of Pará, in which lead and arsenic reached up to 0.15% and 0.09%, respectively, suggesting lower geoenvironmental risk associated with tailings from the Bom Futuro mine. In addition, the residual presence of tungsten (WO_3) and tantalum

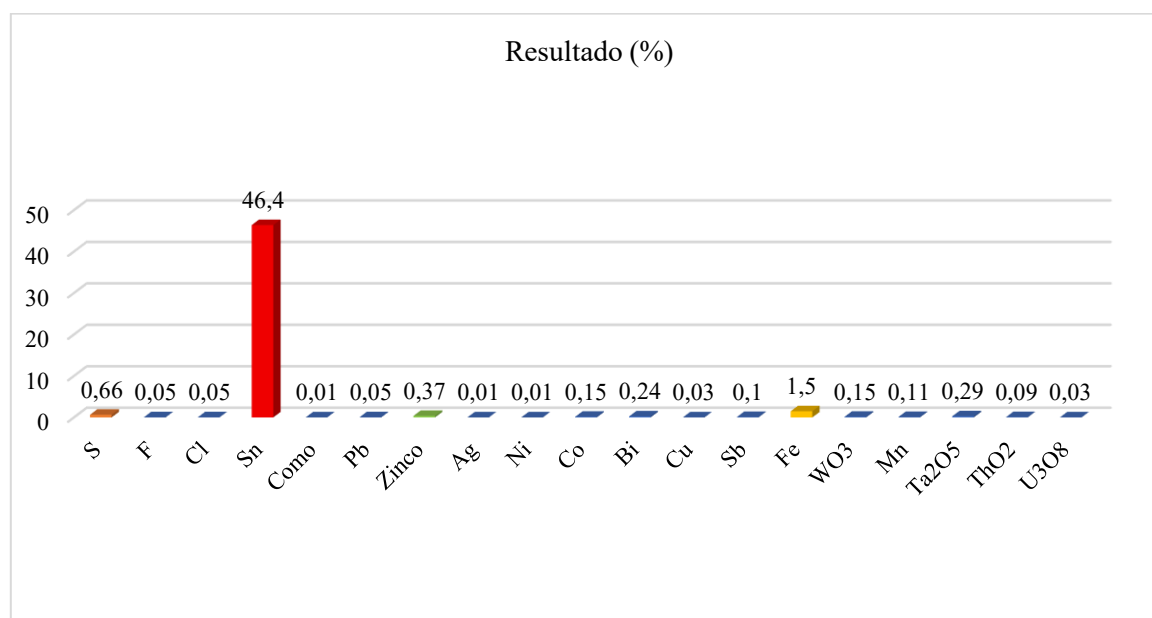
($\text{Ta}_2\text{O}_5 = 0.23\%$) suggests potential complementary economic use, since these metals are considered strategic for the modern technological industry (Costa et al., 2022).

In addition, the low humidity (0.17–0.23%) and the compositional uniformity between different samples reinforce the good representativeness of the collections and the analytical reliability of the results obtained by XRF and ICP-OES. These data support the potential for mineral reuse of low-grade cassiterites, especially through more selective physicochemical processing processes, capable of concentrating tin and minimizing metallic impurities. From an environmental perspective, the low content of heavy metals reinforces the importance of integrated geochemical and ecotoxicological monitoring studies, as defended by Oliveira *et al.* (2021) and Santos and Lima (2023), which highlight the need for sustainable tailings management to reduce the risks of soil and groundwater contamination in mining areas in the Amazon.

Figure 3 shows the percentage levels of the elements in the sample of low-grade cassiterite from **Lot No. BRA (Bom Futuro)**, collected at the Bom Futuro Mine (RO).

Figure 3

Result of the percentage contents of the elements determined in a sample of low-grade cassiterite Lot no. B RA (Bom Futuro)



Source: Prepared by the authors themselves (2025)

Tin (Sn) is the predominant element, with about **45.7%**, followed by small amounts of **iron (Fe = 1.55%)** and traces of other metals. The presence of **WO₃, Mn, Ta₂O₅, Pb, Zn** and

As, at levels below 1%, indicates natural impurities and elements of economic or environmental interest. The chemical profile obtained is typical of alluvial cassiterites from Western Amazonia. These results reinforce the potential for mineral use and the importance of environmental monitoring of the area.

The comparative analysis between the samples of low-grade cassiterite from **the Bom Futuro mine (RO)** reveals consistent results regarding the predominance of **tin (Sn)** as the major element. In **Lot No. BRA**, the Sn content was **46.4%**, a value slightly higher than that observed in the previous sample (**45.7%**), indicating a relatively homogeneous chemical composition among the analyzed lots. This result reinforces the representativeness of the collections and the compositional stability of the ore in the region, whose mineralogy is dominated by cassiterite (SnO_2). The small variation in the levels of **iron (Fe = 1.5%)** and **tungsten (WO_3 = 1.5%)** suggests the influence of accessory minerals, such as wolframite and ilmenite, commonly associated with secondary tin deposits of the Western Amazon, as described by **Souza et al. (2019)** and **Mitchell et al. (2018)** element.

When comparing the trace elements, it is noted that both lots have low levels of **potentially toxic metals** (Pb, As, Sb and Zn), all below 0.5%, which reduces the geoenvironmental risk associated with the processing tailings. However, the **BRA Lot** showed a slight increase in some elements, such as **Zn (0.37%)** and **Bi (0.24%)**, which may be related to the natural heterogeneity of the deposit and the local variation in the composition of the accompanying minerals. Similar studies conducted by **Silva and Oliveira (2021)** in cassiterite deposits in Pará recorded comparable concentrations, reinforcing the regional geochemical pattern of low contamination and limited presence of metallic impurities. These results, therefore, demonstrate the good mineral quality of the analyzed samples and support the potential for economic use of low-grade cassiterite from the Bom Futuro mining region.

5 CONCLUSION

The methodology adopted in this study demonstrated high technical rigor and analytical consistency, ensuring the reliability in the geochemical characterization of low-grade cassiterite samples from the Bom Futuro mine, located in the Western Amazon, state of Rondônia. The integration of systematized protocols for sample preparation, quality control and high-precision instrumental analysis — notably X-ray Fluorescence (XRF) and Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) — resulted in representative and reproducible data, fundamental for the integrated evaluation of the

economic potential and environmental implications associated with mineral exploration in the area under study.

The sampling design, structured based on geological, mineralogical and historical exploration criteria, made it possible to obtain consistent results between different mining fronts and sample lots. The average tin (Sn) contents, ranging between 45% and 46%, corroborate the predominance of secondary alluvial mineralizations, typical of the tin deposits of the Western Amazon. The moderate presence of iron (Fe) and tungsten (WO_3), associated with reduced concentrations of potentially toxic metals (Pb, As, Cd and Zn), shows an ore of stable composition, with low metallic contamination and reduced geoenvironmental risk.

Such results, combined with the low moisture content and the compositional homogeneity of the samples, indicate the feasibility of the economic reuse of low-grade cassiterite through selective physicochemical beneficiation processes, capable of maximizing metallurgical yield and minimizing environmental liabilities. From an environmental point of view, the low presence of potentially hazardous trace elements reinforces the need for geochemical monitoring policies and sustainable tailings management, in order to mitigate impacts on Amazonian ecosystems and ensure the sustainability of mining activity.

Thus, the results obtained confirm the technical, economic and environmental feasibility of the geochemical characterization of the low-grade cassiterites of the Bom Futuro Mine, contributing significantly to the advancement of knowledge about secondary tin deposits in the Western Amazon and providing relevant scientific subsidies for the planning and sustainable management of regional mining.

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**MEDICINAL PLANTS FOR TRADICIONAL USE IN THE CORCOVADO
COMMUNITY, MARAJÓ MESOREGION**

**PLANTAS MEDICINAIS DE USO TRADICIONAL NA COMUNIDADE DE
CORCOVADO, MESORREGIÃO DO MARAJÓ**

**PLANTAS MEDICINALES DE USO TRADICIONAL EN LA COMUNIDAD DE
CORCOVADO, MESORREGIÓN DE MARAJÓ**

 <https://doi.org/10.56238/sevened2025.036-016>

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ABSTRACT

Medicinal plants are of great importance for promoting people's health, especially for residents of rural communities such as Corcovado, located in the municipality of Breves, Marajó Mesoregion, Pará States. The study aimed to conduct an ethnobotanical survey of medicinal plants in the research site, as well as to determine their importance to the health of local residents. The research was conducted through on-site visits to properties to collect socioeconomic and ethnobotanical data, and through guided tours to conduct semi-structured interviews with 49 residents. In total, 66 species from 40 botanical families were cited in the study. The most frequently cited plants were bloodroot, cow's foot, pariri, peppermint and quebra pedra. The leaves were the most frequently cited part for preparing teas to alleviate or cure various symptoms. The categories of circulatory system disorders and endocrine diseases presented the highest rates according to the Informant Consensus Factor. In the Corcovado Community, it was evident that the use of medicinal plants plays a central role in health, strengthening territorial belonging and sociocultural and environmental preservation.

Keywords: Medicinal Plants. Health. Belonging to the Territory. Environmental Preservation. Corcovado Community. Marajó Mesoregion.

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RESUMO

As plantas medicinais retratam aspecto de grande importância para a promoção da saúde das pessoas, especialmente para os moradores de comunidades rurais como a de Corcovado que se localiza no município de Breves, Messorregião do Marajó, Estado do Pará. A pesquisa objetivou realizar o levantamento etnobotânico das plantas medicinais existentes no lócus da pesquisa, bem como verificar a importância delas para a promoção de saúde dos moradores do local. A pesquisa foi realizada por meio de visita in loco às propriedades para o levantamento de dados socioeconômicos e etnobotânicos, por meio do método turnê-guiada para a realização de entrevistas semiestruturadas com 49 moradores. Ao todo, 66 espécies de 40 famílias botânicas foram citadas no estudo. As plantas mais citadas foram for sangue, pata da vaca, pariri, hortelã pimenta e quebra pedra. A folha foi a parte mais citada para o preparo de chás para alívio ou cura de diversos sintomas. As categorias de transtornos do sistema circulatório e de doenças endócrinas apresentaram os maiores índices de acordo com o Fator de Consenso do Informante. Evidenciou-se na Comunidade de Corcovado que o uso de plantas medicinais desempenha um papel central na saúde, no fortalecimento de pertencimento ao território e na preservação sociocultural e ambiental.

Palavras-chave: Plantas Medicinais. Saúde. Pertencimento ao Território. Preservação Ambiental. Comunidade de Corcovado. Messorregião do Marajó.

RESUMEN

Las plantas medicinales son de gran importancia para promover la salud de las personas, especialmente para los residentes de comunidades rurales como Corcovado, ubicado en la municipio de Breves, Messorregión de Marajó, Estado do Pará. El estudio tuvo como objetivo realizar un relevamiento etnobotánico de plantas medicinales en el sitio de investigación, así como determinar su importancia para promover la salud de los residentes locales. La investigación se llevó a cabo mediante visitas in situ a propiedades para recopilar datos socioeconómicos y etnobotánicos, y mediante visitas guiadas para realizar entrevistas semiestruturadas con 49 residentes. En total, se citaron en el estudio 66 especies de 40 familias botánicas. Las plantas citadas con mayor frecuencia fueron sanguinaria, pata da vaca, pariri, menta piperita y quebra pedra. Las hojas fueron la parte más citada para preparar tés para aliviar o curar diversos síntomas. Las categorías de trastornos del sistema circulatorio y enfermedades endocrinas presentaron las tasas más altas según el Factor de Consenso del Informante. En la Comunidad de Corcovado se evidenció que el uso de plantas medicinales juega un papel central en la salud, el fortalecimiento de la pertenencia territorial y la preservación sociocultural y ambiental.

Palabras clave: Plantas Medicinales. Salud. Pertenencia Al Territorio. Preservación Ambiental. Comunidad Corcovado. Messorregión de Marajó.

1 INTRODUCTION

Since time immemorial, medicinal plants have been used as a primary source of treatment and cure for a wide range of ailments. Even before the development of modern medicine, our ancestors relied on the vast knowledge of the medicinal properties of plants to relieve symptoms and promote health recovery. This ancestral knowledge, passed down from generation to generation, continues to be valued to this day, especially in societies where access to conventional medicine may be limited (Braga and Silva, 2021).

It is important to emphasize that in the face of constant progress in modern civilization, they have led to numerous cultural changes, thus losing part of the traditional perception regarding the active elements of medicinal plants, consequently generating forgetfulness about some beneficial effects and risks. After all, every plant contains active ingredients and toxins, and if ingested incorrectly can cause undesirable parallel damage. Therefore, despite the many benefits, it is essential to understand more and more about these herbs that are so impetuous in herbal treatments in human health (Silva *et al.*, 2023).

According to the above, the present study aimed to carry out a diagnosis of popular knowledge and the use of plants of medicinal species (their main forms of preparation) in the Community of Corcovado, located in the rural area of the municipality of Breves-Pará, in the Mesoregion of Marajó, and to reconcile traditional knowledge and scientific knowledge of the study of medicinal plants.

This article addresses topics such as the importance of medicinal plants, the biodiversity of medicinal plants in the Amazon, the interface between traditional and scientific knowledge about the use of medicinal plants, the description of the Corcovado Community, the methodological procedures addressed and the results obtained during the study. The study comes from the research project "Perception and knowledge about medicinal plants of the population of the urban area of the municipality of Breves, in the Marajó Archipelago, Pará.", fostered by Public Notice No. 01/2025 - Girls in Science. In addition, the importance of medicinal plants that were cataloged by the project team in the locus of the research and the phytotherapeutic use of some of these botanical species by the residents of this community will be described here.

2 THEORETICAL FRAMEWORK

2.1 IMPORTANCE OF THE BIODIVERSITY OF MEDICINAL PLANTS IN THE AMAZON

The therapeutic use of plants is an old practice, recognized and approved by several health policies in several countries, including Brazil (Nery *et al.*, 2021). Brazil has enormous cultural and ethnic diversity, resulting in a considerable accumulation of knowledge about medicinal plant management (Marconccine, 2022). In addition to the assimilation of indigenous knowledge, the contributions brought by African and European cultures played an important role in the emergence of a rich folk medicine in the country (Ferreira *et al.*, 2021).

In the Amazon region alone, it is estimated that 25 thousand species of plants are used to cure various conditions such as snuff, mambe, toé and other options that have indigenous origin (Villar, 2020). In addition, African peoples enslaved to Brazil incorporated their knowledge about plants into the local context, adapting to the Brazilian flora and exchanging experiences with indigenous peoples. This exchange brought plants such as rue, boldo, barbatimão, lemon balm, incense and rosemary, which are species widely used in teas, baths and compresses, serving both to treat physical ailments and for spiritual protection. This tradition is maintained by quilombola communities in the Amazon where the relationship with nature is deep and respectful and traditional medicine plays a central role in health promotion (Pinheiro, 2024).

The Amazon is a relevant granary for the cultivation of these inputs of the local flora, although there is still limited evidence about the chemical-pharmacological properties and natural products (Amazonas and Figueiredo, 2021). For example, Calvimontes *et al.* (2020) analyzed the experience of miners in Amazonian communities, who despite precarious work experiences and vulnerability accentuated by the pandemic, they were able to find alternative and cooperative solutions, including the use of medicinal plants to face the crisis. Therefore, studies such as these not only highlight the continued relevance of traditional practices, but also suggest pathways for a broader integration of these practices into contemporary health systems, promoting a holistic and culturally sensitive approach to public health (Régis *et al.*, 2025).

A survey carried out by a group of pharmacists in the Amazon found that the seven species most cited and used by the population of Pará are: boldo, mint, rue, lemon balm, copaiba, andiroba. According to this ethnopharmacological study, 16% of the population of Pará uses these medicinal plants to treat infections, 20% for inflammation in the digestive

system, and 12% for the treatment of flu symptoms and problems related to the respiratory system (Federal Council of Pharmacy, 2022).

The prospects for the future of research on medicinal plants in the Amazon are promising. The fusion of traditional knowledge with scientific research can result in innovative discoveries and the development of new drugs. However, to make the most of this potential, it is essential to prioritize the preservation of Amazonian biodiversity, ensuring the sustainable use of natural resources (Miranda *et al.*, 2025).

2.2 INTERFACE BETWEEN TRADITIONAL AND SCIENTIFIC KNOWLEDGE ABOUT THE USE OF MEDICINAL PLANTS

The world is currently witnessing a reformulation of the correction of life with natural and ecological values and today it is possible to perceive that they return in all spheres of scientific knowledge and practical life, in the determination of new precepts. Therefore, the use of plants for medicinal purposes has renewed and stimulated interest in the knowledge of the properties of medicines extracted by plants, including their morphology, chemical constituents, pharmacological properties, etc. (Soares *et al.*, 2023).

The use and conservation of biodiversity by traditional peoples contribute to the development of sustainable practices, seek ways to reduce the socio-environmental and food impacts of today, recognize the socio-cultural identity and ensure the permanence of these peoples in their territories (Batista *et al.*, 2020).

Traditional communities, sertanejo peoples, riverside dwellers, indigenous communities, quilombola peoples, among others, have made and continue to use medicinal plants since the most remote times, the improvement and use of these methods for the use of medicine is a great advance in the context of the health of the population, where it is important to understand the benefits that popular knowledge has brought to society to advance technically and scientifically (Cabral e Sousa *et al.*, 2021).

Phytotherapy is the therapy characterized by the use of medicinal plants in their different pharmaceutical forms, without the use of isolated active substances, still of plant origin (BRASIL, 2012). In Brazil, the National Policy on Integrative and Complementary Practices in the SUS, agreed upon by the Tripartite Interagency Commission and approved by the National Health Council (Ordinance GM No. 971, of May 3, 2006), proposes the inclusion of medicinal plants and phytotherapy as therapeutic options in the Unified Health System (SUS). Currently, in the SUS, there are 12 herbal medicines in the National List of

Essential Medicines (RENAME) that can be offered in the public network after agreement between state and municipal managers (STÊNICO *et al.*, 2021).

Living pharmacy is fundamental in the integration of traditional and scientific knowledge about medicinal plants and promotes sustainability by allowing the local cultivation and use of plants, benefiting communities with limited access such as in rural contexts and indigenous communities, where traditional knowledge about medicinal plants is deep and widely disseminated (Moraes *et al.*, 2020).

In addition to preserving biodiversity and traditional knowledge, the living pharmacy establishes the autonomy of health systems, reducing dependence on industrialized drugs, contributing to the validation and standardization of natural treatments, reinforcing the safe and rational use of herbal resources (Silva, 2024).

The Ministry of Health will invest R\$5.5 million in six projects for the implementation or structuring of live pharmacies in the Unified Health System (SUS). The action aims to ensure the access of users in the public health network to herbal medicines with quality, safety and effectiveness. In addition, the strategy provides for the promotion and recognition of popular and traditional practices for the use of medicinal plants and herbal medicines (BRASIL, 2024).

2.3 DESCRIPTION OF THE COMMUNITY OF CORCOVADO (LOCUS OF THE RESEARCH)

The research was developed in the Corcovado Community, which is located in the rural area of the municipality of Breves (southwest of the Marajó Mesoregion, latitude 01° 40' 56" south and longitude 50° 28' 49" north), on the banks of the Parauaú River, where access can be made in two ways: by land or river, and by land the time to reach the community varies from 35 to 60 minutes and the river trip takes 30 minutes (Authors, 2025).

The community carries with it an important historical and social legacy, being a milestone in the economic development of the region during the mid-twentieth century. During this period, the Community of Corcovado stood out for the installation of several rubber processing factories, which significantly boosted the local economy. Industrialization has attracted hundreds of families, reaching approximately 1,200 families, a number that contrasts with the current reality, where about 50 families reside. Even with the population decrease and the closure of industrial activities, the community preserves a rich cultural and traditional heritage, especially with regard to the use of medicinal plants as a form of health

care (Santos *et al.*, 2020). Currently, the Corcovado Community is home to 66 families, with approximately 400 people residing there (Authors, 2025).

The popular knowledge present in the Community of Corcovado (Figure 1) reflects a form of knowledge that goes beyond the healing aspect, as it integrates spiritual, cultural and ecological aspects. It is important to highlight that this practice is in line with the principles of education in agroecology, which defends the valorization of local knowledge, respect for cultural diversity and the construction of sustainable alternatives for rural development (Paula *et al.*, 2022). In this context, the use of medicinal plants represents the importance of inclusive care, but also a relevant strategic factor of cultural resistance and the affirmation of peasant identity (Lima, 2025).

Figure 1

Aerial view of the Corcovado Community



Source: Reis, 2023.

3 METHODOLOGY

A qualitative and quantitative social research was carried out (RODRIGUES *et al.*, 2021), using simple descriptive statistics through the Microsoft Excel program. First, semi-structured interviews were conducted with 49 residents, aged 30 to 80 years, of the Corcovado Community. The interview questionnaires were based on standardized forms (Martin, 2004) and information on the interviewees' knowledge was provided after reading, consenting and signing the Informed Consent Form. Finally, the ethical guidelines of the International Society of Ethnobiology (ISE, 2006) were adopted in an adapted form. The survey was conducted from May to July 2025.

In these interviews with the residents of the Corcovado Community, information was obtained on the socioeconomic profile (gender, age, level of education and monthly income) and plants used for medicinal purposes, their uses, preparations and parts used, using the free listing technique (Mussi *et al.*, 2021). The interview script was based on a semi-structured questionnaire, containing objective and discursive questions. Visits were made to more than 15 properties.

For the ethnobotanical survey of the medicinal plant species of the Corcovado Community, they were identified through photographic records, specialized literature, reference materials and consultation of the botanical database present in virtual herbaria in the PlantNet Identify and the Re flora/CNPQ Program applications. Due to the unfavorable conditions of flowering and fruiting of the species mentioned in the topic Results and Discussions and the short period (study derived from a research project), it was not possible to perform exsiccates.

In order to achieve the objective of evaluating the perception of the use of medicinal plants by the residents of the Corcovado Community, the data from the interviews were tabulated. Among the analyses, the Informant Consensus Factor (FCI) was obtained according to the technique developed by Troter and Logan (1986), evaluating the level of fidelity (NF). This consensus is based on the agreement between the informants' answers for a main therapeutic indication (ind.). The formula $NF = (Ip/Iu) \times 100\%$ was used, where Ip= number of informants who mentioned the main use of the species and Iu= number of informants who mentioned the species for any purpose, adapted by Beltreschi (2016).

The Informants' Consensus Factor (FCI) was calculated using the formula $FCI = Nur - Nt / Nur - 1$, where Nur= sum of the uses recorded by each informant for a category and Nt= number of species indicated for each category. The FCI ranges from 0 to 1, with the maximum value being a local consensus among informants about medicinal plants for a specific category.

The diseases mentioned were classified into categories according to the International Statistical Classification of Diseases 11th Revision (ICD-11), The global standard for diagnostic health information, according to the WHO in 2022.

4 RESULTS AND DISCUSSIONS

Among the 49 interviewees, most were women (91.8%; 45 ind.) and approximately 59.2% (29 ind.) were married. The predominant age group was 65-69 years (22.4%; 11 ind.), followed by 60-64 years (18.4%; 9 ind.). Regarding the level of education, 42.8% (21 ind.) of the interviewees are illiterate and 24.5% (12 ind.) are people who have not completed elementary school, and only 4.1% (2 ind.) have completed higher education as shown in Table 1. This result is in agreement with data found in the literature, as the elderly are considered the wisest people to share traditional knowledge about the use of medicinal plants for the next generations (Vieira *et al.*, 2024).

Most of the interviewees (approximately 95.9%) are owners of the area where they live and, among the economic activities, retirement is the main source of income (26.5%; 13 ind.), followed by government aid such as Bolsa Família (16.3%; 9 ind.). The family income reported by the interviewees with the highest percentage was up to one minimum wage (71.4%; 35 ind.), followed by those who receive from 1 to 2 minimum wages (18.4%; 9 ind.) and, in a lower percentage, those with income from 3 to 5 minimum wages (10.2%; 5 ind.). Residents who have lived in the Corcovado Community for more than 10 years represent the majority of the interviewees (53.1%; 26 ind.), followed by those who have lived for more than 5 years (36.7%; 18 ind.) in the locus of the research, as can be seen in Table 1. This prolonged time of residence of the residents constitutes an essential element of traditional care, the strengthening of belonging, autonomy and the appreciation of ancestry, proposing a dialogue between popular knowledge and scientific knowledge (Pinheiro *et al.*, 2025).

Table 1

Socioeconomic profile of the residents interviewed in the Corcovado Community

Variable	Category	Number of residents	%
Gender	Female	45	91,8
	Male	4	8,2
Marital status	Single	13	26,5
	Married	29	59,2
	Stable Union	2	4,1
	Widower	5	10,2
Age group	30-34 years old	4	8,2
	35-39 years old	2	4,1

	40-44 years old	2	4,1
	45-49 years old	4	8,2
	50-54 years	6	12,2
	55-59 years	7	14,2
	60-64 years old	9	18,4
	65-69 years	11	22,4
	70 years or older	4	8,2
Education Degree	Illiterate	21	42,8
	Incomplete Elementary School	12	24,5
	Complete Elementary School	4	8,2
	Incomplete High School	2	4,1
	Complete High School	5	10,2
	Incomplete Higher Education	3	6,1
	Complete Higher Education	2	4,1
Household income	Up to 1 minimum wage	35	71,4
	More than 1 to 2 minimum wages	9	18,4
	From 3 to 5 minimum wages	5	10,2
Length of residence in the community	1 year ago	2	4,1
	More than 2 years	3	6,1
	More than 5 years	18	36,7
	More than 10 years	26	53,1

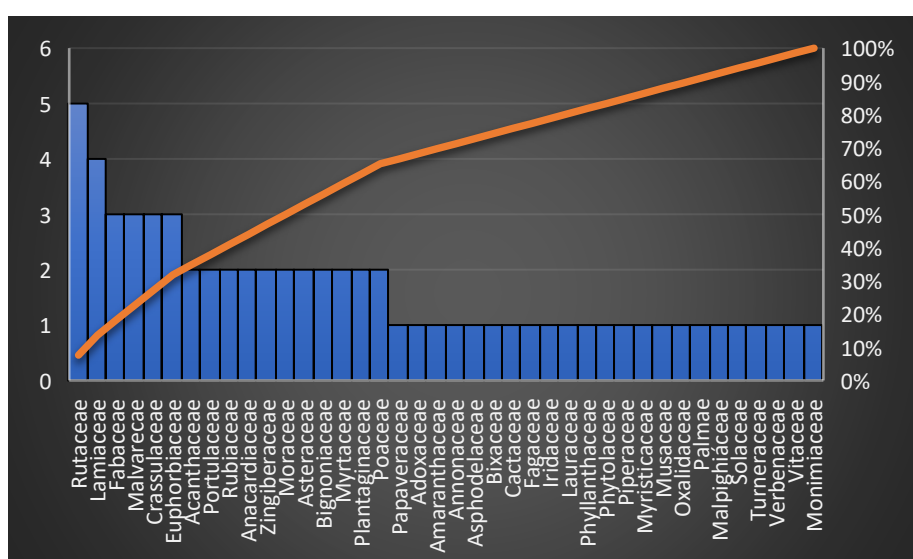
Source: Authors, 2025.

Regarding the question whether he considered the use of medicinal plants important, only one interviewee reported that he did not. She was also the one who commented that she did not use any species of medicinal plant.

The interviewees reported the presence of more than 80 species on their properties. However, the authors only photoFigureed 66 species (spp.) of medicinal plants, which are distributed in 40 botanical families as shown in Figure 1 and 57 genera as shown in Figure 1, for comparison in existing databases in the PI@ntNet Identify and the Reflora/CNPQ Program applications. Many species reported by residents were not photoFigureed because access to some parts of the community could only be made through a boat, since a wooden tip was not safe. In addition, the interviewees mentioned that some species died and needed to be replanted. This reinforces that medicinal plants play a central role in promoting health and conserving biodiversity, highlighting the concern of residents of rural communities to ensure sociocultural and environmental preservation (Paiva *et al.*, 2025). The families with the highest number of species (spp.) were Rutaceae (5 spp.; 7.9%) and Lamiaceae (4 spp.; 6.3%) as can be seen in Figure 1. The species most used by the interviewees in the Corcovado Community are for sangue (*Justicia polygonoides* Kunth), cow's paw (*Bauhinia forficata* Link), pariri (*Arrabidaea chica* Verlot.), peppermint (*Mentha x piperita* L.) and stone breaker (*Phyllanthus niruri* L) as shown in Figure 2.

Figure 1

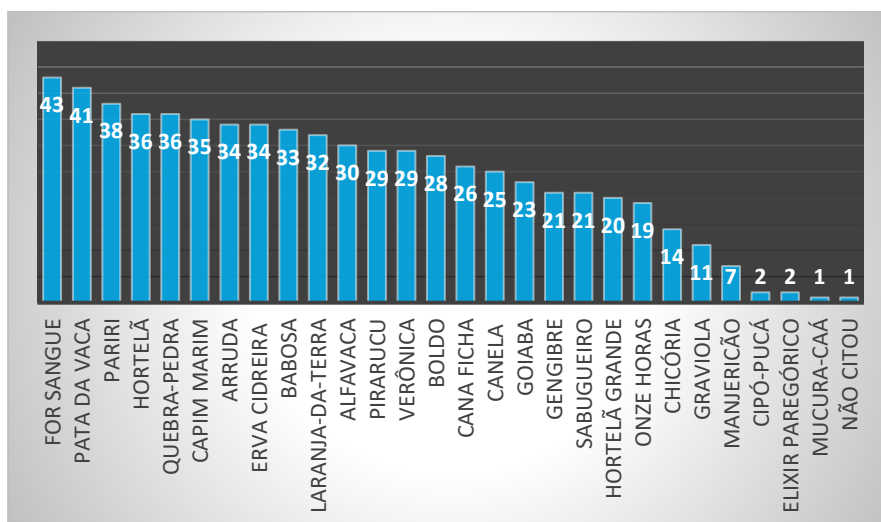
Classification of botanical families and quantity of species recorded by the project team at the locus of the research



Source: Authors, 2025.

Figure 2

Number of citations of medicinal plant species most used by the families of the interviewees from the Corcovado Community

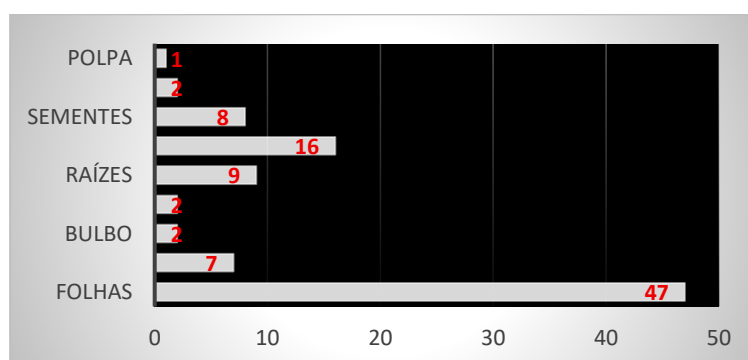


Source: Authors, 2025.

Regarding the parts most used in medicinal preparations, the leaf (47 citations) was the most cited, followed by the bark of the tree (16 citations) as can be seen in Figure 3. Some important factors for the leaves to be the parts used are easy access and prolonged availability throughout the year; in addition to its metabolite effects being more noticeable, unlike flowers and fruits (Falcão *et al.*, 2022). Another factor to highlight is that, even in large quantities, the use of leaves is not harmful to the plants, unlike what occurs when using the bark and root, which can compromise the vegetable (Carbolim *et al.*, 2024).

Figure 3

Number of citations of the most used parts of medicinal plants by the interviewees in the Corcovado Community

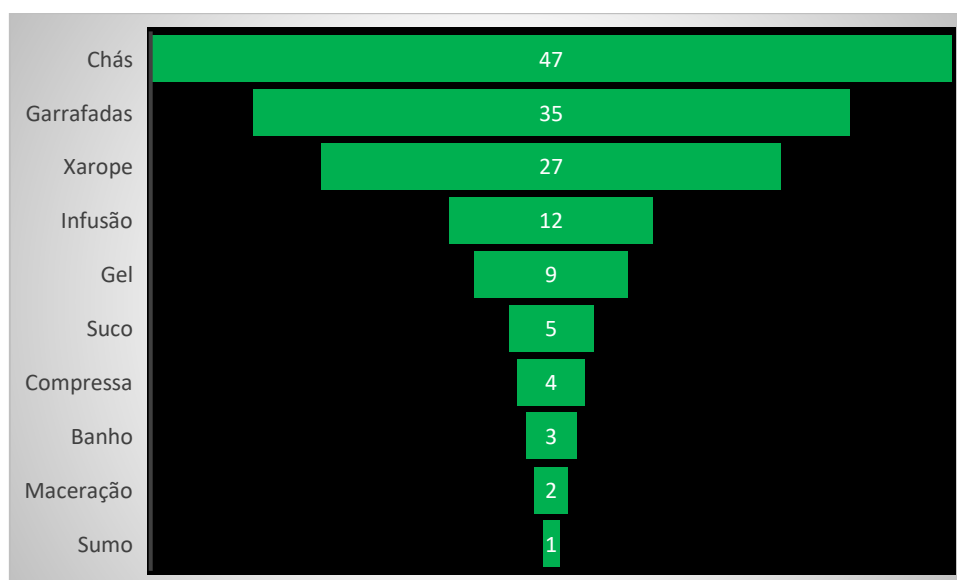


Source: Authors, 2025.

As for the most common method of preparation, tea was the most cited (47 citations), followed by garrafada (35 citations), syrup (27 citations) as can be seen in Figure 4. Teas are traditional preparations widely disseminated among people of different backgrounds and in different communities, constituting an ancient cultural practice (Mota-Santos *et al.*, 2021). In addition, the use of teas has been an alternative source for the vast majority of the population due to factors such as the high cost of industrialized medicines and, sometimes, restriction to a quality health system (Assis *et al.*, 2025).

Figure 4

Number of citations of the most used forms of preparation of medicinal plants by the interviewees in the Corcovado Community



Source: Authors, 2025.

The species of medicinal plants were indicated for the prevention and treatment of 66 symptoms and diseases, mentioned in the Category column in Table 2, which were classified into 13 categories of body systems, with circulatory system disorders and endocrine diseases, as the most relevant categories pointed out by the interviewees in the Community of Corcovado as shown in Table 2. Many studies in Brazil that use the Informant Consensus Factor (FCI) as a methodology, regardless of the region, present very varied values between the categories, however it is possible to identify a pattern in relation to Circulatory System Disorders, since in several studies they have cited the largest number of species for the treatment of diseases in this system, always appearing among the top three systems with the highest FCI (Ribeiro *et al.*, 2014; Saraiva, 2015; Vieira *et al.*, 2022). Endocrine diseases,

such as diabetes, do not usually appear in the first places taking into account the FCI. However, several factors can be pointed out for the prevalence of this category among the interviewees, such as socioeconomic inequalities, a situation experienced by the residents of the Corcovado Community who see medicinal plants as alternative sources for improving health indicators. According to Hoth *et al.* (2025), the analysis of DATASUS data showed that regions with lower per capita income and lower levels of education concentrate a higher burden of diabetes. Studies show that the North and Northeast regions concentrate municipalities with low human development indexes (HDI) and, therefore, present challenges such as a shortage of health professionals, medicines, and adequate infrastructure for the prevention and treatment of endocrine diseases (Fernandes and Carneiro, 2023; Melo *et al.*, 2022).

Table 2

Body System (CS), popular names of the species recorded, number of reported citations of diseases according to CS, forms of use and Informant Consensus Factor (FCI)

Category	Popular names of plant species	Number of citations reported	FCI
Circulatory system disorders (stroke, hypertension, blood pressure control, thrombosis, hemorrhoids)	Acerola, alfavaca, garlic vine, mulberry, stingray, coffee, cashew tree, chanana, two loves, guava tree, soursop, jambu, jackfruit, mangueira, mucura caá, eleven o'clock, elephant ear, palm tree, papiropoba, cow's paw,	45	0,52

	purple pine nut, pirarucu		
Endocrine diseases (diabetes, high cholesterol, blood glucose control, weight loss)	Acerola, alfavaca, arraia, coffee, cashew tree, fixed cane, cinnamon, pucá vine, copaiba, guava, soursop, jambu, jackfruit, mango, noni, palmitero, pariri, pata da vaca, allspice, quebra pedra,	35	0,44
Undefined symptoms (headache, fever, antispasmodic, anti- inflammatory, antimicrobial, analgesic and antioxidant activities, allergy)	Cotton, grown love, aranto, stingray, rue, aloe, boldo, cocoa, cashew, camapu, fixed cane, cinnamon, lemongrass, paregoric elixir, ginger, yellow ginger, large mint, peppermint, lime, cayano lemon, marupazinho, nutmeg, papiropaba,	48	0,29

	cow's paw, penicillin, allspice, fence pine nut, pirarucu, quebra pedra, rinchão and saratudo		
Skin diseases, lesions, poisoning and other external consequences (acne, itching, erysipelas, ringworm, healing, moisturizing, aging, wounds, burns and antiseptic)	Aranto, aloe, fixed cane, lemongrass, copaiba dois amores, for blood, soursop, jackfruit, lime, Galician lemon, marupazinho, nutmeg, eleven o'clock, palmiteiro, pariri, allspice, purple pine nut, pirarucu, rinchão, elderberry, saratudo, annatto, broom, veronica	34	0,27
Other indications (vomiting, hair strengthening, toothache, back pain, anemia, oral health, canker sores, improved	Grown love, mulberry, stingray, aloe, banana, boldo, cashew, cinnamon, camapu, holy grass, cipó	48	0,25

memory, and rheumatism)	pucá, for blood, ginger, yellow ginger, guava, soursop, large mint, peppermint, jambu, jackfruit, baby tear, earth orange, lime, cayano lemon, marupazinho, mucura caá, noni, ora pro nobis, pariri pata da vaca, allspice, fence pine nut, pomelo, saratudo, broom, veronica		
Disorders of the respiratory system (strengthening immunity, coughing, bronchodilator and expectorant actions, asthma, flu, colds, throat inflammation and tonsillitis)	Alfavaca, garlic vine, chanana, copaiba, yellow ginger, large mint, peppermint, jambu, orange, lime, cayan lemon, Galician lemon, mango, nutmeg, papiropoba, pariri, pomelo, elderberry,	26	0,24

	annatto, veronica		
Gastrointestinal system disorders (liver, ulcer, stomach pain, gastritis, and hepatitis)	Grown love, boldo, lemongrass, paregoric elixir, yellow ginger, large mint, peppermint, mango, nutmeg, eleven o'clock, pariri, rinchão, saratudo, broom, veronica	20	0,23
Nervous system disorders (Alzheimer's disease, tranquillizer, sedative action, anxiety)	Boldo, lemongrass, cupuaçu, lemon balm, peppermint, large mint, baby tear and cork oak	10	0,22
Disorders of the genitourinary system (urinary and vaginal infections, menstrual cramps, diuretic action and uterus)	Alfavaca, cotton, garlic vine, boldo, cinnamon, chanana, ginger, noni, pariri, allspice, purple pine nut, quebra pedra, broom	17	0,18
Infectious diseases (diarrhoea, malaria)	Saratudo, banana tree, cashew tree, guava tree,	7	0

marupazinho, amor grown-up and pariri			
Neoplasms (antitumor action, leukemia)	Aloe, banana, noni and pariri	4	0
Diseases of the musculoskeletal system (cramp and treatment of bone problems)	Banana tree and fence pine nut	2	0
Diseases of the eye (Conjunctivitis)	Pariri	1	0

Source: Authors, 2025.

Regarding the level of fidelity, the cow's leg (92.7%) stands out for the treatment of cardiovascular diseases and the blood leg (90.6%) for the treatment of anemia. Pariri (89.5%) was indicated as essential for anti-inflammatory activity, while peppermint obtained 83.3% for the same phytotherapeutic property. It is worth mentioning the importance of rue (88.2%) because of its analgesic activity. Veronica (86.2%) and cinnamon (84%) were pointed out as the main botanical species that help in the treatment of diabetes according to the NF. Finally, breaking stone was the main highlight in controlling blood glucose and reducing cholesterol (94.4%) and for the treatment of kidney problems (77.7%). In addition, lemongrass (74.3%) is an important medicinal plant to treat wounds.

5 CONCLUSION

The traditional knowledge of the residents of the Corcovado Community proved to be relevant, where the locus of the research presents a variety of medicinal plants where 66 botanical species for phytotherapeutic purposes were identified through photoFigureic records and comparison of these photos in the database present in virtual herbaria in the applications PI@ntNet Identify and the Re flora/CNPQ Program. Therefore, it is important that new research be carried out so that this important knowledge can be safeguarded, both for the use and production of drugs from these ethnobotanical species.

Regarding the methodological aspect, the lack of logistical support made it difficult to identify other species of medicinal plants and even the formation of exsicata that would be of fundamental importance to represent the flora of the Corcovado Community, as well as to

enable the evaluation of environmental impacts and subsidize agroecological management plans.

This research showed that the residents of the Corcovado Community have difficulties in accessing health services, which reinforce the dependence of the local population on natural therapeutic practices, and the interviewees use medicinal plants for the treatment of various symptoms and diseases, mainly related to disorders of the circulatory system and endocrine diseases. In addition to medicinal plants playing a central role in promoting health in the locus of research, the herbal practices carried out by the residents demonstrate respect for the conservation of the environment and are essential for strengthening belonging to the territory, maintaining ancestral knowledge and preserving sociocultural and environmental traditions in the Marajó Mesoregion. Therefore, it is recommended to carry out public policy actions that promote the sustainable management of natural resources and integrate health, environment and culture.

Phytotherapy and the ethnobotanical survey are subjects that must be constantly explored and discussed in favor of the strategic and significant planning of health agencies to guarantee the health and well-being of the population, especially community residents.

ACKNOWLEDGMENTS

To the Dean of Research, Graduate Studies and Innovation (PROPPG) of IFPA for the promotion of research through Public Notice No. 01/2025 - Girls in Science.

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MILITARY DOCTRINE AND TECHNICAL-MILITARY COOPERATION AS DRIVERS OF INDUSTRIAL DEVELOPMENT IN DEFENSE: STRATEGIC LESSONS FROM SOUTH AMERICA APPLIED TO THE ECUADORIAN CONTEXT

DOCTRINA MILITAR E COOPERAÇÃO TÉCNICO-MILITAR COMO MOTORES DO DESENVOLVIMENTO INDUSTRIAL EM DEFESA: APRENDIZADOS ESTRATÉGICOS A PARTIR DA AMÉRICA DO SUL COM APLICAÇÃO AO CONTEXTO EQUATORIANO

DOCTRINA MILITAR Y COOPERACIÓN TÉCNICA-MILITAR COMO MOTORES DE DESARROLLO INDUSTRIAL EN DEFENSA: APRENDIZAJES ESTRATÉGICOS DESDE SUDAMÉRICA CON APLICACIÓN AL CONTEXTO ECUATORIANO

 <https://doi.org/10.56238/sevened2025.036-017>

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ABSTRACT

The new contexts in the fields of defense demand flexible strategies and policies that enable adaptation and immediate responsiveness in crisis scenarios. This research focuses on analyzing doctrine as a regulatory category within technical military cooperation processes and how this relationship shapes policy progress and the development of defense industrial capacities in South America. Through a theoretical qualitative approach, based on a descriptive analytical and comparative document analysis, 23 academic articles and official documents were examined, highlighting doctrinal experiences, cooperation initiatives, and policy implementations aimed at strengthening the regional defense industrial base. The results reveal the need to transform doctrine, consolidate its adaptive nature, and foster the emergence of technical military cooperation programs as key pillars for the technological advancement of States. Furthermore, the study emphasizes the necessity of reformulating Ecuador's defense doctrine to integrate national capabilities, reinforce technical ties with regional strategic partners, and promote a civil – military technological innovation ecosystem.

Keywords: Military Doctrine. Technical-Military Cooperation. Defense Industry. Adaptive Doctrine. Military Interoperability.

RESUMO

Os novos contextos na área da defesa exigem estratégias e políticas flexíveis que possibilitem adaptação e capacidade de resposta imediata em cenários de crise. A presente investigação concentra-se na análise da doutrina como categoria reguladora dos processos de cooperação técnico-militar e na forma como essa relação condiciona os avanços das políticas e o desenvolvimento das capacidades industriais de defesa na América do Sul. Por

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meio de uma metodologia de abordagem teórico-qualitativa, baseada em análise descritivo-analítica e documental, com perspectiva comparada. São examinados 23 artigos acadêmicos e documentos oficiais que evidenciam experiências doutrinárias, de cooperação, desenvolvimento e aplicação de políticas voltadas ao fortalecimento da base industrial de defesa regional. Os resultados revelam a necessidade de transformação da doutrina, da consolidação de seu caráter adaptativo e da emergência de programas de cooperação técnico-militar como alicerces para o avanço tecnológico dos Estados. Ademais, destaca-se a necessidade de reformulação da doutrina equatoriana, de forma que integre capacidades nacionais, fortaleça os vínculos técnicos com parceiros estratégicos regionais e promova um ecossistema de inovação tecnológica civil-militar.

Palavras-chave: Doutrina Militar. Cooperação Técnico-Militar. Indústria de Defesa. Doutrina Adaptativa. Interoperabilidade Militar.

RESUMEN

Los nuevos contextos en defensa requieren estrategias y políticas flexibles que permitan adaptación y capacidad de respuesta inmediata en escenarios de crisis. La presente investigación se enfoca en el análisis de la doctrina como categoría reguladora de los procesos de cooperación técnico-militar y esta relación como reguladora de los avances de las políticas y el desarrollo de las capacidades industriales de defensa en América del Sur. Mediante una metodología de enfoque teórico-cualitativo, basado en un análisis descriptivo-analítico- documental con visión comparativa, se examinan 23 artículos académicos y documentos oficiales que visibilizan experiencias de doctrinas, cooperación, desarrollo y aplicación de políticas que generan desarrollo de la base industrial de defensa regional. Los resultados evidencian la necesidad de la transformación de la doctrina, la generación de su carácter adaptativo y la necesidad emergente de programas de cooperación técnico-militar como base de generación de avance tecnológico de los estados. Además, la necesidad de la reformulación de la doctrina ecuatoriana que integre capacidades propias fortalezca los vínculos técnicos con socios estratégicos regionales y promueva un ecosistema de innovación tecnológica civil-militar.

Palabras clave: Doctrina Militar. Cooperación Técnica-Militar. Industria de Defensa. Doctrina Adaptativa. Interoperabilidad Militar.

1 INTRODUCTION

In the dynamic geopolitical landscape of the twenty-first century, Latin American states are challenged to strengthen their strategic defense capabilities without reproducing patterns of technological or doctrinal dependence. In particular, in the case of South America, there is a growing need for the coherent articulation of military doctrine, military-technical cooperation and the development of a defence industrial base that responds to national interests. This interrelationship not only reconfigures the classic notion of security, but also consolidates itself as a central axis in the construction of technological sovereignty and strategic autonomy. In this sense, military doctrine ceases to be an isolated body of legislation and becomes a policy tool that serves as a guide in the operational and industrial spheres. In this study, the existence of a structural gap in the Ecuadorian case will be assumed: thus, despite the relative advances with professionalized armed forces and a geostrategic location of relevance, it presents serious deficiencies at the doctrinal level, little linkage between international cooperation and technical-industrial capabilities, and a scarcely integrated productive base for defense. In fact, the latter has led to a historical dependence on external inputs, little capacity for technological absorption and a markedly reactive doctrine, inappropriate for its regional environment and the emerging hybrid challenges. In this way, this work should focus on this scheme. Thus, the central purpose of this paper is to analyze the strategic role of military doctrine as an articulating axis for the integration between military-technical cooperation and defense industrialization, in the light of regional experiences such as those of Brazil, Colombia, Chile, Argentina, the Dominican Republic, and Venezuela. Within this framework, the specific purpose lies in identifying doctrinal patterns, structural tensions and opportunities for convergence between these three dimensions in order to formulate proposals applicable in the Ecuadorian case. Methodological, the research is framed in the field of strategic and defense sciences, with a qualitative, theoretical-descriptive and comparative approach. The documentary analysis, supported by a bibliographic selection of 23 academic and official sources, supports the study based on cases of South American countries selected for their doctrinal and industrial importance. This analysis aims to contribute to the collection of knowledge that serves as an input for information that allows the formulation of inclusive and independent national policies, among doctrines, cooperation and industrial capacity, to contribute to the design of coherent, sustainable and sovereign national strategies. Therefore, it can be located that the present proposal is located in the category of peace and war, more specifically in studies that link the doctrine and formulation

of militarist policies. It also seeks to enrich the current discussion on strategic autonomy with a critical and proactive vision. Based on experiences learned in South America, it is proposed to argue that the doctrine is no longer just the engine of the operational thinking of the Armed Forces, but an activator of innovation, regional integration and autonomous industrial development.

2 THEORETICAL FRAMEWORK

2.1 MILITARY DOCTRINE AS A STRUCTURING AXIS

According to Jordán (2023), military doctrine is composed of three elements: theory, culture, and authority, this forms the fundamental trilogy, by which the Armed Forces orient their actions to the achievement of objectives, encompassing a generalized concept that is applied to the different levels of military operations. Military doctrine has traditionally been understood as a normative and conceptual body that prepares and guides the military organization for efficient use in predefined scenarios. However, when executing the planning of military operations, uncertain scenarios are presented, characterized by their unpredictability and ambiguity, so flexibility is required in their application and, above all, the analysis, evaluation and correct decision-making of the human factor, also taking into account that the academic interest, specifically of the doctrine, has had a significant decrease in strategic studies.

According to Piedrahita and Torres (2022), it is constituted as a dynamic system of institutionalized ideas that articulates strategic, operational, and technical knowledge, responding to both national realities and external influences. Cardona (2022), on the other hand, when studying the Colombian case, states that the doctrine is not a priori, but derives from operational experience, institutional transformation, and international cooperation efforts. Therefore, it is necessary to take into account military doctrine as a priority and fundamental issue.

From a conceptual point of view, it is quite possible to identify at least three fundamental approaches to the meaning and function of military doctrine in general. First, as a prescriptive phenomenon, doctrine is described as a set of norms, which are formal and limiting in terms of establishing the requirements that just mentioned guide the "action" of military forces at all levels of their command. In other words, the doctrine is a kind of "anchoring," and it is something that offers the military "a total of structurally anchored guidance" by providing a unified standardized reference basis for decision-making; the

second, more pragmatic, sees doctrine as a flexible tool, aimed at providing an effective response to harsh operational realities. Here, flexibility and the ability to adapt to constantly evolving factors are superimposed on doctrinal rigidity, allowing a better connection between strategic and tactical principles; and, the third approach sees doctrine as a symbolic instrument, a bearer of institutional meaning that strengthens the identity of the armed forces and gives legitimacy to decisions at the high command level (Angstrom, Widen, 2016; Posen, 1984; Kier, 1997). This typology allows us to understand how doctrines are shaped by internal strategic demands, such as organizational culture or national political needs, external demands derived from the geopolitical environment or emerging threats, and technology transfer processes that incorporate innovations through military-technical cooperation or the defense industrial base (Farrell, 2008; Posen, 1984).

A recurring pattern in military doctrinal evolution is its ability to adapt to local, regional, and global scenarios in constant transformation, especially based on the analysis of lessons learned by like-minded organizations. Along these lines, Angstrom and Widen (2016) argue that modern doctrines often contain a fusion of prescriptive and pragmatic principles. It notes that "all current operations are prescriptive, but they also all have sufficient flexibility and room for manoeuvre to allow those who use them to take a more pragmatic approach."; This approach is critical to respond to a challenge as dynamic as hybrid conflicts, which contain elements of regular tactics and irregular warfare. In this sense, doctrinal responses must be both revolutionary and adaptive. At the same time, cyber dimension is increasingly reflected in contemporary military doctrine. This transformation, identified by Libicki (2009), has resulted in the development of doctrinal frameworks that focus particularly on cyber defense capabilities and working together with international allies and partners. It is not just a technical exercise: it is clearly a signal that public policy must build institutional capacities for specialized education and training in new technology and make international cooperation more effective. Along the same lines, Posen (1984) warns that doctrine fulfills functions that transcend the operational, as it is frequently aligned with national political interests, serving as a mechanism of legitimation and institutional cohesion. These elements allow us to affirm that the design of public policies in defense must contemplate a sustained investment in technological innovation, supported by versatile and effective regulatory frameworks.

However, there are also underlying tensions that drive this doctrinal process. One of the clearest is the distance between regulatory invariability, which is essential for a uniform operation in which a response of cohesion and stability is necessary, as well as the need for

greater flexibility in a world that is so susceptible to variability in which what is a greater good today, a damage tomorrow. On the one hand, regulatory frameworks must support organizational cohesion and control when actions occur in a predisposed environment. On the other hand, tactics must be flexible when the enemy presents an unconventional asymmetric threat. For example, Angstrom and Widen (2016) warn that regulatory reinforcement is beneficial for the use of different weapons in an operational environment, equally required as reinforcement of military action, because an operational environment in which the rules of engagement are not previously stipulated becomes an uncertain environment. Similarly, Farrell (2008) highlights how a more pragmatic approach supports greater control and promotes decision-making in a mobile theater of operations. Hoffman (2007) confirms that hybrid conflicts challenge the rigidity of traditional doctrines and that we win the war through speed. This tension is exacerbated in multinational operation scenarios, where the requirements for coordination between forces with different institutional cultures and technological levels increase complexity. Farrell et al. (2013) insist that this type of friction requires more flexible doctrinal frameworks, supported by training processes adapted to strategic volatility and the intensive use of emerging technologies, as Klein (1998) already anticipated. In this sense, it is crucial that military doctrines are periodically subjected to revisions and practices that allow adaptation without undermining discipline, as proposed by Libicki (2009).

On the other hand, from a critical point of view, one could also state that, while the doctrinal prescription helps to shed light on some of the procedures, it can also quickly turn against dealing with situations of extreme uncertainty such as cyberattacks or hybrid threats. In such cases, autonomous decision-making and the ability to integrate multiple vectors of action become decisive factors. Hoffman (2007) stresses that this type of conflict demands complex operational structures that often come into friction with traditional models of rigid command.

In addition, another structural tension emerges: the one between the aspiration to national sovereignty and the need for technical-military linkage with external actors. With regard to interoperability with potential allies, Farrell et al (2013), with a certain NATO framework, cautions that the integration of distinctive military capabilities not only improves collaboration, but also increases vulnerability in terms of strategic autonomy. With numerous reasons for concern, countries can also become overly dependent on technologies from other countries. Such dependence is not only applicable, but also a problem for essential areas

such as cybersecurity assurance and artificial intelligence. In addition, according to the same author, the relationship between prioritizing investments in conventional capabilities or in new and emerging domains, such as space and digital, leaves governments with insoluble strategic dilemmas. Therefore, these tensions require public policies that combine standardisation with flexibility, and that, in addition, promote the development of a defence industrial base capable of guaranteeing margins of technological autonomy and operational sovereignty. Resolving these frictions is key to ensuring operational effectiveness in volatile contexts.

In terms of opportunities, the need to integrate emerging technologies, such as artificial intelligence and autonomous systems, allows the development of predictive and rapid response capabilities, according to Singer and Brooking (2018). This opens the door to policies that promote research and development in the defense industrial base, seeing doctrine as a base element of military-technical cooperation, to standardize procedures, align common objectives, and share intelligence, strengthening collective resilience (Farrell et al., 2013).

A critical examination of the patterns, tensions, and opportunities identified leads to the fundamental broad outlines that should guide the formulation of public policies in national defense. First, a more adaptable military doctrine must be encouraged. It should be a doctrine that allows commands to make adjustments to the running of their operations in real time, a level of dynamism that is adaptable enough to work in volatile and ever-evolving environments. This doctrinal adaptation must also be reflected in the need for a radical change in training and training processes, which must emulate "realistic" environments characterized by uncertainty and be in constant change. This approach is needed as tools will eventually become more sophisticated, and artificial intelligence, in particular, would be a no-brainer in supporting operational and emergency decision-making (Klein, 1998). This doctrinal flexibility must be consolidated as a strategic competence, not as an exception in the face of the unexpected.

Secondly, it is a priority to advance in the development of a robust and technologically sovereign defence industrial base. To this end, public policies must direct investments towards the local production of dual-use technologies – civilian and military – that reduce structural dependence on foreign inputs and systems, as suggested by Alic et al. (2006). This industrial autonomy will not only strengthen the strategic-operational capacities of the State, but will also boost key sectors of the national and regional productive apparatus, as well as

the direct connection with new technological scenarios, improving the capacity to respond at critical moments.

Thirdly, it is necessary to intensify military-technical cooperation, prioritising agreements that promote interoperability without sacrificing strategic autonomy. It is not only a matter of aligning with common standards, but of doing so from a position that safeguards national interests and allows the transfer of knowledge and technologies under conditions of reciprocity (Santos, 2020). In addition to allowing the strengthening of the capacities of each state, sharing learning and lessons learned and promoting joint technological developments.

Finally, it is crucial to claim the place of doctrine as a strategic instrument of national security, not only in its operational dimension, but also as an articulating axis of communicational and technological capacities. In this sense, it is urgent to move towards a public policy of strategic communication that makes it possible to raise awareness among both institutional actors and citizens about the need to have their own, up-to-date and functional doctrines. In terms of domestic policy, such a strategy would have to be directed in the sense of generating internal legitimacy, strengthening internal cohesion and fostering greater social support to ensure that it is in the process of doctrinal modernization. This raises the need for a systemic approach that connects continued investment in military capabilities, support gained in the training of highly skilled technical and strategic cadres, and defense diplomacy that supports civilian leaders implementing substantive transformation. Therefore, only in this way, the evolution of doctrine will have the relevance and opportunity necessary to keep pace with a rapidly changing global environment.

2.2 MILITARY-TECHNICAL COOPERATION AS A DOCTRINAL VECTOR

Military-technical cooperation, conceived as the framework of relations between states, international organizations and industries for the development, transfer and sharing of technological capabilities applied to defense, is today an unavoidable strategic component to strengthen national security in an international context marked by uncertainty and complexity (Johnson, 2025). Far from being a simple mechanism for external assistance, this form of cooperation operates as a true doctrinal vector, capable of directly influencing the configuration of regulatory frameworks, operational structures and high-level political decisions.

Critically analyzing the patterns, tensions, and opportunities that run through this dimension allows us not only to understand their impact on the military capabilities of states,

but also to guide the formulation of public policies that favor the efficient use of resources, promote sustained processes of technological innovation, and achieve a prudent balance between regional and international interoperability. on the one hand, and strategic autonomy, on the other (Bonsenberg, 2020).

That is why the definition of military-technical cooperation will be used as the form of defense diplomacy that involves technology transfer, joint training, doctrinal exchange, and operational assistance. Ionescu (2022) demonstrates how Brazil-Russia cooperation was simultaneously a path of technological modernization and a process of doctrinal convergence. In addition, Kurylo (2024) and Pyatakov (2022) point out how the United States, China, and Russia have used military assistance as a mechanism of doctrinal influence in Latin America. These dynamics reveal that cooperation is not a neutral process: imported doctrinal frameworks are adapted, resisted, or transformed according to the institutional capacities of the recipient countries (Mijares, González, 2021).

Thus, the doctrine becomes an interface between external military assistance and strategic national appropriation. A dominant pattern in military-technical cooperation is the search for interoperability among allies to face common threats. In a similar achievement, Farrell et al. (2013) underline that alliances such as NATO have managed to establish a high degree of technological and procedural standardization; therefore, joint operations are perfectly coordinated. By carrying out joint projects, NATO has also shown that interoperability can lead to greater operational capability if planned strategically (Cheung, 2021), i.e., affirms the existence of the pattern. Although, in military-technical collaboration, this pattern refers to the joint use of technology, including missile defense equipment and AI. At the same time, it is taking place with motivations driven by the urgency to fight modern threats, which can come from both non-state actors and emerging regional powers.

In this regard, Alic et al. (2006) argue that technology transfer agreements not only raise the operational level of the armed forces, but also promote innovation within defense industrial bases, especially in dual-use technologies. These processes suggest that public policies should prioritize the signing of agreements that not only strengthen shared capabilities, but also promote joint research projects, positioning military-technical cooperation as a key instrument to maintain and project strategic advantage.

However, various barriers and sources of tension mark the evolution of the field of military-technical cooperation. Among the most obvious—and perhaps most substantive—sources of tension is that concerning the relationship between state sovereignty and the

growing dependence on foreign technology. As Bitzinger (2016) warns, states whose own defense architecture is based on critical systems supplied by outsiders expose themselves to risk in terms of the deterioration of their own strategic autonomy, particularly in terms of changing geopolitical conditions. It is not, therefore, a tangential or peripheral phenomenon, but a key aspect concerning the room for maneuver of states in conflict or other forms of international extortion. A second source of tension is provided by the tension between standardization—favored by multilateral frameworks—and the capacity for endogenous doctrinal innovation. While interoperability arrangements allow for the deployment of joint forces more efficiently, they also impose constraints on the ability to determine doctrines contextually tailored to national history, geography, and socio-political idiosyncrasies. This is evidenced by Farrell's (2008) NATO case, whose research suggests that interoperability arrangements can serve as an anchor that prevents the evolution of more flexible and contextually sensitive local doctrinal approaches. A third source of relevant tension is given by the risks around the transfer of sensitive technology. In the absence of appropriate regulatory and safeguarding frameworks, technology can result in a leakage of key strategic knowledge and, therefore, an erosion of the host state's structural security capacity. Libicki (2009) already warned that, in an environment of increasing cyber-interdependence, sharing critical information without adequate protection measures can open deep cracks in the national defense system.

Faced with this panorama, it is essential that public policies achieve a delicate balance: consolidating strategic alliances without giving up on the protection of fundamental interests. Developing a robust national defense industrial base—capable of absorbing, adapting, and even innovating based on cooperation—is a necessary condition for reducing dependency and mitigating strategic risks (Andrade, 2020). Reconciling these tensions implies assuming a clear and lucid negotiating position, but with a long-term perspective, when defining military-technical cooperation agreements. However, beyond the tensions, there are also relevant opportunities that cannot be missed. Joint research and development—especially in areas such as artificial intelligence and cybernetics—allows states to access recent technological advances, but without having to bear the high costs that such development may entail in its entirety, as Alic et al. (2006) point out. In the same vein, practices such as tied military exercises and routine intelligence sharing—also highlighted by Farrell et al. (2013)—are not only instruments for raising the standards of hybrid threat preparedness, but are also elements that can be converted into strategic trust among allies. As long as they are part of

a long-term perspective, they allow for the generation of operational synergies and the construction of more robust and sustainable ties of cooperation. To this end, it is necessary for public policies to adopt a proactive approach of concluding bilateral and multilateral agreements with concrete incentives for technological co-production, together with robust clauses that ensure the protection of sensitive information aligned with this long-term vision. In this sense, it is worth remembering what Bitzinger (2009) outlined regarding the importance of traditional partners in regional technological development. The effective implementation of these measures will require not only a fine balance between international collaboration and national development, but also coherent strategic diplomacy and a forward-looking vision that articulates sovereignty, innovation, and security in an integrated manner.

2.3 DEFENCE INDUSTRIAL BASE AND STRATEGIC AUTONOMY

The IDB is a more complex piece than a simple system of deep factories for the supply of military equipment. The IDB forms an interconnected judgment ecosystem of relationships through technologies, critical infrastructure and facilities, laboratories and research centers, design firms, and logistics networks. This set of special relationships forms the production of goods and provision of services in the direction of improving the strategic capabilities of the armed forces. As a result, the IDB consists of weapons systems, electronic platforms, next-generation tactical vehicles and disposition, disruptive technologies such as artificial intelligence.

Alic et al. (2006) emphasize that the IDB does not only fulfill an operational supply function, but also constitutes a driving force for dual-use technological innovation, with direct impacts both on defense and on key civilian sectors. Therefore, its role is not merely logistical: it is projected as a structural element of national development. Along the same lines, Bitzinger (2016) states that: "first, a robust industrial base not only expands the margin of state strategic autonomy but also drastically reduces exposure to external vulnerabilities in supply, given the decreasing dependence on foreign suppliers in critical areas." Consequently, strengthening the defence industrial base is a necessary condition for technological sovereignty and defence autonomy. In effect, the IDB stands as the industrial mainstay of a country's military capacity, providing it with structural resilience in the face of global threats and room for maneuver for autonomous decision-making in defense matters. However, the development of a robust and sustained IDB over time cannot be conceived apart from a clear and functional military doctrine. The specialized literature underscores this interdependent relationship:

Cheung (2022) and Bitzinger (1994) warn that innovation in defense does not occur in a vacuum, but within doctrinal ecosystems that integrate strategic vision, technology, industrial capabilities, and human talent.

In this way, it is constituted as the guiding axis that makes it possible to comply with operations, with a vision to walk hand in hand with technological advances within the framework of a defense policy aimed at the consolidation of strategic autonomy. Its function is not restricted, then, to the definition of operational guidelines; acquires, as a structure, the ability to give meaning and direction to the different components involved in the defense system – technology, industry, training and international cooperation – under an articulating gaze. In the case of the South American region, the development of the A-Darter missile, conceived from a process of technological cooperation between Brazil and South Africa, clearly demonstrates the risks of advancing on complex initiatives without the support of a robust doctrine that guides, supports and projects long-term efforts. As Santos and Oliveira (2023) foresee: the lack of a doctrinal framework ends up encouraging institutional fragmentation, political discontinuity and lack of technical sustainability, weakening the strategic power that such undertakings could result. In addition, Magnani (2020) reinforces this idea by pointing out that the countries of the region have transitioned between import substitution models, South-South cooperation schemes, and periods of high external dependence, without managing to consolidate a comprehensive defense policy model based on technological sovereignty and strategic autonomy. In this scenario, it is evident that the doctrine cannot be a mere regulatory compendium: it can constitute a tool for political leadership and industrial planning.

Finally, the insertion of the IDB, as a link between the IDB and military-technical cooperation, materializes in co-production agreements, technology transfer schemes and joint development of strategic capabilities. As instances of articulation that both optimize available resources and redistribute risks more equitably, as well as enable the creation of sustainable synergies between States, armed forces and national industries. However, for such processes to reach their transformative potential, it is imperative that public policies recognize the IDB not as a simple operational instrument, but as a long-range strategic asset. This recognition must be firmly anchored in a proactive doctrinal vision, coherent with the needs of the environment and focused on the real strengthening of national autonomy in matters of defense. Farrell et al. (2013) highlight that alliances such as NATO facilitate the exchange of critical technologies, such as cyber defense systems, strengthening the IDB of

member countries.

Bitzinger (2016) recognizes that, in the best of cases, this collaboration allows the IDB to access foreign innovation but also poses ties of dependence. In addition, military doctrine relates to the IDB since it needs it to translate operational requirements into technological solutions. Angstrom and Widen (2016) highlight that modern doctrines impose the need for advanced technologies, such as autonomous systems, which means that the IDB needs them to achieve strategic objectives. For example, a doctrine that is aware of hybrid warfare requires the IDB to produce dual equipment, such as drones or electronic countermeasures. Another pattern in the IDB is a direct connection to technological innovation since all modern BIBs are highly dependent on it to maintain strategic advantage. Alic et al. (2006) explain that modern BIDs have adopted a focus on dual-use technology, which is artificial intelligence and which is crucial for the civilian economy and defense in a complementary way. Today, one of the most significant patterns in the recent evolution of the defense industrial base is the astonishingly increasing globalization of supply chains. Therefore, to this day, many States can still obtain highly specialized components in technological terms, which only a few decades ago, would be inaccessible to their local capabilities. However, this degree of integration and internationalization of technology transfer at the IDB at the same time raises several new issues. However, along with increased interdependence, new sources of vulnerability to geopolitical conflicts emerged. In this sense, Bitzinger (2016) warns that dependence on strategic nodes located in foreign territories can significantly compromise the operability and security of national defense systems, becoming a latent threat to strategic autonomy.

Added to this dynamic is the proliferation of co-production schemes with strategic allies, which, while expanding national capacities, also introduce external constraints. A case in point is the multinational development of the F-35 fighter, where technical interoperability and transnational collaboration are seen less as options but rather as front-line strategic imperatives (Farrell, 2008). Moreover, it is increasingly clear that the IDB's doctrinal agendas and innovation pathways are converging. This transversality allows technological advances to better respond to emerging, cyberspace, and orbital region threats, thus creating a new battlefield, constructions, and challenges (Johnson, 2021). These trends not only reflect the substantive rules of change in the forms of production and cooperation on this issue. In addition, they illustrate the inevitable urgency of examining public policies from the perspective of the military-industrial ecosystem and the urgent need to prioritize their agility

and innovation. However, they also set the most pervasive structural stresses. The most fundamental says that situations of protectionism are too untenable because of the desire to guarantee our national autonomy and not allow larger-scale foreign states to influence our militaries. While collaboration with external partners facilitates access to cutting-edge capabilities, it can also condition sovereign decisions, especially when it comes to critical components or sensitive strategic technologies (Bitzinger, 2016). Added to this problem is budgetary pressure: the development of cutting-edge technologies requires substantial investments that force States to establish hierarchies between conventional and emerging capabilities, as Alic et al. (2006) point out. This strategic choice does not always respond to technical criteria, but to political or logistical factors. In addition, the competition between the public and private sectors within the IDB introduces another source of friction: while states demand solutions with a high national impact, companies prioritize economic profitability.

In the same vein, Libicki (2009) adds that, when sensitive technologies such as cyber defense systems are incorporated, security risks also increase if intellectual property rights are not adequately safeguarded. Finally, the IDB's subordination to strongly centralized and rigid doctrines limits the ability to investigate disruptive innovations that are not within the scope of prioritized military concerns. In the face of the set of tensions already mentioned, it is imperative to design public policies that combine sustained investment, clear regulatory frameworks and flexible international cooperation mechanisms. This is the only way to make the IDB's strategic role possible without compromising innovative development or jeopardizing national security.

In contrast, clear opportunities are also emerging that can be capitalized on through informed policy decisions. Strategic investment in emerging technologies—particularly artificial intelligence, autonomous systems, and space capabilities—allows states to access high value-added technological niches (Johnson, 2021). Military-technical cooperation, on the other hand, opens up the possibility of reducing high research and development costs through joint projects, accelerating implementation times and expanding interoperability margins (Farrell et al., 2013).

On the other hand, the Defense Industrial Base (IDB) is a multiplying factor for the national economy, since it allows the generation of qualified employment, energizes local industry and promotes applied research in strategic civilian sectors, especially invoking the dual use of technologies. The integration between the doctrine and the IDB makes it possible to boost the operational capabilities of a State, accompanied by anticipated solutions to

threats such as hybrid conflicts or cyberattacks, through the implementation of innovative and contextualized solutions proposed. In this sense, given technological evolution and internationalization, it implies paying attention to synergy, that is, the efficient coordination between the State and the market to capitalize on potential; therefore, a specific public policy is needed that implements tax incentives for innovation in defense, regulations that ensure the co-production of safe technology, and concrete training of operational skills at the IDB's demand. With these analyses, the concept of the IDB ceases to be simply a logistical link and takes center stage as a strategic investor in national security and development, according to Johnson (2021). In short, countries must form an active and equitable engagement with allied countries without sacrificing the politics of decision-making. With this in mind, several strategic recommendations are proposed that can facilitate the future development of defence policy. First, investment in new technologies, particularly in artificial intelligence and semi-autonomous systems, must be strengthened and oriented towards an application of IDB research. In addition, the supply chain must be more diverse, both to reduce operational disruption and to allow consumers to enter controlled industries such as the defense sector. Third, according to the Governments, they must sign military-technical cooperation agreements. Finally, to ensure alignment with the interests of the military defense doctrine, it is necessary to ensure mechanisms that allow the viability of operational demand in industrial projects. In this order of ideas, public communication has an active role in making visible the economic and strategic value of the defense industrial base. The technical policies designed are not enough, it is necessary to build a solid and convincing narrative that poignantly presents the synergies between defense, technological innovation and collective well-being. Our argument has been to propose a radial and long-term vision that combines strategic autonomy, institutional collaboration and promotion of applied research. In this framework, positioning the defense industrial base as a true engine of national development implies the identification of concrete links with sectors such as technical education, science and advanced industry. To do this, people must identify at the base not only an isolated or exclusively military expenditure, but a source of specialized jobs, technological sovereignty and productive capacities. The construction of a coherent, sustained and transversal narrative also has the potential to politically shield investments in defense, preventing setbacks due to partisan ups and downs or international pressures. When the IDB is integrated into the civilian agendas of innovation, sustainable development, and higher education, its legitimacy expands beyond the military sphere. Thus, a defense model is

consolidated that not only fulfills deterrent functions, but also actively contributes to the country.

3 METHODOLOGY

3.1 TYPE OF RESEARCH

This study is based on a theoretical-qualitative, descriptive-analytical approach and with a regional comparative perspective. This approach involves the use of the form of documentary analysis involving historical material and contemporary documentation, facilitated by an approach to content speech analyzed in terms of the interpretive argument of the underlying discursive patterns. Within the categories of analysis: doctrine, military-technical cooperation and defense industrial base, the process focused on determining the subcategories: patterns, tensions and opportunities, which allow future public policies in the field of national defense to be guided.

3.2 SOURCES AND DOCUMENTARY CORPUS

23 documents were analyzed, including academic articles, books, case studies and official documents published between 2003 and 2024. They were found in the Scopus, SciELO and Web of Science databases, located by the following Boolean search engines: doctrine category: "military doctrine" AND "technical military cooperation" OR "military doctrine*" AND "military-technical cooperation" OR "technical cooperation" AND "doctrine". It includes experiences from Brazil, Colombia, Argentina, Chile, the Dominican Republic, Venezuela, and Ecuador, selected for their doctrinal, technical, and industrial relevance.

3.3 ANALYSIS TECHNIQUE

Although the present research is based on a thematic documentary analysis, the use of axial coding techniques allowed the organization and interpretation of the analyzed material in a systematic and rigorous way. Through this qualitative methodology, three main analytical categories were identified: doctrine, military-technical cooperation and defence industrial base. Likewise, each of them corresponded to three cross-cutting subcategories: patterns, tensions and opportunities. This structuring not only facilitates the establishment of conceptual links between the contents analyzed, but also unravels the underlying dynamics that sustained and sustain the development of strategic capabilities in the field of defense, especially in the South American region.

3.4 LIMITATIONS

The study is based on secondary sources; It does not include interviews or original empirical data. Therefore, there is no access to the perspective of the actors involved. The comparison focuses on selected cases; it does not cover the entire continent. Therefore, the vision is not complete, however, it is counteracted by including in the analysis the cases of the countries with the greatest doctrinal relevance on the continent. The applicability to the Ecuadorian case is exploratory, in the absence of recent publicly available official doctrinal documentation.

4 RESULTS AND DISCUSSIONS

The documentary analysis made it possible to establish the existing relationships between the categories: doctrine, military-technical cooperation and defense industrial base with their fundamental contribution to the generation of defense public policies in the different countries of South America. In addition, it was possible to establish the axes of regional analysis regarding: the forms of development and application of the doctrine (patterns), the sources of tension that drive apparent conflicts (tensions) and the various defense strategies that can be combined with technology transfer processes (opportunities).

The findings show that there are countries with greater doctrinal development in South America (Colombia and Brazil), and that by maintaining doctrines with a pragmatic emphasis they can adapt and guide their applicability in complex operational scenarios, which respond to the current requirements of conflicts. Above all, considering technological, tactical and weapons innovation and transformation, from the perspective of the contribution of technology and the establishment of new forms of conflict such as: cyber warfare, the use of drones that guarantee the effectiveness of the attack and multinational operations. Adaptability that guarantees the application of conventional and unconventional tactics, conjugation of tactical-operational levels, developing a strategic vision according to the new world scenarios.

4.1 MILITARY DOCTRINE

Regarding the patterns observed, we can verify that in all the South American countries analyzed there has been a significant doctrinal evolution in recent years; one that has ranged from a relatively prescriptive set of initial models to hybrid operations that combine regulatory contexts, structured framework with flexible practices. In this sense, the transition

would seem to have been more of a search for a balance between institutional standardization – necessary for cohesion and interoperability – and tactical autonomy – essential to be able to interact effectively with an increasingly uncertain environment of combat scenarios. At the same time, military doctrine has acquired a greater articulation in relation to emerging technological threats, although cyberwarfare, hybrid operations and, in certain cases, projections of quantum scenarios. This complex of doctrinal mandates not only requires operations to be more innovative, but also represents that more frequent and systematic doctrinal review mechanisms should be adopted that could be developed around massive changes in results in the strategic environment.

In terms of tensions, to a large extent, military doctrine faces friction between the need to be unifying through common norms and procedures and the requirement to respond immediately to ever-changing realities, such as asymmetrical conflicts and unconventional events. In this sense, a basic structural tension is identified between, on the one hand, the national doctrinal orientation and, on the other, the need for, in contexts of cooperation, doctrines of another type, supranational. This friction establishes the danger of strategic coherence if it is not managed with a vision of complementarity and not of doctrinal subordination.

In terms of opportunities, doctrinal dynamism could be transformed into an instrument of strategic projection if it is channeled into the construction of capacities that are, at the same time, interoperable and flexible. This would make it possible for the Armed Forces to insert themselves into multinational security networks without granting operational sovereignty. It could also function as a tool for the formation of a national defence innovation agenda, if it is used as a framework for combined exercises, artificial intelligence simulations and validation of new operational concepts, as a bridge between strategic planning and technological transformation.

4.2 MILITARY-TECHNICAL COOPERATION

A dominant pattern in the region is the use of military-technical cooperation as a channel for indirect doctrinal transfer. Military assistance and bilateral agreements not only deliver equipment, but also entail operational principles that ultimately modify local practices. International cooperation has tended to consolidate itself in regional or hemispheric interoperability schemes that generate common platforms for instruction, doctrine and crisis management that, in turn, promote the standardization of responses to globalized threats.

There are also permanent frictions resulting from the conflict, between the need to adopt doctrinal frameworks, platforms and/or equipment that allow the Armed Forces to respond to the world in a national context and to safeguard the national operational or professional security identity with strategic partners. Worse, these frictions will not disappear when there are no agreements. There are also socio-political frictions that emerge from an inherent technological imbalance between a country and its ally. In many cases, recipient countries do not have sufficient capacity to absorb these technologies, culture and doctrine independently and autonomously, entering into structural capitulations with their "donors".

On the other hand, as opportunities, it can be mentioned that military-technical cooperation can be redirected towards co-design and collaborative research schemes, where not only products but also processes are shared, which would allow greater internal strengthening of industrial and doctrinal capabilities. In addition, this type of cooperation would position the countries of the region as partial producers of dual and priority technologies, especially if agreements with shared intellectual property clauses and local production are prioritized.

4.3 DEFENSE INDUSTRIAL BASE

Most South American experiences express a fragmented and dependent IDB, where production patterns are bordered on "opportunistic" acquisitions rather than purchases that will attend to future operations. However, it is a fact that some countries have begun to incorporate technological innovation as the axis of their IDB. The IDB-doctrine cooperation qualification is still incipient. However, a number of countries are beginning to emerge in which the doctrine has begun to operate as a guide to bring industrial production to real operational requirements, closing the circle between production and income in the operating cycle.

However, there is a structural tension between the logics of efficiency entrenching the defense industry and the possibly idiosyncratic demands that military doctrines impose. While operating logic facilitates scalability based on economic sustainability and large-scale production economics, it is less effective in the specific operational contexts of each doctrine. Those are defined as threats, geographies, or local capabilities. Such dissonance may imply that, in many cases, industries will not be able to adapt supporting products through each doctrine without significant cost or losing competitiveness. Additionally, this tension can be particularly problematic when the defense industrial base is critically dependent on foreign

technologies, especially in critical areas or critical technologies. In such circumstances, such dependence undermines the strategic autonomy of the State and exposes the defence industrial base to structural vulnerabilities. These weaknesses can be exploited in contexts of geopolitical imbalances, diplomatic or commercial pressures from third parties. Consequently, the integration between doctrine and industrial production cannot be limited to efficiency criteria, but must seriously consider the factors of sovereignty and technological resilience.

The IDB can leverage these forms of military-technical cooperation not only to acquire technology, but to foster innovation processes and regional value chains, allowing it to strengthen autonomous capabilities without giving up its ability to learn from and with others. There are also windows of opportunity in the promotion of dual-use technologies, which extend the financial and political basis for the development of a solid IDB and the increase of its impact on state and private investment.

Table 1

Comparison of Latin American countries

COUNTRY	DOC	CTM	IDB
Brazil	High doctrinal institutionalization with a focus on strategic autonomy and multiple missions.	High levels of technology transfer with Russia, Israel and south-south programs.	Robust industrial base, with state investments and export capacities.
Argentina	Doctrine influenced by border operations and peacekeeping missions.	Technical relations based on defense production and cooperation from neighboring countries.	Industrial capacity in the process of recovery with a focus on regional self-sufficiency.
Chile	Professionalized evolutionary doctrine oriented towards regional interoperability.	Participation in combined exercises and strategic bilateral agreements.	Industrialization that focuses on the alliance in innovation and cyber defense.
Colombia	Post-conflict doctrinal transformation and adaptive flexibility in the face of hybrid threats.	Partnerships with the U.S. and South-South cooperation for training and assistance.	Moderate development of productive capacities, focused on maintenance and logistics.
Ecuador	Doctrine in the process of restructuring, marked by foreign regulatory dependence.	Specific military-technical relations, low sustainability and limited interoperability.	Incipient capacity, limited public investment and lack of integrated industrial policy.
Dominican Republic	Incipient doctrinal development with orientation to basic formation.	Limited cooperation with emphasis on basic assistance and donations.	Limited capacity, dependent on imports and external assistance.
Venezuela	Doctrine marked by territorial focus and ideological influence.	Russian and Chinese influence on modernization programs.	IDB oriented to national development with strong state control.

Source: Authors' elaboration based on documentary analysis (2025).

4.4 IMPLICATIONS AND CONTRIBUTIONS TO THE ECUADORIAN CONTEXT

In general, Ecuador faces serious structural limitations in the field of national defense, which are manifested through the weak connection between military doctrine, military-technical cooperation in the defense sector, and its industrial base. The existing doctrine does not have a systemic vision that allows it to respond effectively to emerging and complex operational scenarios; instead, it remains tied to outdated conceptual frameworks and with a very low degree of practical applicability.

At the same time, the country's military-technical relations have been reactive and fragmented, based on acquisitions rather than effective technology transfer or even the construction of domestic doctrine, which continues to perpetuate operational and strategic dependence. The country's defense industrial base is also strongly dissociated, presented with a high degree of institutional fragmentation and no effective investment in innovation or alignment with doctrinal priorities or technologies. There is no possibility of moving towards real strategic autonomy. The three dissociations underlined strongly limit the resilience of the defence system and its possibilities of responding with sovereignty to today's threats.

From the perspective of the Ecuadorian case, a delay in updating the doctrine in the face of current operational challenges is identified. Taking the South American experience, the dynamics towards flexible doctrines necessarily require joint experiences and simulations of emerging technologies, which simultaneously consider imperativity and adaptation. In the Ecuadorian case, therefore, the lack of real technique has generated an incipient doctrine. Ecuador did not transcribe foreign manuals with technical instructions, nor was it inspired by lessons learned in neighboring nations. Military-technical cooperation was therefore circumstantial and, in the long run, is not projected in terms of acquisition and sustainability. When compared with the region, it can be seen that the integration of real technologies is necessary and urgent, not only versatile, but also inducing doctrinal development, and reinforcing an industrial base for national defense. Ecuador reflects institutional fracture, disjointed competition in the sector, as well as a critical disconnect between the doctrine and the dynamics of the defense industrial base. Not only is this lack of coherence a weakness, but also the effectiveness of modernization processes and progress towards greater autonomy are compromised. South American experiences suggest, on the other hand, that a synergistic approach – where doctrine guides strategic requirements, international cooperation facilitates access to critical technologies and national industry is able to land

these requirements in contextualized operational solutions. it is a step towards the strategic of an autonomy that is, for a change, both realistic and far-reaching.

Thus, the delay in updated theorizing does not allow us to guide the operational challenges of the present. The South American experience opts for the institutionalization of flexible doctrines, supported by joint exercises and simulations with emerging technologies, in which prescription coexists with adaptation. Since the above, our country's military-technical cooperation has historically focused on spot assistance, without absorption or maintenance mechanisms. The comparison of experiences confirms the need to reach agreements with a true technological legacy, focused on energizing national doctrines and capacities.

Ecuador's defense industrial base is highly fragmented and insufficiently integrated with military doctrine. Taking into account the region's experience, the synergistic approach – in which doctrine informs demand, cooperation facilitates access and industry provides contextualized solutions – can be vital to move towards a genuinely realistic and sustainable strategic autonomy.

Military doctrine, beyond its internal function of standardization and training, has been consolidated in South America as a key tool to guide and sustain military-technical cooperation. This relationship is evident in experiences such as that of Colombia, where the implementation of the Damascus Doctrine has facilitated interoperability with strategic partners such as the United States, Chile, and NATO, while promoting a doctrinal structure consistent with the processes of technical assistance and internationalization of capabilities (Armed Forces Colombia, 2022; Mijares, González, 2021).

In the Brazilian case, the consolidation of a doctrine of joint use, formalized in strategic documents such as the National Defense Policy and the White Paper on National Defense (2012, 2020), has served as a key enabler for the development of large-scale military-technical cooperation initiatives. In a sense, the doctrine does not establish operational guidelines. Rather, the doctrine is a broader strategic framework that helps ensure coherence between defence sector planning, boosting the industrial base and international integration. Among other things, this doctrine guided and allowed Brazil to place its capabilities on the regional and international stage, uniting technology, doctrine, and industry under a coherent strategic vision. From this logic, Brazil carried out emblematic projects, such as the A-Darter missile, in collaboration with South Africa (Santos, Oliveira, 2023). Another example is the KC-390 military transport aircraft, in partnership with Portugal and India. Even the ambitious

submarine program, thanks to French technology. In all cases, Brazilian doctrine acts as a kaleidoscope, progressively promoting technological autonomy, aligning national capacities with long-term strategic objectives. As Piedrahita and Torres (2022) point out, a solid doctrine allows "structuring military thinking as a guide for institutional action", which translates into clarity of strategic objectives when negotiating or implementing cooperation agreements.

5 CONCLUSIONS

Based on the analysis carried out, it can be established that the findings affirm what was mentioned by Farrell et al. (2013), when they consider that: doctrine, military-technical cooperation and defense industrial base, are issues that are directly and strategically related, and that they are unfailing modulating variables of the defense policies that are established in the different countries. This articulation also allows the development of sustainable technological innovation processes that generate processes of institutional strengthening and institutional insertion. On the other hand, the cases analyzed from Colombia and Brazil show fundamental aspects such as the consideration that the doctrine allows for the articulation of strategic partners through cooperation, technical assistance and technological development.

Colombia, with the application of the Damascus doctrine, implemented by its Armed Forces, has not only favored operability with strategic partners, but has also made it possible to integrate training, technical assistance, and progressive industrialization, ratifying what Mijares and González (2021) proposed. In addition, Ionescu (2022) ratifies the proposal, considering that the Brazilian doctrinal strategy, based on the notion of gradual technological autonomy, has led to high value-added projects, such as the KC-390 aircraft or the submarines in cooperation with France. These examples confirm that a structured doctrine with a long-term vision becomes a catalyst for technical alliances and its own industrial capabilities.

However, this scenario does not avoid contradictions and tensions. Fragmented doctrines, detached from current operational needs or subjected to old models, are presented as a contradiction to the principles of progress and the thinking of cooperation and innovation. As Vitelli (2018) warns: Argentina is a concrete example, which has an industrial critical mass, which includes the Argentine Aircraft Factory FAdA; however, their inability to articulate doctrine, science and production impede the sustainability of strategic projects. The same situation is replicated in Ecuadorian doctrine, in which, according to Andrade (n.d.), the doctrine lacks organization, structure and articulation with technical processes.

In this sense, the implications for Ecuador are referents that require immediate attention, especially from the consideration that, lacking a flexible and modernized doctrine, which places us as lacking a doctrinal vision adaptive to technological contexts and prevents military-technical cooperation as a sustainable process that strengthens the scope of a national strategy. In comparison with Brazil and Colombia, which have managed to establish assertive processes of cooperation that have marked the path of their technological autonomy. Ecuador has not made significant progress in this regard, without even being able to generate effective defense investments (Cheung, 2022) that would allow it to insert itself into regional technological consortia and execute combined operations.

The basis of a flexible doctrine with a clear vision allows the strengthening of strategic technological niches in which Ecuador has not been able to act, such as: simulators, logistical maintenance and cyber defense, areas that do not require large investments but that seek articulation and technical-military cooperation, which ratifies what Albano (2017) proposed, who proposes the importance of the doctrine in achieving the technological development of weapons. In addition, it will allow it to establish strategic alliances with countries in the region that have developed a medium technological level, facilitating co-production processes and progressive technology transfer (Malafaia, 2021).

The findings of this research show that the consolidation of strategic autonomy in defense cannot be achieved without the effective articulation between military doctrine, military-technical cooperation and defense industrial base. Based on the comparative analysis of the cases of Colombia, Brazil, Argentina, Chile, the Dominican Republic, Venezuela and Ecuador, it is found that the countries that have managed to integrate these three dimensions have advanced in military modernization processes that are more sustainable, resilient and in accordance with their geopolitical contexts. In particular, the Colombian case demonstrates how an adaptive doctrine, nourished by internal operational experience and international assistance processes, allows institutional reform to be guided based on its own capacities (Cardona, 2021; Mijares, González, 2021). Similarly, Brazil has shown that military-technical cooperation, combined with strategic investments in its defense industrial base, can energize a virtuous cycle of innovation and autonomy (Malafaia, 2021; Ionescu, 2019).

Unlike these processes, Ecuador continues to operate under a doctrinal system largely based on foreign documents, without its own regulatory structure that consolidates national experiences or aligns with regional strategic objectives. This doctrinal dependence limits the

country's ability to interpret its threats from a sovereign perspective and formulate coherent strategic responses. The findings of this research confirm what Ionescu (2019) proposed, that the doctrine, understood as a technical-administrative product of high strategic sensitivity, should stop being conceived exclusively as a normative discourse for internal use, and start operating as a tool of public management in defense, connected to processes of international cooperation, institutional design and technological production.

In this sense, the models analyzed demonstrate that a functional and adaptive doctrine not only regulates military action, but also acts as a critical interface between operational decisions, technologies in use, and defense policies. Argentina and Chile, for example, have generated doctrinal reforms that integrate elements of regional interoperability without renouncing their own decision-making frameworks, while the Dominican Republic has managed to position its joint doctrine as a basis for more cohesive cooperation with a greater geostrategic vision (Ministry of Defense RD, 2020). These examples underscore why it should be a very urgent task to reformulate Ecuadorian doctrine and to direct this reformulation to a model that reflects national operational lessons, that incorporates technical standards shared in the regional environment and minimizes the risk of uncritical reproduction of foreign doctrinal frameworks. It was also concluded that the doctrine is not a merely functional artifact in collaboration in the military-technical field, but a structurally significant actor in the creation and maintenance of the national project, or rather in the strategy that may or may not exist in one way or another. In the cases of Brazil, Colombia and Venezuela, it was proven that military technical cooperation, if supported by solid doctrines and an industrial base under construction, became an effective tool to increase the degrees of autonomy from two perspectives at the same time, the political and the military. In the case of Ecuador, the pattern of integration of collaboration seemed much more dispersed and weak in the doctrinal dimension. In this context, it is imperative to rethink this relationship, adopting a proactive approach that prioritizes the construction of regional strategic alliances aligned with common and sustainable goals in the long term.

Finally, the research shows that, without a national defense industrial base articulated to a reformed doctrine and an effective cooperation policy, Ecuador will continue to be limited in its capacity to respond to contemporary scenarios of hybrid threat, cybersecurity, and geopolitical pressure. Based on this, it is proposed to formulate a national doctrine that integrates its own capabilities, strengthens technical links with regional strategic partners and promotes an ecosystem of civilian-military technological innovation. This task cannot be

postponed: doctrinal sovereignty and strategic autonomy are today sine qua non conditions for effective, resilient and legitimate national defense.

ACKNOWLEDGMENTS

This work was possible thanks to the support and trust of the Ecuadorian Army and the University of the Armed Forces ESPE; to the academic support and professional guidance of the teaching staff of the Graduate Program (Doctorate) in Military Sciences (PPGCM) of the Meira Mattos Institute of the Escola de Comando e Estado-Maior do Exército (ECEME). Its contribution has provided solidity and rigor to the development of this research and, at the same time, has allowed the formation of a critical, analytical perspective committed to the study of international security, regional defense and the production of strategic knowledge from a Latin American perspective. In the same way, we recognize the work of the authors of academic articles, specialized books, and official documents that made up the documentary corpus of this study, which have allowed us to build this reflection, and their value is manifested in the essential basis they constitute for the academic debate on military doctrine, military-technical cooperation, and the strengthening of defense capabilities in South America. Finally, we thank the colleagues, reviewers, and readers who, with their substantive comments, contributed to strengthening the methodological approach and analytical soundness of the manuscript.

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VIOLENCE AGAINST WOMEN IN TOCANTINS: ANALYSIS OF DOMESTIC VIOLENCE AND FEMICIDE CRIMES IN THE POST-PANDEMIC PERIOD

VIOÊNCIA CONTRA MULHER NO TOCANTINS: ANÁLISE DOS CRIMES DE VIOÊNCIA DOMÉSTICA E FEMENICÍDIO NO PERÍODO PÓS- PANDEMIA

VIOLENCIA CONTRA LAS MUJERES EN TOCANTINS: ANÁLISIS DE LOS DELITOS DE VIOLENCIA DOMÉSTICA Y FEMENICIDIO EN EL PERÍODO POSPANDÉMICO

 <https://doi.org/10.56238/sevened2025.036-018>

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ABSTRACT

The fight against gender-based violence remains one of the most serious forms of denial of fundamental rights in Brazil, with worrying rates persisting despite recent legal advances. In Tocantins, cases of gender-motivated killings and domestic aggressions are structural phenomena, intensified by cultural and socioeconomic conditions. This study aimed to examine the evolution of such offenses between 2022 and 2024, focusing on the effects of the post-COVID-19 pandemic context on their incidence, recurring motives, and institutional mechanisms created for victim protection. The research adopted a bibliographic and documentary design, guided by the hypothetical-deductive method, and considered as central references Law No. 11.340/2006, known as the Maria da Penha legislation, and Law No. 13.104/2015, which classified femicide as a criminal type. Data were collected from official reports issued by the Public Security Secretariat of Tocantins (SSP/TO) and analyzed through descriptive statistics combined with content analysis. Findings reveal that, even with consolidated legal frameworks, the rates remain high, underscoring the urgency of more effective public policies and the expansion of specialized support networks in the interior regions of the state.

Keywords: Gender-Based Violence. Femicide in Tocantins. Post-COVID Pandemic. Protection Actions. Support System

RESUMO

O enfrentamento à violência dirigida a mulheres ainda representa uma das mais graves formas de negação dos direitos fundamentais no Brasil, mantendo índices preocupantes mesmo diante dos avanços legais recentes. No Tocantins, os casos de assassinatos motivados por gênero e de agressões no ambiente doméstico configuram fenômenos estruturais, agravados por condições culturais e socioeconômicas. Este estudo buscou

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analisar a evolução desses delitos entre 2022 e 2024, observando os impactos do contexto pós-pandemia da COVID-19 sobre sua ocorrência, os fatores motivadores recorrentes e os mecanismos institucionais criados para proteção. A pesquisa, de natureza bibliográfica e documental, foi conduzida pelo método hipotético-dedutivo, tomando como referenciais centrais a Lei nº 11.340/2006, conhecida como legislação Maria da Penha, e a Lei nº 13.104/2015, que tipificou o feminicídio. As informações foram coletadas em relatórios oficiais da Secretaria de Segurança Pública do Tocantins (SSP/TO) e submetidas a estatística descritiva combinada à análise de conteúdo. Os resultados indicam que, mesmo com instrumentos jurídicos consolidados, os índices permanecem elevados, reforçando a necessidade de políticas públicas mais eficazes e da expansão da rede de atendimento especializado no interior do estado.

Palavras-chave: Violência Motivada por Gênero. Feminicídio em Tocantins. Pós-Pandemia da COVID. Ações de Proteção. Sistema de Atendimento.

RESUMEN

La lucha contra la violencia contra las mujeres sigue representando una de las formas más graves de negación de los derechos fundamentales en Brasil, manteniendo índices preocupantes incluso a la luz de los recientes avances legales. En Tocantins, los casos de asesinato por motivos de género y violencia doméstica representan fenómenos estructurales, agravados por las condiciones culturales y socioeconómicas. Este estudio buscó analizar la evolución de estos delitos entre 2022 y 2024, observando los impactos del contexto pospandemia de COVID-19 en su ocurrencia, los factores motivadores recurrentes y los mecanismos institucionales creados para su protección. La investigación, de naturaleza bibliográfica y documental, se realizó mediante el método hipotético-deductivo, tomando como referencias centrales la Ley n.º 11.340/2006, conocida como la ley Maria da Penha, y la Ley n.º 13.104/2015, que penalizó el feminicidio. La información se recopiló de informes oficiales de la Secretaría de Seguridad Pública de Tocantins (SSP/TO) y se sometió a estadística descriptiva combinada con análisis de contenido. Los resultados indican que, incluso con instrumentos legales consolidados, las tasas siguen siendo elevadas, lo que refuerza la necesidad de políticas públicas más efectivas y de la ampliación de la red de atención especializada en el interior del estado.

Palabras clave: Violencia de Género. Femicidio en Tocantins. Pospandemia de COVID-19. Medidas de Protección. Sistema de Servicios.

1 INTRODUCTION

Aggressions directed at the female public are configured as serious transgressions of fundamental guarantees, remaining a persistent global challenge. It is a structural problem that affects women in multiple community and cultural environments, evidencing its historical permanence. The Atlas of Violence points out that about a third of women on the planet have already been victims of bodily attacks, which reveals the magnitude of the problem (IPEA, 2024; WHO, 2020).

In Brazil, the picture presents similar complexity. Domestic occurrences and gender-related murders remain at a high level, producing relevant collective effects and significant economic costs (FBSP, 2024). To face this scenario, significant legal frameworks were instituted: Law No. 11,340/2006 created innovative mechanisms aimed at supporting victims and punishing the perpetrators of aggression (BRASIL, 2006); Law No. 13,104/2015 began to recognize femicide as a qualifying circumstance for homicide (BRASIL, 2015); and Law No. 14,994/2024 transformed it into an autonomous criminal type, expanding sanctions and strengthening the legal debate (BRASIL, 2024). Even with these advances, records of violence remained high and intensified in the period after the pandemic, influenced by social isolation, economic difficulties, and the overload of public services (CUNHA, 2020; BRAZIL, 2025; UN WOMEN, 2016).

In Tocantins, territorial and cultural factors increase the complexity. The difficulty in expanding specialized services and the vulnerabilities that affect indigenous, quilombola, and riverine groups result in a critical scenario (MOREIRA, 2024; RIBEIRO, 2017). Actions such as the Maria da Penha Patrol and the Phoenix Project, implemented in Araguaína, have made progress, but official data on homicides of women and intrafamily violence reveal that such initiatives are still not enough to reverse the situation (TOCANTINS, 2025).

The work proposes to investigate the dynamics of gender abuse in Tocantins, articulating scientific production with social demands. The research adopts a qualitative-quantitative approach, of exploratory and descriptive character, guided by the hypothetical-deductive method. Bibliographic, documental and statistical analyses are combined, as well as theoretical and normative references, giving greater robustness to the interpretations (BARDIN, 2011; MARCONI; LAKATOS, 2017).

The main objective is to examine the cases of domestic violence and femicides registered in Tocantins between 2022 and 2024, considering the impacts of the period after the pandemic, seeking, in a specific way, to measure the variation of indicators, map

elements of vulnerability, assess the limits and advances of public policies and present recommendations for the improvement of mechanisms to prevent and combat abuse in the family environment.

2 MATERIAL AND METHODS

The research was developed with a qualitative-quantitative approach, of exploratory and descriptive character, supported by the hypothetical-deductive method, according to the guidelines of Petenate (2013). The concept of scientific investigation presented by Marconi and Lakatos (2017) was used, which emphasize the importance of methodological rigor in the construction of knowledge. It was hypothesized that the indicators of intrafamily violence recorded in Tocantins, between 2022 and 2024, underwent changes related to the sociopolitical and organizational scenario after the COVID-19 pandemic. The analysis sought to confirm or refute this hypothesis based on empirical information combined with theoretical and normative references.

Data collection was organized into three complementary stages. Initially, a literature and documentary review was carried out based on the PRISMA protocol (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*), which ensures transparency and traceability in the selection of sources (MOHER et al., 2009). Next, a qualitative analysis was carried out, based on the content analysis technique proposed by Bardin (2011), applied to legislation, institutional reports, government plans — with emphasis on the State Plan for Women's Rights 2022–2025 (TOCANTINS, 2022) — and scientific productions. Finally, a descriptive quantitative analysis was carried out, involving the calculation of frequencies, percentages and annual variations of records made available by the Department of Public Security and the Military Police of Tocantins.

The materials analyzed covered national and state legislation, including the Federal Constitution of 1988, Law No. 11,340/2006 (Maria da Penha Law) and its amendments, Law No. 14,994/2024 (Femicide Law) and other state regulations (TOCANTINS, 2019). Official reports, action plans, public policies to combat gender violence, as well as scientific articles, dissertations, theses, and institutional communications identified throughout the systematic review were also considered.

The period investigated corresponded to the years 2022 to 2024, a phase marked by the reopening of social, economic, and administrative activities after the restrictions established by Federal Law No. 13,979/2020 and the guidelines of the World Health

Organization (WHO). This context may have impacted both the frequency of crimes against women and the response capacity of public institutions.

The treatment of the data followed a deductive and interpretative approach, starting from general assumptions about gender violence in Brazil until reaching specific conclusions for Tocantins. To increase the reliability of the results, triangulation of sources was applied, cross-referencing legislation, reports, official statistics and scientific literature. As Petenate (2013) points out, this strategy confers greater methodological robustness and reduces biases, allowing for more consistent inferences

3 CONCEPTUAL AND LEGAL ASPECTS OF THE PROTECTION OF WOMEN

Acts of violence against women are a complex phenomenon that, in the Brazilian legal system, is defined by a set of rules that aim to promote the complete protection of women's dignity. Cunha (2020) observes that conflicts that occur in the domestic environment can be understood as offensive acts practiced against women in family or intimate living spaces, exploiting their position of inequality. This understanding expands the concept of violence, making it clear that it is not restricted to physical aggression, but encompasses psychological, sexual, moral and patrimonial dimensions, composing a multifaceted picture of rights violations.

In the criminal field, Brazilian legislation has advanced by recognizing femicide as a qualified form of homicide through Law No. 13,104/2015, which included this framework in the Penal Code. This recognition establishes that the death of women motivated by gender reasons must receive differentiated legal treatment, especially in situations that occur in the intrafamily environment resulting from inequality and/or debasement of this condition. Subsequently, Law No. 14,994/2024 made significant progress by transforming this criminal act into an autonomous criminal type, now provided for in article 121-A of the Penal Code. With this update, the punishment moved to an interval of 20 to 40 years of imprisonment, classifying it among the most serious crimes in the legal system and reinforcing the need for punitive responses and more effective actions (BRASIL, 2024)

It should be noted that the enactment of Law No. 14,994/2024 was not limited to transforming femicide into an autonomous criminal type; it also made important adjustments to Law No. 11,340/2006. The modifications expanded the scope of protection measures, streamlined the procedures for granting these measures, and strengthened the mechanisms for punishing offenders. With these changes, the legislation began to offer faster and more

effective responses, aimed at safeguarding women and confronting gender violence practices. (BRAZIL, 2006; BRAZIL, 2024).

4 THEORETICAL AND NORMATIVE APPROACHES TO FEMALE SAFEGUARDING

The harmful conducts that affect the female public in Tocantins are a social and legal problem of great relevance, marked by cultural, regional and institutional particularities. Examining this issue requires going beyond the mere observance of legal provisions. It is necessary to articulate these instruments with theoretical frameworks that make it possible to interpret both vulnerability factors and institutional responses to femicide and attacks in the post-pandemic context (WALKER, 1979; MOREIRA, 2024).

4.1 INTERNATIONAL PERSPECTIVE AND NORMATIVE FRAMEWORKS

On the international scene, essential documents have been consolidated. The Inter-American Convention on the Prevention, Punishment and Eradication of Violence against Women – known as the Convention of Belém do Pará (1994) – recognized this violence as a violation of human rights and attributed to States the duty to prevent it, punish those responsible and promote eradication policies. At the Brazilian level, this commitment resulted in legal frameworks recognized worldwide. Among them, the Maria da Penha Law (Law No. 11,340/2006) stands out, which classified the various forms of offensive conduct in the home and instituted protection mechanisms and emergency measures aimed at women's integrity (BRASIL, 2006; OAS, 1994).

4.2 ECOLOGICAL MODEL FOR UNDERSTANDING CONFLICTS

The population health model, widely disseminated by the WHO, interprets these occurrences as the result of the interaction of four levels: individual, relational, community and sociocultural (WHO, 2002). This broader perspective shows that these are not just isolated episodes, but a set of factors that reinforce each other. In Tocantins, aspects such as excessive alcohol use, illegal availability of weapons, and barriers to access to services in rural and riverside regions significantly increase women's exposure to risk situations (MOREIRA, 2024).

4.3 DYNAMICS OF THE CYCLE OF ABUSE

Walker (1979) described marital violence as a cyclical process, composed of three phases: the accumulation of tension, the explosion of aggression and reconciliation, characterized by apologies or promises of change from the aggressor. This pattern generates in the victim the expectation that the partner can become and also that keeps him trapped in an unequal power relationship. Later studies identified variations: in some situations, the reconciliation phase disappears, making the cycle more direct and lethal; in others, it is replaced by periods of silence and withdrawal, equally marked by intimidation and psychological control (DOBASH; DOBASH, 2004).

In Tocantins, the permanence of women in abusive relationships is not explained only by economic dependence. Research points to factors such as low education, lack of knowledge about rights, difficulty in accessing support services outside the capital, persistent fear of the partner, responsibilities with young children, and lack of social or psychological support (MOREIRA, 2024).

Added to this scenario are the continuity of patriarchal values and the cultural acceptance of these acts in family relationships, which reinforces imprisonment and restricts women's autonomy (SAFFIOTI, 2004). This picture demonstrates that the cycle of abuse should not be analyzed only from an individual or relational perspective, but as an expression of historical structures of gender disparity, sustained by cultural practices and institutional weaknesses. Understanding these dimensions is crucial to construct government guidelines that also guarantee immediate protection and transformation of the social conditions that maintain this situation (WALKER, 1979; SAFFIOTI, 2004; MOREIRA, 2024).

4.4 COERCIVE CONTROL AND INVISIBLE FORMS OF DOMINATION

Stark (2007) developed the notion of coercive control, which broadens the understanding of power dynamics by showing that this phenomenon is not restricted to physical harm. It consists of a continuous pattern of imposition, exercised methodologically planned through emotional, psychological, economic and collective resources. Among the recurrent behaviors, the following stand out: social isolation (restriction of friendships and family contacts), surveillance of habits and communications (monitoring of cell phones, messages and others), financial control (appropriation of salary, limitation of resources) and emotional intimidation (blackmail involving children, threats or public defamation) (STARK, 2007; BANDEIRA, 2014).

Another important aspect is the use of the institutions themselves as an instrument of coercion. In these situations, the perpetrator of the abuse manipulates police records, threatens to remove responsibility for the children or uses the judicial bureaucracy as a strategy of psychological and economic exhaustion. Research shows that, in several situations, psychological and institutional pressure overlaps with physical pressure, creating even more complex obstacles to the autonomy of victims (PASINATO, 2011; FILE; GONÇALVES, 2018).

In Tocantins, this situation also occurs. In 2024, Dial 180 recorded an increase of 18.3% in service records and 14.8% in complaints compared to the previous year, indicating greater visibility of forms of psychological and technological abuse (BRASIL, 2025). These data confirm that confronting these practices requires recognizing the subtle and "invisible" forms of hierarchical imposition, which silently erode female autonomy and challenge the effectiveness of the protection system.

4.5 INTERSECTIONALITY AND OVERLAPPING VULNERABILITIES

The notion of intersectionality, formulated by Crenshaw (1989), demonstrates how different systems of oppression – sex, ethnicity and class – intersect, producing peculiar forms of submission. In Brazil, authors such as Carneiro (2003) and Ribeiro (2017) show that Afro-descendant or brown women face particular vulnerabilities, marked by the combination of structural racism and socioeconomic inequality. The same occurs with indigenous women and women from traditional communities, who are often excluded from access to basic health services, the justice system and institutional support.

In Tocantins, the issue is intensified by the great geographical distances and the difficulty of expanding specialized services. Indigenous, quilombola, and riverine women face additional obstacles, such as cultural discrimination, institutional racism, and denial of linguistic rights. The absence of ethnic-racial data in official records increases this invisibility, making it difficult to formulate effectively intersectional public policies (CRENSHAW, 1989; CARNEIRO, 2003; RIBEIRO, 2017).

4.6 MASCULINITIES AND PRACTICES OF DOMINATION

Connell (1995) presented the notion of hegemonic masculinity, which exalts attributes such as virility, strength, and power of control, establishing standards that legitimize female

subordination. Such cultural construction goes beyond the individual sphere, permeating social structures, shaping expectations of behavior and naturalizing forms of coercion.

In Brazil, surveys by the Brazilian Security Forum indicate that a large portion of homicides of women result from the refusal to maintain the relationship, evidencing a pattern of male ownership and resistance to female autonomy (FBSP, 2024). In Tocantins, the records confirm this reality: in several situations, marital separation or unaccepted breakup was the central motivation, reflecting the perception that the body and life in women are treated as the property of the partner.

Femicide, therefore, should not be interpreted as an isolated fact, but as the extreme manifestation of a system of systematic male pressure, sustained by cultural narratives and management habits that still tend to relativize the seriousness of the phenomenon. The maintenance of the term "crime of passion" in news reports and the opposition of conservative sectors to the full application of the laws reinforce this logic (SAFFIOTI, 2004; CONNELL, 1995; FBSP, 2024).

5 RESULTS AND DISCUSSION

The survey shows that, in the period between 2022 and 2024, Tocantins presented a heterogeneous panorama of gender-based aggressions. The tables reveal not only the dimension of the problem, but also changes in its spatial configuration.

The Secretariat of Public Security of Tocantins (SSP-TO) discloses the crimes under study separating Palmas (capital) and Araguaína, the second largest municipality, grouping the others in the "Interior" category. This methodological option is adequate, as it considers the population weight of these cities and the effect of specific local policies, such as the Phoenix Project and Operation Atrium. As the official reports do not present individualized numbers for intermediate-sized municipalities such as Gurupi, Porto Nacional and Paraíso, it was not possible to make isolated comparisons for these locations.

5.1 RESULTS

According to the survey, the information was systematized in absolute and relative numbers, as shown in table 1. With this, it was possible to visualize the evolution of the records in relation to the territorial distribution.

Table 1

Occurrences of femicide in Tocantins (2022–2024)

Year	Palms (n)	Palmas (%)	Araguaína (n)	Araguaína (%)	Total
2022	8	57.1%	2	14.3%	14
2023	7	41.2%	1	5.9%	17
2024	6	42.9%	0	0.0%	14

Source: SSP/TO (2025).

Table 1 presents the distribution of femicides recorded in Tocantins between 2022 and 2024, discriminating occurrences in Palmas and Araguaína and indicating the relative percentages. It is observed that the total number remained stable in the period, with 14 records in 2022, 17 in 2023 and again 14 in 2024.

Palmas concentrated most of the cases in all the years analyzed, ranging from 57.1% in 2022 to 42.9% in 2024, which reveals a slight proportional reduction. Araguaína showed a continuous drop, going from two cases in 2022 to just one in 2023 and reaching zero in 2024. This downward trajectory suggests a positive effect of local policies, such as the Phoenix Project and Operation Átria (TOCANTINS, 2024; MJSP, 2023).

The joint reading of these numbers allows us to highlight two central findings: the persistence of high rates in the capital and the localized reduction in Araguaína. These results reinforce the importance of territorialized policies and continuous monitoring of indicators to understand the factors that affect the dynamics of crimes in the state.

Ligue 180 records indicate that, between 2023 and 2024, there was a significant growth in the number of calls (18.3%) and formal complaints (14.8%), as shown in table 2. More than indicating a simple increase in violence, these numbers suggest an increase in women's access to support channels and greater trust in protection institutions. This movement may be associated with social mobilization campaigns, such as Agosto Lilás, and the expansion of the support system, which have contributed to reducing underreporting and making the problem more visible.

Table 2

Calls and complaints in Dial 180 (2023–2024): absolute numbers and percentages of variation

Year	Attendances (n)	Change (%)	Complaints (n)	Change (%)
2023	3.681	-	549	-
2024	4.353	18.3%	630	14.8%

Source: Ministry of Women (2025).

In a cross-reading of the two tables, it is possible to identify three movements: I - persistence of high levels of femicide, even without growth in total; II - differentiated effects of local policies, with Araguaína zeroing the registrations while the interior expanded its participation; and III - strengthening of institutionalized denunciation, evidenced by the growing use of Dial 180. These elements dialogue directly with the research question: to understand how the post-pandemic period influenced the patterns of oppression and gender abuse in the State. The scenario suggests that the social tensions of the period may have kept violence at high levels, but well-targeted policies, when applied consistently, have the potential to alter local trajectories.

The interpretative analysis was conducted by inference, starting from general premises about gender violence in Brazil and advancing to the reality of Tocantins. The objective was to relate the statistical data to current regulations and scientific evidence, building a broader reading of the phenomenon. Table 3 summarizes this path, articulating evidence, sources and conclusions at different levels of analysis.

Table 3

Interpretative and deductive approach to gender aggressions in Brazil and Tocantins

Level of analysis	Key evidence	Triangulated fonts	Interpretative conclusions
General Assumptions (Brazil)	High prevalence of gender-based violence; femicide recognized by law (Law No. 13,104/2015);	Federal legislation, national studies (IPEA, FBSP, UN Women).	Violence against women is structural and requires an intersectoral response.

		national policies to confront it.		
Regional trends (North/Midwest)		Rates above the national average; marked underreporting; barriers to access services.	FBSP reports, academic literature on peripheral regions.	Regional inequality intensifies female vulnerabilities.
State context (Tocantins)		Stable femicides in absolute numbers (2022–2024); increased use of Dial 180; specific policies in Araguaína (Phoenix Project, Operation Atrium).	SSP/TO, Ministry of Women, official press.	The phenomenon combines structural permanence with specific local advances.
Specific conclusions		Significant reduction in Araguaína; interior concentrates more cases; institutional strengthening through campaigns.	Statistical data, government reports, supporting literature.	Focused territorial policies can change local realities.

Source: Prepared by the authors based on legislation, institutional reports, statistical data and scientific literature (2025).

The examination of Table 3, interpretative and deductive, begins at the national level. According to data released by UN Women in 2023, Brazil remains among the countries with the highest rates of femicide in the world, which shows that gender-based aggression remains a structural phenomenon. This data also reveals the seriousness of the problem and helps to understand why the object under debate has been treated not only as a criminal issue, but also as a matter of public health and the dignity of the person. There were legislative achievements and undeniable advances. However, recent data from the FBSP (2024) and IPEA (2023) indicate that such norms, although fundamental, have not been sufficient to stop the escalation of intrafamily brutality. There is still a distance between the legal provision and the daily reality that exposes weaknesses in the execution of the law and gaps in the support network

In the North and Midwest regions, the situation is aggravated by underreporting, lack of specific investigation units in many cities, and reduced supply of shelters. Regional studies show that indigenous, quilombola, and rural women are even more exposed, either because of the geographical distance of services or because of historical conditions of inequality.

In Tocantins, this logic is repeated with its own nuances. Occurrences of femicide remained stable between 2022 and 2024, but their territorial distribution changed. Palmas continued to concentrate in most of the records; Araguaína, on the other hand, showed a downward trajectory until it reached zero in 2024, a result associated with focused policies such as the Phoenix Project and Operation Atrium. Meanwhile, the interior began to accumulate the age of majority in number of occurrences, showing that, without the same intensity of government guidelines, violence persists or even intensifies. At the same time, there was a significant increase in calls and complaints from Dial 180, which suggests both greater institutional trust and greater visibility of the problem. It is not possible to say that there was more violence, but there was certainly more willingness to report it and seek shelter.

The specific findings reinforce two central ideas. The first is that the violence linked to the manifestations of inequalities under study is persistent, structural in nature, and will hardly be eliminated by isolated measures. The second is that intersectoral policies and territorialities can generate concrete impacts. The experience of Araguaína, where precautionary and repressive measures were combined with community communication strategies, shows that it is possible to change local trajectories. This case reveals a broader lesson: it is not enough to have advanced legislation; It is essential to ensure its effective implementation, strengthen the support system and adapt the actions to the particularities of each territory.

These findings suggest that gender-based violence is multicausal and that its mitigation depends on a combination of intersectoral policies, strengthening of the reception network, and actions adapted to local specificities. The experience of Araguaína demonstrates that, when prevention, repression and community awareness are articulated, it is possible to significantly reduce the incidence of cases.

5.2 DISCUSSION

The apparent stability in the total number of these crimes cannot be confused with immobility. Behind the numbers, there are distinct movements between the territories. Palmas

maintained high rates, the interior expanded its participation and Araguaína managed to reduce occurrences to zero in 2024. This variation demonstrates that abusive investments respond directly to the intensity and quality of institutional policies. The example of Araguaína, where the Phoenix Project and Operation Átria were applied more consistently, reinforces that focused and articulated actions can transform local realities. This result dialogues with Castro (2002), when he highlights the strength of integrated security strategies in delimited contexts, and also with Baldissera (2008), for whom institutional communication, when well directed, enhances the reach of policies.

The growth of calls and complaints on Dial 180 suggests another relevant movement: the consolidation of social trust in official channels. It is not only about an increase in violence, but an increase in the willingness to denounce. Campaigns such as Agosto Lilás and articulated operations reinforced this visibility. Kunsch (2003) had already observed that the combination of wide-ranging institutional messages and proximity actions increases both the victim's perception of protection and the risk perceived by the aggressor.

When looking at the whole, a fundamental problem emerges: regional inequalities. Municipalities with a stronger institutional presence advanced, while areas with low coverage maintained high rates. This disparity is consistent with the analyses of Saffioti (2004) and Connell (1995), who relate these abusive attitudes to patriarchal structures and the maintenance of hegemonic masculinities. In other words, the absence of the State in certain territories allows the reproduction of dynamics of oppression that resist despite advances in legislation.

The discussion also requires an intersectional perspective. Authors such as Crenshaw (1989) and Ribeiro (2017) draw attention to the class of black, indigenous, and quilombola women, who face overlapping social, economic, and racial vulnerabilities. The lack of these cuts in official statistics makes part of the abuse invisible and limits the formulation of specific policies. Thus, although the data reveal some advances, it is likely that a significant portion of the cases remain out of the records.

The findings in Table 3 reinforce this deductive interpretation. Starting from the general premises of Brazil, marked by high rates of femicide although progressing in the legislatures, we arrive at the specific conclusions of Tocantins. The state picture mirrors the national structure, but also shows how localized policies can alter trajectories. Araguaína has become an example of how intersectoral strategies — combining repression, prevention, and community communication — produce visible effects. In contrast, the interior demonstrates

how the absence of these policies magnifies inequalities. The deductive reading, therefore, shows that crimes are simultaneously structural and territorial phenomena.

It is necessary to acknowledge, however, the limitations of this study. Underreporting remains an obstacle, the lack of data disaggregated by race prevents a more accurate analysis, and methodological differences between agencies make direct comparisons difficult. These weaknesses do not invalidate the results, but reinforce the urgency of more integrated and standardized databases.

In summary, these abusive attitudes mentioned in Tocantins reflect the Brazilian contradictions: persistent and structural, but also sensitive to well-designed policies. The data confirm that legislation is a necessary condition, but not sufficient. It is necessary to expand the territorial presence of the State, invest in institutional communication and incorporate intersectional cuts. Only then will it be possible to transform specific advances into lasting changes.

6 FINAL CONSIDERATIONS

In summary, this study allowed us to understand that gender abuse in Tocantins, between 2022 and 2024, remained at high levels, but presented important transformations in its territorial distribution. The results show that, although femicides remained stable, the main difference between the regions analyzed was significant: Palmas maintained high rates, Araguaína reduced to zero occurrences in 2024, and the interior had an increase in occurrences.

These results reinforce the understanding that this type of crime continues to be a structurally based phenomenon, but sensitive to the implementation of targeted policies. The Araguaína experiment is in line with the conviction that the combination of qualified repression, community prevention and institutional communication can change local realities. On the other hand, the interior of the state, without similar coverage, ratifies that the lack of structured actions keeps abuses at high levels.

The results also point to another advance: the growth of Ligue 180. This data suggests greater social trust in official channels and corroborates the importance of public integration and educational campaigns. It can be considered that this institutional strengthening is a positive indicator, although insufficient in the face of the persistence of femicides.

The contributions of this work are located in the critical analysis of the post-pandemic scenario and in the practical demonstration that intersectoral policies can generate

measurable impacts. The study provides subsidies for both public managers and researchers, by expressing the demands to territorialize policies and increase the internalization of the support system.

The limitations for this study were the underreporting of records, the lack of information disaggregated by cultural characteristics, and methodological differences between agencies. These constraints limit the scope of the conclusions, but do not invalidate the identified trend. The results would be more conclusive if there were more standardized and complete databases, especially with intersectional cuts.

For future work, it is recommended the introduction of qualitative data on the concrete cases of the victims, the deepening of the intersectional analysis and the longitudinal evaluation of the public policies implemented. Such advances can offer a more comprehensive picture and contribute to more effective coping strategies.

To recover the initial argument, it can be generalized that violence against women in Tocantins reflects national patterns, but also demonstrates that well-structured policies are capable of changing local trajectories. The challenge, therefore, is to transform successful one-off experiences into permanent practices, with reach throughout the state.

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**ANALYSIS OF PRECIPITATION ESTIMATION MODELS USING TIME SERIES:
A BIBLIOMETRIC ANALYSIS**

**ANÁLISE DOS MODELOS DE ESTIMATIVA DE PRECIPITAÇÃO UTILIZANDO
SÉRIES TEMPORAIS: UMA ANÁLISE BIBLIOMÉTRICA**

**ANÁLISIS DE MODELOS DE ESTIMACIÓN DE PRECIPITACIÓN UTILIZANDO
SERIES DE TIEMPO: UN ANÁLISIS BIBLIOMÉTRICO**

 <https://doi.org/10.56238/sevened2025.036-019>

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ABSTRACT

This study conducts a bibliometric analysis of precipitation estimation models using time series, aiming to identify trends, methods, and scientific contributions over the last four decades. The research is justified by the importance of precipitation as a primary variable in hydrological modeling and the scarcity of accurate rainfall data, especially in regions with high spatial and temporal variability. The work seeks to map the main precipitation estimation models, analyze their spatial and temporal resolution, and identify methodological trends and innovations in the field. The methodology adopted included a bibliometric approach, using the Scopus database to collect scientific articles, followed by statistical analyses and term co-occurrence networks using the VOSviewer software. Seventy-eight articles published between 1982 and 2023 were analyzed, focusing on the 40% most cited in each decade. The results reveal a significant evolution in precipitation modeling, with the transition from simple statistical methods to advanced techniques such as artificial neural networks (ANNs) and deep learning (LSTM). Daily temporal and regional spatial resolution predominated in the studies, and the integration of satellite data and artificial intelligence (AI) techniques has become a dominant trend in the last decade. The conclusion is that advances in precipitation modeling have significant practical impacts on water resource management and agriculture, contributing to the prediction of extreme events and adaptation to climate change.

Keywords: Precipitation. Time Series. Hydrological Modeling. Bibliometric Analysis. Artificial Intelligence. Climate Change.

RESUMO

Este estudo realiza uma análise bibliométrica sobre os modelos de estimativa de precipitação utilizando séries temporais, com o objetivo de identificar tendências, métodos e contribuições científicas ao longo das últimas quatro décadas. A pesquisa justifica-se pela importância da precipitação como variável primordial na modelagem hidrológica e pela escassez de dados pluviométricos precisos, especialmente em regiões com alta variabilidade espacial e temporal. O trabalho busca mapear os principais modelos de estimativa de precipitação,

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analisar sua resolução espacial e temporal, e identificar as tendências metodológicas e inovações na área. A metodologia adotada incluiu uma abordagem bibliométrica, utilizando a base de dados Scopus para coleta de artigos científicos, seguida de análises estatísticas e de redes de coocorrência de termos com o auxílio do software VOSviewer. Foram analisados 78 artigos publicados entre 1982 e 2023, com foco nos 40% mais citados de cada década. Os resultados revelam uma evolução significativa na modelagem da precipitação, com a transição de métodos estatísticos simples para técnicas avançadas, como redes neurais artificiais (ANN) e deep learning (LSTM). A resolução temporal diária e espacial regional predominou nos estudos, e a integração de dados de satélites e técnicas de inteligência artificial (IA) tornou-se uma tendência dominante na última década. Conclui-se que os avanços na modelagem da precipitação têm impactos práticos significativos na gestão de recursos hídricos e na agricultura, contribuindo para a previsão de eventos extremos e a adaptação às mudanças climáticas.

Palavras-chave: Precipitação. Séries Temporais. Modelagem Hidrológica. Análise Bibliométrica. Inteligência Artificial. Mudanças Climáticas.

RESUMEN

Este estudio realiza un análisis bibliométrico de modelos de estimación de precipitación utilizando series de tiempo, con el objetivo de identificar tendencias, métodos y contribuciones científicas en las últimas cuatro décadas. La investigación se justifica por la importancia de la precipitación como variable primaria en el modelado hidrológico y la escasez de datos precisos de lluvia, especialmente en regiones con alta variabilidad espacial y temporal. El trabajo busca mapear los principales modelos de estimación de precipitación, analizar su resolución espacial y temporal e identificar tendencias metodológicas e innovaciones en el campo. La metodología adoptada incluyó un enfoque bibliométrico, utilizando la base de datos Scopus para recopilar artículos científicos, seguido de análisis estadísticos y redes de co-ocurrencia de términos utilizando el software VOSviewer. Se analizaron setenta y ocho artículos publicados entre 1982 y 2023, centrándose en el 40% más citado en cada década. Los resultados revelan una evolución significativa en el modelado de precipitación, con la transición de métodos estadísticos simples a técnicas avanzadas como redes neuronales artificiales (ANN) y aprendizaje profundo (LSTM). La resolución espacial temporal y regional diaria predominó en los estudios, y la integración de datos satelitales y técnicas de inteligencia artificial (IA) se ha convertido en una tendencia dominante en la última década. La conclusión es que los avances en la modelización de precipitaciones tienen un impacto práctico significativo en la gestión de los recursos hídricos y la agricultura, contribuyendo a la predicción de eventos extremos y la adaptación al cambio climático.

Palabras clave: Precipitación. Series Temporales. Modelado Hidrológico. Análisis Bibliométrico. Inteligencia Artificial. Cambio Climático.

1 INTRODUCTION

The understanding of hydrological phenomena is essential for rainfall-flow modeling, in which precipitation stands out as a primary input variable. However, the difficulty in obtaining accurate rainfall data compromises the realistic representation of hydrological events, especially in basins where high spatial variability and flaws in records can result in significant discrepancies between the model and reality. Studies such as the one by Arai *et al.* (2009) demonstrate the relevance of precipitation in the characterization of the regional climate and its direct impact on agriculture, while Silva *et al.* (2011) show that prolonged periods of drought affect agriculture and reduce water levels in rivers, reservoirs and springs, even impacting the generation of hydroelectric power. Lucena *et al.* (2008) complements this view, emphasizing that rainfall intensity is influenced by large-scale atmospheric and oceanic phenomena.

In the Brazilian context, the network of stations of the National Institute of Meteorology (INMET) faces challenges due to the limited distribution of stations and inconsistencies in the historical series, arising from technical and data processing problems. To mitigate such challenges, techniques such as multiple linear regression have been shown to be effective in adjusting and filling gaps in historical data (Pedro Júnior *et al.*, 1994), and methodologies based on multiple regression analysis correlate precipitation with physiographic and temporal variables (Antonini *et al.*, 2019). Given the scarcity of rainfall data and the complexity inherent to precipitation modeling, it is essential to identify the main models used, as well as the spatial and temporal resolution (hourly, daily, monthly or other periodicity) of these models, in addition to understanding the trends and methodological innovations over the decades.

Bibliometric analysis emerges, in this scenario, as a robust tool that uses statistical and mathematical techniques to map scientific productivity and identify authorial, institutional, and thematic patterns (Wu, 2017; Guedes & Borshiver, 2005; Café & Brascher, 2008; Job, 2018). Thus, this study proposes to integrate precipitation modeling with a bibliometric and network approach, aiming to identify the main precipitation estimation models from time series, analyze the resolution and periodicity of these models, map the main researchers and institutions in the area, and evaluate the most used methods in the calibration and validation of the models.

2 THEORETICAL TABLEWORK

2.1 CLIMATE

Climate is the set of meteorological phenomena that characterize the average state of the atmosphere over a given place on the earth's surface. (HANN, 1882 apud MONTEIRO, 1991). Through this definition, it is possible to understand the central idea of what climatology would be.

It is extremely important to understand that climate and weather are not the same, and therefore, they have some differences. Time is understood as a set of studied elements that expresses the conditions of the atmosphere observed at a current moment, that is, at an instant in the atmosphere. Climate, on the other hand, will have its understanding associated with a set of elements studied through records, left over years and years.

According to Borsato (2000), the climatic elements somewhere on the earth's surface can be defined as: air temperature, relative humidity, atmospheric pressure, cloudiness, solar radiation, dust, wind direction and speed, electric field, water vapor voltage, positive and negative ions, horizontal visibility and vertical electric current, acting simultaneously and together, considered as a specific property of the action of each air mass.

2.1.1 Climate Components

According to Silva (2001), the study of climate and knowledge of its origin lead us to an understanding related to factors that can be defined as: generics and modifiers.

According to Vecchia (2001) the elements of climate are: air temperature, air humidity, atmospheric pressure, wind direction and speed, cloudiness and atmospheric precipitation, that is, it includes not only meteorological phenomena, but also phenomena that are influenced by the conditions of the place

2.1.1.1 Generic factors

These are dynamic factors that condition the climate, these meteorological phenomena originate from solar radiation and atmospheric and maritime movements, they are defined:

- Solar radiation: it is the factor that promotes global thermal exchange processes due to the warming of the Earth's surface. (CARLETTO, 2005)
- General circulation of the atmosphere: it combines the thermal forces, whose circulation is meridian, that is, in the north-south direction, and the dynamic forces that are

caused by the rotation of the earth and that promotes a modification in the air flow that tries to create a zonal circulation, in an East-West direction, according to Vecchia (2001).

- Sea currents: transfer heat from regions with temperature differences. They act in two ways mainly: by increasing the pressure of water vapor, that is, the humidity of the air, and by modifying the wind regime, according to Vecchia (2001).

2.1.1.2 Modifying factors

They are the static factors that act on the climate and create local variations, they are: geographical, topological, biological and cultural. Most of the time, the variations caused by these factors take on large magnitudes. Vecchia (2001) summarizes the main modifying factors in descending order of magnitude:

- Geographic: latitude, altitude, and the relationship between land and water masses.
- Topographic: elevation, sun orientation and soil structure.
- Biological: fauna and flora.
- Cultural: changes in the soil, pollution of the atmosphere and hydrological modifications.

The elements and especially the factors of climate are sometimes so complex and variable, highly dynamic, sometimes with chaotic behavior, that it is impossible to define their precise functioning.

2.2 PRECIPITATION

Precipitation, as defined by Bertoni and Tucci (2009), consists of all water from the atmosphere that reaches the earth's surface, regardless of its physical state, such as drizzle, rain, snow, hail, frost or dew. In Brazil, approximately 99% of precipitation occurs in the form of rain, while less than 1% manifests itself in the other forms (Santos *et al.*, 2001). Rainfall is a widely studied climatic element, especially due to meteorological and hydrological records, which in some regions date back to the beginning of the twentieth century (Cavalcanti *et al.*, 2009).

Clouds, which allow precipitation to occur under specific conditions, are formed by the mixture of air, water vapor, and liquid or solid droplets, whose diameters vary between 0.001 and 0.03 mm (Bertoni and Tucci, 2013). The main characteristics of precipitation include its duration, total precipitated volume, temporal and spatial distribution. In terms of

hydrometeorological processes, rainfall is the element that presents the greatest monthly and annual variability when compared between different regions.

According to Bertoni and Tucci (2013), the formation of precipitation is associated with the upward movement of humid air masses, which causes a dynamic or adiabatic cooling, leading the water vapor to reach its saturation point. From the condensation level, under favorable conditions and in the presence of hygroscopic nuclei, water vapor condenses, forming tiny droplets around these nuclei. For the water droplets to precipitate, it is necessary that they reach such a volume that their weight exceeds the forces that keep them in suspension, thus acquiring a speed of fall superior to the ascending vertical components of atmospheric movements. Raindrops have diameters ranging from 0.5 to 2.0 mm, and can reach maximum values of 5.0 to 5.5 mm. When a droplet reaches a diameter of 7.00 mm, its fall velocity reaches approximately 9 m/s, at which time its deformation occurs and subsequent fragmentation into smaller droplets due to air resistance (Bertoni and Tucci, 2009).

3 METHODOLOGY

For the development of the research, a unified methodological approach of bibliometric analysis was implemented, providing greater robustness to the study. Table 1 presents the relationship between the research questions, the analyses proposed in our methodological approach and the data used for their execution. The table is structured in three main fields: the questions of interest, the analysis used to answer them, and the type of data used.

Table 1

Description of the relationship between work issues, analyses, and data sources

Questions	Analysis	Data
What are the trends in publications on precipitation models using time series?	General statistics/Word co-occurrence network/Co-authoring spatial network	All papers
Which countries contributed the most to research on precipitation models using time series?	General statistics/Word co-occurrence network/Co-authoring spatial network	All papers
Do the articles specify the geographical area covered by the precipitation model and the spatial and/or temporal resolution of the model?	Metrics	40% more cited

Do the surveys identify the relevant climate and weather variables that affect precipitation and the data sources used to provide these variables?	Metrics	40% more cited
Do studies consider different types of precipitation and the physical and meteorological processes in the precipitation model?	Metrics	40% more cited
The studies present the most used methods for calibration and validation of precipitation models and what are these methods?	Metrics	40% more cited
How can advances in precipitation modeling impact water resources management and agriculture?	General statistics/general characteristics	40% more cited
What are the emerging trends in precipitation modeling, and how are artificial intelligence and machine learning being integrated into precipitation models?	General characteristics	40% more cited
What are the most influential publications on precipitation models using time series?	General statistics/Word co-occurrence network/Co-authoring spatial network	40% more cited

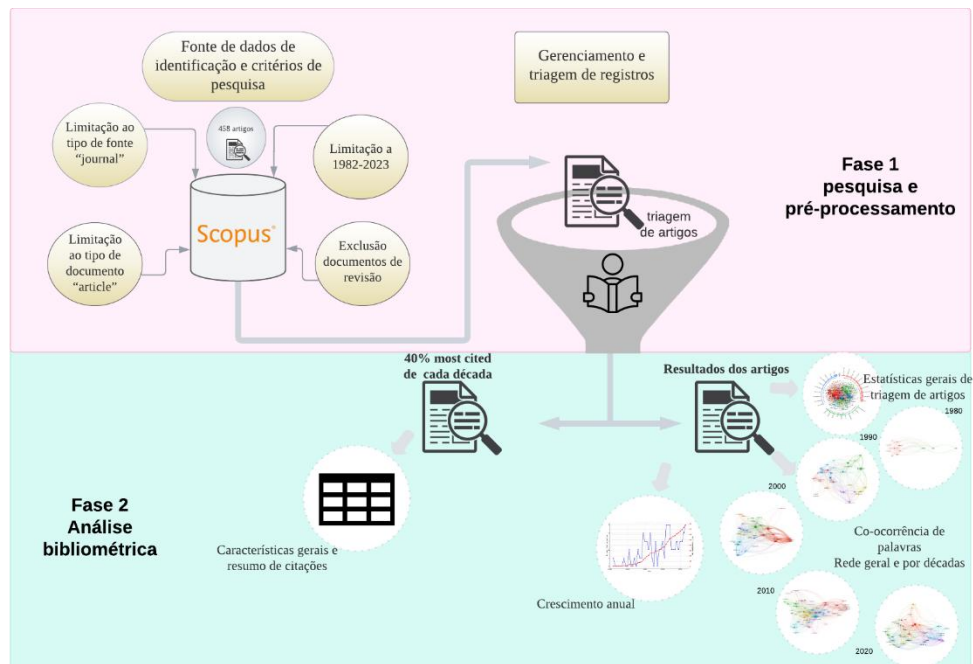
Source: Prepared by the authors.

The approach and methodological steps used are illustrated in Figure 1, which involves the choice of the search database, the identification of terms relevant to the theme and the application of filters in the search engine. Then, a manual screening was carried out, with the reading of the titles and abstracts of the retrieved articles, in order to identify and exclude those that did not align with the research objectives, characterizing Phase 1 of the research. Subsequently, analyses were carried out for two sets of data: all selected articles, a total equivalent to 78 articles, and for the 40% most cited in each decade.

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Figure 1

Logical scheme, methodological approach and data analysis



Source: Prepared by the authors themselves.

3.1 DATABASE

The selection of the Scopus database for the collection of bibliometric data is justified by its comprehensiveness and quality, being recognized as one of the largest global multidisciplinary databases. Scopus provides access to more than 27,800 peer-reviewed journals and more than 330,000 books, as well as conference proceedings, ensuring extensive and reliable coverage of scientific information (ELSEVIER, 2024). Its advanced data analysis and retrieval tools allow the identification of trends, citation patterns, and collaboration networks, essential aspects for the mapping of scientific knowledge.

In the present study, Scopus is particularly relevant for the analysis of time-series-based precipitation estimation models, as it facilitates the retrieval of articles that address the validation of specific models and methodologies. The restriction of the search to articles published in journals aims to ensure the originality and robustness of the data, avoiding common duplications in reviews, book chapters or conference proceedings. This rigor in the selection of sources reflects the need for a consolidated and reliable basis for detailed bibliometric analyses, reinforcing the choice of Scopus as the primary source.

The use of Scopus, with its robust tools for exporting and analyzing data in multiple formats, contributes significantly to bibliometric studies. Such studies allow us to understand

scientific developments in specific areas, identify gaps in the literature, and guide future research and the development of new methodologies, standing out as an essential resource for academic research.

3.2 SCREENING SEARCH AND REGISTRATION STRATEGY

The research strategy used in the Scopus database focused on the analysis of precipitation estimation models and time series analysis, taking into account their validation methods. For the construction of the dataset, the search was structured using Boolean operators, such as OR and AND, which allowed combining different terms and synonyms to refine the results and include only the articles relevant to the scope of the study. The terms chosen, such as "Rainfall Estimation Statistic Model*", "Rainfall Data Analysis Model*", "Rainfall Model*", among others, aimed to identify the most significant publications in the area of precipitation modeling. The use of these Boolean operators helped to select articles that addressed modeled time series and the analyses associated with mathematical modeling, essential aspects for scientific development on the subject.

To structure the dataset, Boolean operators OR and AND were used. The keywords used in the research were selected with the objective of identifying essential aspects that contribute to the understanding of the scientific development related to precipitation modeling, as well as to identify gaps in the literature on the subject. Several preliminary tests were conducted with different terms and synonyms until the final set of keywords pertinent to the study was reached.

The terms of the final equation: TITLE-ABS-KEY (("Rainfall Model*" OR "Precipitation Model*" OR "Rainfall Estimation Model*" OR "Precipitation Estimation Model*" OR "Rainfall Estimation Statistic Model*" OR "Precipitation Estimation Statistic Model*" OR "Rainfall Data Analysis Model*") AND ("Time Series Analysis*" OR "Time Series*" OR "Temporal Data Analysis" OR "Temporal Data" OR "Rainfall Data Model")) AND PUBYEAR > 1981 AND PUBYEAR < 2024 AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (DOCTYPE , "ar")).

The final search equation further refined the results by limiting the year of publication between 1982 and 2023 and the type of document to finished research articles (peer-reviewed articles), ensuring that the data collected was of high quality and relevance.

After this initial stage, the titles and abstracts of the retrieved articles were carefully reviewed, excluding those that were not aligned with the objectives of the study. This

approach allowed the bibliometric analysis to be based on a robust and well-defined dataset, which was later exported in CSV format for qualitative and quantitative analyses. These analyses included the geographic distribution of the studies, allowing a comprehensive view of the evolution and impact of research on precipitation models over time (SANTANA *et al.*, 2021).

This initial process made it possible to identify emerging patterns and evolution in research topics over time. Subsequently, a detailed systematic review was carried out on 40% of the most cited articles in each period.

This study, by integrating a quantitative and qualitative approach, not only maps the historical development of the area of environmental sciences, but also highlights the gaps and future opportunities, reinforcing the importance of methodological innovation and international collaboration in scientific research.

3.3 SEMANTIC AND GENERAL NETWORK ANALYSIS

The construction of the term networks was carried out using the VOSviewer program, a software developed for bibliometric analysis of scientific literature (VAN ECK; WALTMAN, 2010) that uses the VOS mapping technique to visualize similarities and allow the development of bibliometric maps. The software was used to make maps based on data of co-occurrences between the terms. The use of this software was based on the possibility of running on many hardware platforms, operating systems, being free and also the possibility of being used directly from the internet (VAN ECK; WALTMAN, 2010; VAN NUNEN *et al.*, 2018). The minimum number of occurrences of a keyword is five times for the decades and general network, for titles, abstracts, and keywords of all publications to build a network.

VOSviewer can be used to build networks of scientific publications, scientific journals, researchers, research organizations, countries, and keywords. Items in these networks can be connected by co-authorship, co-occurrence, citation, bibliographic coupling, or co-citation links (VAN ECK; WALTMAN, 2010). The bibliometric maps produced in VOSviewer use principles related to text mining (VAN ECK; WALTMAN, 2010). The analysis of the keywords between titles and abstracts shows the connection between related terms, providing the division into groups called clusters, which groups all terms considered similar.

The counting method for this study was full counting, corresponding to the total count, where each link of co-occurrences has the same weight, which means that all occurrences of the term in the document will be counted, but there is binary counting only observing the

presence or not of the term existing in the document (VAN ECK; WALTMAN, 2010).

The graphical representations expressed in the maps relate the proportionality of similarities and co-occurrences of terms in the publications: the co-occurrence networks are composed of nodes and edges. In which nodes are objects such as the co-occurrence of words and countries. Between any pair of knots there can be an edge. An edge is a connection or a relationship between two nodes. The distance between two nodes in the visualization roughly indicates the relationship between the searched terms in terms of co-occurrence. Node size is determined by the weight of an item in a given network (VAN ECK; WALTMAN, 2010).

For the creation of the clusters, a thesaurus file was prepared, which represents a thesaurus dictionary in txt format, where the word is as the label is and replace by, which is the way the term is to be (WALTMAN; VAN ECK; NOYONS, 2010). The thesaurus is used to clean up terms, and can ignore some, exclude, change the way they are written and/or unify terms that have similar meanings.

3.4 STATISTICAL ANALYSIS OF THE NETWORK

The bibliometric analysis, essential to understand the panorama of scientific production in certain areas of study, was conducted through the Bibliometrix statistical package, an open-source tool integrated with the R language, widely recognized for its versatility in scientific data analysis (ARIA; CUCCURULLO, 2017).

For the development of this analysis, the necessary commands for the installation and activation of the Bibliometrix package were implemented in the R Studio environment. First, `install.packages("bibliometrix")` was used to ensure the installation of the package, followed by `library(bibliometrix)` and `biblioshiny()`, which activated the interactive graphical interface, allowing a more intuitive visualization of the data. From there, a database with scientific publications was entered into the system, and variables such as the contribution of different countries and the productivity of the authors were analyzed, these data were processed and organized manually, using adjustments in the frequency histograms to refine the presentation of the results.

In short, the use of the Bibliometrix package in R Studio, with its wide range of resources for analysis and visualization, made it possible to elaborate an in-depth mapping of scientific production, allowing a better understanding of the dynamics and trends of the field under study.

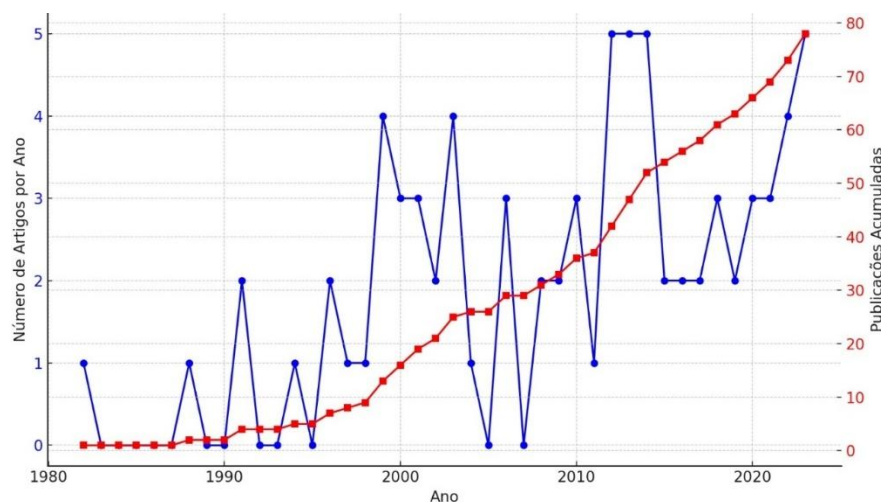
4 RESULTS AND DISCUSSIONS

4.1 PRECIPITATION MODELING TRENDS PUBLICATIONS

After processing the bibliographic data and manual filtering, the final sample resulted in 78 articles published between 1982 and 2023, with an average of 1.86 articles per year and a standard deviation of 1.59, i.e., 1.86 ± 1.59 . This indicates that, on average, there were approximately 1.86 annual publications, with a variation of 1.59 articles around this average. There was also an annual growth of 4.0%, as shown in Figure 2.

Figure 2

Articles published by year and accumulated in the period 1982-2023



Source: Prepared by the authors themselves.

When annual growth is evaluated, the data indicate a modest and irregular growth in the number of articles published between 1982 and 2023. The analysis reveals years with production peaks, such as 1999, 2003, 2012 and 2023, as well as periods without publications or with few productions (for example, between 1983 and 1987). This behavior reflects the growing interest in precipitation modeling as new technologies and data have become available, as well as the impact of global and regional events.

Precipitation modeling, especially utilizing techniques such as kriging and Fourier analysis, has benefited from advances in computing and remote sensing, such as the use of satellites, which have become more accessible in recent decades. Factors such as the climate crisis and the need to predict extreme events (floods and droughts) also drove the growth in scientific production from the 2000s onwards. The increase in production can be

explained by the growing need for more accurate predictive tools, especially in regions with scarce rainfall data, such as Bahia, for example.

Table 2 shows a clear trend of increase in the number of articles published over time.

Table 2

Evolution of the number of publications over the decades, with percentage, mean and standard deviation

Decade	Total Publications	Percentage of Total (%)	Average Articles/year	Standard deviation
1982-1989	2	2,56%	0,25	0,43
1990-1999	10	12,82%	1,1	1,22
2000-2009	26	33,33%	2	1,26
2010-2019	36	46,15%	3	1,41
2020-2023	12	15,38%	3,75	0,83

Source: Prepared by the authors themselves.

Figure 2 and Table 2 show that with regard to the growth of accumulated publications, it is necessary to reflect the consolidation of precipitation modeling as an important research area. The cumulative graph shows a consistent increase from 1999 onwards, which coincides with increased access to technological tools such as models based on geospatial data and the use of advanced computational techniques. From 2010 onwards, growth accelerated, highlighting the fundamental role of modeling to face contemporary climate challenges, such as extreme variations in precipitation, changes in rainfall patterns and the sustainable management of water resources.

When the analysis is carried out by decades, it is found that, in the 80s (1982-1989), 2 publications were made, corresponding to 2.56% of the total. This period presents a low number of articles, reflecting the initial stage of research in precipitation modeling. In the 90s (1990-1999) we had 10 publications, representing 12.82% of the total. The 1990s marks the beginning of a more significant increase in interest in climate modeling, possibly driven by growing concern about the impact of climate change. In the 2000s (2000-2009) there were 26 publications, representing 33.33% of the total. This decade sees a notable increase in scientific output, which can be associated with the emergence of remote sensing technologies, more sophisticated climate models, and the widespread use of meteorological data from satellites. From 2010-2019, 2010s, 36 publications, corresponding to 46.15% of the total. This period consolidates precipitation modeling as a mature research area, with the intensive use of big data, artificial intelligence, and the development of more advanced predictive modeling techniques, such as kriging and spectral analysis. And finally, the decade

still in formation, 2020-2023, there are already 12 publications so far, representing 15.38% of the total. Even with fewer years, production continues to grow, reflecting the increasing relevance of precipitation modeling, especially in response to extreme weather events and the need to more accurately predict the impacts of climate change.

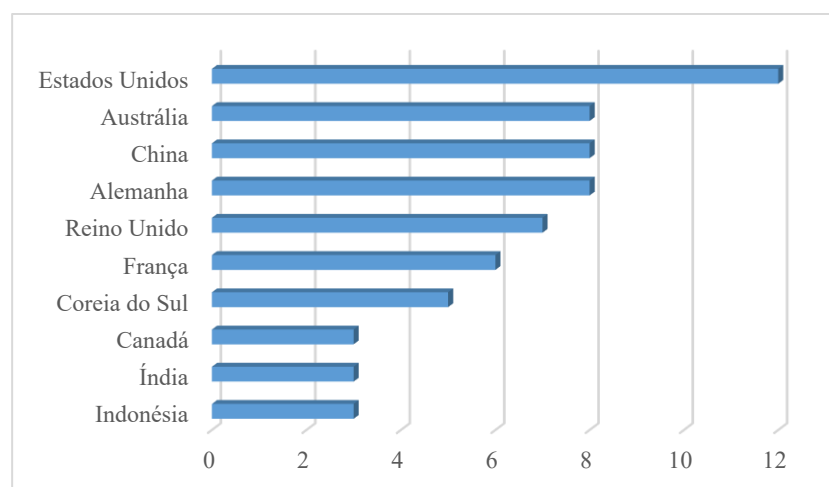
Still analyzing Figure 2, it is possible to observe that the peaks and falls in publications can be justified by technological factors and global events. The 1999 peak may be related to increased interest in precipitation modeling due to the Kyoto Protocol and growing concern about climate change. In the 2000s, the use of satellites and techniques such as kriging boosted publications. Between 2012 and 2013, the use of big data and artificial intelligence further expanded interest in the field. The relative drop in 2020-2023 may have been influenced by the COVID-19 pandemic, which impacted global scientific production, although interest remained high due to the relevance of the topic. These data justify the mean and standard deviation presented in Table 2.

4.2 COUNTRIES CONTRIBUTED TO RESEARCH ON PRECIPITATION MODELING

A bibliometric network was built to visualize the collaboration networks and the distribution of publications around the world related to the application on precipitation modeling. Figure 3 shows how the quantities of publications were distributed among the 10 countries with the highest number of publications in the area in question.

Figure 3

Number of publications by country



Source: Prepared by the authors themselves.

The United States occupies the first place, with a total of 30 publications, and Brazil occupies the ninth position in the global ranking of the geographical distribution of scientific productions relative to the number of citations by countries, and Table 3 shows the percentage of each country.

Table 3

Number of articles published and percentages

Countries	Frequency	Percentage (%)
United States	30	12,66
United Kingdom	26	10,97
Australia	22	9,28
France	19	8,02
China	18	7,59
Germany	14	5,91
Indonesia	11	4,64
South Korea	10	4,22
Brazil	6	2,53
Ecuador	5	2,11

Source: Prepared by the authors themselves.

4.3 GEOGRAPHICAL AREA AND RESOLUTION

The analysis of the 32 articles reveals that all of them (100%) specify the geographical area covered by the precipitation model and the spatial and/or temporal resolution of the model. This indicates that the scientific community has a consensus on the importance of clearly defining the scope and resolution of precipitation models.

Regarding temporal resolution, the most common is the daily resolution, present in 90.6% of the articles. Hourly resolution appears in only 3.1% of cases, while the combination of daily and monthly resolution is observed in 6.3% of articles. This suggests that everyday resolution is preferred in most studies, likely due to its balance between detail and computational feasibility.

With regard to spatial resolution, the most frequent is regional, present in 93.8% of the articles. Local resolution appears in only 6.2% of cases, indicating that most studies focus on larger geographic areas, such as regions or watersheds, rather than specific locations.

When analyzing the trends over the decades, a consolidation of daily and regional resolution is observed. In the 1980s, only daily and regional resolution was observed. In the

1990s, there was a small diversification, with the introduction of time and local resolution. However, from the 2000s onwards, daily and regional resolution became dominant, with 100% prevalence in the 2010s and 2020s. This reflects a standardization in modeling approaches, possibly driven by technological advances and the need for comparability between studies.

Therefore, the data show that the scientific community prioritizes daily and regional resolution in precipitation modeling, with a clear trend of consolidation of these characteristics over time. Time and local resolution, although present in some studies, is less common, suggesting that they are applied in specific contexts or in early stages of research.

4.4 CLIMATE VARIABLES AND DATA SOURCE

The analysis of the 32 articles reveals that 59.4% of them identify the relevant climatic and meteorological variables that affect precipitation, while 40.6% do not identify them, but mention the data sources used. This indicates that, although most studies seek to understand the factors that influence precipitation, a significant portion focus more on the collection and use of data than on the exploration of specific climate variables.

Over the decades, a clear evolution has been observed both in the climate variables studied and in the data sources used. In the 1980s, articles focused on precipitation-related variables, such as depth and duration of events, using primarily rain gauge data. In the 1990s, there was an introduction of more complex variables, such as atmospheric circulation, temperature, and pressure, with the use of atmospheric pressure data and meteorological records.

In the 2000s, precipitation modeling expanded to include variables such as topography, terrain gradient, and relative humidity, using reanalyses, interpolated data, and radiosonde. The 2010s marked an even greater diversification, with the introduction of variables such as altitude, latitude, longitude, and oceanic-atmospheric indices (IPO-PDO), in addition to the expansion of the use of satellite data, regional climate models, and paleoclimate series.

In the 2020s, there was a reduction in the number of articles identifying climate variables, with only 20% of studies highlighting specific variables. However, there is a consolidation of the use of advanced data sources, such as satellites and global climate models (GCMs), reflecting a trend to prioritize the collection and processing of high-resolution data.

It is thus concluded that, over time, there has been a transition from studies focused on simple variables and local data (such as rain gauges) to a more complex and integrated approach, which combines detailed climate variables with advanced data sources, such as satellites and global models. This evolution reflects technological advances and the need for more accurate models to deal with the challenges of climate change and water resources management.

4.5 TYPES OF PRECIPITATION AND PHYSICAL PROCESSES

The analysis of the 32 articles reveals that 59.4% of them consider physical and meteorological processes in their precipitation models, while 40.6% do not address these processes. This indicates that, although most studies seek to understand the mechanisms that influence precipitation, a significant portion focus more on the collection and use of data than on the exploration of the underlying physical and meteorological processes.

Over the decades, there has been a clear evolution in the approach to physical and meteorological processes. In the 1980s, studies focused on specific processes, such as convective storms. In the 1990s, there was an introduction of broader concepts, such as the relationship between atmospheric circulation and the occurrence of rainfall, in addition to the influence of temperature and humidity on the formation of precipitation. In the 2000s, studies expanded to include spatial gradients and orographic effects, reflecting greater complexity in modeling.

From the 2010s onwards, there was a significant diversification of the processes considered, with the introduction of concepts such as advection, diffusion, convection, monsoon circulation and interannual variability. This trend continued in the 2020s, with a consolidation of the use of statistical relationships between temperature and precipitation, indicating a prioritization of quantitative analysis and modeling.

It is important to highlight that, in all articles, the only form of precipitation considered was rain. There was no mention of other types of precipitation, such as snow or hail, which reflects the focus of the studies on regions and contexts in which rain is the predominant form of precipitation.

Thus, over time, there has been a transition from studies focused on specific and local processes to a more complex and integrated approach, which combines multiple physical and meteorological processes with advanced statistical analysis techniques. This evolution

reflects technological advances and the need for more accurate models to deal with the challenges of climate change and water resources management.

4.6 CALIBRATION AND VALIDATION METHODS

The analysis of the methods of calibration and validation of precipitation models over the decades reveals a significant evolution, driven by the advancement of technology and the need for more accurate and reliable models. Table 4 shows the most used methods by decade.

Table 4

Most used methods over the decades

Decade	Most Used Methods
1980	Correlation between depth and duration; observational data.
1990	Conditional probabilities; stochastic models, maximum verisimilitude.
2000	Markov Chains; simulated annealing; nonlinear regression; adjustment of distributions.
2010	Neural Networks (ANN); MCMC; cross-validation; adjustment of distributions; satellite data.
2020	Deep learning (LSTM); copulations; heuristic optimization (ISPSO); integration of satellites.

Source: Prepared by the authors themselves.

In the 1980s, calibration and validation methods were relatively simple and based on descriptive statistics. The article analyzed from this period used correlations between depth and duration of precipitation events and reliable observational data in semi-arid zones. These methods reflected the technological limitations of the time, focusing on empirical adjustments and basic correlations. The lack of diversification of techniques can be attributed to the scarcity of data and limited computational capacity.

In the 1990s, there was a significant advance with the introduction of more sophisticated statistical methods. The articles of this decade used conditional probabilities based on time series of atmospheric circulation patterns and stochastic models applied on a regional scale. In addition, methods such as maximum likelihood and comparison of observed and simulated statistics began to be employed. These techniques allowed for a better representation of climate variability and a more robust validation of the models.

The 2000s marked a period of diversification and optimization of calibration and validation methods. The articles analyzed showed the use of techniques such as Markov chains, simulated annealing and nonlinear regression. These methods allowed for more precise adjustments of the model parameters and a better representation of precipitation at different spatial and temporal scales. In addition, adjustment of distributions (Weibull, GEV, Kappa) has become common, reflecting a growing concern with the statistical representation of data.

The 2010s were marked by the use of computationally intensive methods and the concern with the quantification of uncertainties. With 12 articles analyzed, techniques such as artificial neural networks (ANN), Bayesian methods (MCMC) and cross-validation stand out. These methods allowed for more accurate calibration and the incorporation of uncertainties into the models. In addition, adjustment of distributions (Poisson, geometric, exponential) and integration of satellite data have become commonplace, reflecting the increasing availability of data and the advancement of technology.

In the 2020s, calibration and validation methods reached a new level of sophistication. The analyzed articles observed the use of techniques such as deep learning (LSTM), copulas and heuristic optimization (ISPSO). These methods allowed for a more accurate representation of precipitation, especially at thin temporal and spatial scales. In addition, the integration of satellite data and distributed hydrological models (such as W-flow) has become a trend, reflecting the need for more realistic models that are applicable in different contexts.

Over the decades, calibration and validation methods have evolved from simple, empirical techniques to computationally intensive and sophisticated approaches. This evolution has been driven by the advancement of technology and the increasing availability of data. From the 2010s onwards, there was a growing concern with the quantification of uncertainties, using methods such as MCMC and cross-validation. This reflects the need for more reliable and robust models. In the 2020s, the integration of satellite data and hydrological models became a trend, allowing for a more realistic representation of precipitation and its variability. The use of artificial intelligence techniques such as neural networks (ANN) and deep learning (LSTM) became commonplace in the 2010s and 2020s, reflecting the potential of these techniques to improve the accuracy of models.

4.7 IMPACTS ON WATER RESOURCES MANAGEMENT AND AGRICULTURE

Advances in precipitation modeling have positively impacted water resource management and agriculture in a number of ways. Firstly, improved forecasting of precipitation events allows for more efficient management of reservoirs and irrigation systems. More accurate models help predict water availability, which is crucial for agricultural planning, especially in semi-arid regions where water is a scarce resource. Additionally, the ability to predict extreme events such as droughts and floods has been essential for risk mitigation and natural disaster preparedness.

The integration of satellite data and ground-based observations has brought significant advances in extreme event prediction and water resource management. Models that incorporate this data allow early warnings for floods and droughts, helping in the operation of reservoirs and in the planning of water infrastructure. This is particularly important for agriculture, where predicting water availability and mitigating agricultural risks are critical to ensuring food security.

Another important impact of advances in precipitation modeling is adaptation to climate change. Models that incorporate future climate projections allow farmers and water resource managers to prepare for climate change scenarios, such as changes in precipitation patterns and an increase in the frequency of extreme events. This is crucial for the sustainable management of water resources and for the resilience of agriculture in the face of climate change.

Exhibit 5 below summarizes the main impacts of advances in precipitation modeling in water resources management and agriculture by decade.

Table 5

Major advances in water resources management and agriculture

Decade	Impacts on Water Resources Management and Agriculture
1980	Improved prediction of precipitation events; support for agriculture in semi-arid areas.
1990	Forecast of droughts and floods; water resources planning and agriculture based on atmospheric patterns.
2000	Generation of realistic spatial patterns; improvement in the allocation of water resources; support for agriculture.
2010	Early warnings for extreme events; forecast of water availability for agriculture; water infrastructure planning.
2020	Flow forecasting and reservoir management; mitigation of agricultural risks; adaptation to

	climate change.
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Source: Prepared by the authors themselves.

Therefore, advances in precipitation modeling have had a significant impact on water resources management and agriculture. Improved precipitation event forecasting, satellite data integration, and climate change adaptation are some of the key benefits of these advancements.

4.8 EMERGING TRENDS AND INTEGRATION OF NEW TECHNOLOGIES

In the 1980s and 1990s, precipitation modeling was dominated by traditional statistical methods, such as event-based and stochastic models, focusing on semi-arid zones and atmospheric patterns. These approaches, while effective for the context of the time, were limited by a lack of data and computational power. From the 2000s onwards, there was a significant advance with the introduction of techniques such as random cascade models and statistical downscaling, which allowed for a more accurate representation of precipitation at regional and local scales.

The 2010s marked the beginning of the integration of AI/ML techniques in precipitation modeling, with the use of artificial neural networks (ANN) for downscaling and precipitation prediction. In addition, the integration of satellite data and the use of Bayesian methods for quantification of uncertainties have brought significant advances in the accuracy of forecasts. In the 2020s, the consolidation of deep learning techniques, such as LSTM (Long Short-Term Memory), and the use of copulas and heuristic optimization (ISPSO) stood out as emerging trends. These techniques allowed for more accurate and adaptable predictions to climate change scenarios.

The integration of AI/ML in precipitation modeling began to gain prominence in the 2010s, with the use of neural networks (ANN) for downscaling and precipitation forecasting. However, it was in the 2020s that these techniques took hold, with the widespread use of deep learning (LSTM) and heuristic optimization techniques. These advances have made it possible not only to improve the accuracy of forecasts, but also to quantify uncertainties and adapt models to climate change scenarios.

Table 6 presents a summary of the evolution of trends and modeling over the decades according to the articles analyzed.

Table 6

Trend analysis and integration with AI/ML for decades

Decade	Emerging Trends	AI/ML integration
1980	Event-based models; focus on semi-arid areas.	Not mentioned.
1990	Stochastic models; atmospheric classification.	Not mentioned.
2000	Random cascade models; statistical downscaling; adjustment of distributions.	Not mentioned.
2010	Integration of satellite data; Bayesian models; neural networks (ANN).	Neural networks (ANN) for downscaling and forecasting.
2020	Deep learning (LSTM); copulations; integration of satellite data; Heuristic optimization.	Deep learning (LSTM); ML techniques for parameter tuning and optimization.

Source: Prepared by the authors themselves.

4.9 CHARACTERISTICS OF THE MOST INFLUENTIAL PUBLICATIONS ON PRECIPITATION MODELS USING TIME SERIES

The four percent of the most cited articles in each decade of analysis, between 1982-2023, were evaluated. Table 7 shows the number of articles per decade and the corresponding total read to 40% of each decade.

Table 7

Data on the number of articles after final screening divided by decades and quantity read

Decade	Total Articles	Amount read
1980	2	1
1990	11	5
2000	20	8
2010	30	12
2020	15	6

Source: Prepared by the authors themselves.

The final number of articles after all exclusion analysis was 78, in which when extracting the 40% of each decade that were read, the sum corresponds to the equivalent of 32 articles, which corresponds to about 41% of the final total of selected articles.

The most cited published articles are shown in Table 8.

Table 8

Published articles

No.	Title	Authors	Year
1	Practical generation of synthetic rainfall event time series in a semi-arid climatic zone	Bogárdi, János J.; Duckstein, Lucien; Rumambo, Omar H.	1988
2	Modeling daily rainfall using a semi-Markov representation of circulation pattern occurrence	Bardossy, Andras; Plate, Erich J.	1991
3	Regression model for generating time series of daily precipitation amounts for climate change impact studies	Buishand T.A.; Klein Tank A.M.G.	1996
4	Further developments of the neyman-scott clustered point process for modeling rainfall	Cowpertwait, P.S.P.	1991
5	Precipitation and air flow indices over the British Isles	Conway, D., Wilby, R.L., Jones, P.D.	1996
6	Generating precipitation time series using simulated annealing	Bárdossy, A.	1998
7	The collaborative historical African rainfall model: Description and evaluation	Funk, Chris; Michaelsen, Joel; Verdin, Jim; Artan, Guleid; Husak, Greg; Senay, Gabriel; Gadain, Hussein; Magadzire, Tamuka	2003
8	Time series analysis model for rainfall data in Jordan: Case study for using time series analysis	King Abdul Aziz University, Jeddah, Saudi Arabia	2009
9	Tests of a space-time model of daily rainfall in southwestern Australia based on nonhomogeneous random cascades	Jothityangkoon, Chatchai; Sivapalan, Murugesu; Viney, Neil R.	2000
10	Downscaling temperature and precipitation: A comparison of regression-based methods and artificial neural networks	Schoof, J.T., Pryor, S.C.	2001
11	Multivariate rainfall disaggregation at a fine timescale	Koutsoyiannis, D., Onof, C., Wheeler, H.S.	2003
12	A spatial rainfall generator for small spatial scales	Willems, P.	2001
13	A space-time hybrid hourly rainfall model for derived flood frequency analysis	Haberlandt, U., Ebner Von Eschenbach, A.-D., Buchwald, I.	2008

14	Coupled rainfall model and discharge model for flood frequency estimation	Arnaud, P., Lavabre, J.	2002
15	A rainfall model based on a Geographically Weighted Regression algorithm for rainfall estimations over the arid Qaidam Basin in China	Lv, Aifeng; Zhou, Lei	2016
16	Finding the most appropriate precipitation probability distribution for stochastic weather generation and hydrological modelling in Nordic watersheds	Li, Zhi; Brissette, François; Chen, Jie	2013
17	Downscaling transient climate change using a Neyman-Scott Rectangular Pulses stochastic rainfall model	Burton, A., Fowler, H.J., Blenkinsop, S., Kilsby, C.G.	2010
18	A dynamic nonstationary spatio-temporal model for short term prediction of precipitation	Sigrist, F., Künsch, H.R., Stahel, W.A.	2012
19	Application of a stochastic weather generator to assess climate change impacts in a semi-arid climate: The Upper Indus Basin	Forsythe, N., Fowler, H.J., Blenkinsop, S., ... Harpham, C., Hashmi, M.Z.	2014
20	Climate-informed stochastic hydrological modeling: Incorporating decadal-scale variability using paleo data	Henley, B.J., Thyer, M.A., Kuczera, G., Franks, S.W.	2011
21	Precipitation Modeling by Polyhedral RCMARS and Comparison with MARS and CMARS	Özmen, A., Batmaz, İ., Weber, G.-W.	2014
22	Statistical downscaling of precipitation using a stochastic rainfall model conditioned on circulation patterns - an evaluation of assumptions	Haberlandt, U., Belli, A., Bárdossy, A.	2015
23	Regionalization of the modified bartlett-lewis rectangular pulse stochastic rainfall model	Kim, D., Olivera, F., Cho, H., Socolofsky, S.A.	2013
24	Short time step continuous rainfall modeling and simulation of extreme events	Callau Poduje, A.C., Haberlandt, U.	2017
25	Models of daily rainfall cross-correlation for the United Kingdom		2013

		Burton, A., Glenis, V., Jones, M.R., Kilsby, C.G.	
26	Regionalization of the Modified Bartlett–Lewis rectangular pulse stochastic rainfall model across the Korean Peninsula	Kim, D., Kwon, H.-H., Lee, S.-O., Kim, S.	2016
27	Forecast of rainfall distribution based on fixed sliding window long short-term memory	Chen, C., Zhang, Q., Kashani, M.H., ... Dash, S.S., Chau, K.-W.	2022
28	Rainfall Generation Revisited: Introducing CoSMoS-2s and Advancing Copula-Based Intermittent Time Series Modeling	Papalexiou, S.M.	2022
29	Trends of rainfall and temperature in Northeast Brazil Rainfall and temperature trends in Northeast Brazil	de Carvalho, A.A., A. Montenegro, A.A., da Silva, H.P., ... de Moraes, J.E.F., da Silva, T.G.F.	2020
30	Development and hydrometeorological evaluation of a new stochastic daily rainfall model: Coupling Markov chain with rainfall event model	Gao, C., Booij, M.J., Xu, Y.-P.	2020
31	A robust method to develop future rainfall IDF curves under climate change condition in two major basins of Iran	Khazaei, M.R.	2021
32	The Reliability of W-flow Run-off-Rainfall Model in Predicting Rainfall to the Discharge	Tama, D.R., Limantara, L.M., Suhartanto, E., Devia, Y.P.	2023

Source: Prepared by the authors themselves.

4.10 TOPOLOGY OF THE DECADES AS RESEARCH FOCUSES AND SEMANTIC NETWORKS

Figure 2 shows an analysis of the network of co-word occurrence, which can be used to identify the state of the art. The research topic that is Mathematical Modeling of precipitation was categorized into four colored clusters, following the composition over time: 1980s (2 clusters), 1990s (7 clusters), 2000s (9 clusters), 2010s (10 clusters), 2020s (7 clusters).

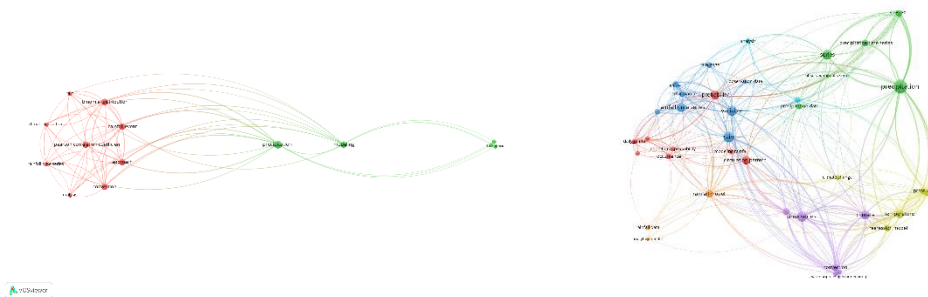
The 10 most cited terms across the clusters include: "precipitation," "rainfall," "probability," "time series," "performance," "climate change," "precipitation intensity," "distribution," "accuracy," and "forecast." These terms reflect the evolution of precipitation

modeling, moving from simple rainfall and probability analyses to complex predictive models that integrate time-series data, extreme event forecasts, and the impact of climate change.

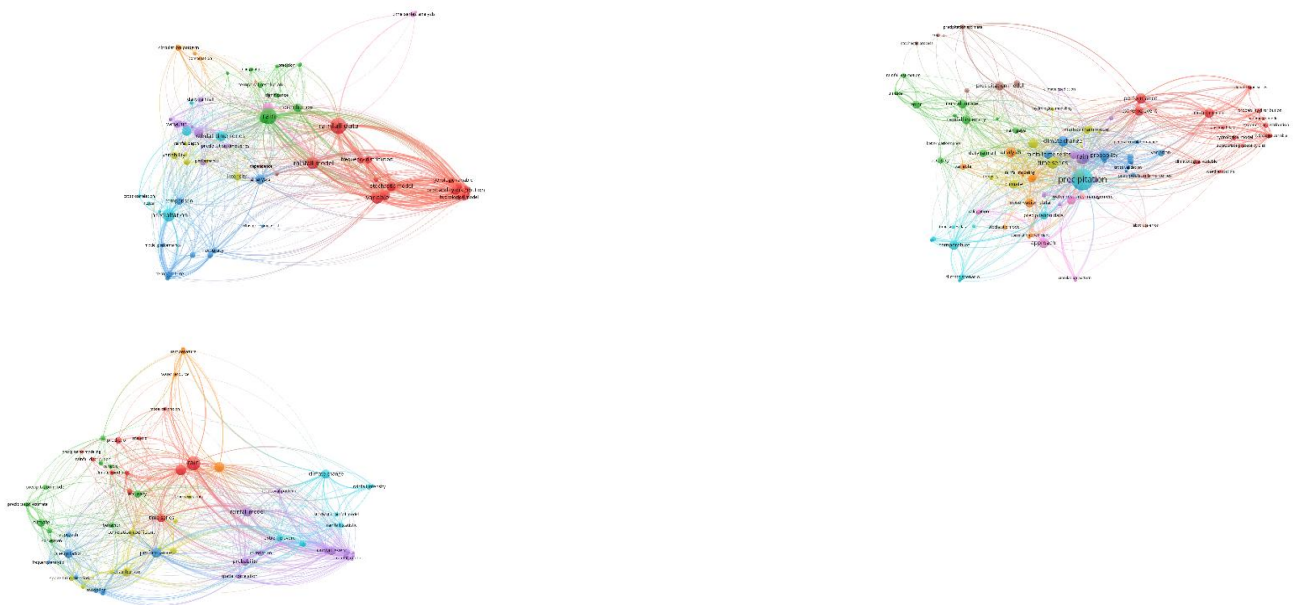
Figure 1

Co-occurrence network of words presented in the titles, abstracts and keywords for each decade (1980, 1990, 2000, 2010 and 2020)

1980s 1990s



2000s 2010s 2020s



Source: Prepared by the authors themselves.

Between 1982 and 1989, studies on precipitation modeling, with only two publications, focused on two main clusters. Cluster 1 includes terms such as "rainfall", "binomial distribution" and "precipitation event", reflecting an approach based on statistical and probabilistic methods, such as the binomial distribution and Pearson's correlation coefficient, to analyze rainfall events. The presence of "time series" and "convection" indicates the use of temporal data and atmospheric processes in the study of these phenomena. Cluster 2, on

the other hand, highlights terms such as "precipitation", "modeling" and "behavior", suggesting a focus on modeling precipitation processes and analyzing the behavior of these phenomena under different climatic conditions. These clusters mark the beginning of investigations into rainfall patterns and their variations.

Between 1990 and 1999, studies on precipitation modeling expanded, with 11 publications distributed in seven clusters. Cluster 1 highlighted terms such as "probability", "daily precipitation" and "conditional probability", indicating the use of advanced statistical methods to model rainfall events and their probabilities. Cluster 2 focused on "precipitation", "time series" and "precision", reflecting temporal analysis and the search for greater accuracy in the prediction of precipitation data. Cluster 3 combined "rainfall", "probability", "observation data" and "performance", pointing to the use of observational data and performance metrics in climate models. Cluster 4 introduced variables such as "temperature", "pressure", "climate change" and "regression model", relating climate change to precipitation patterns. Cluster 5 highlighted "time series", "climate" and "convection", with a focus on climate analysis and atmospheric circulation models. Cluster 6 emphasized "variation" and "analysis," exploring climatic variations and analytical techniques. Finally, Cluster 7 highlighted "precipitation model" and "precipitation data", reflecting quantitative modeling based on observational data. These clusters show an evolution in methods, with greater integration of statistics, time series, atmospheric variables, and climate change in the study of precipitation.

Between 2000 and 2009, studies on precipitation modeling became more complex, with 20 publications distributed in nine clusters. Cluster 1 highlighted terms such as "precipitation data", "precipitation model", "stochastic model" and "probability distribution", indicating the use of statistical and hydrological models to analyze precipitation variability. Cluster 2 focused on "rainfall", "distribution", "temporal resolution" and "daily data", with emphasis on the spatial and temporal distribution of precipitation. Cluster 3 combined "analysis", "accuracy" and "temperature", reflecting the evaluation of climate models and the analysis of atmospheric data. Cluster 4 highlighted "variability", "intensity", "climate scenario" and "depth of precipitation", exploring variations and intensities of rainfall in different scenarios. Cluster 5 focused on "time series" and "variation", with modeling of precipitation in space-time. Cluster 6 included "precipitation," "precipitation time series," "rain gauge," and "precipitation estimation," using observational data to feed models. Cluster 7 highlighted "circulation pattern", analyzing the interaction between atmospheric patterns and precipitation. Cluster 8 focused on "dependence" and "amplitude", studying interrelationships

between climate variables and precipitation events. Cluster 9 emphasized "approach" and "time series analysis", with a methodological focus on time series and detailed data analysis. These clusters show a significant advance in precipitation modeling, with greater complexity, integration of time series, hydrological variables, and stochastic models, reflecting the evolution of climate research techniques.

Between 2010 and 2019, studies on precipitation modeling presented a diversified and highly technical approach, with 30 publications distributed in ten clusters. Cluster 1 highlighted terms such as "performance", "distribution", "extreme event" and "probability distribution", with a focus on the evaluation of precipitation models and prediction of extreme weather events. Cluster 2 emphasized "precipitation model", "precipitation intensity", "error" and "rain gauge", indicating interest in measuring rainfall intensity and the accuracy of models based on observational data. Cluster 3 addressed "probability", "climate change" and "precipitation time series", relating climate change to precipitation modeling with an emphasis on temporal data. Cluster 4 focused on "time series", "variability", "intensity" and "Markov chain model", using advanced methods to predict variations in precipitation. Cluster 5 highlighted "rainfall" and "forecast", with terms such as "statistical model" and "time series analysis", showing the application of statistical models for rainfall forecasting. Cluster 6 explored "precipitation", "temperature" and "climate scenario", analyzing interactions between climate variables and future scenarios. Cluster 7 included "analysis", "validation" and "observation data", with a focus on model validation and precision analysis. Cluster 8 highlighted "precipitation model", "kriging" and "stochastic process", using advanced spatial and stochastic techniques. Cluster 9 emphasized "approach" and "calibration," reflecting the importance of model calibration to ensure accuracy. Cluster 10 focused on "precipitation time series" and "water resources management", highlighting the relevance of temporal analysis for the efficient management of water resources. These clusters demonstrate a high degree of sophistication, with advances in statistical techniques, prediction of extreme events, spatial modeling, and integration of climate variables, reflecting the complexity and interdisciplinarity of climate research in this period.

Between 2020 and 2023, studies on precipitation modeling delved into topics such as climate predictions, variability, and rainfall events, with 15 publications distributed in seven clusters. Cluster 1 highlighted "rainfall", "forecast", "analysis" and "precipitation data", with a focus on rain event forecasts based on detailed analyses of observational data. Cluster 2 emphasized "accuracy," "climate," "meteorological data," "precipitation model," and

"precipitation estimation," reflecting the search for greater reliability in climate models. Cluster 3 focused on "performance", "approach" and "modeling", with studies aimed at evaluating and improving modeling techniques. Cluster 4 highlighted "distribution", "variability", "correlation coefficient" and "time series data", indicating detailed analyses of precipitation variability over time. Cluster 5 focused on "precipitation model", "temporal pattern", "probability" and "precipitation event", with a focus on stochastic modeling and analysis of rainfall temporal patterns. Cluster 6 highlighted "climate change", "extreme event", "hydrological modelling" and "precipitation intensity", exploring the impacts of extreme events and climate change on hydrology. Cluster 7 emphasized "temperature," "water resources," and "precipitation time series," analyzing the effects of temperature on water availability and precipitation variability. These clusters show a strong emphasis on improving the accuracy of models, analyzing extreme events and climate change, and using time series to understand precipitation patterns and variations.

5 CONCLUSION

This study performed a comprehensive bibliometric analysis on precipitation estimation models using time series, identifying trends, methods, and significant contributions over the last four decades. The main findings reveal a marked evolution in precipitation modeling, with a progressive increase in the complexity and precision of the methods used. Initially, in the 1980s, models were based on simple statistical techniques, such as binomial distributions and basic correlations. Over time, there has been a transition to more sophisticated methods such as stochastic models, artificial neural networks (ANN), and more recently, deep learning (LSTM) and heuristic optimization (ISPSO) techniques.

The analysis highlighted the importance of temporal and spatial resolution, with most studies adopting daily and regional resolutions, reflecting a balance between detail and computational feasibility. Additionally, the integration of satellite data and the utilization of artificial intelligence (AI) and machine learning (ML) techniques have become dominant trends over the past decade, allowing for more accurate and adaptable predictions to climate change scenarios.

The practical impacts of these advances are significant, especially in water resources management and agriculture. More accurate models allow for more reliable prediction of extreme events, such as droughts and floods, contributing to risk mitigation and sustainable planning of water and agricultural infrastructures. Adaptation to climate change was also a

central theme, with models that incorporate future projections helping to prepare farmers and managers for adverse climate scenarios.

In terms of theoretical contributions, the study mapped the main methodological trends, highlighting the importance of quantifying uncertainties, the integration of multiple climate variables, and the use of advanced statistical and spatial analysis techniques. The bibliometric analysis also identified the main contributing countries and institutions, with the United States leading in number of publications, followed by the United Kingdom and Australia.

In summary, this study reinforces the relevance of precipitation modeling as a crucial research area to address contemporary climate challenges. The findings highlight the continued need for methodological innovation, international collaboration, and the integration of new technologies, such as AI and ML, to enhance the accuracy and applicability of precipitation models. These advances not only contribute to scientific advancement, but also have significant practical implications for sustainable water resource management and food security in a context of global climate change.

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**INNOVATION, INSTITUTIONALIZATION AND REGIONAL DEVELOPMENT: THE
TRAJECTORY OF INTEG AS A REFERENCE FOR BUSINESS INCUBATORS IN
MEDIUM-SIZED CITIES**

**INOVAÇÃO, INSTITUCIONALIZAÇÃO E DESENVOLVIMENTO REGIONAL: A
TRAJETÓRIA DA INTEG COMO REFERÊNCIA PARA INCUBADORAS EM
CIDADES DE MÉDIO PORTE**

**INNOVACIÓN, INSTITUCIONALIZACIÓN Y DESARROLLO REGIONAL: LA
TRAYECTORIA DE INTEG COMO REFERENCIA PARA INCUBADORAS EN
CIUDADES MEDIANAS**

 <https://doi.org/10.56238/sevened2025.036-020>

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ABSTRACT

Technological innovation is a key pillar of sustained economic growth in contemporary economies, being recognized as a strategic element in shaping dynamic and competitive environments. This study aims to analyze the creation, development, and institutionalization process of INTEG – the Technological Business Incubator of Guarapuava, Paraná – between 2003 and 2023. The research is grounded in the Sociological Institutional Theory and adopts a qualitative approach, combining a specialized literature review, document analysis, and semi-structured interviews with managers and key stakeholders. The results show that INTEG's consolidation stemmed from a gradual institutionalization process, strongly supported by inter-institutional articulation among local, state, and federal agents. These articulations were crucial for the formation of a local innovation ecosystem, fostering the sustainability of technological ventures and promoting territorial development. It is concluded that the INTEG model offers a relevant analytical reference for public innovation policies in medium-sized cities.

Keywords: Technological Innovation. Institutional Theory. Innovation Ecosystems. Regional Development. Business Incubators. Public Policy.

RESUMO

A inovação tecnológica constitui um dos pilares centrais do crescimento econômico sustentado nas economias contemporâneas, sendo reconhecida como elemento estratégico na conformação de ambientes dinâmicos e competitivos. Este estudo tem por objetivo

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analisar o processo de criação, desenvolvimento e institucionalização da INTEG – Incubadora de Empresas de Base Tecnológica de Guarapuava, Paraná – no período compreendido entre 2003 e 2023. A pesquisa fundamenta-se na Teoria Institucional de Base Sociológica, adotando uma abordagem qualitativa que articula revisão de literatura especializada, análise documental e entrevistas com gestores e atores-chave. Os resultados demonstram que a consolidação da INTEG decorreu de um processo de institucionalização progressiva, sustentado por articulações interinstitucionais entre agentes locais, estaduais e federais. Tais articulações foram determinantes para a formação de um ecossistema de inovação local, impulsionando a sustentabilidade de empreendimentos tecnológicos e promovendo o desenvolvimento territorial. Conclui-se que o modelo da INTEG constitui uma referência valiosa para políticas públicas de inovação em cidades de médio porte.

Palavras-chave: Inovação Tecnológica. Teoria Institucional. Ecossistemas de Inovação. Desenvolvimento Regional. Incubadoras de Empresas. Políticas Públicas.

RESUMEN

El papel de la innovación tecnológica como motor del desarrollo económico ha sido ampliamente reconocido en las últimas décadas, especialmente en el contexto de economías emergentes que buscan diversificar sus matrices productivas y aumentar su competitividad a nivel regional y global. En este marco, el presente estudio analiza el proceso de creación, consolidación e institucionalización de INTEG – Incubadora de Empresas de Base Tecnológica de Guarapuava, estado de Paraná (Brasil), en el período comprendido entre 2003 y 2023. La investigación se fundamenta en la Teoría Institucional de base sociológica, permitiendo comprender los procesos mediante los cuales las organizaciones emergentes adquieren legitimidad, estabilidad y reconocimiento en su campo organizacional. Se adoptó una metodología cualitativa, con énfasis en el análisis documental y entrevistas semiestructuradas realizadas a gestores, fundadores y actores institucionales vinculados a la incubadora. Los resultados muestran que la consolidación de INTEG estuvo estrechamente vinculada a la articulación entre diferentes niveles de gobierno —municipal, estatal y federal— y a la participación activa de actores locales, como universidades, asociaciones empresariales y agencias de fomento. Esta articulación permitió la configuración de un ecosistema regional de innovación, favoreciendo la creación y sostenibilidad de emprendimientos tecnológicos y promoviendo el desarrollo territorial. Se concluye que la experiencia de INTEG constituye un modelo replicable para ciudades medianas que buscan implementar políticas públicas orientadas al emprendimiento innovador.

Palabras clave: Innovación Tecnológica. Teoría Institucional. Ecosistemas de Innovación. Desarrollo Regional. Incubadoras de Empresas. Políticas Públicas.

1 INTRODUCTION

The investigation of regional economic development in Brazil, according to Santos and Vieira (2012) is carried out based on economic models and their interrelations with variables such as sustainability and economic growth.

Innovation and technology play a fundamental role in economic expansion, within economic models technology was incorporated into economic growth by Solow (1956), which is considered exogenous, "to demonstrate that a market economy can grow in the long run in a permanent, sustained way and exhibiting a relatively stable equilibrium trajectory without government intervention in the economy." (Silva, 2020, p. 31).

Phan et al. (2005) argue about the impact of technological incubators on the development of innovation and technology, reflected in the greater attention of researchers to incubators, especially in order to verify their impact on the performance of incubated companies.

The development of an incubator demands, therefore, a great effort and an important sum of human, financial and material resources, whose management and monitoring are fundamental for the creation, development and consolidation of the new institution.

Located in the city of Guarapuava, in the central-west region of Paraná, the Guarapuava Technological Incubator, hereinafter INTEG is a consolidated incubator within its innovation environment, which brings together universities, technology parks, companies and representatives of civil society. In view of the fact that it has already been operating for twenty years and a more advanced consolidation than most similar incubators established in the interior of the State of Paraná, this work presents the following guiding questions: What was the theoretical model adopted in the creation of INTEG? Based on this model, what were your experiences that were considered successful and those that, over time, were found to need to be rethought based on the reality found? Does this theoretical model present itself as a safe foundation for the installation and consolidation of incubators or should it be adopted with repairs? What are the concrete lessons obtained from INTEG's trajectory?

The theoretical framework of this article is based on the institutional theory of sociological basis, which encompasses the level of analysis of the intraorganizational field and as a unit of analysis of institutions. According to Hall and Taylor (2003) "institutions provide moral and cognitive models that allow interpretation and action", allowing the analysis of the phenomenon studied.

The research method chosen was the descriptive one that seeks to "illustrate the complexity of the situation and the aspects involved in it" (Godoy, 2010, p. 124) and for its categorization the Case Study was defined which, for Godoy (2010, p. 122) the researcher questions local actors, in order to "develop concepts and understand the patterns that emerge from the data".

Finally, this article begins with the presentation of the Theoretical Framework and the Literature Review on the Institutional Theory of Sociological Base in Administration, presenting its concepts and the Institutionalization Process of an organization. After the discrimination of the research methods and techniques adopted, the documentary analysis and the content analysis of the interviews with the managers of the Incubator are carried out, confronting this information with the Theoretical Framework under analysis in order to evaluate the coherence between the actions developed and the theoretical elements presented.

2 THEORETICAL FRAMEWORK

2.1 INSTITUTIONAL THEORY OF SOCIOLOGICAL BASIS

The Institutional Theory of Sociological Basis, also called neo-institutionalism, is a theory that has as its level of analysis the intra-organizational field and as the unit of analysis of institutions.

According to Hall and Taylor (2003), institutions provide moral and cognitive models that allow interpretation and action. The individual is conceived as an entity deeply involved in a world of institutions composed of symbols, scenarios and protocols that provide filters of interpretation, applicable to the situation or to oneself, from which a line of action is defined. Not only do institutions provide useful information from a strategic point of view, but they also affect identity, self-image and preferences that guide action.

These institutions, according to Carvalho and Vieira (2005), are political, social or economic, and which have been gradually undergoing transformations and acquiring power, becoming complex and effective.

This approach observes the influence of social and cultural factors on organizations, considering institutions as values, symbols, principles, (in)formal rules, standards, myths. Forming and behaving as a mechanism of monitoring and inspection, defining the way of acting, thinking, speaking and behaving, characterizing itself as "the foundations of social life" (Campbell, 2004, p. 1).

The sociological aspect of the institutional perspective received a special contribution from the sociology of knowledge, developed by Berger and Luckmann (1991), whose main concern is centered on the investigation of the nature and origin of the social order. The basis of his argument is that the social order is based on the "social construction of reality" generated by interaction with nature.

Selznick (1957) characterizes the process of institutionalization as the action that becomes continuous, strengthened and repeated, thus assuming the expectation of institutionalization based on practice. However, the process stands out, truly institutionalization as a process, in which repetition and activities become habitual (Scott, 1987).

The sociological strand is an alternative model to rational theories of technical contingency or strategic choice. In organizational studies, she argues that the rationalist order is an "iron cage" that imprisons humanity (Dimaggio; Powell, 2007). That is why they propose that reality is socially constructed and, therefore, is not concrete, objective; but that organizations and individuals have agency power, influencing action.

The institutional theory of sociological basis encompasses organizations, their individuals, norms of conduct and their interrelationships, for the structuring and functioning of modern society. The importance of studies with an approach to institutional change is highlighted in order to understand the deinstitutionalization of existing forms and their replacement by new arrangements, which gradually become institutionalized. (Scott, 2008)

In this context, as the approach of the Sociologically-Based Institutional Theory observes the influence of social and cultural factors on organizations (Campbell, 2004), it was taken as a basis, considering the processes inherent to institutionalization to make explicit the operationalization of the General Law of Micro and Small Enterprises.

According to Pettigrew (1985), understanding the context in which organizations are located is essential to be able to understand their structures and processes. The context shapes the decisions that are made and thus facilitates the predictability of organizational action. But organizations are not passive collective social elements and, in turn, shape the context itself, which leads us to draw a picture of complex interaction between organizations and contexts in permanent dynamic movement, therefore far from configuring a deterministic and unequivocal relationship.

Therefore, the institutional perspective abandons the conception of an environment formed exclusively by human, material, and economic resources to highlight the presence of cultural elements—values, symbols, myths, belief systems, and professional programs.

2.1.1 Concept of organization

Regarding the concept of organization, there are two different approaches, characterized as a technical and institutional environment. The technical environment basically portrays the economic and commercialization aspect, in the sense of exchange (Scott, 2008). The institutional environment, in turn, is seen as norms, cultural/social aspects that occur to generate legitimacy or acceptance by those involved in the process (Scott, 2008).

Institutional theory presupposes that "organizations are influenced by normative pressures, sometimes from external sources, such as the State, other times arising from the organization itself" (Zucker, 1987, p. 443), so that organizations are no longer seen as closed systems, but on the contrary, as open systems that relate to the environment to which they belong in cultural and social aspects (Scott, 2008).

Organizations are the materialization/materialization of institutions, for example, companies, which practice norms, cultural and social aspects, to be accepted by those involved in the process (Scott, 2008).

Campbell (2004), in the face of environmental pressures and/or values, organizations need to adapt and generally make changes in response.

Selznick (1957) characterizes the process of institutionalization as the action that becomes continuous, strengthened and repeated, thus assuming the expectation of institutionalization based on practice. However, the process stands out, truly institutionalization as a process, in which repetition and activities become habitual (Scott, 1987).

For Berger and Luckmann (1967), institutionalization comes from three phases: externalization, objectification and internalization. Outsourcing represents the conditions experienced by all those who are part of the environment in which the institutions are inserted, above all, the way things happen; all those involved have their representativeness and influence (objectification), so each one abstracts what suits him to form his structure (internalization) (Scott, 1987; Rossetto; Rossetto, 2005).

The core of the interpretation of institutionalization is legitimacy, succeeding isomorphism as a vital factor for survival. Legitimacy, in Scott's (2008) view, is social acceptability and credibility, as material resources and technical information are not enough for organizations to survive and thrive in their environments. Therefore, from the institutional perspective, it is a condition in which the actors of a social environment visualize, in a generalized way, that the actions carried out are desirable. Institutional isomorphism is evident for institutions that seek legitimacy (Machado-da-Silva; Fonseca, 1993; Dimaggio; Powell, 1983; 1991).

Selznik (1996) considers legitimacy as the "imperative" for neo-institutionalism, the importance of symbol and myth in the construction of interorganizational reality, the dynamics of the functioning of institutions in the public and private segments and in their direct influence on society. Once social norms and standards are legitimized, continuous reproduction occurs on the part of organizations. The confrontation between the need to maintain competitiveness and to have institutional legitimacy is the point of conflict, where internal and external needs duel to find the ideal bending point for each organization, often giving in to institutional pressure.

In the search for legitimacy, what Dimaggio and Powell (2007) explain by isomorphism can happen, based on what is proposed by Meyer (1979) and Fennell (1980). In this sense, the authors question why organizations have homogeneity of forms and practices, concluding that this is due to the search for good performance. To this end, they explain that there is competitive isomorphism, in which companies recognize market pressures and deliberately make decisions to adapt to competitive advantage. However, the Sociologically-Based Institutional focus is institutional isomorphism, which argues that organizations, through non-deliberate actions, become alike in the search for legitimacy to face internal and external pressures.

In addition, institutions have three pillars that support their processes and that are interdependent; they are: regulatory, normative and cultural-cognitive (SCOTT, 2001). The regulatory pillar has a coercive aspect and uses laws and rules to condition the environment and processes; In this case, aspects of domination are noted from the figure of power. In the normative pillar, values and norms are related, resulting from normative adequacy or isomorphism, also considered as professionalization. Finally, the cognitive cultural, which emphasizes the function of institutions with their social aspect; representations and

symbolisms as mechanisms arising from the process of institutionalization (Dimaggio and Powell, 1983; Scott, 2001; Machado-da-Silva; Foster; Crubellate, 2005).

Figure 1

Three Pillars

	Regulatório	Normativo	Cultural-Cognitivo
Bases de Conformidade	Utilidade	Obrigação social	Aceitação de pressupostos e Entendimento compartilhado
Bases de Ordem	Regras regulatórias	Expectativa de adesão	Esquemas Constitutivos
Mecanismos	Coercitivo	Normativo	Mimético
Lógica	Instrumental	Adequação	Ortodoxia
Indicadores	Regras, Leis e Sanções	Certificação e Aceitação	Crença comum e Lógica compartilhada de ação
Bases de Legitimação	Legalmente sancionado	Moralmente governado	Conceitualmente correto e Culturalmente sustentado

Source: Scott (2001, p. 51).

2.1.2 Processes inherent to institutionalization

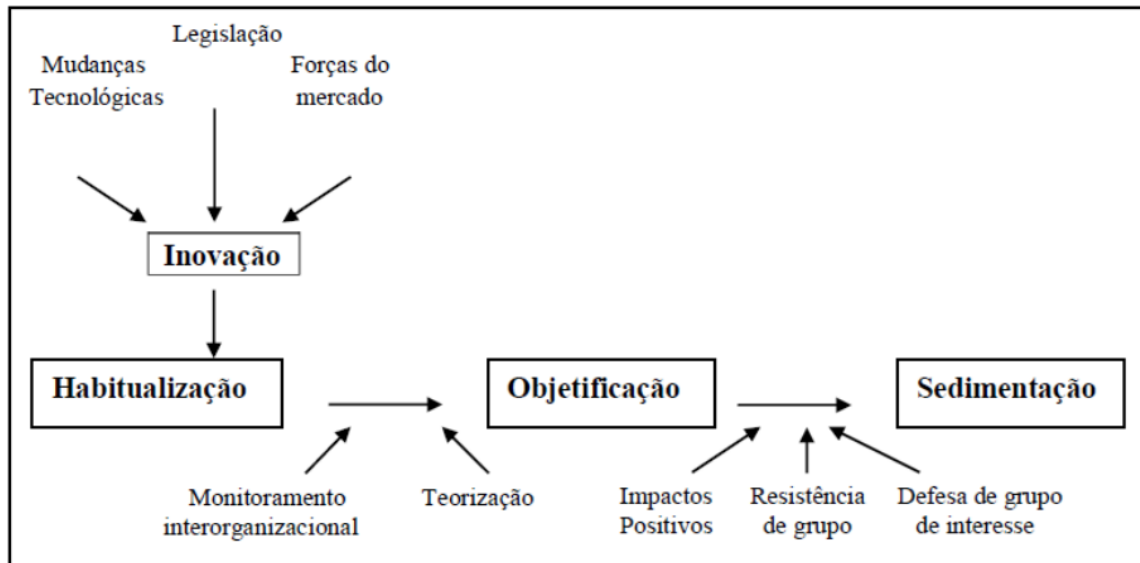
Berger and Luckman (1967) developed a model of institutionalization by virtue of phenomenological analyses that incorporates three distinct phases: exteriorization, objectification and internalization. In a logical sequence, it is noted that exteriorization is influenced by the social world, it is external, coercive and sedimented; therefore, it is understood and objectified, to finally be internalized, that is, the objectification and exteriority of an action lead to institutionalization. For this reason, the authors judge man as a product resulting from society. However, Berger and Luckman's analysis focused on the individual rather than organizations. Meyer and Rowan (1977) and Zucker (1977), in turn, also discuss the process of institutionalization based on social evidence. Then, Tolbert and Zucker (1998) developed a new model, based on the findings of Berger and Luckman (1967).

For institutionalization to occur, Tolbert and Zucker (1998) propose internships. That is, a consequence of actions and behaviors of individuals or groups, to face recurring problems.

Thus, as a result of innovation, the stages that make up this process are habituation, objectification and sedimentation, in order to have the new institutionalized structure, as shown in Figure 2.

Figure 2

Processes Inherent to Institutionalization



Source: Tolbert and Zucker (1998, p. 207).

In this context, the need to innovate can happen due to technological changes, legislation, market forces, among other situations. To face this situation, in the **Habitualization** standardized actions are carried out, adapted to the context in which the process is developed.

Thus, it is possible to monitor the action and theorize what happens, so that **objectification** occurs, a moment in which the general meanings of the actions adopted are developed and shared, which can have a positive impact, generate resistance or defense of interest groups (Tolbert; Zucker, 1998).

When actions are carried out as intended or exceeding expectations, that is, presenting themselves as a reality proper to the context, it can be said that **sedimentation has occurred**, completing the institutionalization process if the structure is perpetuated by several generations of members of the organization (Tolbert; Zucker, 1998).

2.2 INCUBATORS IN THE THEORY OF INSTITUTIONALIZATION

The innovation process within organizations is often an arduous task and many entrepreneurs resort to specialized help. This consultancy can be offered by incubators, which can be defined as:

a mechanism that stimulates the creation and development of micro and small industrial or service companies, technology-based or light manufacturing through the

complementary training of the entrepreneur in its technical and managerial aspects and that, in addition, facilitates and speeds up the process of technological innovation in micro and small companies. To this end, it has a physical space specially built or adapted to temporarily house micro and small industrial or service companies and which, necessarily, has a series of services and facilities. as (Ministry of Science and Technology - MCT, 2000, s/n)

Many of the incubators are linked to educational institutions such as universities where they seek to link the theory of academic concepts with the practice of incubated companies, generating knowledge (Cecato, Callegari and Biscaia, 2021). University incubators have the role of transforming researchers and scientists into entrepreneurs, through the various instruments and services available so that they can be informed about the market. (Catapan et al, 2018).

Thus, the theoretical approximation between the institutional model of an incubator and the phases of an institutionalization process is evident, as we can see in the creation, development and consolidation of INTEG, according to documentary analysis and interviews analyzed below.

2.2.1 The creation of INTEG and its relationship with the institutions around it

The creation of a technology-based company incubator demands a lot of energy from those interested in the development and installation process. To a large extent, the installation takes place in public entities, universities and other bodies linked to the public sector. This is because, in a way, it is believed that the structure will be shared with the existing body. This study demonstrates that the work is indeed more arduous and demands great effort from various institutions and people to advance in a direction of expected success. Currently located at the CEDETEG/UNICENTRO Campus, at Rua Simeão Camargo Varela de Sá, nº 03, in the Cascavel neighborhood, in Guarapuava/PR, the Guarapuava Technological Incubator (INTEG) was founded on November 29, 2001 (INTEG, 2001), according to the Minutes of the Assembly of this respective date.

Created as a non-profit Civil Association, with an indefinite term of duration and endowed with administrative and financial autonomy with or without the support of its sponsoring partners (Art. 1), INTEG already had the mission of "fostering the entrepreneurial culture and providing an adequate environment for pre-incubation programs and incubation of technological projects, innovative or not, providing opportunities for the generation of new technology-based companies". (Art. 2).

Associations are legal entities governed by private law made up of people who join forces to achieve non-economic purposes, as recommended by article 53 of Law No. 10,406/2002 (Civil Code).

Although its legal nature is that of a non-profit Civil Association, its Statute determines that it is governed by the applicable legislation, in this case the Civil Code (CC), committing, however, to observe the principles of legality, impersonality, morality, publicity, economy and efficiency, guiding guidelines of the Public Administration.

In turn, the State University of the Midwest (UNICENTRO), where INTEG is headquartered, is constituted in the form of an Autarchy, an entity that is part of the Indirect Public Administration of the State of Paraná, especially of the Higher Education System under the baton of the State Secretariat of Science, Technology and Higher Education of Paraná (SETI).

Once the INTEG is contextualized, it should be noted that Articles 4 and 5 of its statute indicate the Objectives and the means that the Incubator must observe.

The theoretical framework in a study comprises a critical and organized analysis of the literature pertinent to the theme, providing a theoretical contextualization and defining the key concepts. It should comprehensively contain previous theories, models, and research, identifying gaps, contradictions, and consensuses in the literature that are important to the focus of the work being developed.

3 METHODOLOGICAL PROCEDURES

3.1 RESEARCH PARADIGM

In the most diverse situations, people can see the world from different perspectives, for Burrell (1999) "[...] paradigms define, in an agreed and deeply established sense, a way of seeing the world [...]"

In this study, the Functionalist paradigm of Social base will be used, which, according to Morgan (2007), starts from the understanding of the role of the individual in society, in an orderly and regulated way through concrete and tangible social relationships, within a system accepted by a group of researchers.

And analysis is focused on the intra-organizational relationship, for the construction of the reality of society. The research approach is characterized as qualitative. The choice of this method is justified by providing the researcher with a close approximation with the social context studied, offering a valid explanation to better understand it (MARTINS, 2004). The

study is based on questions of "how" and "why" the facts happen in this context (BAUER; GASKELL, 2008).

Considering the objective, the research is descriptive, since it seeks to "illustrate the complexity of the situation and the aspects involved in it" (GODOY, 2010, p. 124), exposing its configuration, structure, activities, relationship with other phenomena, etc. This description has as a research method the case study, which allows to deepen in a unit of analysis, with the use of multiple sources of data collection, to study the phenomenon in its context.

The decisions to be made in this type of study are in relation to what, where, how, who and when the phenomenon will be observed.

Among the benefits of the chosen method, he highlights the characteristics of the qualitative method is flexibility, for example, in relation to data collection techniques (MARTINS, 2004), defined according to the context being studied.

Thus, the data collection instruments used were both primary, through open interviews with a semi-structured script, field diary with non-participant observation, AND secondary, documents such as reports, websites and records in archives.

3.2 RESEARCH CATEGORY

For this study, the Case Study was defined, which, according to Godoy (2010, p. 122), in the case study, the researcher questions local actors, in order to "develop concepts and understand the patterns that emerge from the data".

From the perspective of Triviños (1987), he defines a case study as a category of research whose object is a unit, which is deeply analyzed. With the objective of deepening the description of a certain reality.

Thus, "the case study contributes to the understanding we have of individual, organizational, social and political phenomena. Not surprisingly, the case study has been a common research strategy in psychology, sociology, political science, management, social work, and planning" (Yin, 1983).

The choice of respondents was based on selection and judgment "the key characteristic of sampling by judgment is that the elements of the population are selected intentionally. This selection is made considering that the sample will be able to offer the requested contributions." (Churchill, p. 301)

The criterion for choosing the interviewees is centered on their relationship with the implementation of INTEG in the municipality of Guarapuava, as this way they have pertinent information to answer the research problem.

3.3 ANALYSIS TECHNIQUE

The analysis technique to be employed will be the one proposed by Bardin (2016, p. 37) as content analysis, which consists of "a set of communication analysis techniques", which systematically and objectively describes the content of the message.

Content Analysis is more than an analysis technique, it is a methodological approach with its own characteristics, which reinterpret documents and texts beyond ordinary reading. It is thus part of the theoretical and practical search in the field of social investigations, helping to reinterpret the content itself.

Thus, content analysis is a technique for reading and interpreting the content of all kinds of documents, which, when properly analyzed, open the doors to the knowledge of aspects and phenomena of social life that are otherwise inaccessible. (OLABUENAGA and ISPIZÚA, 1989).

The raw material of Content Analysis can be any material from verbal or non-verbal communication, such as posters, reports, interviews, films, photographs, among many others. It is also worth mentioning that according to (Bardin, 2011) Content Analysis should use matrix tables by category, similar to the figure of Tolbert and Zucker, with Innovation, Habituation, Objectification and Sedimentation, which facilitates the visualization, interpretation and differentiation of each category. Once this is done, the final point of the methodology is reached, which is the phase of interpretation of the collected data and its inference, presentation and treatment of results.

4 RESULTS AND DISCUSSIONS

From the triangulation, the institutional theory, an interview with an INTEG actor and the institution's researched documents, the analysis framework was set up according to the assumptions to understand the existing process and identify in which phase of institutionalization is the following:

Table 1

Analysis Framework to Identify the Institutionalization Phase

Analysis Categories	Interview Result and Researched Documentation	Reasons
Innovation	"It was created at FIEP in 2000, it was here at Sesi SENAI in Guarapuava. He was SESI/ESNAI coordinators together with Sebrae. It was in 2002." Triangulated via document (statute) researched. "So, a union of several institutions was created there, they created this incubator for Guarapuava.	According to Dimaggio and Powell (2007) Desire to improve performance
Habitualization Also Called Pre-Institutionalization Stage	In 2004, the federal innovation law, the national innovation law and the UNICENTRO innovation agency were enacted. In 2005, with the departure of the president of the institution, Unicentro was transferred. It was agreed with the president of the INTEG Incubator, the Acting Rector and the other entities participating in the Deliberative Council."	Tolbert and Zucker (1998), it is the response to specific problems that a given organization or organizations have, in the form of new structural arrangements, policies and procedures.
Organizational Monitoring and Theorizing	"It presents once a year to this assembly, so then the rector is the president. And the direction to the executive board that is there in our statute? He is a coordinator of the innovation agency. So, he is the one who takes the 2 positions. The rectory assigns someone specific to the incubator. Sometimes it doesn't depend on what they have on the possibility of positions and functions." "Because it is a civil organization of an educational center and we have financial autonomy, because we are able to raise funds for the incubator through the incubator's CNPJ. So, we have a bank account."	<i>Champion</i>, that is, as a defender of the objective or project (TOLBERT; ZUCKER, 1998). Theorization is marked by the "development of theories that diagnose the sources of dissatisfaction or failure, in a way that is compatible with the presentation of a specific structure as a solution" project (TOLBERT; ZUCKER, 1998)

Isomorphism	"Know, right, where it came from so we can continue. And so, in the state of Paraná, everyone already knows what I can contribute. So that all state universities can do it, right? Walk the same line, look for what the others have already learned, because if not, we will be trying to invent the wheel. Let's see what the others did not to make mistakes in the same things, or right, so that we can all of us there with an incubator, have well-structured needs, so all these environments." "Every beginning of the year, January, a continuous flow notice is published to receive new business entry processes. So, and the structuring of the executive summary, receives the proposal, constitutes a board and even if sometimes it is for a company, because that thing like sending. The company, I came there in March because January is on vacation. Monday will open the process, it's February, the selection process will open, it will start in March." Availability to the entrepreneur, not failing to meet the demands of society. "To ensure a process of credibility in the selection is to have an external member on the board, so the procedure we adopt"	Dimaggio and Powell (2007), when referring to the isomorphism/homogeneity of organizational forms and practices, as environmental conditions influence the units of a population to have similarities.
Objectification or Semi-Institutionalization	"The Incubator has an average of 11 incubated businesses. If we don't look for it, our average is 10. So like this it has 9. Sometimes there are 12. Companies come and go, so we have an average within what we can meet. All these other issues to solve. So it's no use wanting to embrace the world. So it's that experience of the team. We bring this look. Importance of having a team with beyond this, this commitment, but that has. Follow-up over time with the incubator or with the innovation agency." "The monthly fee for the rooms varies between 150.00 and up to 300.00 reais, so there are rooms for 150, 200.00, 250.00 and 300.00." The non-resident incubation that does not need to occupy physical space is 50.00 reais, symbolic value"	At the moment of objectification, actions are no longer simple imitation, but the structure is adapted to the context, with a normative basis (TOLBERT; ZUCKER, 1998).
Group Resistance,	"... So there are several institutions, so we are	It is relevant to identify

Positive Impacts, and Advocacy	accountable to society, so they follow up. The fiscal council enters the structure of administrative management there." "We give as a counterpart to hire Sebrae projects and all this accountability, then we do everything with the dean's monitoring. This resource goes in there and is much easier to spend, as it is an association. I don't need to enter the Bidding programs that we enter into the Sebrae rules, because it is not a public resource. So we receive it from Sebrae, but the control is extremely, rigorous, working with 03 budgets and all the necessary documents."	factors that influence the propagation of the new structure, as well as its long-term conservation, such as group resistance, in which "a set of actors who are, in some way, adversely affected by the structures and thus are able to collectively mobilize against them" (TOLBERT; ZUCKER, 1998, p. 210)
Legitimacy	"The CERNE certification, although it is tied, complex and all. I see it as a reference. Which contributes a lot to the process, but we need to model, we are here with a SEBRAE consultant, who the Sebrae project authorized us to hire the consultant for the incubator to work with the certification."	The influencing factor in the propagation of the new structure consists of the positive impacts of the results achieved, as a strong positive relationship between the structure and the desirable results strengthens the diffusion and maintenance of the structure (TOLBERT; ZUCKER, 1998).
Sedimentation	"If it is applicable in other environments like this, I can already say, because it is also the importance of this, of our differentiated format that we have here at UNICENTRO, it is a consistent model of technological incubator."	Sedimentation involves the propagation of the structure throughout the group of theorized actors (TOLBERT; ZUCKER, 1998) "a process that is fundamentally based on the historical continuation of the structure and,

		especially, on its survival by the various generations of members of the organization"
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Source: prepared by the authors.

Based on the analysis promoted in the table above, with the trajectory of INTEG since its foundation, its consolidation, the Pre-institutionalization phase passing the presidency to Unicentro, achievement of CERNE certification, the companies that participate in the incubation event, which today works with a continuous selection process. With the development, INTEG is fundamental for the development of Startups in Guarapuava and Region.

In the interview, it is clear the importance and propagation of the model and that it already happens with the visitation of Universities, public authorities participating in congresses and lectures at the state and national levels. Characterizing the last phase of institutionalization, the sedimentation that occurs from this model.

Thus, the research hypothesis is confirmed: the consolidation of INTEG provides a path and a methodological contribution for the implementation of incubators in cities of similar size, that is, medium-sized cities in cities in the interior.

In the interviews and in the documents, it is possible to identify the methodological contribution to the implementation of incubators in cities of similar size, that is, medium-sized cities in cities in the interior, based on the main positive points and challenges, considering the events that occurred and the analysis of the data collected.

5 CONCLUSION

The implementation of INTEG was the result of the merger of several entities and the participation of professionals who believed in an Incubator of technology-based companies in a medium-sized city.

From the understanding of the script followed by the managers who installed the incubator in the city of Guarapuava, it is possible to conclude that the creation and installation of INTEG was a successful case, considering the theoretical paradigm of the Institutional

Theory of Sociological Base of Administration. Thus, there are valuable lessons for those who intend to install similar institutions in medium-sized cities in Brazil.

Firstly, the interviews showed that it is clear in the implementation process that INTEG has received knowledge and energy from various entities and technicians, and that these efforts are significant for the goal of installing a technology-based Incubator to be achieved. The genesis of INTEG is found in the initiative of FIEP and SEBRAE, together with the Commercial Association, entities that, although they did not have the capacity to offer all the necessary support for implementation, remain linked to INTEG to this day, being part of its governance.

However, with a view to its effective implementation, the support of a university was very important, offering physical space and technicians with experience and technical capacity in the management of the process. Even today, INTEG is physically located within UNICENTRO, which provides the payment of the professionals who manage the Incubator.

However, as demonstrated in the interviews, the fact that it has its own legal personality, as an association, instead of being an organ of the university, gained greater administrative autonomy for the Incubator, thus highlighting the proposition that an institution with this purpose should not remain administratively subordinate to a university, in view of the peculiarity of its institutional performance and its strategic objectives.

Thus, the functioning and success of INTEG Guarapuava can be pointed out as a successful example of the State of Knowledge in its area, demonstrating, through its results, the validity of the parameters and concepts of the Institutionalization Process present in the Institutional Theory of Sociological Basis of Administration in the creation, development and consolidation of institutional actors related to the promotion of science, technology and innovation applied to entrepreneurship in society.

ACKNOWLEDGMENT

We thank the partner entities and INTEG managers for their support during the research.

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SLEEP, ANXIETY AND SOCIAL MEDIA USE IN CHILDREN AND ADOLESCENTS: INTERCONNECTIONS AND CHALLENGES IN CONTEMPORARY CARE

SONO, ANSIEDADE E USO DE REDES SOCIAIS EM CRIANÇAS E ADOLESCENTES: INTERCONEXÕES E DESAFIOS NO CUIDADO CONTEMPORÂNEO

SUEÑO, ANSIEDAD Y USO DE REDES SOCIALES EN NIÑOS Y ADOLESCENTES: INTERCONEXIONES Y DESAFÍOS EN LA ATENCIÓN CONTEMPORÁNEA

 <https://doi.org/10.56238/sevened2025.036-021>

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ABSTRACT

Introduction: Sleep disorders and anxiety disorders have become increasingly common among children and adolescents, reflecting the behavioral and technological changes in contemporary society. Excessive use of social media, especially at night, has emerged as a significant risk factor for sleep fragmentation, reduced melatonin levels, and increased alertness. This scenario contributes to the worsening of anxiety and depression symptoms, creating a feedback loop between sleep deprivation, anxiety, and digital hyperconnectivity.

OBJECTIVE: To analyze, through a narrative review of the literature, the relationship between sleep disorders, anxiety, and excessive use of social media in children and adolescents, identifying their causes, consequences, and management strategies described in recent literature.

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Methods: This narrative review was conducted in the PubMed, SciELO, LILACS, and PsycINFO databases, covering publications published between 2015 and 2025 in Portuguese, English, and Spanish. The descriptors used were sleep disorders, anxiety, social media, children, and adolescents. Studies focused on children and adolescents and the relationship between sleep, anxiety, and technology use were included. Thematic analysis grouped the findings into three areas: causes and mechanisms, psychosocial impacts, and management strategies.

Results: The reviewed studies indicate that nighttime exposure to screens and compulsive social media use reduce sleep duration and quality, in addition to significantly increasing anxiety levels. Adolescents with intense digital use are up to 2.5 times more likely to develop anxiety and depressive symptoms. Sleep deprivation impairs emotional regulation and cognitive performance, while anxiety reinforces vigilance behaviors and digital dependence. Interventions based on sleep hygiene, digital education, and cognitive-behavioral therapy have proven effective in reducing these impacts.

Conclusion: The interaction between sleep, anxiety, and social media use in childhood and adolescence is multifactorial and bidirectional. Promoting the conscious use of technology, strengthening family ties, and implementing public digital education policies are essential measures to prevent emotional dysfunction and preserve the well-being of new generations in the digital age.

Keywords: Sleep. Anxiety. Social Media. Adolescent. Mental Health. Digital Technology.

RESUMO

Introdução: Os distúrbios do sono e os transtornos de ansiedade têm se tornado cada vez mais frequentes entre crianças e adolescentes, refletindo as mudanças comportamentais e tecnológicas da sociedade contemporânea. O uso excessivo de redes sociais, especialmente no período noturno, tem se destacado como fator de risco significativo para a fragmentação do sono, a redução da melatonina e o aumento do estado de alerta. Esse cenário contribui para o agravamento de sintomas ansiosos e depressivos, configurando um ciclo de retroalimentação entre privação de sono, ansiedade e hiperconectividade digital.

Objetivo: Analisar, por meio de revisão narrativa da literatura, a relação entre distúrbios do sono, ansiedade e uso excessivo de redes sociais em crianças e adolescentes, identificando suas causas, consequências e estratégias de manejo descritas na literatura recente.

Métodos: Trata-se de uma revisão narrativa realizada nas bases de dados PubMed, SciELO, LILACS e PsycINFO, abrangendo publicações entre 2015 e 2025, nos idiomas português, inglês e espanhol. Utilizaram-se os descritores sleep disorders, anxiety, social media, children e adolescents. Foram incluídos estudos com foco na população infantojuvenil e na relação entre sono, ansiedade e uso de tecnologia. A análise temática agrupou os achados em três eixos: causas e mecanismos, impactos psicossociais e estratégias de manejo.

Resultados: Os estudos revisados apontam que a exposição noturna às telas e o uso compulsivo de redes sociais reduzem a duração e a qualidade do sono, além de aumentar significativamente os níveis de ansiedade. Adolescentes com uso digital intenso apresentam até 2,5 vezes mais risco de desenvolver sintomas ansiosos e depressivos. A privação de

sono prejudica a regulação emocional e o desempenho cognitivo, enquanto a ansiedade reforça comportamentos de vigilância e dependência digital. Intervenções baseadas em higiene do sono, educação digital e terapia cognitivo-comportamental mostraram-se eficazes para reduzir esses impactos.

Conclusão: Conclui-se que a interação entre sono, ansiedade e uso de redes sociais na infância e adolescência é multifatorial e bidirecional. A promoção do uso consciente da tecnologia, o fortalecimento dos vínculos familiares e a implementação de políticas públicas de educação digital são medidas essenciais para prevenir disfunções emocionais e preservar o bem-estar das novas gerações na era digital.

Palavras-chave: Sono. Ansiedade. Redes Sociais. Adolescente. Saúde Mental. Tecnologia Digital.

RESUMEN

Introducción: Los trastornos del sueño y la ansiedad se han vuelto cada vez más comunes entre niños y adolescentes, lo que refleja los cambios conductuales y tecnológicos en la sociedad contemporánea. El uso excesivo de las redes sociales, especialmente por la noche, se ha convertido en un factor de riesgo significativo para la fragmentación del sueño, la reducción de los niveles de melatonina y el aumento del estado de alerta. Este escenario contribuye al empeoramiento de los síntomas de ansiedad y depresión, creando un ciclo de retroalimentación entre la privación del sueño, la ansiedad y la hiperconectividad digital.

Objetivo: Analizar, a través de una revisión narrativa de la literatura, la relación entre los trastornos del sueño, la ansiedad y el uso excesivo de las redes sociales en niños y adolescentes, identificando sus causas, consecuencias y estrategias de manejo descritas en la literatura reciente.

Métodos: Esta revisión narrativa se realizó en las bases de datos PubMed, SciELO, LILACS y PsycINFO, abarcando publicaciones publicadas entre 2015 y 2025 en portugués, inglés y español. Los descriptores utilizados fueron trastornos del sueño, ansiedad, redes sociales, niños y adolescentes. Se incluyeron estudios centrados en niños y adolescentes y la relación entre el sueño, la ansiedad y el uso de la tecnología. El análisis temático agrupó los hallazgos en tres áreas: causas y mecanismos, impactos psicosociales y estrategias de manejo.

Resultados: Los estudios revisados indican que la exposición nocturna a pantallas y el uso compulsivo de redes sociales reducen la duración y la calidad del sueño, además de aumentar significativamente los niveles de ansiedad. Los adolescentes con un uso intensivo de la tecnología tienen hasta 2,5 veces más probabilidades de desarrollar ansiedad y síntomas depresivos. La privación del sueño perjudica la regulación emocional y el rendimiento cognitivo, mientras que la ansiedad refuerza las conductas de vigilancia y la dependencia digital. Las intervenciones basadas en la higiene del sueño, la educación digital y la terapia cognitivo-conductual han demostrado ser eficaces para reducir estos impactos.

Conclusión: La interacción entre el sueño, la ansiedad y el uso de redes sociales en la infancia y la adolescencia es multifactorial y bidireccional. Promover el uso consciente de la tecnología, fortalecer los lazos familiares e implementar políticas públicas de educación digital son medidas esenciales para prevenir la disfunción emocional y preservar el bienestar de las nuevas generaciones en la era digital.



Palabras clave: Sueño. Ansiedad. Redes Sociales. Adolescentes. Salud Mental. Tecnología Digital.

1 INTRODUCTION

In recent decades, there has been a significant increase in the prevalence of sleep disorders among children and adolescents, which has aroused growing concern among health professionals, parents, and educators. Sleep is an essential biological process, fundamental for physical, cognitive, and emotional development, playing a crucial role in memory consolidation, mood regulation, and metabolic and immunological homeostasis (OGUNDELE *et al.*, 2022). Contemporary society, marked by intense digital stimuli and the acceleration of routines, has significantly altered the sleep patterns of this population, resulting in relevant implications for public health (AMERICAN ACADEMY OF PEDIATRICS, 2016).

Adolescence is a transition period characterized by intense biological, psychological, and social changes, in which the sleep pattern undergoes natural changes. The physiological delay of the sleep phase — known as sleep phase delay — is common in this age group, but has been accentuated by the nocturnal use of electronic devices and prolonged exposure to blue light, which inhibits melatonin secretion and compromises the circadian rhythm (SCOTT; BIJOOR; LEE, 2022). As a consequence, there is a reduction in total sleep time, fragmentation of rest, and daytime sleepiness, factors that directly interfere with learning and emotional stability (OGUNDELE *et al.*, 2022).

The exponential growth in the use of digital social networks has profoundly transformed the ways young people interact and socialize. Platforms such as Instagram, TikTok, and WhatsApp have become central in the process of building identity and maintaining interpersonal relationships (LEVENSON *et al.*, 2017). Although they favor communication and a sense of belonging, these tools also expose children and adolescents to an environment of constant social comparison and search for external approval, which can generate insecurity, anxiety, and reduced self-esteem (MOROMIZATO *et al.*, 2019).

Several studies indicate that excessive use of social networks is associated with higher levels of anxiety and sleep disorders, especially when it occurs in the hours before rest (LEVENSON *et al.*, 2017; SCOTT; BIJOOR; LEE, 2022). The phenomenon known as Fear of Missing Out (FOMO) — the fear of being excluded from online social experiences — induces prolonged screen time and delayed sleep onset. Thus, constant digital interaction keeps the nervous system in a state of alert, making it difficult to relax and favoring insomnia and fragmentation of the sleep-wake cycle (WORLD HEALTH ORGANIZATION, 2023).

The relationship between sleep disorders and anxiety disorders is known to be bidirectional. Sleep deprivation affects the amygdala and prefrontal cortex, brain regions responsible for emotional regulation, leading to more intense responses to negative stimuli and reduced capacity for emotional control (SCOTT; BIJOOR; LEE, 2022). On the other hand, anxiety increases the production of cortisol, the stress hormone, interfering with the ability to initiate and maintain sleep (MOROMIZATO *et al.*, 2019). This circular dynamic reinforces the need for an integrated approach to child and adolescent mental health care (LEVENSON *et al.*, 2017).

From the point of view of global development, chronic sleep deprivation in children and adolescents is related to significant cognitive, emotional, and behavioral impairments. Studies show that young people with insufficient sleep have greater irritability, impulsivity, difficulty concentrating, and worse school performance (OGUNDELE *et al.*, 2022). In addition, there is a correlation between sleep restriction and metabolic changes, such as obesity and insulin resistance, which reinforces the systemic impact of this problem (WORLD HEALTH ORGANIZATION, 2023).

The contemporary sociocultural context intensifies these vulnerabilities. Digital technology, although it plays an important role in education and communication, has often been used as an instrument of excessive entertainment and emotional regulation, replacing physical activities, family life and outdoor leisure (AMERICAN ACADEMY OF PEDIATRICS, 2016). The absence of clear limits on the use of social networks and early exposure to inappropriate content favor patterns of technological dependence and compulsive behaviors, especially in individuals with greater emotional sensitivity (MOROMIZATO *et al.*, 2019).

These phenomena show that sleep disorders and anxiety disorders in childhood and adolescence should not be understood in isolation, but as interconnected manifestations of the same biopsychosocial context. Hyperconnectivity, excessive stimuli and lack of emotional regulation form a scenario conducive to mental overload and deterioration of sleep health (LEVENSON *et al.*, 2017; BLACHER *et al.*, 2024). Thus, understanding the interdependence between these conditions is essential to outline effective preventive and therapeutic strategies.

From the point of view of collective health, the promotion of healthy sleep habits and the conscious use of technology are fundamental pillars in the prevention of mental disorders in young people. Interventions based on digital education, sleep hygiene, and strengthening family bonds have been shown to be effective in reducing anxiety symptoms and improving

sleep quality (SCOTT; BIJOOR; LEE, 2022; OGUNDELE *et al.*, 2022). In this context, schools and health professionals assume a strategic role in the formation of a generation that is more aware of the impacts of technological use on the body and mind.

Therefore, the purpose of this chapter is to analyze in an integrative way the interconnections between sleep disorders, anxiety and the use of social networks in children and adolescents. Based on recent scientific evidence, we seek to understand the causes, consequences, and possibilities of managing these conditions, contributing to the construction of a contemporary care model that combines mental health, digital balance, and the promotion of biopsychosocial well-being (WORLD HEALTH ORGANIZATION, 2023; OGUNDELE *et al.*, 2022).

2 GOALS

This chapter aims to analyze, through a narrative review of the literature, the interconnections between sleep disorders, anxiety disorders and the excessive use of social networks in children and adolescents. It is intended to understand how these factors relate and enhance each other, affecting the biopsychosocial development of young people.

Among the specific objectives, the following stand out:

1. To identify the main causes of sleep disorders in childhood and adolescence, with emphasis on the influence of digital technologies;
2. Discuss the psychological and behavioral implications of intense use of social networks, especially in the emergence or worsening of anxious symptoms;
3. To investigate the bidirectional relationship between anxiety and sleep quality, based on neurobiological and clinical evidence;
4. To bring together management and prevention strategies described in recent literature, considering interdisciplinary approaches that involve family, school, and health professionals.

The relevance of this study is justified by the growing incidence of complaints related to sleep deprivation and anxiety among young people, phenomena that have repercussions on school performance, interpersonal relationships, and collective mental health (WORLD HEALTH ORGANIZATION, 2023; OGUNDELE *et al.*, 2022). Thus, integrative analysis aims to provide scientific subsidies for preventive interventions and policies to promote digital and mental health.

3 METHODOLOGY

It is a narrative review of the literature, a method that allows gathering, synthesizing and critically analyzing the knowledge produced on a given topic, enabling the integration of studies with different methodological approaches (MENDES; SCOTT; GALVÃO, 2008). This modality is especially suitable for understanding complex phenomena, such as the interaction between psychological, behavioral and technological factors in the context of children and adolescents.

The search was carried out in the PubMed, SciELO, LILACS and PsycINFO databases, selected for their relevance in the area of health and psychology. The following descriptors and their combinations in Portuguese and English were used: *"sleep disorders"*, *"children"*, *"adolescents"*, *"anxiety"*, *"use of social networks"*, *"sleep disorders"*, *"children"*, *"adolescents"*, *"anxiety"* and *"social media use"*. The search took place between August and September 2025, adopting the Boolean operators *"AND"* and *"OR"* to expand the scope and precision of the results (MENDES; SCOTT; GALVÃO, 2008).

Studies that addressed the central theme of the study, which is the relationship between sleep, anxiety, and the use of social networks in children and adolescents, studies that were available in full and published in the last 10 years, were included. Duplicate articles, reviews without critical analysis, isolated case reports, and studies involving exclusively adults were excluded.

As this is a literature review, there was no need for approval by the Research Ethics Committee, according to Resolution No. 510/2016 of the National Health Council, since it did not involve primary data from human beings (BRASIL, 2016).

Methodological integrity was guaranteed by transparency in the process of selection, analysis and citation of the sources used, ensuring the reliability and reproducibility of the results (MENDES; SCOTT; GALVÃO, 2008).

4 DEVELOPMENT

The literature review allowed us to identify a consistent set of evidence that reinforces the relationship between sleep disorders, anxiety disorders, and excessive use of social networks in children and adolescents. The studies analyzed converge in pointing to the contemporary digital environment as one of the main factors impacting mental health and sleep pattern in this population (MOROMIZATO *et al.*, 2019 OGUNDELE *et al.*, 2022).

4.1 PHYSIOLOGICAL AND BEHAVIORAL CAUSES AND MECHANISMS

Sleep disorders in young people result from a combination of biological, behavioral, and environmental factors. The natural delay of the circadian phase in adolescence — characterized by the tendency to sleep and wake up later — is amplified by exposure to artificial light emitted by electronic screens at night. This blue light suppresses the release of melatonin, an essential hormone for inducing sleep, and prolongs the state of wakefulness (SCOTT; BIJOOR; LEE, 2022). In addition, the emotional and interactive content of social networks, associated with the intermittent reinforcement of notifications, stimulates the release of dopamine and keeps the brain alert, making it difficult to relax beforehand necessary for the onset of sleep (LEVENSON *et al.*, 2017).

Longitudinal studies show that adolescents who use digital devices for more than three hours a day have up to a 50% higher risk of developing symptoms of insomnia and daytime sleepiness (WORLD HEALTH ORGANIZATION, 2023). Cognitive hyperstimulation and the absence of time limits in the use of social networks contribute to the irregularity of bedtimes, generating patterns of cumulative sleep deprivation. Such changes have a direct impact on executive functions, emotional regulation, and academic performance (OGUNDELE *et al.*, 2022).

4.2 PSYCHOSOCIAL AND EMOTIONAL IMPACTS

The analysis of the studies shows that sleep deprivation and excessive use of social networks have a bidirectional relationship with anxious and depressive symptoms. Lack of adequate sleep is associated with amygdala hyperactivity and reduced connectivity between cortical structures responsible for emotional modulation, which favors exaggerated responses to stress and reduces frustration tolerance (LEVENSON *et al.*, 2017). On the other hand, social anxiety and fear of exclusion (FOMO) drive the constant checking of notifications, even during the night, perpetuating the cycle of sleep deprivation and emotional exhaustion (SCOTT; BIJOOR; LEE, 2022).

Adolescents exposed for long periods of time to social networks are more likely to engage in social comparison and internalize idealized aesthetic and behavioral patterns. This process, added to the emotional vulnerability of the phase, increases the incidence of generalized anxiety disorders, social phobia, and depressive symptoms (MOROMIZATO *et al.*, 2019). In a recent Brazilian study, it was found that 72% of adolescents who reported

nocturnal use of social networks had difficulties falling asleep and a higher frequency of nocturnal awakenings (OGUNDELE *et al.*, 2022).

In addition to the emotional effects, the behavioral impacts are remarkable. Sleep deprivation has repercussions on attention, memory, and decision-making capacity, directly affecting school performance and interpersonal relationships. Children with irregular sleep routines and nighttime exposure to screens demonstrate higher levels of irritability, impulsivity, and lower capacity for self-control (WORLD HEALTH ORGANIZATION, 2023). In the long term, these factors contribute to social isolation, increased aggressiveness, and greater vulnerability to risky behaviors, such as the use of psychoactive substances and self-mutilation (SCOTT; BIJOOR; LEE, 2022).

4.3 MANAGEMENT STRATEGIES AND PREVENTIVE INTERVENTIONS

Recent literature highlights the importance of multidisciplinary approaches in the management of sleep and anxiety disorders associated with social media use. Sleep hygiene is pointed out as a central strategy, encompassing measures such as the regularity of bedtime and wake-up times, the control of light and sound stimuli in the bedroom, and the restriction of the use of electronic devices at least two hours before bedtime (AMERICAN ACADEMY OF PEDIATRICS, 2016).

Psychoeducational interventions involving parents, teachers, and health professionals have shown efficacy in modifying technological habits and promoting behavioral self-regulation. School programs that associate digital education with mental health have reduced insomnia and anxiety complaints among participating adolescents by up to 30% (WORLD HEALTH ORGANIZATION, 2023). The implementation of public awareness campaigns on the "responsible use of screens" has also been recommended by medical societies and international health agencies.

From a clinical point of view, cognitive behavioral therapy (CBT) has stood out as a first-line intervention for both anxiety and insomnia management. CBT applied to sleep hygiene helps to identify dysfunctional beliefs, establish healthy routines, and develop strategies to cope with pre-sleep anxiety (MOROMIZATO *et al.*, 2019). In more severe cases, multidisciplinary follow-up — involving a pediatrician, psychologist, and psychiatrist — is essential for comprehensive and individualized treatment (OGUNDELE *et al.*, 2022).

In addition, some studies point to the positive influence of regular physical activity and relaxation practices, such as meditation and guided breathing, on improving sleep quality and

reducing anxiety symptoms (LEVENSON *et al.*, 2017). These interventions, when associated with the reduction of screen time and the strengthening of family bonds, have been shown to be effective in restoring emotional balance and promoting global well-being.

4.4 SUMMARY OF FINDINGS

In general, the results of the literature analyzed demonstrate that sleep disorders and anxiety in childhood and adolescence are interdependent phenomena, amplified by the dynamics of excessive use of social networks. The current pattern of hyperconnectivity alters the biological and emotional rhythms of young people, compromising cognitive and relational functions that are fundamental for development. The evidence reinforces the need for public policies and educational interventions that integrate mental health, digital education, and sleep regulation as complementary axes of health promotion.

5 DISCUSSION

The results of this review demonstrate that sleep disorders and anxiety disorders in childhood and adolescence are interconnected phenomena, strongly influenced by the contemporary digital context. The literature reveals that the excessive use of social networks not only alters the architecture of sleep, but also acts as a trigger and maintainer of anxious conditions, configuring a feedback loop between hyperconnectivity and emotional vulnerability (LEVENSON *et al.*, 2017; SCOTT; BIJOOR; LEE, 2022).

From a neurophysiological point of view, exposure to blue light and digital stimuli during the night inhibits melatonin secretion, prolonging alertness and reducing sleep quality (AMERICAN ACADEMY OF PEDIATRICS, 2016). This hormonal change affects memory consolidation and emotional regulation, leading to greater reactivity to stress and difficulty in modulating mood (MOROMIZATO *et al.*, 2019). In addition, constant exposure to notifications, sounds, and digital interactions prevents the cognitive shutdown necessary for restorative rest. In this way, the nocturnal digital environment becomes a potent circadian disruptor, especially in adolescents, whose biological predisposition to sleep delay is already natural (OGUNDELE *et al.*, 2022).

From a psychological perspective, the role of social networks goes beyond simple physiological interference. The content consumed and produced in these environments often promotes social comparisons and reinforces idealized patterns of success and appearance, generating feelings of inadequacy and anxiety (LEVENSON *et al.*, 2017). The fear of *Missing*

Out (FOMO) leads to the continuous use of the platforms, including during the night, compromising sleep and mental recovery (SCOTT; BIJOOR; LEE, 2022). This dynamic highlights how emotional and technological factors are intertwined, reinforcing the importance of multidimensional approaches in youth mental health care.

The bidirectionality between sleep and anxiety is widely recognized in the literature. Sleep deprivation impairs the functioning of the prefrontal cortex, reducing the ability to inhibit intense emotional responses and increasing the activation of the amygdala, which intensifies symptoms of anxiety and irritability (MOROMIZATO *et al.*, 2019). On the other hand, the anxious state raises cortisol levels, making it difficult to start sleeping and fragmenting its cycle. This circular relationship explains why isolated interventions—focused only on sleep or only on anxiety—have limited results. Integrated approaches, involving behavioral changes, digital education, and psychotherapeutic support, demonstrate greater effectiveness (WORLD HEALTH ORGANIZATION, 2023).

The social dimension of this phenomenon also deserves to be highlighted. The increase in technological dependence reflects not only individual transformations, but a broader cultural change, in which permanent connectivity is valued as synonymous with productivity and belonging. However, this logic reinforces dysfunctional habits and reduces the time allocated to rest and family life (AMERICAN ACADEMY OF PEDIATRICS, 2016). The absence of parental mediation and clear limits of use aggravates the problem, especially in families with a high workload and little supervision time. Thus, the management of sleep disorders and anxiety also requires a sociocultural approach, involving educational policies and public awareness campaigns.

The reviewed studies converge in pointing out that preventive strategies based on digital education and sleep hygiene are effective in reducing anxious symptoms and improving the quality of rest (OGUNDELE *et al.*, 2022). The implementation of school programs aimed at promoting mental health and the conscious use of technology contributes to the development of emotional and digital self-regulation skills. In addition, family involvement in creating structured sleep routines and monitoring screen time is essential for the success of interventions (WORLD HEALTH ORGANIZATION, 2023).

Another relevant point is the role of cognitive behavioral therapy (CBT), widely recognized as one of the most effective approaches for the treatment of insomnia and anxiety. CBT allows the identification and modification of dysfunctional beliefs related to sleep and daily concerns, in addition to favoring the development of adaptive coping strategies

(MOROMIZATO *et al.*, 2019). In adolescents, the combination of CBT with relaxation and mindfulness techniques has been shown to be especially useful in reducing sleep latency time and nocturnal anxious rumination (LEVENSON *et al.*, 2017).

However, despite the growing evidence, there are still important gaps in the literature. Most studies are cross-sectional in nature, which limits causal understanding between phenomena. More longitudinal trials are needed to assess the long-term impact of digital use on sleep neurobiology and psychological outcomes (SCOTT; BIJOOR; LEE, 2022). In addition, few studies address the role of moderating variables, such as gender, social class, and family context, in the relationship between technology, sleep, and anxiety.

Finally, the contemporary discussion on this topic needs to be guided not only by a biomedical perspective, but also by an ethical and social perspective. The exclusive responsibility of the individual or the family for the excessive use of technology ignores the influence of the economic and cultural structures that sustain digital consumption. Thus, the construction of healthier digital environments requires articulated actions between public authorities, schools, technological platforms, and civil society (WORLD HEALTH ORGANIZATION, 2023). Only with a systemic approach will it be possible to mitigate the impacts of hyperconnectivity on the sleep and mental health of children and adolescents.

6 CONCLUSION

The present narrative review shows that sleep disorders and anxiety disorders in children and adolescents are an emerging public health problem, deeply influenced by today's technological and cultural transformations. The excessive use of social networks acts as an important factor of physiological and emotional dysregulation, interfering with the sleep architecture and psychological stability of young people. Nocturnal exposure to screens, hyperconnectivity, and emotional involvement with digital platforms cause an imbalance in the circadian cycle, increased alertness, and intensification of anxious symptoms (LEVENSON *et al.*, 2017; SCOTT; BIJOOR; LEE, 2022). Thus, the contemporary digital context becomes a favorable terrain for the emergence of conditions that compromise the biopsychosocial development and quality of life of adolescents.

The analyzed findings reinforce that this relationship is bidirectional and multifactorial, involving neurobiological, cognitive, and social mechanisms. Sleep deprivation favors changes in emotional regulation and attention control, enhancing symptoms of anxiety and stress. At the same time, anxiety leads to prolonged activation of the sympathetic nervous

system, making it difficult to induce sleep and perpetuating a negative feedback loop (MOROMIZATO *et al.*, 2019 OGUNDELE *et al.*, 2022). Such evidence points to the need for integrated therapeutic approaches, involving digital education, cognitive-behavioral therapy, and sleep hygiene strategies, as well as intersectoral actions aimed at promoting mental health and the balanced use of technology.

It is concluded, therefore, that mitigating the impacts of hyperconnectivity on sleep and child and adolescent anxiety requires a collective effort, which goes beyond the clinical scope and reaches educational, family and political dimensions. The creation of school digital education programs, the strengthening of family bonds and the regulation of the use of electronic devices before sleep are priority measures. Likewise, it is essential that public managers and health institutions develop awareness campaigns about the risks of abusive use of social networks and encourage practices that promote digital well-being (AMERICAN ACADEMY OF PEDIATRICS, 2016; WORLD HEALTH ORGANIZATION, 2023). By integrating science, education, and health policies, it becomes possible to build a more balanced environment, favoring the healthy development of new generations amid the demands of the technological age.

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**INFLUENCE OF AFFORDABILITY ON THE MICROCLIMATE OF THE
ANANINDEUA-PA REGION**

**INFLUÊNCIA DA ARBORIZAÇÃO NO MICROCLIMA DA REGIÃO DE
ANANINDEUA-PA**

**INFLUENCIA DE LA ASEQUIBILIDAD EN EL MICROCLIMA DE LA REGIÓN DE
ANANINDEUA-PA**

 <https://doi.org/10.56238/sevened2025.036-022>

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ABSTRACT

This study analyzes the influence of vegetation cover on the urban microclimate, focusing on temperature and relative humidity parameters. Measurements were taken in two areas with different levels of afforestation in the municipality of Ananindeua, Pará, allowing for comparison between forested and non-forested environments. The results indicate that vegetation contributes significantly to thermal regulation, promoting a reduction in maximum daytime temperatures and an increase in relative humidity, especially during periods of greater sunlight. Furthermore, it was observed that factors such as cloud cover, paving, and land use influence microclimate variations, potentially even reversing expected trends. The research reinforces the importance of urban afforestation as an effective strategy for mitigating heat island effects, improving thermal comfort, and promoting greater environmental balance in cities.

Keywords: Microclimate. Temperature. Humidity.

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RESUMO

Este estudo analisa a influência da cobertura vegetal sobre o microclima urbano, com foco nos parâmetros de temperatura e umidade relativa do ar. As medições foram realizadas em duas áreas com diferentes níveis de arborização no município de Ananindeua, PA, permitindo a comparação entre ambientes arborizados e não arborizados. Os resultados indicam que a vegetação contribui significativamente para a regulação térmica, promovendo redução nas temperaturas máximas diurnas e aumento da umidade relativa, especialmente em períodos de maior incidência solar. Além disso, observou-se que fatores como nebulosidade, pavimentação e uso do solo interferem nas variações microclimáticas, podendo até inverter tendências esperadas. A pesquisa reforça a importância da arborização urbana como estratégia eficaz para mitigar os efeitos das ilhas de calor, melhorar o conforto térmico e promover maior equilíbrio ambiental nas cidades.

Palavras-chave: Microclima. Temperatura. Umidade.

RESUMEN

Este estudio analiza la influencia de la cobertura vegetal en el microclima urbano, centrándose en los parámetros de temperatura y humedad relativa. Se realizaron mediciones en dos zonas con diferentes niveles de forestación en el municipio de Ananindeua, Pará, lo que permitió comparar entornos forestados y no forestados. Los resultados indican que la vegetación contribuye significativamente a la termorregulación, promoviendo una reducción de las temperaturas máximas diurnas y un aumento de la humedad relativa, especialmente durante los períodos de mayor insolación. Además, se observó que factores como la nubosidad, la pavimentación y el uso del suelo influyen en las variaciones del microclima, pudiendo incluso revertir las tendencias esperadas. La investigación refuerza la importancia de la forestación urbana como estrategia eficaz para mitigar los efectos de isla de calor, mejorar el confort térmico y promover un mayor equilibrio ambiental en las ciudades.

Palabras clave: Microclima. Temperatura. Humedad.

1 INTRODUCTION

The phenomenon of urbanization is growing and global. In recent decades, cities have shown great growth in population, space, and activities, drastically transforming both the natural and the built environment (PEREIRA, 2025).

The urbanization process, defined as the increase in the population of urban areas to the detriment of rural areas, has been occurring in Brazil since the beginning of the twentieth century in all regions and biomes of the country. In the vast majority of cases, this process takes place from inadequate planning, generating disorderly growth, accompanied by the lack of infrastructure capable of guaranteeing the minimum environmental quality (OLIVEIRA, 2021).

This new built environment has been undergoing significant climate change, with damage to the quality of life of populations (LABAKI *et al.*, 2011; OLIVEIRA *et al.*, 2013). This disorderly growth favors the removal of a large part of the vegetation for the expansion or construction of roads, buildings and land parcels, increasing the paved coverage of this area (ABREU, 2008; PEREIRA, 2023).

In this sense, the urban environment should be a place where the user's feeling of comfort is achieved, however, in many cases, these environments do not offer adequate conditions for this, whether thermal, acoustic, luminous or visual comfort (GUSMÃO, 2025).

The city is in itself a major climate modifier, due to the large paved areas and decrease in green areas, the air layer tends to be warmer in urban areas than in rural areas (FORMIGA, 2022). In addition, human activity in cities creates profound changes in the local climate, and can also alter the temperature and rainfall regime of the region (GONÇALVES *et al.*, 2012).

Vegetation cover provides several ecosystem services that help mitigate the effects of heat islands (UHI), formed by the process of urbanization and reduction of vegetation areas, helping to raise the quality of life of urban inhabitants and the sustainability of cities (ZHANGA, ESTOQUE, MURAYAMA, 2017). The transpiration of trees promotes cooling and humidification of the environments where they are inserted, in addition to being a source for latent heat flow (ZHENG *et al.*, 2021).

The effect of UHIs is characterized by the development of higher temperatures, between the ranges of 3.4 and 4.5 °C, in urban areas when compared to rural areas (ZHANGA, ESTOQUE, MURAYAMA, 2017). This effect is the result of the removal of vegetation cover and consequently the decrease in evapotranspiration, increasing the release of sensible heat (STONE *et al.*, 2010; ZHENG *et al.*, 2021).

This increase in the release of sensible heat causes large heat waves that act negatively on urban ecosystems and human comfort, in addition to helping the growth of electricity and water consumption for cooling; (HATVANI-KOVACS et al., 2016; STOCK; MURAYAMA; MYINT, 2017). Therefore, the presence or absence of urban forests causes, respectively, major positive or negative impacts on society and the sustainability of cities.

For all these factors, this research came from the need to quantify the contribution of urban afforestation to thermal comfort, that is, the attenuation of solar radiation by vegetation and its influences on air temperature and humidity. Thus, the objective of this work was to analyze the differences in temperature and relative humidity of the air in two distinct neighborhoods of the municipality of Ananindeua with similar characteristics of area, standing out for the difference in the existing tree vegetation, in order to subsidize the discussion of urban afforestation as a measure to mitigate the increase in temperature and favor thermal comfort.

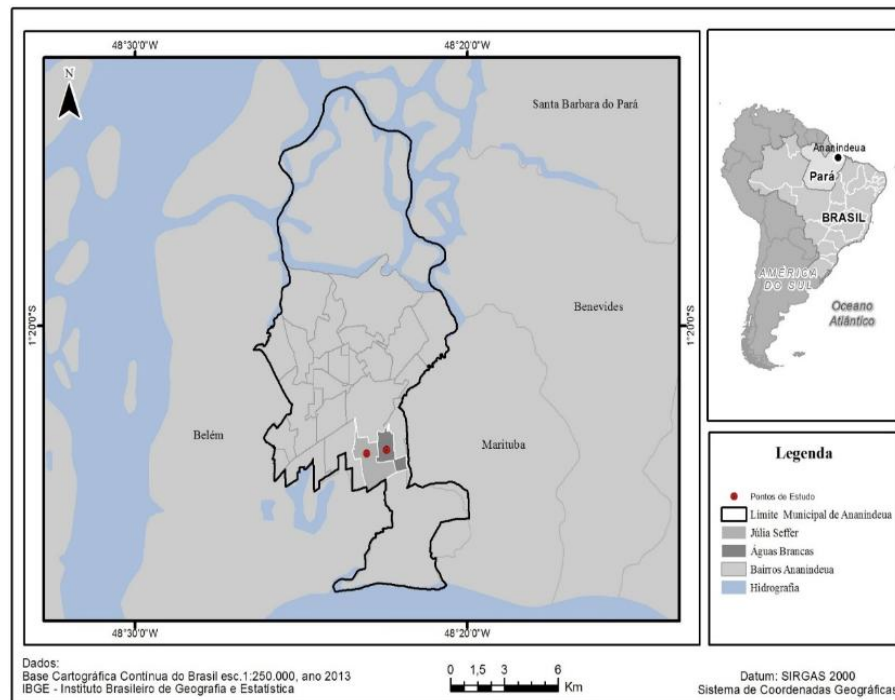
2 METHODOLOGY

2.1 CHARACTERIZATION OF THE STUDY AREA

With an area of 191.4 km², the municipality of Ananindeua is located between the geographic coordinates 01° 13' and 01° 27' south latitude and 48° 19' and 48° 26' west longitude (IBGE, 2010). The study was developed at two different points (Figure 1), the first data collection was carried out in the area of Bosque Uirapuru, an area of abundant vegetation and apparently preserved, and the second point was the area of Residencial Jardim Amazônia 2, which has significant anthropic action.

Figure 1

Map of the location of the municipality of Ananindeua/PA with the points of the Analysis



Source: Prepared by the authors, 2025.

To evaluate the influence of vegetation on thermal comfort, temperature and air humidity, measurements were carried out at two different points located in the central region of the municipality of Ananindeua, PA. The selected areas present significant differences in terms of vegetation density and types of pavement, although they share similar topographic characteristics (Figure 2). With an approximate distance of 1,500 meters between them, it is possible to consider that both are exposed to comparable climatic conditions, which favors the analysis of the effects of vegetation cover on the local microclimate.

Figure 2

Areas selected for the study



*Area 1: Uirapuru Forest, located at R. Coletora Oeste, Águas Lindas, Ananindeua – PA, Júlia Seffer set. A well-wooded place has a varied plant composition, with well-distributed medium and large trees, shrubs and flowers. Planned by the federal savings bank of Pará.

*Area 2: Area 2: Residencial Jardim Amazônia 2, Estr. for Industry - Águas Brancas, Ananindeua – PA. Housing complex where more people were observed moving around in their cars, with little movement of people during the day, with an increase in passersby in the late afternoon.

Source: Authors.

To capture the variables, the device was positioned at a height of 2.00 meters from the ground. Following the methodology of Gonçalves *et al.* (2012) modified, the data – temperature and relative humidity – were recorded every 1 hour, for 15 minutes in the central part of each area, starting the measurements in the first area at 08:00 hours and ending at 18:00 at night. For data collection, a digital Higo-thermometer (model Instrutemp ITHT-2220) was used with a temperature range of 0°C to 50°C, relative humidity range of 1.0% RH to 99% RH, accuracy with temperature: $\pm 0.5^{\circ}\text{C}$ ($\pm 1.8^{\circ}\text{F}$) and relative humidity $\pm 3\%$ RH. The data collection of the first and second areas was in the months of September, October, November and December of the year 2017, always on the 28th of the respective months, from 08:00 am to 6:00 pm, with variations in atmospheric weather, clear sky situation in the morning and rain in the afternoon, in the rainiest months such as November and December there were clouds and gusts of wind, which are directly and indirectly related to the variables analyzed in this study. Finally, the collected data were tabulated in Excel, analyzed and the graphs that composed the discussion were elaborated.

3 RESULTS AND DISCUSSION

Climate regulation by vegetation cover consists of interferences in climatic conditions close to the surface, such as sensible and latent heat and, consequently, air temperature and humidity. The amount of radiation that a surface absorbs or reflects results in a warmer or colder climate in a given region (OLIVEIRA, 2021).

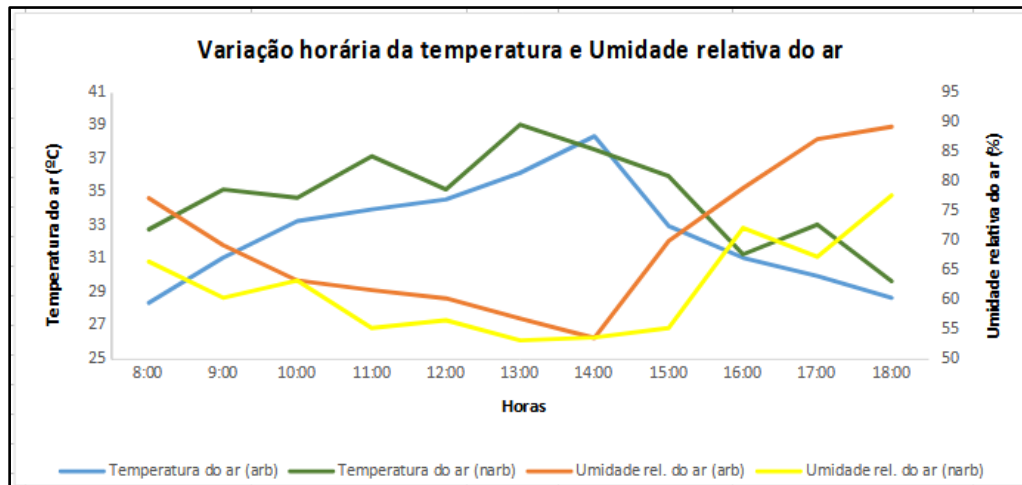
The presence of vegetation in urban environments contributes significantly to the attenuation of maximum diurnal temperatures, by reducing radiative exchanges on the soil surface. This effect manifests itself both indirectly, through the decrease in the flow of sensible heat from colder surfaces, and directly, through evaporative cooling promoted by plant transpiration. Several studies in the area corroborate the hypothesis that the scarcity of vegetation cover in cities is associated with the increase in air temperature during the day. On the other hand, large-scale afforestation initiatives have the potential to mitigate daytime district heating (ERELL *et al.*, 2010).

In the wooded area, there is a reduction in air temperature and an increase in relative humidity in the wooded area, possibly associated with a higher density of vegetation cover. However, an inversion of this pattern is observed at 2 pm, with an increase in temperature and a decrease in relative humidity. Such variation indicates that, although vegetated, the area is inserted in the urban fabric, being influenced by anthropic factors such as paving, adjacent buildings and changes in land use and occupation. These elements contribute to the modification of the local microclimate, evidencing the complex interaction between the natural environment and urban dynamics (Figure 3).

Gonçalves and Paiva (2004) state that the excess of asphalt and cement, together with the impermeabilization of the soil, cause excess heat to occur in certain urban environments. Therefore, the high temperature will come from the direct incidence of the sun's rays on these elements and the degree of absorption, retention and reflection of this heat in these structures.

Figure 3

Graph referring to the measurements of air temperature and humidity in September 2017



*Blue and orange lines refer to point 1; Green and yellow lines refer to point 2.

Source: authors, 2018.

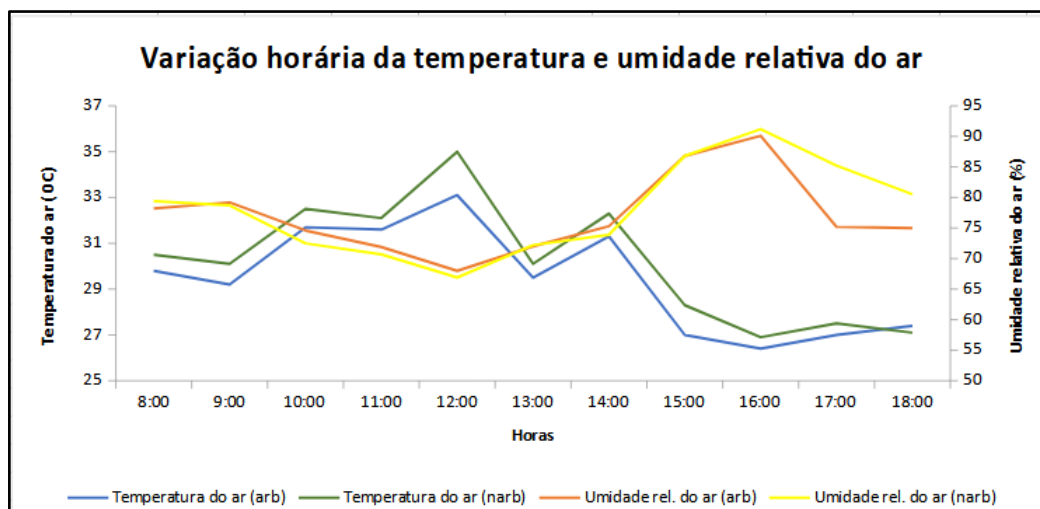
The insolation received in a given place on the Earth's surface can vary, and one of the factors responsible for this variation is cloudiness (SILVA, 2011). Because clouds cause a variation in the intensity of solar radiation incident on the surface, and because of this variation in radiation the variability of radiation incident in a region is explained (BASTOS *et al.*, 2002). In addition, only part of the solar radiation reaches the Earth's surface, due to atmospheric transmissivity (PEREIRA; OLIVEIRA, 2011).

In certain periods, the air temperature in the wooded area (blue line) presented values higher than those of the non-wooded area (green line), which contradicts the expected trend. This anomaly can be explained by the presence of cloud cover over the non-wooded area, which reduced the incidence of solar radiation and, consequently, the local temperature. It is also considered that the month of October marks the beginning of the rainy season in the region (Figure 4), which may have caused specific microclimatic variations and interfered with the results obtained.

The intensity of solar radiation that reaches a horizontal surface is variable, due to the attenuation suffered when crossing the atmosphere, due to the presence of clouds, dust, pollution and others. Naturally, on a cloudy day, the intensity of solar radiation will be lower and, consequently, the performance of the module will be impaired. The opposite occurs on a clear day or with cloudless skies (MARQUES; PEAR TREE; ASSIS, 2000).

Figure 4

Graph referring to air temperature and humidity measurements in October 2017



*Blue and orange lines refer to point 1; Green and yellow lines refer to point 2.

Source: authors, 2018.

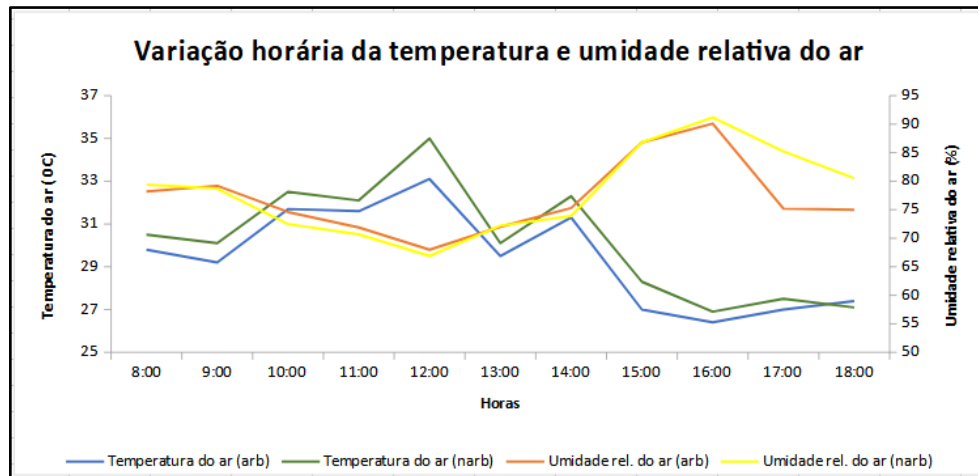
It was observed in the period of November and December that the air temperature in the wooded place (area 1) compared to the non-wooded one (area 2), was of greater divergence from early morning until noon, where we see a higher concentration of heat. A sharp increase in temperature was observed in area 1, varying up to 2 °C degrees of difference until the beginning of rainfall in both areas. From 1 pm on, the rain began causing the heat to be controlled and dissipated in area 1, reaching close to the air temperature value of area 2, of 0.5°C degrees, as shown in figure 5.

During the rainy season, there is a predominance of precipitation and intense cloud cover throughout the area, which results in reduced levels of solar irradiation. In contrast, in the dry season or with lower rainfall, there is an increase in the incidence of solar radiation, favored by the decrease in cloudiness and the less frequent occurrence of rainfall, which causes a difference between the first hours of the day and the peak, around noon (FERREIRA *et al*, 2023).

The influence that vegetation exerts on the climate is often addressed in several studies, although the evaluation of the parameters involved still represents a complex challenge. The energy exchanges between vegetation and the atmosphere — carried out through the radiation balance (R_n) and the fluxes of sensible (H) and latent (LE) heat — are fundamental to understand environmental dynamics. These components reflect physical processes that occur both on a local and global scale (FERREIRA *et al*, 2023).

Figure 5

Graph referring to air temperature and humidity measurements in November 2017



*Blue and orange lines refer to point 1; Green and yellow lines refer to point 2.

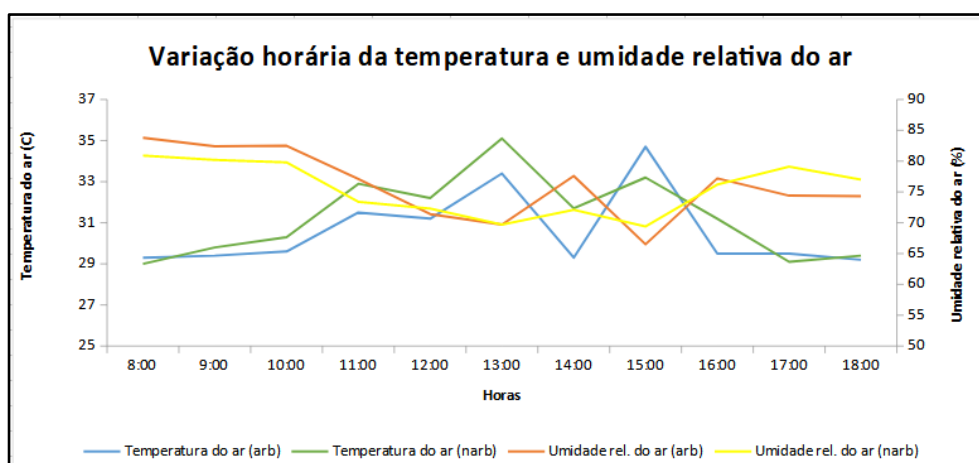
Source: authors, 2018.

As for the temperature measured in degrees Celsius ($^{\circ}\text{C}$), in area 2, the well-wooded region with medium and large trees had an average temperature of 30.4°C , while in area 1, devoid and with little trees, it had an average temperature of 31.2°C in December. For the air temperature, it is noted that the area with trees remained below the non-trees. The values referring to the relative humidity of the air, area 1, presented an average of 76.0%, area 2, average humidity is 62.2%. The values related to the measurements of temperature and relative humidity can be seen in figure 6.

Wooded areas tend to have higher levels of relative humidity, especially after the leaf regrowth period, when temperatures are higher and there is a higher incidence of rainfall (GOTARDO *et al.*, 2019). *In these environments, the water accumulated in the leaves favors direct evaporation, contributing to the increase of local humidity. In contrast, regions that are poorly wooded or devoid of vegetation do not offer the same support for water retention, which can result in a drier and less stable microclimate.*

Figure 6

Graph referring to air temperature and humidity measurements in December 2017



*Blue and orange lines refer to point 1; Green and yellow lines refer to point 2.

Source: authors, 2018.

4 CONCLUSION

The results obtained demonstrate that the presence of vegetation in urban environments exerts a direct influence on the regulation of the microclimate, especially in the reduction of air temperature and in the increase of relative humidity. Wooded areas have a greater capacity to retain water in the leaves and promote evaporative cooling through plant transpiration, which contributes to the mitigation of heat. However, occasional variations, such as the increase in temperature at specific times, indicate that urban factors — such as paving, buildings, and land use — also significantly interfere with thermal dynamics, even in places with vegetation cover.

In addition, the distribution of solar radiation is affected by atmospheric elements such as cloudiness, pollution, and humidity, which alter the intensity of the irradiance received. The comparison between wooded and non-wooded areas shows that vegetation acts as a climate moderator, reducing the impacts of urban warming. Therefore, planned afforestation strategies are essential to mitigate the effects of heat islands, improve thermal comfort, and promote greater environmental balance in cities.

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DIGITAL ENTREPRENEURSHIP: A DIGITAL MARKETING STRATEGY WITH E-COMMERCE AND DROPSHIPPING

EMPREENDEDORISMO DIGITAL: UMA ESTRATÉGIA DE MARKETING DIGITAL COM E-COMMERCE E DROPSHIPPING

EMPRENDIMIENTO DIGITAL: UNA ESTRATEGIA DE MARKETING DIGITAL CON E-COMMERCE Y DROPSHIPPING

 <https://doi.org/10.56238/sevened2025.036-023>

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ABSTRACT

This academic work developed an applied study focused on the relationship between Digital Entrepreneurship, Digital Marketing, E-Business, E-Commerce, and the Dropshipping model as an innovative strategy for online business development. The research adopts a qualitative and experimental approach, grounded in a comprehensive literature review and the practical implementation of an e-commerce platform named Pawzzi, specialized in pet products. Using the Business Model Canvas framework, the study structured a digital business model aligned with the principles of cost reduction, scalability, and technological integration. The results demonstrated that the dropshipping modality, when supported by effective digital marketing strategies and customer relationship management, represents a viable, flexible, and profitable alternative for micro and small entrepreneurs seeking entry into the digital market. The findings also emphasize the centrality of user experience (UX) design, mobile responsiveness, and social proof in achieving competitiveness and long-term sustainability in the e-commerce ecosystem.

Keywords: Digital Entrepreneurship. Digital Marketing. E-Business. E-Commerce. Dropshipping.

RESUMO

Este trabalho acadêmico desenvolveu um estudo aplicado focado na relação entre Empreendedorismo Digital, Marketing Digital, E-Business, E-Commerce e o modelo Dropshipping como estratégia inovadora para o desenvolvimento de negócios online. A pesquisa adota uma abordagem qualitativa e experimental, fundamentada em uma revisão abrangente da literatura e na implementação prática de uma plataforma de e-commerce chamada Pawzzi, especializada em produtos para animais de estimação. Utilizando o framework Business Model Canvas, o estudo estruturou um modelo de negócio digital

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alinhado aos princípios de redução de custos, escalabilidade e integração tecnológica. Os resultados demonstraram que a modalidade dropshipping, quando apoiada por estratégias eficazes de marketing digital e gestão de relacionamento com o cliente, representa uma alternativa viável, flexível e lucrativa para micro e pequenos empreendedores que buscam entrada no mercado digital. Os resultados também enfatizam a centralidade do design de experiência do usuário (UX), da responsividade mobile e da prova social para alcançar competitividade e sustentabilidade a longo prazo no ecossistema de e-commerce.

Palavras-chave: Empreendedorismo Digital. Marketing Digital. E-business. E-commerce. Dropshipping.

RESUMEN

Este trabajo académico desarrolló un estudio aplicado centrado en la relación entre el emprendimiento digital, el marketing digital, el comercio electrónico, el e-business y el modelo de dropshipping como estrategia innovadora para el desarrollo de negocios en línea. La investigación adopta un enfoque cualitativo y experimental, basado en una revisión exhaustiva de la literatura y la implementación práctica de una plataforma de comercio electrónico llamada Pawzzi, especializada en productos para mascotas. Utilizando el marco del Business Model Canvas, el estudio estructuró un modelo de negocio digital alineado con los principios de reducción de costos, escalabilidad e integración tecnológica. Los resultados demostraron que la modalidad de dropshipping, cuando se apoya en estrategias efectivas de marketing digital y gestión de la relación con el cliente, representa una alternativa viable, flexible y rentable para micro y pequeños empresarios que buscan ingresar al mercado digital. Los hallazgos también enfatizan la importancia del diseño de la experiencia de usuario (UX), la capacidad de respuesta móvil y la prueba social para lograr la competitividad y la sostenibilidad a largo plazo en el ecosistema del comercio electrónico.

Palabras clave: Emprendimiento Digital. Marketing Digital. Negocios Electrónicos. Comercio Electrónico. Dropshipping.

1 INTRODUCTION

Technological advancement and globalization have profoundly transformed the way organizations and individuals interact with the market and the very concept of work. Physical borders have given way to a dynamic digital environment characterized by the speed of information, global connectivity, and constant innovation. In this scenario, entrepreneurship has taken on new dimensions, becoming more accessible, flexible, and comprehensive. Thus, digital entrepreneurship has emerged, a trend that uses information and communication technologies as a foundation for creating, managing, and expanding businesses.

Concepts such as e-business, digital marketing, e-commerce, and dropshipping have become essential parts of the vocabulary of entrepreneurs and consumers, reflecting the transformation of traditional models into integrated digital structures. Companies have begun operating on virtual platforms, offering products and services with greater reach, efficiency, and personalization. Consumers, in turn, have gained prominence in this new context, actively participating in the value creation process and influencing brand strategies.

Therefore, we live in a society marked by hyperconnectivity, where the strategic use of technology is crucial for business competitiveness and sustainability. Digital entrepreneurship is not just a trend, but a consolidated reality that redefines economic, social, and cultural relations. Therefore, this article aims to present a broad overview of these topics, analyzing their interrelationships and the relevance of each concept within the contemporary economic landscape, from the innovative and transformative perspective of digital entrepreneurship.

2 METODOLOGY

This study adopts a qualitative and exploratory approach, supported by bibliographic and experimental methods, aiming to analyze how digital entrepreneurship can be effectively structured through digital marketing strategies, e-business practices, and the dropshipping model. The study was conducted in two complementary stages. The first involved a comprehensive literature review of books, academic articles, and institutional publications from SEBRAE, focusing on the theoretical consolidation of key concepts such as digital entrepreneurship, e-commerce, and digital marketing. The second stage consisted of an applied experiment, in which an e-commerce platform named Pawzzi was designed to sell pet products using the dropshipping model.

The methodological process included the application of the Business Model Canvas, a visual strategic planning tool used to identify the essential components of the proposed business model, such as value proposition, customer segments, key partners, and cost structure. The store's digital environment was developed through web design techniques emphasizing usability (UX/UI), mobile-first architecture, and digital marketing integrations, such as SEO, social media engagement, and performance analytics.

Data were analyzed qualitatively to assess the feasibility, scalability, and competitiveness of the dropshipping business model when combined with digital marketing tools. The methodological choices aimed to align theory and practice, providing a replicable model for entrepreneurs and researchers interested in understanding the intersection between technology, innovation, and entrepreneurship in the digital economy.

3 THEORETICAL FRAMEWORK

3.1 ENTREPRENEURSHIP

Entrepreneurship is an essential phenomenon for a country's economic and social development. It is characterized by the ability to identify opportunities, innovate, and transform ideas into sustainable businesses.

The 21st century marked a profound revolution in the way we do business, communicate, and generate value. Technological advancement, globalization, and the digitalization of markets have radically transformed consumer relations and business models. In this context, entrepreneurship, combined with marketing and digital marketing strategies, has become the foundation for sustainable and innovative growth for companies worldwide.

Entrepreneurship today requires more than a good idea; it requires strategic vision, market knowledge, mastery of digital tools, and the ability to constantly adapt. The synergy between these three elements allows us to understand consumer behavior, intelligent position brands, and create meaningful experiences in an increasingly competitive environment.

According to Valenciano (2005, apud Nascimento, 2023, p. 2), "entrepreneurship is the involvement of people and processes that, together, lead to the transformation of ideas into opportunities, and the perfect implementation of these opportunities leads to the creation of successful business".

An entrepreneur is someone who takes calculated risks, mobilizes resources, and promotes creative solutions that generate value for society (VIANNA et al., 2025). More than

just starting a business, entrepreneurship represents a mindset focused on innovation, overcoming challenges, and the constant pursuit of improvements in production processes and services offered (POEL, 2022). In a world of constant transformation, according to (PINTO, MARTENS and SCAZZIOTA, 2023), "entrepreneurship has become a strategic tool for driving economic growth, generating jobs, and promoting technological advancement." Therefore, understanding its role is essential for those who wish to operate in the market in a competitive and innovative manner.

3.2 DIGITAL ENTREPRENEURSHIP

With the advent of the internet, digital technologies, and the connected society, digital entrepreneurship emerged, characterized by the creation and management of businesses based on online platforms. Unlike the traditional model, according to Filipini (2016), "this type of entrepreneurship reduces barriers to entry, expands geographic reach, and allows scalability with lower operating costs." Examples include businesses based on apps, social networks, online courses, and online stores.

As stated by Poel et al.:

Digital entrepreneurship is a new form of entrepreneurship or an intersection between digital technologies and entrepreneurship. [...] It emerged from the introduction of digital technologies to innovate and undertake, to change processes, generate results, with increased uncertainty and reduced limits for the entrepreneur [...] considered a derivative or subcategory of entrepreneurship, in which part of the organization, the enterprise, or the product or service offered is digitalized (POEL et al., 2022).

According to Gomes (2019), "the digital entrepreneur must have technological skills, creativity and the ability to constantly adapt to changes in the virtual environment".

3.3 E-BUSINESS

Because of the internet and the consequent evolution of the way we do business through digital media, the opportunity to undertake business through e-commerce has emerged.

E-business, including e-commerce, are now fundamental to the modernization of the productive sector, as they allow for the expansion and diversification of markets and the improvement of business activities (NASCIMENTO, p. 21, 2023).

"E-commerce is experiencing unparalleled growth rates, both in business-to-consumer transactions and in business-to-business transactions, which is currently where the highest level of revenue generation occurs." (SOCINFO, 2000, apud Nascimento, 2023, p. 21).

The term "E-Business" refers to the use of digital technologies to optimize and integrate business processes (CHAFFEY, 2011). While "E-Commerce" specifically addresses online commercial transactions, "E-Business" encompasses a broader spectrum, including inventory management, supplier relationships, customer service, and automated marketing (FERNANDES, FERREIRA and CALVOSA, p. 52, 2022).

According to Wang et al. (2025), "E-Business" represents the complete digitalization of a company's operations, making it more agile, efficient, and competitive in the global market.

3.4 MARKETING

Marketing is the set of strategies and actions designed to identify, create, and satisfy consumer needs and desires. According to Kotler et al. (2025), "marketing is not limited to sales, but involves the entire process of market analysis, product development, pricing, communication, and distribution."

According to Fernandes, Ferreira, and Calvosa:

[...] Small businesses have difficulty implementing marketing strategies to boost their sales. Due to a lack of resources or limited management experience, smaller organizations are slow to adopt effective approaches capable of developing a relationship with customers that precisely meets their needs and desires (FERNANDES, FERREIRA, and CALVOSA, p. 50, 2020).

According to Marroque et al. (2025), the purchasing process is influenced by situational, social, and marketing factors. They believe that each consumer's specific needs must be intrinsically understood and met. Marketing seeks to understand consumer behavior to offer superior value and build lasting relationships between companies and customers. (DE LIMA, DE LIMA, FOFONCA and LOPES, 2023).

3.5 DIGITAL MARKETING

Digital marketing is the natural outcome of technological transformation. It involves the use of online channels and tools, such as social media, search engines, email marketing, SEO, paid advertising, and automation, to attract, convert, and retain customers.

According to SEBRAE (2025a), "Digital Marketing is the promotion of products and brands through online channels, such as blogs, websites, social media, email, apps, and others."

In other words, Digital Marketing is essential for increasing sales, expanding your business, and strengthening your brand. It is the primary tool for evaluating the performance of your actions, measuring return on investment, and establishing clear and simple metrics to make the best decisions for your business.

Digital Marketing is the application of traditional marketing principles to the online environment, using technological tools and digital platforms to promote products and services (KINGSNORTH, p. 48, 2022). Its most used strategies include SEO (Search Engine Optimization), content marketing, social media, email marketing, and paid advertising (ADS). This modality allows you to precisely target your audience and measure results in real time, making it essential for companies' competitiveness in the digital age (VIDAL et al., p. 14964, 2023). Therefore, digital marketing is a direct way to address your customers' desires and establish personalized communication at the right time, aiming to boost your sales.

According to Ryan (2020), "digital marketing is not just about technology, but about human behavior mediated by technology." This approach reinforces the need to understand users, their journeys, and touchpoints. Its most used strategies include:

SEO (Search Engine Optimization): website optimization to achieve better rankings on Google.

Social media: content creation to engage and strengthen communities.

Email marketing: direct and targeted communication with customers.

Paid traffic (ADS): advertising on platforms such as Google Ads and Meta Ads.

Content marketing: production of educational materials that build authority.

Influencer marketing: partnerships with digital creators to increase brand visibility.

Each of these tactics needs to be integrated into a coherent strategic plan, aligned with the brand's purpose and audience profile.

In the context of the evolution of digital marketing, the advancement of artificial intelligence (AI) and big data has transformed digital marketing into a predictive science. Tools such as recommendation algorithms and behavioral analysis enable hyper-personalized campaigns.

Kotler et al. (2025) state that "marketing 6.0 is the meeting of technology and human empathy," where data is used to understand emotions and predict needs before the consumer even expresses them.

Key trends include voice marketing, social commerce, augmented reality, and the use of generative AI in content creation. Brands that embrace these technologies ethically and creatively gain a competitive advantage and strengthen their digital presence.

3.6 E-COMMERCE

According to the ECBR (2025), e-commerce refers to the buying and selling of products or services online. This type of commerce has expanded exponentially in recent years, driven by convenience, transaction security, and a variety of available offerings (MARTINS, 2020).

Unlike offline sales, which take place through a point of sale, with pre-established opening hours and limited coverage area, online sales, e-commerce, offers countless possibilities for closing a deal, as it is not restricted to geographical location or business hours (VIANNA et al., 2025).

E-commerce operates through a platform with features and integrations that enable a complete purchasing process, post-sale service with loyalty, and integration with marketplaces (an online platform where sellers and buyers meet to conduct commercial transactions), as stated by Chaffey (2011).

There are different types of e-commerce, such as B2C (Business to Consumer), B2B (Business to Business), C2C (Consumer to Consumer), and C2B (Consumer to Business). For Santos et al. (2024), e-commerce is one of the most significant expressions of digital transformation, democratizing market access and enabling small businesses to reach consumers on a global scale.

3.7 DROPSHIPPING

A segment of e-commerce that has been booming worldwide is commerce based on the dropshipping model. According to SEBRAE (2025a), dropshipping is, in a simplistic definition, the combination of two terms: "drop," which loosely translates to "to drop," and "shipping," which, translated into Portuguese, can be understood as "shipment." Mostarac, Kavran, and Piskovic (2020, apud Nascimento, 2023, p. 22) cite the concept of dropshipping as "a supply chain management method in which the retailer does not keep goods in stock,

but instead transfers customer orders, with delivery handled by the manufacturer or wholesaler."

Dropshipping is an e-commerce model in which the entrepreneur acts as an intermediary between the supplier and the end consumer, without the need to maintain their own inventory. In this system, the seller makes the sale, and the supplier takes care of storing, packaging, and shipping the product. This modality reduces costs and risks, making it a viable alternative for new digital entrepreneurs. However, it requires attention to supplier quality and delivery times, which are crucial factors for customer satisfaction (CARDOSO, 2023).

Figure 1 illustrates Dropshipping without stock or inventory.

Figure 1

Dropshipping No Stock



Source: ISTOCK (2025).

According to Allen (2021), dropshipping is a business model through which the retailer sells without its own inventory, acting as an intermediary, passing the customer's order to the supplier, who will then be responsible for delivery. This enables new business opportunities with more affordable investments, and suppliers can be domestic or international.

Figure 2 illustrates Amazon's dropshipping practice example.

Figure 2
Amazon Dropshipping Structure



Source: WEBOLTO (2025).

According to Nascimento (2023), "based on the simplification of implementing an online business using the dropshipping model, it is likely that the number of these businesses will increase worldwide every day."

In 2021 alone, approximately 33% of online stores worldwide operated through dropshipping, and this market is expected to grow by an average of 28.8% by 2025 (ALLEN, 2021).

4 METHODOLOGICAL PROCEDURES

To broaden the understanding of the topic and contextualize it as a Digital Marketing Strategy, this study used information provided by an IME (Individual Micro Entrepreneur). To support the technical basis of the research, reference scientific articles in the areas of digital entrepreneurship, digital marketing, e-commerce, and dropshipping were consulted as the foundational points of this research.

The research uses direct information from SEBRAE (Brazilian State Electricity Regulatory Agency), books, and scientific articles, all on the topic proposed by this work, as its main sources. The approach adopted includes a deep dive into key concepts to understand how to develop a business model for Pawzzi, a company developing its online e-commerce store for pet products tailored to the needs of dogs and cats.

The study used a qualitative, experimental approach to validate the proposed business model specifically for an online store selling products for dogs and cats.

5 RESULTS AND DISCUSSIONS

The results of this study are presented, allowing the definition of the Business Model Canvas for a Pet E-Commerce, as well as the proposition of the Pawzzi E-Commerce Virtual Store (a company characterized as an Individual Micro Entrepreneur - IME, *Micro Empreendedor Individual* - MEI, in Portuguese).

5.1 BUSINESS MODELO CANVAS

The Business Model Canvas is a visual strategic planning tool that allows you to describe, design, challenge, and innovate business models in a simple and organized way. It consists of a framework with nine blocks that represent the key components of a business (DORNELAS, 2016).

According to SEBRAE (2025b), the nine-block framework is composed as follows:

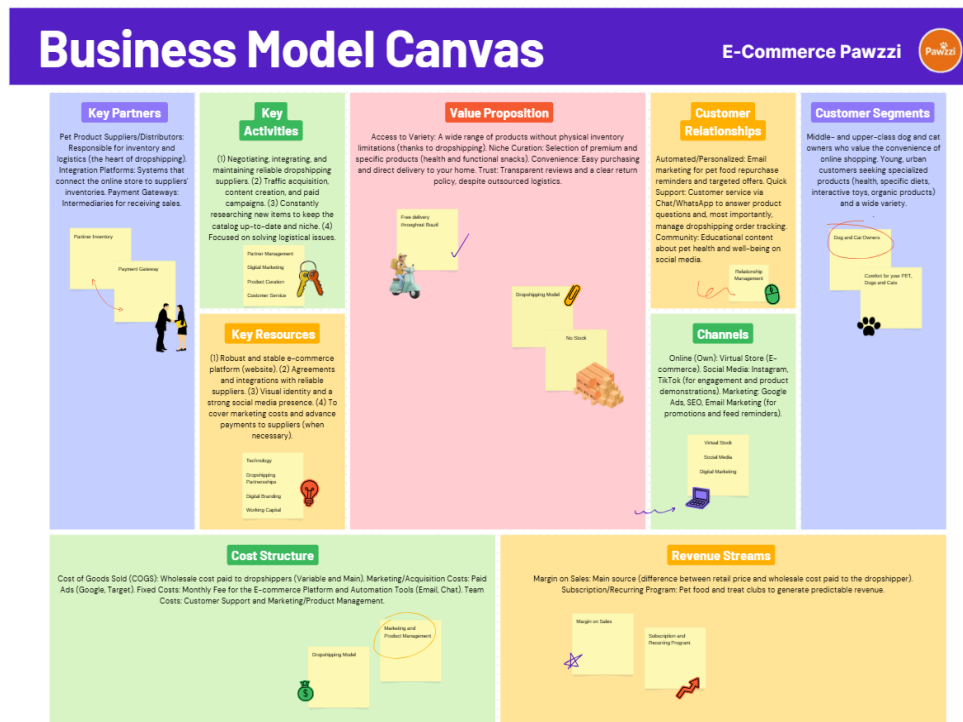
- (1) **Value Proposition:** What the company offers to the market that is valuable to customers.
- (2) **Customer Segments:** Who the target customers are.
- (3) **Channels:** How the product or service reaches the customer.
- (4) **Customer Relationships:** How the company relates to its different customer segments.
- (5) **Revenue Streams:** How the company generates revenue.
- (6) **Key Resources:** The essential resources (human, financial, technological, etc.) for the business to operate.
- (7) **Key Activities:** The essential activities for delivering the value proposition.
- (8) **Key Partners:** Key activities performed by third parties and key resources that are acquired externally.
- (9) **Cost Structure:** The relevant costs to operate the business.

Canvas is a tool that allows you to create images of new or existing Business Models. This framework is responsible for revolutionizing the way entrepreneurs and companies build their new businesses, and I'm sure it will be for you too (SEBRAE, 2025b).

Figure 3 illustrates the Business Model Canvas to Pet E-Commerce (Dropshipping).

Figure 3

Business Model CANVAS [Pawzzi E-Commerce]



Source: Adapted to Dornelas (2016).

According to Dornelas (2016), the Canvas model is a versatile tool that can be used by entrepreneurs and business development teams. Its main features include:

- Business visualization:** represented by a 9-block framework, which provides an overview of how the business operates, as shown in the previous image.
- Focus on customer value:** the first block is the value proposition, which focuses on understanding the value the business offers to its customers.
- Key activity analysis:** key activities are the actions that need to be performed for the business to function, and the Canvas Model aims to optimize them.
- Key resource identification:** the model aims to identify the business's key resources, including human, financial, and technological resources.
- Key partnership focus:** strategic partnerships are an important part of many businesses and, as such, should be optimized.
- Revenue source analysis:** the methodology highlights the importance of identifying and optimizing the business's revenue sources.
- Understanding the cost structure:** This is an important part of any business, therefore crucial for balancing expenses.

h) **Flexible tool:** It can be adjusted to meet the specific needs of each business.

Thus, the Canvas model is a visual and intuitive tool that offers an overview of how a company operates, focusing on customer value, key activities, key partnerships, revenue sources, and cost structure.

5.2 PAWZZI ONLINE STORE (E-COMMERCE)

The development of the Pawzzi Online Store was the culmination of the Digital Entrepreneurship and Digital Marketing strategy detailed in this study, operating exclusively through dropshipping. By adopting the dropshipping model, Pawzzi positions itself as a sales intermediary, focusing on products for pets, dogs, and cats, eliminating the need for its own physical inventory, reducing operating costs, and maximizing business scalability.

The e-commerce platform was designed to be robust, intuitive, and fully responsive, ensuring an optimized user experience (UX) for both desktop and mobile access.

The desktop interface was designed to convey trust and ease of navigation, essential pillars for e-commerce success, according to Chaffey (2011), as illustrated below:

Figure 4

Pawzzi E-Commerce - Rotating Banner - Step 1



Source: Prepared by Juan Boente (2025).

Figures 4 and 5 represent the store's first visual impression on the desktop, focusing on customer attraction and acquisition elements. The header is fixed and features the search bar, the Pawzzi logo, and account access (Login/Register), as well as the shopping cart,

where products are temporarily stored until the purchase is completed. The central element is the rotating banners, which communicate the Pawzzi online store's main value propositions and promotions, as described in Business Model Canvas.

In Figure 4, the highlight is "Free Shipping to All of Brazil," a crucial marketing strategy in the dropshipping model.

Figure 5

Pawzzi E-Commerce - Rotating Banner - Step 2



Source: Prepared by Juan Boente (2025).

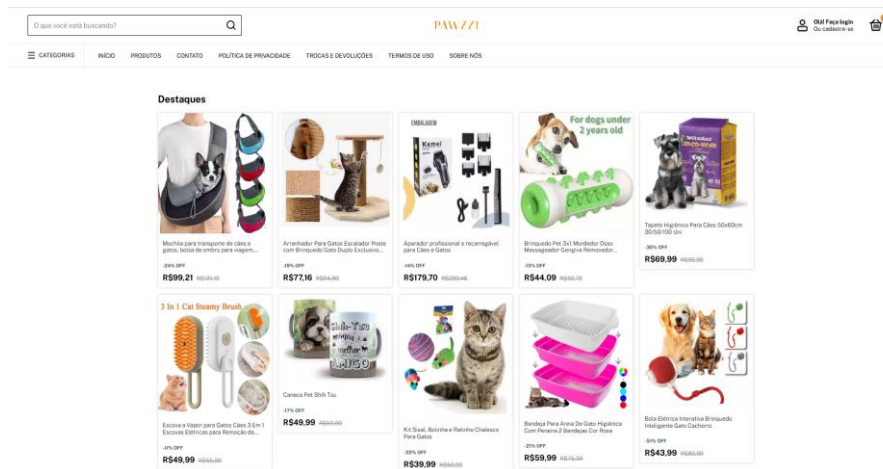
In Figure 5, the focus shifts to quality, promoting "the best products on the market," a reinforcement of online sales management.

The presence of testimonials just below the banner demonstrates the focus on "Customer Relationship Management" (CRM), building social proof of engagement with the Pawzzi online store.

Figure 6 shows a screen displaying the product showcase, essential for the purchasing journey. The "Featured" section presents a wide variety of dog and cat items from various partner suppliers, showcasing the vast offerings available through the dropshipping model.

Figure 6

Pawzzi E-Commerce - Featured Products in the Online Store



Source: Prepared by Juan Boente (2025).

Each product is listed with a clear image, name, original price, and promotional discount, utilizing scarcity triggers and opportunities to encourage immediate purchase.

Figure 7 shows the product detail page, the most important point for closing a sale. In figure, a specific product (Teething Toy), displaying multiple images, color variants, price with a highlighted discount, and payment options (including a 5% discount via Pix, encouraging cash payment as a marketing strategy). The shipping calculation field by zip code informs the customer of the delivery time (managed by the dropshipping supplier), ensuring transparency in the logistics distribution process.

Recognizing that most e-commerce traffic is currently mobile, and that many online store users use mobile apps, Pawzzi was designed with the Mobile-First principle in mind, ensuring a seamless and complete smartphone experience.

According to Lopes (2014), Mobile-First is a concept applied to web projects where the initial focus of architecture and development is directed to mobile devices and then to desktops. This technique has become increasingly popular among marketing and technology professionals, and for this reason, it was also adopted in this project.

Figure 7

Pawzzi E-Commerce - Details of Products for Sale in the Online Store



Source: Prepared by Juan Boente (2025).

In Figure 8, as in the desktop version, the mobile home screen is dominated by promotional banners ("Free Shipping" and "Best Products on the Market"), adapted to the vertical format specific to mobile devices. The design is clean, with the "hamburger menu" (three bars) in the upper left corner and the user, search, and cart icons in the upper right corner, keeping usability in mind.

In Figure 9, the visualization focuses on the vertically optimized product listing. Items (such as the "Cold Cooling Mat" and the "3x1 Pet Chew Toy") are arranged in columns that are easy to view and click to access. The presence of "Sort" and "Filter" buttons at the top of the listing is crucial for mobile navigation, allowing the customer to efficiently manage the vast catalog.

Figure 10 shows a product details page for the mobile version that focuses on the clarity of the image and essential information for the sale to take place.

In figure 10 the product image ("Sisal, Ball, and Chalesco Mouse Kit for Cats") takes up a large portion of the screen to generate visual impact on the customer, followed immediately by the product name, the discount highlight, and breadcrumbs (navigation path), which facilitate return to the category.

Figure 8

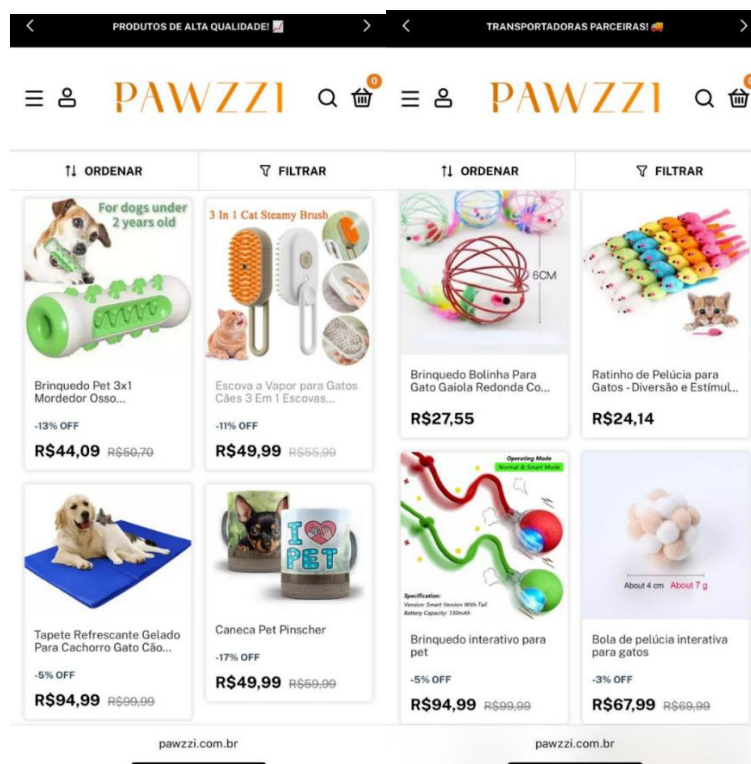
Pawzzi E-Commerce - Mobile Rotating Banner



Source: Prepared by Juan Boente (2025).

Figure 9

Pawzzi E-Commerce - Mobile Featured Products



Source: Prepared by Juan Boente (2025).

This layout optimization aims to reduce friction and accelerate the decision-making and purchasing process for customers browsing the online store via mobile devices.

Figure 10

Pawzzi E-Commerce - Mobile Product Details for Sale



Source: Prepared by Juan Boente (2025).

The integration between the desktop and mobile versions ensures that Pawzzi, operating in dropshipping, effectively utilizes the "Channels" and "Key Activities" described in the Business Model Canvas, reaching customers at any digital touchpoint with the Pawzzi online store.

6 CONCLUSION

This study demonstrated that Digital Entrepreneurship, supported by Digital Marketing strategies and the E-Commerce environment, is a crucial driver for business innovation and growth in the contemporary economy. Through the case of the Pawzzi virtual store, it was possible to verify that the dropshipping model offers significant advantages for microentrepreneurs, such as operational cost reduction, logistical flexibility, and scalability of the business structure.

The development of the Business Model Canvas allowed the visualization of strategic pillars, such as value proposition, key partners, and customer relationships, that sustain the success of a digital enterprise. Furthermore, the integration of mobile-first design principles and user experience optimization proved essential to ensure consumer satisfaction and strengthen brand trust.

Therefore, the research concludes that digital entrepreneurship, when combined with well-structured digital marketing and e-commerce practices, consolidates itself as an efficient path for economic inclusion, technological advancement, and business sustainability in a globally connected and competitive environment. Future studies could explore the impacts of artificial intelligence and data analytics on the evolution of digital business models, expanding the understanding of innovation within the context of digital transformation.

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MUSIC THERAPY, IMPROVISATION AND LISTENING: A STUDY ON CREATIVE PRACTICES CENTERED ON SOUND

MUSICOTERAPIA, IMPROVISACÃO E ESCUTA: UM ESTUDO SOBRE PRÁTICAS CRIATIVAS CENTRADAS NO SOM

MUSICOTERAPIA, IMPROVISACIÓN Y ESCUCHA: UN ESTUDIO SOBRE PRÁCTICAS CREATIVAS CENTRADAS EN EL SONIDO

 <https://doi.org/10.56238/sevened2025.036-024>

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RESUMO

Este artigo apresenta reflexões e resultados de uma pesquisa conduzida com o Coletivo Sonus, grupo composto por seis musicoterapeutas que, ao longo de 2024, reuniram-se mensalmente para realizar práticas de improvisação musical livre seguidas de debates reflexivos. Teoricamente fundamentado na orientação musicocentrada, em autores como Nordoff e Robbins (1977), Zuckerkandl (1973) e Rudolf Steiner (2012), o estudo articula os conceito de experiência (Bondía, 2022) e de criatividade musical (Schafer, 2011). O estudo investigou as percepções e transformações subjetivas dos participantes ao vivenciarem a improvisação como fenômeno relacional e terapêutico. Os dados foram coletados por meio de gravações e transcrições das discussões realizadas em grupo focal, e analisados segundo a técnica de análise de conteúdo (Bardin, 2011). A análise revelou quatro categorias temáticas centrais: (a) senso de liberdade criativa; (b) superação lúdica do erro; (c) audição acurada; e (d) consciência sobre si. Os resultados apontam para a expansão da compreensão musical dos participantes, para a superação de paradigmas estéticos hegemônicos e para o fortalecimento dos processos terapêuticos mediados pelo som através da improvisação. A prática improvisacional revelou-se espaço privilegiado para a realização de experiências significativas, nas quais escuta, criação e subjetividade se entrelaçam, contribuindo para o aprofundamento clínico e formativo em musicoterapia.

Palavras-chave: Musicoterapia. Improvisação Musical. Orientação Musicocentrada.

ABSTRACT

This article presents reflections and findings from a qualitative study conducted with Coletivo Sonus, a group of six music therapists who met monthly throughout 2024 to engage in free musical improvisation sessions followed by reflective discussions. The study is theoretically grounded in a music-centered orientation, drawing on the work of Nordoff and Robbins (1977), Zuckerkandl (1973), and Rudolf Steiner (2012). It integrates the concepts of experience (Bondía, 2022) and musical creativity (Schafer, 2011) to examine improvisation as a relational and therapeutic phenomenon. Data were collected through recordings and

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transcriptions of focus group discussions and analyzed using content analysis (Bardin, 2011). The analysis yielded four central thematic categories: (a) a sense of creative freedom; (b) playful overcoming of error; (c) refined listening; and (d) heightened self-awareness. The results indicate an expansion of participants' musical understanding, a challenging of hegemonic aesthetic paradigms, and a strengthening of therapeutic processes mediated through sound and improvisation. Improvisational practice emerged as a privileged space for meaningful experiences, where listening, creation, and subjectivity intertwine, contributing to both clinical deepening and professional training in music therapy.

Keywords: Music Therapy. Musical Improvisation. Music-Centered Orientation.

RESUMÉN

Este artículo presenta reflexiones y resultados de un estudio realizado con el Colectivo Sonus, un grupo de seis musicoterapeutas que, a lo largo de 2024, se reunieron mensualmente para practicar improvisación musical libre, seguida de debates reflexivos. Con fundamento teórico en enfoques centrados en la música, desarrollados por autores como Nordoff y Robbins (1977), Zuckerkandl (1973) y Rudolf Steiner (2012), el estudio articula los conceptos de experiencia (Bondía, 2022) y creatividad musical (Schafer, 2011). El estudio investigó las percepciones y transformaciones subjetivas de los participantes a medida que experimentaban la improvisación como un fenómeno relacional y terapéutico. Los datos se recopilaban mediante grabaciones y transcripciones de debates de grupos focales y se analizaron mediante análisis de contenido (Bardin, 2011). El análisis reveló cuatro categorías temáticas centrales: (a) sensación de libertad creativa; (b) superación lúdica de errores; (c) escucha precisa; y (d) autoconciencia. Los resultados indican una ampliación de la comprensión musical de los participantes, la superación de paradigmas estéticos hegemónicos y el fortalecimiento de los procesos terapéuticos sonoros a través de la improvisación. La práctica improvisatoria resultó ser un espacio privilegiado para experiencias significativas, donde se entrelazan la escucha, la creación y la subjetividad, contribuyendo a la profundización del desarrollo clínico y educativo en musicoterapia.

Palabras clave: Musicoterapia. Improvisación Musical. Consejería Centrada en la Música.

1 INTRODUCTION

"Music is able to allow access to depths where spirit and nature are still one again."
(Emma Jung).

The present work presents reflections on sound possibilities built from free musical improvisation sessions, undertaken by a group of music therapists gathered in the Sonus Collective. This group arose from the participants' interest in undertaking creative and reflective paths, from which they sought to work with musical creation, through improvisations, with a view to therapeutic work, envisioning possible contributions of the so-called Musicocentric orientation to their clinical and personal initiatives.

From the aforementioned practices of musical improvisation, carried out from the perspective of the centrality in the therapeutic power immanent to the sound phenomenon, the Sonus Collective began, as an increment of its work, theoretical studies that, initially, focused on the work of Victor Zuckerkandl (1973), whose reading was articulated with the lectures of Rudolf Steiner (1989) on the deep human experience with sound⁴

For Sales and Freire (2024), Brazilian researchers who are dedicated to the theme of the centrality of the musical phenomenon in the music therapy context, the term "Musicocentrado" has been present in the field of Music Therapy since the eighties, of the twentieth century.

"The term *Music-Centered* appeared publicly for the first time, in the 1980s, in the name of the institute founded by music therapists Barbara Hesser, Helen Bonny and Carolyn Kenny, the "Bonny Foundation: Institute for Musicocentric Therapies" (SALES and FREIRE, 2024, pg. 02)

It is important to emphasize that, in this work, we use the expression "Musicocentric Orientation" as an allusion to a theoretical and philosophical foundation, which sustains several therapeutic initiatives or Music Therapy models, among which we highlight the Guided Image Method, proposed by Helen Bonny, and the Creative Music Therapy of Paul Nordoff and Clive Robbins. Such models seek to value the subjective musical senses of patients in therapeutic processes.

In Brazil, a proposal for a Music-centered model has recently emerged from the Institute of Creativity and Development based in the city of Porto Alegre, Rio Grande do Sul. This proposal was prepared by Music Therapist André Brandalise, and is called

⁴ Das Wesen des Musikalischen und das Tonerlebnis im Menschen (Rudolf Steiner Verlag - Dornach/Schweiz)

"Musicocentric Music Therapy Model", resulting from a study process started in 2001 and which has as a milestone the publication of the work "Musicoterapia Músico-Centrada", authored by Brandalise. The elaboration of the aforementioned Music Therapy Model also receives important contributions from names such as Gregório Queiroz and Marina Silva and is configured as the first Brazilian initiative to propose a model for the clinic in Music Therapy.

Among the various strategies that can be used in a process of treatment with music, musical improvisation occupies a prominent place in the clinic, in such a way that in Musicocentric Orientation Music Therapy, improvisations contemplate their own musical aspects, obtained from the relationship of the human being with his musicality. Expressive gestures are observed through musical manifestation, through improvisations in which the patient can express his creativity and spontaneity, correlating the internal representative experience of each one.

Musical improvisations or recreations, structured in a Music Therapy setting, allow the patient to relive, update and resignify situations and emotions, explore and express unspeakable feelings, in addition to reflecting on the 'meaning of life' (Petersen, 2021). From the musical dialogue, typical of a relationship built by creative elements loaded with symbolic meanings that constitutes improvisation, valuable meanings are revealed for the therapeutic process itself, which acquires an experiential character.

The concept of representative, or meaningful, experience is of great importance for the debate on Musicocentric Orientation and for this reason we will discuss this concept below.

2 SONICALLY CENTERED EXPERIENCE

Jorge Larrosa Bondía is a philosopher dedicated to the studies of the educational field and who, above all, is dedicated to the theme of experience. For the aforementioned author, experience is the phenomenon that occurs to the subject, moving and/or moving him, so that he can perceive himself, in his immersion in the unique process that occurs to him, that is, in the very unfolding of the experience.

Experience, the possibility that something happens to us or touches us, requires a gesture of interruption, a gesture that is almost impossible these days: it requires stopping to think, stopping to look, stopping to listen, thinking more slowly, looking more slowly, and listening more slowly; to stop to feel, to feel more slowly, to linger on details, to suspend opinion, to suspend judgment, to suspend will, to suspend the automatism of action, to cultivate attention and delicacy, to open our eyes and ears,

to talk about what happens to us, to learn slowness, to listen to others, to cultivate the art of encounter, to be very silent, to be patient and to give oneself time and space. (Bondia, 2022, p. 25).

We understand, therefore, that the phenomenon of experience is a complex phenomenon which requires an attitude, a care, on the part of the subjects who seek to experience something in order to, in some way, achieve valuable effects for their own lives and for the lives of others.

In order to move towards the complexity of music as a phenomenon of experience, we believe it is also pertinent to evoke what Rudolf Steiner says about the sense of hearing, which, according to his approach, Anthroposophy, is one of the four "higher senses". For Steiner (2012), the sense of hearing is on a different, higher level than the other senses, since through it it becomes possible to perceive the interiority of what is external to us. Steiner explains the experience of hearing in the following terms:

We relate even more intimately to the interior of the external world through the sense of hearing. Sound already reveals to us a lot of things about the internal configuration of the outside (...) when I make something sound, I perceive, in a way, intimately the interior of what is sounding (Steiner, 2012, p.13).

For Steiner, therefore, hearing is on the same level as the "sense of the other's self", which in our culture is called empathy, and which is the ability to get closer to what the other feels. Hearing and the sense of the self of the other are higher senses alongside the sense of self and the sense of thought.

Zuckerlandl (1973) points to an important characteristic present in the relationship of people in the West with the sound phenomenon: "when we think of music as art, we isolate it from the world of everyday reality; when we consider it as the art of sounds, we isolate it from the other arts." (p. 12). In his reflections, therefore, the author poses the problem arising from the distancing of music from everyday reality, since it is placed as "art", such a form of human expression moves away from the rituals that primarily constituted its presence in social life.

Blacking (2000) clarifies in a pertinent way the relevance of music in everyday life, even indicating that the social fabric itself is determinant for the elaboration of sound:

We will not be able to explain the principles of a composition or the effects of music until we are able to understand well the relationships between musical experience and

human experience itself (...) I have come to understand the society in which I live better from the moment I have better understood the music in it (Blacking, 2000, p.35).

In this way, it seems to us that the isolation of music as a consumer product leads us to perceive only partially its importance in the constitution of the societies in which we live, making the sound experience not deeply linked with the human experience, since the consumption of musical products gives rise to superficial relations, of a market nature.

For Nachmanovith (2012) *apud* Woituski *et al* (2017), improvisation is a game, which is related to playing, used from our experiences and objects that we love to express ourselves in a free, creative and fun way. In music, the act of improvising enables the encounter with musicality in a communicative function, that is, it is the attempt to take risks, to enter an unknown field, placing oneself in front of any obstacle, with expressive and creative intent.

Considering, therefore, that music has a strong presence in social life and, also, glimpsing that such presence can interfere in the perception that each individual has of himself and his creative potentialities, we launch ourselves into this reflection in search of sound experiences, communally realized, in order to reflect on the possibilities that the act of creating music spontaneously, that is, improvising can bring to the way people take ownership of themselves and become aware of the reality in which they are inserted. The present study will certainly present possibilities or reflexive reverberations for the scope of clinical practice in Music Therapy.

3 METHODOLOGY

The present work employs a qualitative approach to investigate the perceptions of the participants of the Sonus Collective, in moments of free improvisation musical practices, in which the expressive needs of the group members were manifested through collective musical interventions. This group was formed in the first half of 2024 and had the participation of 06 music therapists who, monthly, met to perform a moment of free musical improvisation, followed by debate.

In addition to the meetings for the practice of improvisation, the *Sonus* Collective also held theoretical study meetings which take place in an *online* format. Since the researchers were also members of the aforementioned group (*Coletivo Sonus*), the present reflection is part of the list of what is understood as an experience report, which "situates the knowledge resulting from a process; in other words, it can be considered in an intersection of processes, from the collectivized to the most singular" (Daltro and Faria, 2019, p.226). The main focus

of the research process is the narratives elaborated throughout the process by the participants of the investigated group.

It is important to emphasize that the present study investigates how the members of the Collective *Sonus* perceived and reflected on the practices of free improvisation and that the focus of this research lies in the reflexive narratives elaborated after the moments of improvisation, in the The needs for individual expression are manifested through collectively shared musical interventions. Here the study is inserted in the field of narratives.

We point out that this investigative work effort comprises, as Lüdke and André point out, that the research:

[...] it inevitably brings with it the load of values, preferences, interest and principles that guide the researcher. [...] Thus, the vision of the world, the starting points, the foundations for understanding and explaining this world will influence the way he proposes his research or, in other words, the assumptions that guide his thinking will also guide his research approach. (2020, p.03)

Thus, we sought to collect impressions, perceptions and reflections from the participants of *the Sonus* Collective, which, throughout the year 2024 (from May to December), followed a path made up of shared sound experiences, through which it was sought to establish connections with the theoretical studies carried out by the aforementioned group on one of the main theoretical bases related to the Musicocentric orientation, the work *Sound and Symbol*, by Victor Zuckerkandl (1973).

The research methodology adopted here seeks to value the voice of the subjects of the musical experience, as we understand that each individual has an internal "researcher" who advances when learning in environments of reflective interactions, because, as Josso points out: "it is a question, first of all, of admitting that there is a researcher in each one of us and that this researcher only advances to the extent that he is able to learn himself, thanks to or in spite of interactions with others." (Josso, 2004, p. 166).

Although the present study does not delve into the individual histories of the participants, it seeks to use their reflections from the group musical practice experienced in the *Sonus* Collective, to build a reflective narrative about the therapeutic possibilities of improvisation work, which took place over eight creative and reflective meetings of the aforementioned group, consisting of six participants, during the year 2024.

The research is configured, therefore, as an exploratory study of a qualitative nature, using the moments of debate that occurred after all the moments of improvisation of the

Sonus Collective, for data collection, in such a way that in the moments of exchanges and discussions, the group began to function as a focus group that, in the definition Backes, Colomé, Herdmann and Lunardi, is constituted as:

[...] a space for discussion and exchange of experiences around a certain theme. In addition, the group stimulates debate among participants, allowing the topics addressed to be more problematized than in an individual interview situation. Participants generally listen to the opinions of others before forming their own, and they constantly change their position, or better substantiate their initial opinion, when engaged in group discussion. (2011, p. 439).

Data collection, according to Gil (2009), recognizes the involvement of researchers in the investigation process and in the consequent organization of perceptions emerging from the debates and, thus, is also aligned with the aforementioned perspective of Lüdke and André (2020) who postulate the understanding that research, as a human and social activity, is influenced by values, preferences and principles of the researchers, and there is no neutral separation between these agents, the research and its results.

For the operationalization of the research work and study of the collected data, all the moments of debate of the Sonus Collective, which occurred after the moments of musical improvisation, were recorded and later transcribed, in order to constitute the *corpus* of the present study.

As pointed out, the moments of reflective exchanges (focus group) always occurred after the sound experiences, which were conducted by the members of the group, who took turns to direct the musical work on the occasion of each improvisation meeting. Therefore, a relay strategy was practiced, which allowed all participants to assume, at least once, the conduction of musical improvisation experiences. The reflective occasions, for group discussion, lasted an average of thirty to forty minutes.

The ideas and impressions expressed by the participants, freely expressed, were transcribed and organized into thematic categories according to the meanings that emerged from the speeches of the members of the Sonus Collective. We seek theoretical-methodological support in content analysis techniques, as recommended by Laurence Bardin (2011). Thus, analyzing the senses and meanings of the statements brought by each of the subjects participating in this investigation was the essential procedure for carrying out this work.

We point out, as pertinent, that Bardin indicates that: "content analysis, on the other hand, aims at the knowledge of variables of a psychological, sociological, historical order, etc., by means of a deduction mechanism based on indicators reconstructed from a sample of particular messages." (BARDIN, 2011, p. 50).

Finally, we reiterate that the present research adopted a mostly qualitative approach to understand the perceptions arising from the experiences with free improvisation practices, carried out by the members of the Sonus Collective. Data collection, therefore, took place through debates in a focus group constituted by Music Therapists who are members of the *Sonus* Collective, whose speeches were analyzed using content analysis techniques.

The theoretical bases of this study include, therefore, the articulation between different investigative conceptions: research and training (Josso, 2004); the value of shared experience (Larrosa, 2022); the non-neutrality of the researcher (Lüdke and André, 2020) and Content Analysis (Bardin, 2011).

Considering the methodological approach defined for the present study, we organized the contents of the discourses and speeches that were presented in the moments of discussion that followed the improvisation meetings. The aforementioned work of systematizing the contents led us to identify four thematic categories that permeated or guided the interventions of each participant: a) sense of creative freedom; b) playful overcoming of error; c) accurate hearing and self-awareness.

4 RESULTS AND DISCUSSION

Considering the content analysis strategy defined for the present study, focusing on the manifestations of each participant in the moments of discussion in the focus group, it was possible to perceive the first thematic category translating into the participants' statements. The **sense of creative freedom** was present in the narrative interventions, in the moments in which each member of the group pointed to the awareness of their own musical practice, and to the understanding of this work built from improvisations, whether alone or together. The statements that referred to the awareness of musical practice added that in moments of improvisation there was the possibility of creating and that the creative act was the driving force of music.

As a result of the sound realization made possible by creativity, the participants mentioned that they felt welcomed by the musical making itself, which allowed them freedom to include unusual musical constructions, which revealed themselves as creative possibilities.

Such sound expressions brought unusual musical coherence, in such a way that the dualistic notion of correct and incorrect sound was transcended. Thus, the notion of playful overcoming of error emerged as a second category of analysis of narratives. In this way, it is considered that through the experienced musical making, there is no condition of "wrong note", but possibilities of expressive paths through which the music runs, through a playful sense.

At the same time that the participants felt free to dare sonically through improvisation, it was possible to verify an attentive perception of the sound aspects, which invited everyone to reflect on the practice together, so that each participant had the possibility to ponder on their own musical manifestation, in relation to the other sonorities that were part of the improvisation moment. Thus, the notion of **accurate listening** arose from the observation that each participant was available, in an attitude of active listening, which was sharpened throughout the improvisation practices and was constituted as the third category of analysis of the speech contents presented.

From the first meetings, all participants alluded to somatic reactions that, in their perception, were a result of the musical practice itself. We found in the reports moments in which the perception of the participants' image and body schema was mentioned and alluded to positive changes, establishing the fourth category here called **self-awareness**. Mood swings, or even overcoming physical fatigue, were part of such narratives.

According to the answers obtained from each participant, we observed that there was a balance in the statements referring to each thematic category, because of the total transcribed material, 14 statements referred to the **sense of creative freedom**; 9 brought the idea of **playful overcoming of error**; 15 were linked to the idea of **accurate hearing** and 14 brought the notion of self-awareness, totaling 52 transcribed speeches.

To present some reflections elaborated by the members of the Sonus Collective, in the present work and in order to guarantee the anonymity of its members, we will use an alphanumeric coding, differentiating each participant (P) through an Arabic number. The code "P1" therefore refers to participant number 1 and so on.

We will present the results by initially bringing some answers concerning the category **sense of creative freedom**. In this category, participant 2 (P2) presents the following statement:

I tried not to rationalize about what I was doing and tried to let it flow. I found myself producing sounds like that, which even I was surprised to do. But it's cool because it

seems that even if you release a sound, it always seems to have its value within the whole (P2, on 05/18/2024)

The speech transcribed above dialogues with an intervention by P6 that evokes the issue of freedom, bringing the concept of *Music Child*, which is fundamental in the work of Nordoff-Robbins' Creative Music Therapy (1977). The aforementioned terminology, musical child, points to the understanding that sound creativity, that is, musicality, is an innate manifestation of each being, as a way of responding to musical sound stimuli, as a manifestation of a universal sensitivity to music and its elements (SALES and FREIRE, 2024). Thus, participant P6 expressed himself:

There is a moment in our lives when we are playing, doing something sonically, that we feel a course of freedom (...) and this expression is what for me is this entity, this *music child* that they talk about, which is the freest and most spontaneous way for you to express yourself (P6, on 06/22/2024)

A connection of meaning between the participant's speech, transcribed above, and what participant 5 (P5) says: "it had been a long time since I felt this sensation of a certain freedom and happiness, man, joy, ecstasy of touching", Such manifestations are also connected with what participant 2 (P2) expressed: "Not only reproduce but also develop, create, build, change, expand, whatever the verb of action is, but the idea is always that, and it's very cool" (08/24/24).

This connection with the making of music, experienced from a feeling of freedom, puts the group in tune with aspects of each participant's musicality, so that a possibility of experiencing basic aspects of each individual's musical expression is built and that establishes a sound sense that is inherent to the group itself, as explained by participant 2's manifestation (P2), "We start to create patterns of encounter, no matter how loose it was, the thing organizes itself, without anyone deciding anything" (09/14/24).

Participant P1 presents ideas that reinforce what we have presented so far about the sense of creative freedom, which develops through the musicality of each one, manifested in improvisation, by the group:

You enjoy not the break in isolation, because there were already six people, but what the Germans call *Cluster*, you know, which is that sound block, that mass of sound, which is simply the result of the most sincere manifestation that each one of us can bring at that moment (P1 on 05/18/24).

With regard to the **playful overcoming of error**, another category evidenced by the participants' statements, we verified during some discussions, the occurrence of narratives that pointed to possibilities of sound realization and that allowed space for unusual interventions. P4, takes the following position on such possibilities:

... At first I was very stuck in my thinking, tense, I wasn't relaxed to make sounds, and I was just on that same note, right? very tense. Over time I relaxed, then I loosened up more and made several sounds, I realized that sometimes my sound was influenced by your sound, and I became more relaxed (P4 on 05/18/24).

Another participant, reinforcing P4's statement, points to the possible interdictions of the creative sense when the performer is too concerned with making the sound considered correct:

Sometimes we are so concerned with hitting the right note, that this concern with hitting the right note does not allow us to let the music be spontaneous, that it happens. It anchors, in the sense of arresting one's own creative action (P1 on 10/20/24)

In general, if we consider some common sense beliefs, it is believed that music presents "right" and "wrong" paths, so that the choices of the performer, which interfere with the musical structure at the time of improvisation, impose behaviors that are based on these beliefs and that can hinder spontaneity and creativity in moments of sound immersion. As mentioned in P2:

I tried to get away from all forms of the pattern. And so, it was interesting because you kept it and I tried to go the opposite, but it's so difficult, it's so difficult, so I tried to structure rhythmic patterns that dialogued, but didn't collaborate with this pulse, right? Get out of line. I found it very challenging (P2 on 09/14/24).

The same participant (P2), in another statement, points to the overcoming of the dual belief between "right" and "wrong", when he says that: "there is no right and wrong, at that moment any sound will do a specific function to contribute to this dynamic sound relationship" (P2 on 05/18/24).

It is important to observe the convergence of the statements that point to the overcoming of the concepts of "right" and "wrong" with the reflections of Zuckerkandl (1973) who presents, in his theory, the concept of "dynamic relationship of notes". The aforementioned author expresses his ideas by saying that a note, at the end of a melody, is

a note that becomes active, we hear a state of disturbance of balance, like a desire of itself to meet each other notes.

The statement of participant 3 (P3) seems to allude to an internal state of conflict that the need to "get it right" in music can provoke:

"There were times like this, that thing of panic that you bring, this thing of self-demand. And I'm at a moment now that this is coming, right? something of intimacy (...) but it was something new for me, improvising. And I didn't think because I knew how to play a little flute, I could improvise, that I was nervous" (P3 on 06/22/24).

As it is a group of Music Therapists with academic training in Music, the awareness of the sound relationships established during the improvisations emerged in the speeches in a very significant way. In this sense, a **sense of accurate hearing** is presented in the transcribed interventions. Such a sense, however, does not reveal a desire to adapt the sound produced in improvisations to pre-established sound patterns, but presents an expansion of the conception of music by the members of the Sonus Collective. P2 put himself in the following terms: "the sounds, they attracted each other, I was able to see a little of it (...) " simply the conjuncture of the sounds there: they attracted each other and formed that" (P2 on 06/22/24)

P5's statement is important with regard to this third thematic category, when he points to a search for the other through hearing: "the dialogue, it went to another level where we were able to listen to each other (...) From what I heard from you with a note, I was able to create my impression of that note you made." (P5 on 10/20/24).

This sense of accurate hearing is connected with Rudolf Steiner's postulate about the sense of hearing. The aforementioned author puts it as follows: "when I make something sound, I perceive, in a certain way, intimately, the interior of what is sounding (...) in sound we actually perceive the interior of the external world" (Steiner, 2012, p.13).

According to participant P1, "when we are in a sound perspective that does not have this commitment, for example, there is no defined scale, right? It is always the commitment we have in fact, which is perhaps the most difficult: to let it happen sonically" (P1. 18/05/24).

These ideas express an expanded conception of music itself that, despite the participants having formative links with undergraduate courses in music, transcend the still hegemonic experience, established by tonalism. Also according to participant P1:

It's as if we were talking through this (...) talking through this sound image, that we suddenly realize that it is being constituted there at that moment, it will only exist there, and that it is the heritage of that group, at that moment, and that because it belongs to the group, it also needs to be heard by the whole group (P1. 05/18/24).

Schaffer (2011), referring to an improvisation experience with 5 wind instrumentalists, observes that the analogy between spoken conversation and improvisation in music proves to be a coherent means for the engagement of the performers, which interferes with the fluency during the improvisation game. In this sense, the real value of an experience serves both for the latent development of improvisation and for the exercise of auditory perception.

The notion of **self-awareness** came to the fore as we found manifestations of the participants alluding to mood swings or even physical state, which occurred as a result of improvisation practices. In the very first improvisation meeting, P2 expressed himself as follows:

This state of relaxation is interesting, isn't it? I'm also feeling some pain, exercise pains. But at that moment there, I was standing, and my legs and knees are very locked. But at that moment I wasn't feeling it, it's as if I was just floating, there in the sound (P2 on 05/18/24).

According to P3's speech, still about the expression of tiredness, it is noticeable how the music transposes such an organic condition: "I also feel like this, sometimes a tiredness from work. Today I came very tired from university, (...) but it's another energy, I was able to connect and it was very cool" (P3 on 11/09/24).

In the same direction, in the next meeting, P4 referred to the relief of physical pain related to an anxiety condition he felt at the beginning of the improvisation: "I felt very calm, I was fine, I was a little anxious, you know. Headache and... so, it was only when we started playing that I calmed down more" (P4 on 06/22/24)

In her work on the Guided Imagery Method (GIM) by Helen Bonny, Liesert (2017) presents a reflection that links music and feeling:

(...) Music offers a framework for emotions. This means that music does not inherently "possess" a specific emotional quality. Instead, music provides a framework within which the client can find certain emotional qualities (p.138).

For Helen Bonny, "The affective customer experience must be supported by music, embodying the humanistic concept of the maximum experience". The author has established

six effects that the musical experience can trigger. Among these effects, we highlight the possibility that music, according to Bonny, "promotes positive, oceanic and religious-type experiences, which can have transformative properties for the individual." (Bonny apud Liesert 2017, p. 152).

In this sense, the manifestation of participant P6 is quite pertinent: "intuition is something like this, which seems to speak of our reality, at the same time that it brings memories. (...) it responds to something that is mine, it allows me this state of presence of myself" (P6 on 07.20.24)

The material collected in the discussions that took place after the moments of improvisation, brought very expressive and valuable speeches for the present reflection. The abundant material collected and discussed here allowed us to find connections between the philosophical postulates of Musicocentric Orientation Music Therapy in the face of the creative practices undertaken by the *Sonus Collective*.

5 CONCLUSION

According to the manifestations of the participants of the *Sonus Collective*, the improvisation practices carried out by the group dialogue with the theories of Zuckerkandl, who alludes to the power of attraction of notes, based on the impetus of sensitivity of each performer in contact with music, in a terrain in which there are no pre-defined aesthetic beacons. Such a context calls on the participants to follow the forces of attraction that are proposed by the sound exercise itself, which is carried out based on the creative listening of the musical phenomenon, at the moment it occurs.

The statements collected and analyzed in the present work also point to valuable perceptions that touch an expanded understanding of musical practice and that interfere in the perception that the individual has of his own creative capacities, which, in the musical exercise, contribute to the perception of the subject himself about himself, about his peers and about the reality that welcomes and also conditions them.

The analysis work carried out here also points to the importance of overcoming beliefs about what music is, so that the notion of "right" and "wrong" is seen from a critical perspective, free from predefined aesthetic ties, more linked to therapeutic effects than to artistic aspects that in everyday life can restrict the very notion of music.

From the perspective of the expansion of sound consciousness, of a critical reflection on the ties that the cultural industry imposes on individuals, this reflection becomes valuable

and reveals musical potentials that, in the context of improvisation carried out by the Sonus Collective, have left their state of latency and become sonically manifest contents.

The participants' speeches reveal, in many moments, the pleasure of discovering sound as a relational phenomenon in which the individual summons his creative potential, placing it in dialogue with the creative manifestations of his peers. Such moments are sustained by the ability to listen to oneself and others during the sound explosions provided by the freedom of the act of improvising. A broader sense of listening, which brings together sonically manifested subjectivities, connects with therapeutic conceptions that are based on listening as a path of encounter and dialogue.

The thematic categories from which we organized the analysis of the data indicate, initially, perceptions of a personal nature, however, such findings point to the confluence of subjective senses that dialogue through the unusual and ephemeral music, which dissolves sonically at the end of the improvisation, but which remains as a deep vivid experience, lived by each improvising member.

Each subject reinvents himself in the act of free musical creation. Without ties, or attachments to aesthetic paradigms, but giving wings to sound creation. Unusual possibilities are revealed and strengthen improvising individuals. In a playful way, the notion of error is overcome to give way to a renewed perception of oneself and of others, a perception that, based on accurate listening, evokes a liberating sense of music itself that was imprisoned in cultural moorings.

Music therapy strategies and approaches in our reality still derive from musicological knowledge and, in some cases, it is difficult to establish the boundaries between Music Therapy, Music Education and artistic performance. The work of the members of the Sonus Collective, carried out from the desire to deepen the Musicocentric orientation, reveals a greater breadth with regard to the practice of improvisation. Such a practice is, in the field of musical training, seen as something advanced and, for this very reason, reserved for experienced musicians.

In the case of Coletivo *Sonus*, the sense of improvisation is detached from musical aesthetic expectations and through the sound practices shared in the group's meetings, a broader understanding of music and its therapeutic effects can be observed. The participants reveal in their statements a high level of satisfaction with the experiences they lived, while linking these moments to the theories studied. This indicates that there was an expansion of

the understanding of Musicocentric Orientation Music Therapy from the articulation of theory with the improvisational practice undertaken by the group.

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**JUST ENERGY TRANSITION IN THE AMAZON: ECONOMIC AND
SUSTAINABLE ANALYSIS OF ALTERNATIVE ENERGY SOURCES FOR
RIVERSIDE COMMUNITIES**

**TRANSIÇÃO ENERGÉTICA JUSTA NA AMAZÔNIA: ANÁLISE ECONÔMICA E
SUSTENTÁVEL DE FONTES ALTERNATIVAS PARA COMUNIDADES
RIBEIRINHAS**

**TRANSICIÓN ENERGÉTICA JUSTA EN LA AMAZONÍA: ANÁLISIS
ECONÓMICO Y SOSTENIBLE DE FUENTES ALTERNATIVAS PARA
COMUNIDADES RIBEREÑAS**

 <https://doi.org/10.56238/sevened2025.036-025>

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ABSTRACT

Access to safe and sustainable electrical energy is an essential element for socio-economic development, particularly in remote regions of the Brazilian Amazon. This paper carries out a comparative cost-benefit analysis of three electrification alternatives: off-grid photovoltaic systems, diesel generators, and informal network, based on a case study in the riverside community of Nazaré, Abaetetuba-PA. Employing tools from economic engineering and sustainability metrics, the study evaluates implementation, operational, and maintenance costs, as well as nets present value, cost per kWh generated, and environmental impact. The findings indicate that, although requiring higher initial investments, off-grid photovoltaic systems demonstrate greater economic efficiency in the long term and have a lower socio-environmental impact. This makes them a viable solution for low-income communities, highlighting the potential of solar energy as a strategic approach to energy inclusion. The study supports efforts to reduce inequalities and promote a just energy transition, aligning with Sustainable Development Goals (SDGs 7, 10, and 13).

Keywords: Sustainability. Solar Energy. Energy Access. Riverside Communities. Economic Analysis.

RESUMO

O acesso à energia elétrica de forma segura e sustentável é um elemento essencial para o desenvolvimento socioeconômico, especialmente em regiões remotas da Amazônia brasileira. Este estudo realiza uma análise comparativa do custo-benefício de três fontes alternativas de eletrificação, sistemas fotovoltaicos off-grid, geradores a diesel e redes clandestinas, com base em um estudo de caso realizado na comunidade ribeirinha de

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Nazaré, no município de Abaetetuba-PA. Utilizando ferramentas da engenharia econômica e parâmetros de sustentabilidade, são avaliados os custos de implantação, operação e manutenção de cada sistema, além do valor presente líquido, custo do kWh gerado e impacto ambiental. Os resultados demonstram que, apesar do maior investimento inicial, os sistemas fotovoltaicos apresentam maior eficiência econômica a longo prazo e menor impacto socioambiental, tornando-se uma solução viável para comunidades de baixa renda. O estudo reforça o papel da energia solar como alternativa estratégica para a inclusão energética, contribuindo para a redução das desigualdades e para a promoção de uma transição energética justa, em consonância com os Objetivos de Desenvolvimento Sustentável (ODS 7, 10 e 13).

Palavras-chave: Sustentabilidade. Energia Solar. Inclusão Energética. Comunidades Ribeirinhas. Análise Econômica.

RESUMEN

El acceso a electricidad segura y sostenible es esencial para el desarrollo socioeconómico, especialmente en regiones remotas de la Amazonia brasileña. Este estudio realiza un análisis comparativo de costo-beneficio de tres fuentes alternativas de electrificación: sistemas fotovoltaicos aislados, generadores diésel y redes eléctricas ilegales. Este análisis se basa en un estudio de caso realizado en la comunidad ribereña de Nazaré, en el municipio de Abaetetuba, Pará. Utilizando herramientas de ingeniería económica y parámetros de sostenibilidad, se evalúan los costos de implementación, operación y mantenimiento de cada sistema, junto con su valor actual neto, costo por kWh generado e impacto ambiental. Los resultados demuestran que, a pesar de la mayor inversión inicial, los sistemas fotovoltaicos ofrecen mayor eficiencia económica a largo plazo y menor impacto socioambiental, lo que los convierte en una solución viable para comunidades de bajos ingresos. El estudio refuerza el papel de la energía solar como alternativa estratégica para la inclusión energética, contribuyendo a la reducción de las desigualdades y a la promoción de una transición energética justa, en línea con los Objetivos de Desarrollo Sostenible (ODS 7, 10 y 13).

Palabras clave: Sostenibilidad. Energía Solar. Inclusión Energética. Comunidades Ribereñas. Análisis Económico.

1 INTRODUCTION

Access to electricity is a fundamental pillar of sustainable development, directly impacting essential dimensions such as health, education, food security, and social mobility (FAISAL et al., 2024). Several studies point out that the availability of reliable energy is associated with poverty reduction, income generation, and the promotion of social inclusion (RAJABRATA et al., 2021); (ALEX et al., 2021). On the other hand, the absence or precariousness of this resource is a critical obstacle to economic progress, especially in developing countries (AIGHEYISI et al., 2020), where the challenge of energy poverty highlights deep territorial and social inequalities.

In Brazil, this scenario is particularly pronounced in the North and Northeast regions, which historically have the lowest rates of access and consumption of electricity (GALVÃO et al., 2020); (THIVES et al., 2022). The Amazon, although rich in biodiversity and natural resources, is home to thousands of communities excluded from the National Interconnected System (SIN), as is the case of approximately 400 thousand people who live on the banks of rivers in areas of difficult access, often also deprived of the full exercise of citizenship (COSTA and VILLALVA, 2020).

Although universalization programs such as "Luz para Todos" (Decree No. 7,520/2011) have promoted advances, efforts to expand conventional electricity infrastructure still do not include more remote communities (DA SILVA et al., 2024); (LEDUCHOWICZ-MUNICIO et al., 2024). In the municipality of Abaetetuba-PA, for example, islands such as Sirituba and Campopema received transmission lines, while others, such as Guajará and Nazaré, remain on the margins of public policies, facing logistical and economic barriers to conventional electrification (SEGURA-SALAS et al., 2022).

Faced with this scenario, excluded communities have resorted to alternative solutions, such as clandestine electricity networks, usually pulled from neighboring municipalities, and diesel generators (HENAO and GUZMAN, 2024). However, these options are marked by instability, voltage fluctuations, and frequent interruptions (POPA, 2022), compromising the safety and durability of household equipment and information systems, such as internet providers. In addition, the burning of fossil fuels aggravates environmental impacts and represents a setback compared to global goals for reducing greenhouse gas emissions (GANI, 2021).

The adoption of off-grid Photovoltaic Systems (off-grid SFV) emerges, in this context, as a promising and sustainable alternative, capable of meeting basic demands in a clean,

autonomous, and economically viable way in the medium and long term (HASSAN, 2021). Such solutions align with the principles of the just energy transition, by ensuring access to quality energy for historically neglected populations, while minimizing environmental impacts and promoting greater local resilience.

This study proposes a comparative economic analysis between different alternatives of electric generation, solar photovoltaic, Diesel Generators (DG) and clandestine grids, based on a case study in the riverside community of Nazaré, in Pará. The objective is to evaluate, from the perspective of sustainability, which of the options offers the best performance in terms of cost-benefit, supply stability and socio-environmental impacts. In this context, the research seeks to develop innovative approaches to estimating the cost of electricity in communities isolated from the conventional electricity grid, considering not only the economic aspects, but also the social and environmental effects of each solution. It is also intended to offer technical support to engineering professionals, public managers and policymakers, through economic analysis tools integrated with sustainability criteria. The comparison between the generation alternatives aims to demonstrate the financial impacts on the budget of low-income families, as well as the associated environmental consequences, especially in the case of diesel generators and clandestine networks, still common in the northern region of Brazil. Finally, the research highlights the potential of solar energy as a vector of sustainable development and social inclusion, contributing to the mitigation of energy inequalities and the promotion of a fair energy transition, in alignment with the Sustainable Development Goals (SDGs), particularly numbers 7, 10 and 13.

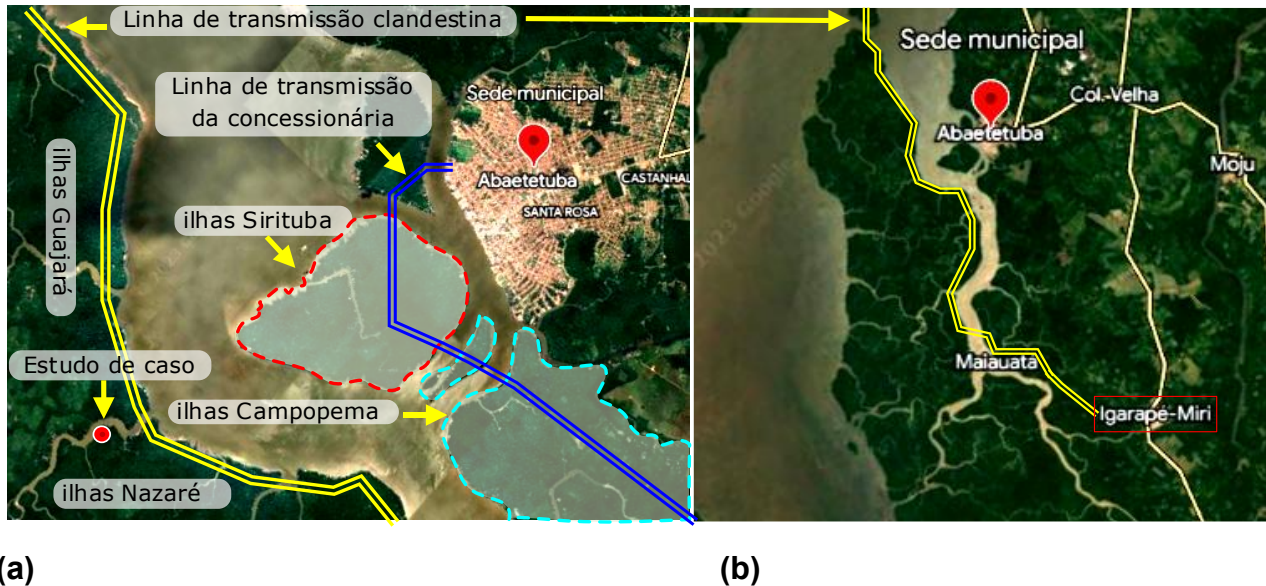
2 PRELIMINARY STUDIES

2.1 ESTIMATION OF THE ELECTRICAL LOAD IN THE COMMUNITY

The Maracapucú River, one of the main watercourses in the municipality of Abaetetuba-PA, is divided into two sections: Maracapucú-Miri and Maracapucú-Grande, which are home to the islands of Nazaré and Guajará, respectively. The present study was conducted on Nazaré Island, which has an estimated population of 1,278 inhabitants, including young people, adults and children. The main local economic activities include family farming, artisanal production and the management of açaí, a fundamental basis of riverside subsistence. The island has approximately 580 residences distributed along its length. The specific area of analysis was a village located on the margins of Nazaré Island, about 1 km away from the urban center of Abaetetuba-PA, as illustrated in Figure 1.

Figure 1

Location of the community and transmission lines: (a) municipal headquarters and community, (b) path of the air lines



Source: Prepared by the authors.

The village consists of seven residences, all built within the standards established by a federal government housing program, which defines uniform design and dimensioning characteristics. Figure 2 illustrates one of the housing units belonging to this complex, located in that community.

Figure 2

Village house (reference house)



Source: Prepared by the authors.

To carry out the economic analysis, it was necessary to survey the electrical load of the residence, based on Equation (1). This survey involved the identification of the nominal power and the average daily time of use of each household appliance, as shown in Table 1.

Table 1

Equipment used and estimated load consumption

Equipment	Number	Hours of Use/Day (t_i)	Power (W)
Stereo	1	1	150
Water Pump	1	1/4	370
Freezer	1	4	100
Lamp	1	8	20
Lamp	2	8	15
Lamp*	2	8	14
Washing machine	1	0,5	290
Acai Berry Beating Machine	1	0,5	180
Router*	1	24	10
32* TV	1	8	74
Total			1,223
			kWh/day

*Priority loads.

Source: Prepared by the authors.

$$E_{Consumida} = \sum_{i=1}^n P_i \cdot t_i \quad (1)$$

Where:

$E_{Consumed}$ = Represents the total energy consumed per day;

P_i = Power of the equipment;

t_i = Corresponds to the interval of use of a piece of equipment per day (h);

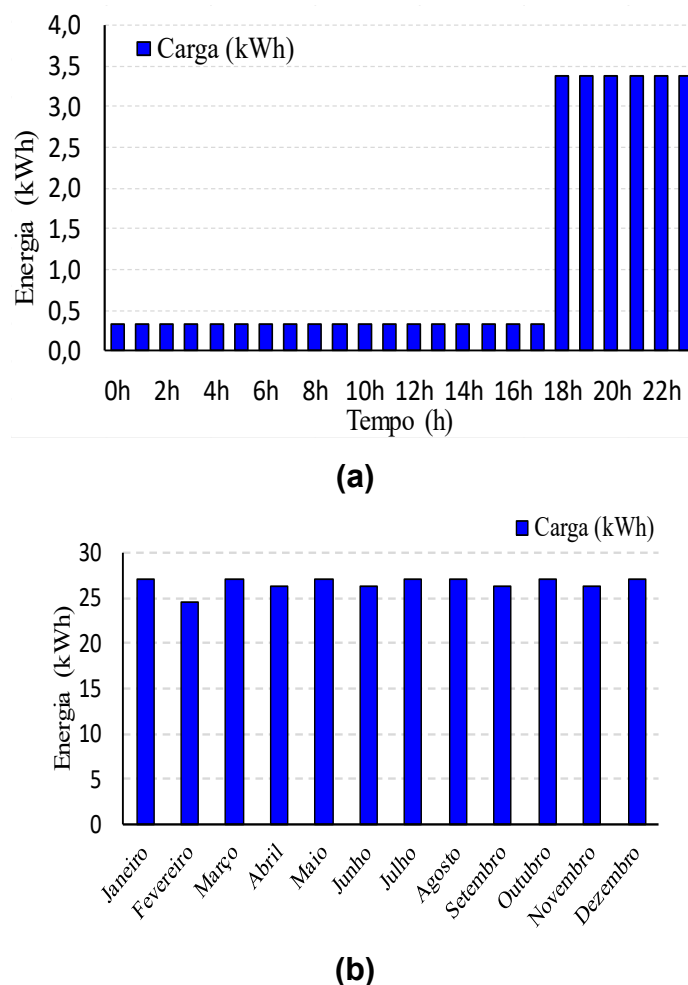
n = Number of equipment;

As shown in Table 1, to fully supply the energy demand of the residence, a *medium-sized off-grid* SFV system would be necessary, consisting of at least four 300 Wp (Watt peak) modules and four 150 Ah (Ampere-hour) batteries. However, the acquisition of a system of this magnitude is not feasible for the villagers, due to factors such as low purchasing power,

the presence of a clandestine electricity grid, albeit unstable, and limited familiarity with photovoltaic solar technology. In view of this scenario, the strategy adopted was the dimensioning of an *off-grid* SFV system aimed exclusively at serving priority loads, making it more accessible and attractive from an economic point of view. According to Table 1, these priority loads correspond to the *internet* router, the television and the lamps. Figure 3 shows the load profile associated with this equipment.

Figure 3

Load of the reference house: (a) daily load, (b) monthly load



Source: Prepared by the authors.

Figure 4 shows the *off-grid* SFV installed in the reference house for load estimation.

Figure 4

Off-grid photovoltaic system installed in the community



Source: Prepared by the authors.

In the economic evaluation that will be shown below, the case studies of the off-grid SFV demonstrated in the previous section are addressed. The analysis includes the exposure of the initial costs, the annual economic balance and the cost of the kWh generated from each system, for the demand conditions.

3 ECONOMIC EVALUATION

3.1 STARTUP COSTS

Table 2 shows the composition and distribution of the costs of the *off-grid SFV components*, as well as the cost associated with the clandestine power grid.

Table 2

Initial Off-Grid SFV Costs

Equipment	Features	Quantity	Value (R\$)
Photovoltaic Module	155 Wp	1	300
Inverter	300 Wp	1	339
Charge Controller	20 A	1	479
Battery	60 Ah	1	430
Total 1,548.00			

Source: Prepared by the authors.

Table 2 shows that the largest expenditure for the implementation of a small *off-grid SFV* corresponds to the acquisition of the charge controller due to the fact that it has technology to search for the maximum power point. However, according to the increase in the system, this initial cost will be for the battery bank.

The generation of electrical power through a single-phase 12.5 kVA (10kW) DG group that provides an output voltage of 127V. Table 3 shows the initial costs associated with this type of electrical power generation.

Table 3

Diesel generator startup costs

Equipment	Features	Quantity	Value (R\$)
Diesel Generator Set	12.5 kVA +motor	1	6.000
Maintenance	annual	3	1.500
Total			7.500,00

Source: Prepared by the authors.

The generation of electricity through the clandestine electric grid had the following initial investment, according to Table 4.

Table 4

Initial costs of the clandestine power grid

Equipment	Characteristic	Quantity	Value (R\$)
Electrical network	By family	1	1.200,00
Total			1.200,00

Source: Prepared by the authors.

3.2 ECONOMIC BALANCE SHEET

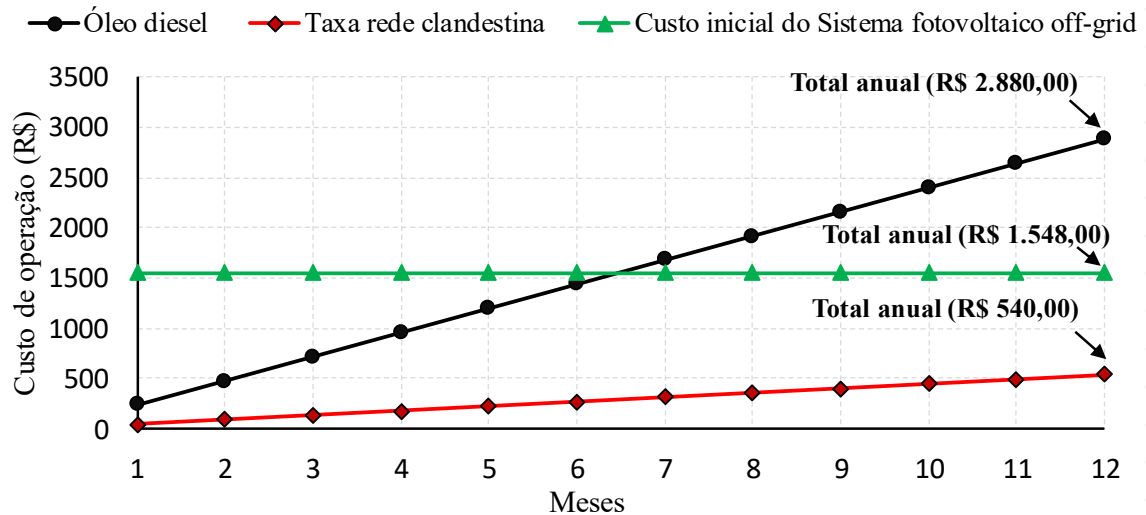
For the economic balance, the following were considered:

Clandestine electricity network - Average rate charged per consumer unit 45.00 R\$/month. The total amount of revenue is used to pay operators who maintain the network, purchase poles, among others (operating expenses).

GD - Cost per liter: 8.00 R\$/Liter. On average, 1 liter of oil is used each day to make up for the lack of the clandestine network (this is a conservative estimate based on ideal operating conditions).

Figure 5

Operating cost curve of energy sources



Source: Prepared by the authors.

3.3 COST OF KWH GENERATED

To determine the cost of the kWh generated for the values of average loads, Equations 2 to 6 were used.

$$CE = \frac{VPLa}{EC} \quad (2)$$

Where:

CE – Cost of electricity (R\$/kWh);

NPV – Annualized net present value (annualized life cycle cost of the system) (R\$);

Ec – Electricity consumed (kWh).

The annualized net present value is determined by the following Equation (3):

$$VPL_A = VPL \times \frac{i \times (1 + i)^n}{(1 + i)^n - 1} \quad (3)$$

i – Minimum attractiveness rate ($a.a$);

n – Analysis period (years);

NPV can be calculated using the following Equation (4):

$$VPL = I + CR_P + \sum_{k=1}^n VP_{(O/M)} \quad (4)$$

Where:

I – Cost of the initial investment (R\$);

CR_P – Replacement cost brought to present value (R\$);

$PV_{(O/M)}$ – Present value associated with the cost of operation and maintenance (R\$).

The term CR_P can be calculated using the following Equation (5):

$$CR_P = \sum_{m=1}^R \left(\frac{CC}{(1+i)^{m \times T}} \right) \quad (5)$$

Where:

R – Number of component replacements during the analysis period;

CC – Component cost (R\$);

T – Useful life of the component (years).

The term $PV_{(O/M)}$ can be calculated using the following Equation (6):

$$VP_{(O/M)} = W \times \frac{(1+i)^n - 1}{i \times (1+i)^n} \quad (6)$$

Where:

W – Sum of total operating and maintenance costs.

4 RESULTS AND DISCUSSIONS

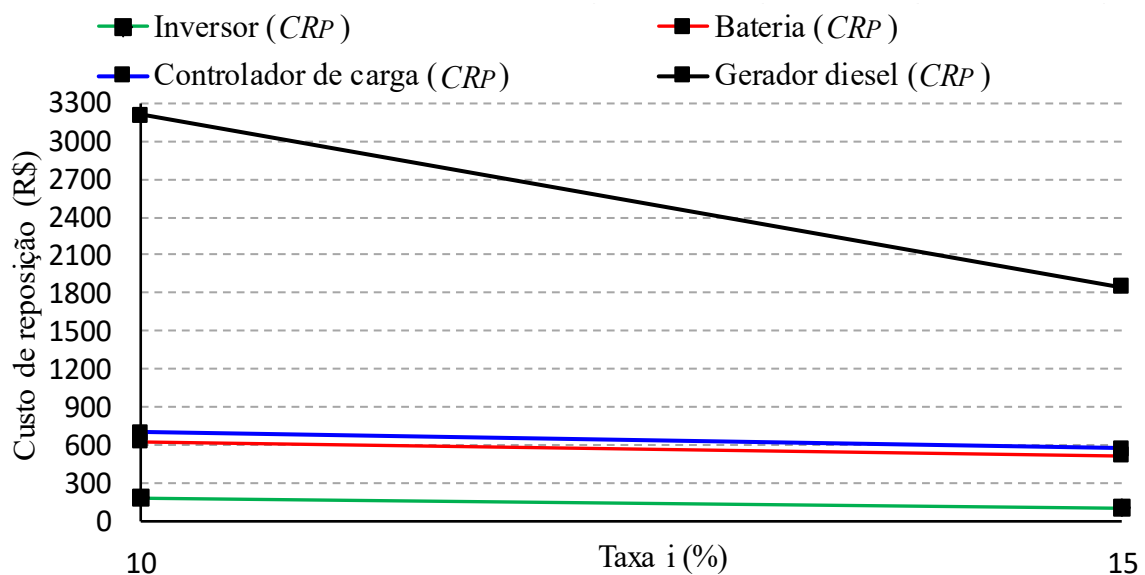
Considering a planning horizon of 20 years, defined based on the useful life of the photovoltaic modules, which represent the component with the longest longevity of the system, minimum attractiveness rates of 10% and 15% were adopted. The annual cost of operation and maintenance of the SFV *off-grid* was estimated at 1% of the initial capital,

totaling R\$ 15.48 per year. The operational useful life of storage batteries is approximately 4 years, which implies four replacements over the period analyzed. For the charge controller, whose average durability is also 4 years, two replacements are planned. The inverter, on the other hand, has a useful life of 10 years, with two replacements estimated during the life cycle of the system. In the case of DG, periodic maintenance costs were estimated at around R\$ 1,500.00 per semester.

Figure 6 shows the replacement costs of the *off-grid SFV components*, as well as those of the diesel generator set. For the inverter, the replacement cost was calculated at R\$ 181.48 with a rate of 10% and R\$ 105.00 with a rate of 15%. The charge controller has estimated values of R\$ 699.00 (10%) and R\$ 571.00 (15%). The battery bank has an estimated replacement cost of R\$ 627.00 with a 10% fee and R\$ 513.00 with a 15% fee. Finally, the diesel generator set has an associated replacement cost of R\$ 3,205.00 (10%) and R\$ 1,850.00 (15%).

Figure 6

Replacement cost of the off-grid SFV components and the diesel generator set



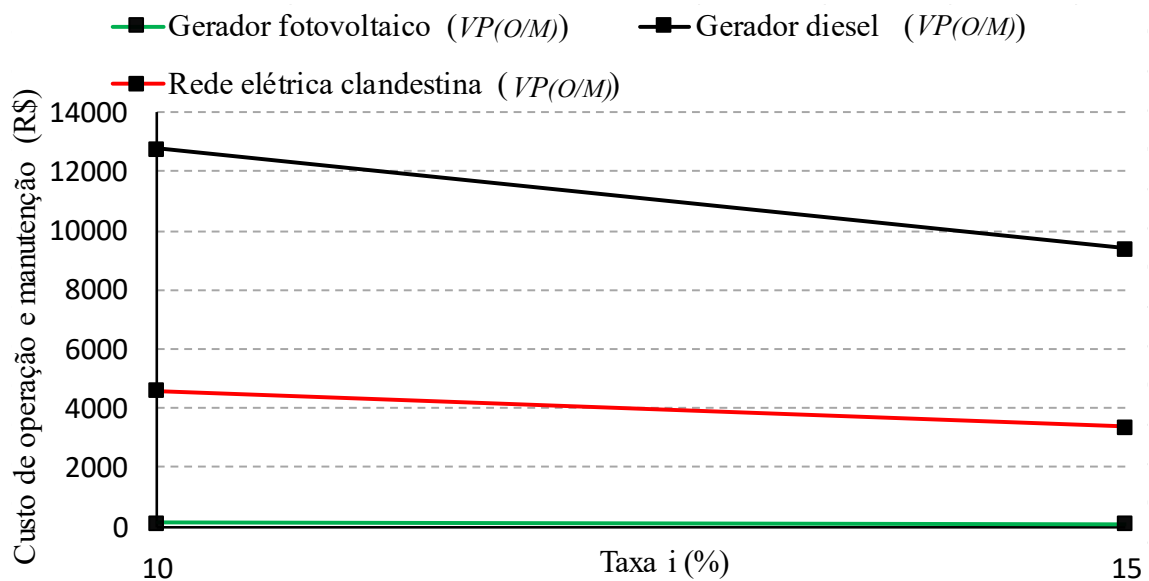
Source: Prepared by the authors.

In the analysis of operation and maintenance costs, the clandestine electricity network was also considered, since the monthly fee charged to each family in the community is intended for the maintenance of the infrastructure, including activities such as tree pruning, cable replacement and general repairs. The total cost associated with the operation and maintenance of this network was estimated at R\$ 4,597.00 for an attractiveness rate of 10%

and R\$ 3,380.00 for 15%. For the off-grid SFV, the corresponding costs were R\$ 132.00 and R\$ 97.00, respectively. DG, on the other hand, had the highest operating costs, totaling R\$ 12,770.00 with a rate of 10% and R\$ 9,389.00 with a rate of 15%. Figure 7 shows the comparison between the operation and maintenance costs of the three energy generation sources analyzed.

Figure 7

Cost of operation and maintenance of electricity generating sources

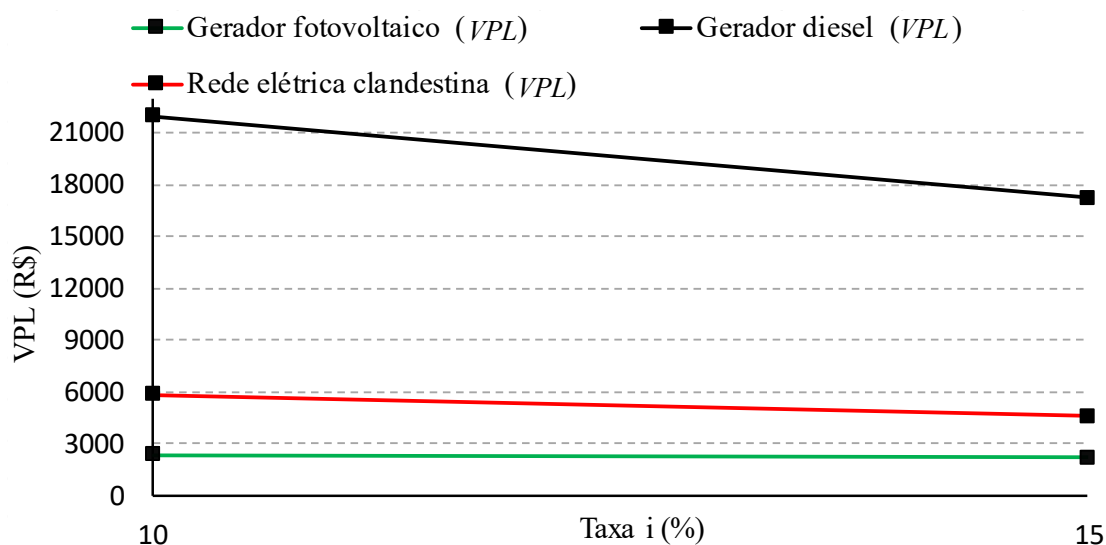


Source: Prepared by the authors.

The *NPV* and *aLPV* of the sources that generate electricity are shown in Figures 8 and 9. The *NPV* of the DG was R\$ 21,975.00 and R\$ 17,239.00, of the SFV *off-grid* was R\$ 2,307.00 and R\$ 2,158.00 and of the clandestine network was R\$ 5,797.00 and R\$ 4,580.00, the rate of 10% and 15% respectively.

Figure 8

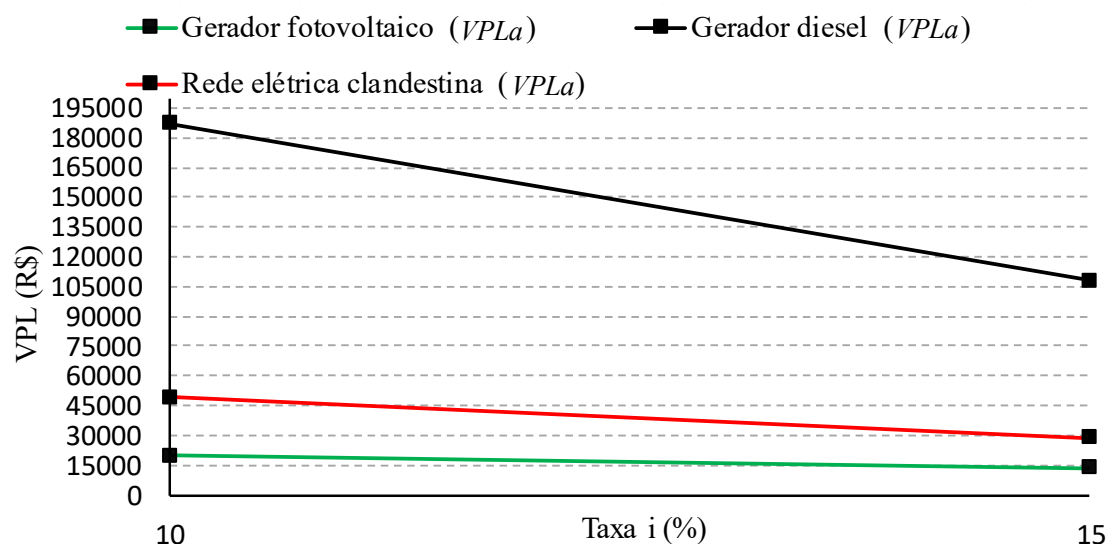
NPV of the electric energy sources



Source: Prepared by the authors.

Figure 9

NPV of the electric energy source

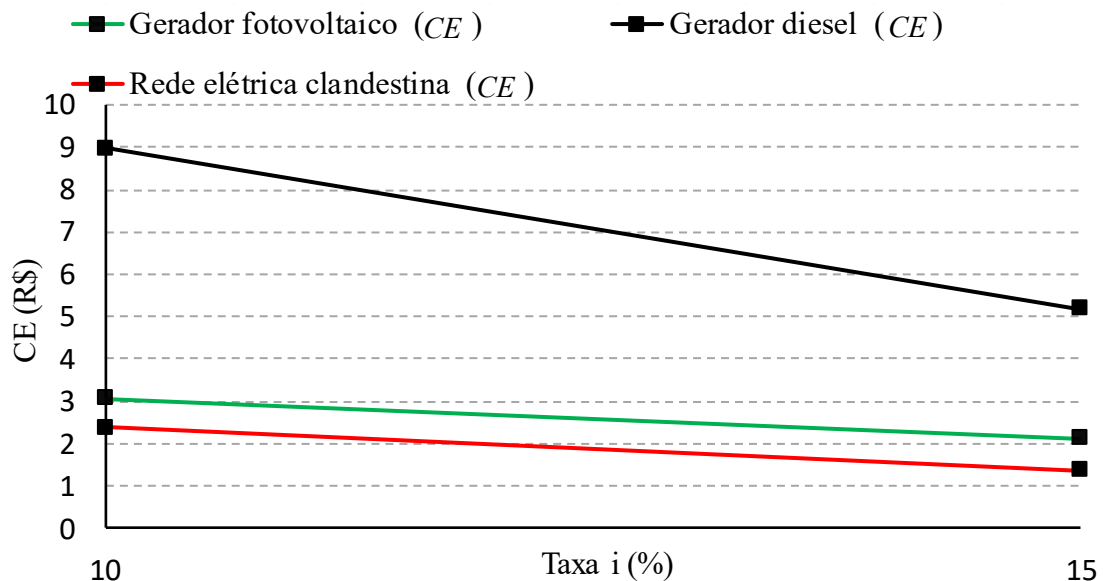


Source: Prepared by the authors.

The cost per kWh of electricity for each generating source is shown in Figure 10. The kWh delivered to the community by the DG was R\$ 9.00/kWh and R\$ 5.20/kWh, the rates of 10% and 15%, respectively. The kWh delivered to the community by the SFV *off-grid* was R\$ 3.10/kWh and R\$ 2.10/kWh and the cost of the kWh supplied by the clandestine network was R\$ 2.40/kWh and R\$ 1.10/kWh at rates of 10% and 15%, respectively.

Figure 10

Cost per kWh of electricity for solar, diesel and hydro sources



Source: Prepared by the authors.

5 CONCLUSIONS

The research presented highlights the importance of adopting *off-grid* photovoltaic systems as a sustainable alternative for the supply of electricity in riverside communities in the Amazon excluded from the National Interconnected System. The economic analysis has shown that while the initial cost of solar systems is higher than that of clandestine grids and diesel generators, their performance over time is more advantageous in terms of cost per kWh, stability in supply, and reduced environmental impacts. Solar energy, in addition to promoting energy autonomy, presents itself as a solution aligned with the needs of low-income populations, contributing significantly to the reduction of energy poverty and the strengthening of sustainable local development. The results obtained reinforce the urgency of public policies that encourage the expansion of clean and decentralized energy solutions, especially in remote areas, strengthening the commitment to an inclusive and just energy transition.

ACKNOWLEDGMENT

The authors would like to thank the Federal University of Pará (UFPA) for its institutional support, laboratory infrastructure, and research incentives, which were fundamental for this study.

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**REDUCING NON-CONFORMITIES WITH THE APPLICATION OF THE PDCA
METHODOLOGY IN A PACKAGING INDUSTRY**

**REDUÇÃO DE INCONFORMIDADES COM A APLICAÇÃO DA METODOLOGIA
PDCA EM UMA INDÚSTRIA DE EMBALAGENS**

**REDUCCIÓN DE NO CONFORMIDADES CON LA APLICACIÓN DE LA
METODOLOGÍA PDCA EN UNA INDUSTRIA DE EMBALAJE**

 <https://doi.org/10.56238/sevened2025.036-026>

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ABSTRACT

The country is undergoing changes due to the speed of information and the dissemination of knowledge, forcing organizations to renew their management to efficiently and effectively meet market demands. This process of meeting these new requirements is linked to the pursuit of quality, which is a priority for every company. The quality management system is no longer a competitive differentiator but a system necessary for the survival of organizations, striving for efficiency and customer satisfaction. This paper addresses the application of the PDCA Cycle continuous improvement method in the quality department of a packaging company, identifying losses due to production defects. This study seeks to analyze the reduction of nonconformities generated by poor production in a container machine. Throughout the study, productivity and quality improvement tools will be discussed according to the analyzed stage used by the case study company. Based on the PDCA roadmap, guidelines for reducing nonconformities will be sought. This paper aims to analyze improvement opportunities to reduce nonconformities identified throughout the process to ensure quality delivery and customer satisfaction.

Keywords: Product Development. Quality Management. Production Improvement. Production Process.

RESUMO

O país passa por mudanças, devido a velocidade da informação e a disseminação de conhecimento, obrigando as organizações a renovarem sua gestão para atender com eficiência e eficácia às exigências do mercado. Este processo de atendimento destas novas exigências está atrelado a busca pela qualidade, sendo prioridade de toda empresa. O sistema de gestão de qualidade deixa de ser um diferencial competitivo e passa a ser um sistema necessário a sobrevivências das organizações, buscando eficiência e satisfação de seus clientes. O trabalho aborda a aplicação do método de melhoria contínua Ciclo PDCA no setor de qualidade de uma indústria de embalagens, verificando as perdas devido a defeitos na produção. Com isso, busca-se analisar a diminuição de não conformidades gerados pela má produção em uma máquina de recipientes. Ao longo do trabalho serão abordadas ferramentas de melhoria da produtividade e qualidade de acordo com a etapa analisada utilizada pela empresa do estudo de caso e, baseado no roteiro PDCA, busca-se a diretriz para a redução de inconformidades. Este trabalho tem por objetivo analisar

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oportunidades de melhoria com a finalidade de reduzir não conformidades identificadas ao longo do processo para garantir a qualidade na entrega e satisfação dos clientes.

Palavras-chave: Desenvolvimento de Produto. Gestão de Qualidade. Melhoria da Produção. Processo de Produção.

RESUMÉN

El país está experimentando cambios debido a la velocidad de la información y la difusión del conocimiento, lo que obliga a las organizaciones a renovar su gestión para satisfacer eficiente y eficazmente las demandas del mercado. Este proceso de cumplimiento de estos nuevos requisitos está vinculado a la búsqueda de la calidad, que es una prioridad para toda empresa. El sistema de gestión de calidad ya no es un diferenciador competitivo, sino un sistema necesario para la supervivencia de las organizaciones, buscando la eficiencia y la satisfacción del cliente. Este trabajo aborda la aplicación del método de mejora continua del Ciclo PDCA en el departamento de calidad de una empresa de embalaje, identificando pérdidas debido a defectos de producción. Este estudio busca analizar la reducción de no conformidades generadas por una producción deficiente en una máquina de envases. A lo largo del estudio, se discutirán herramientas de mejora de la productividad y la calidad según la etapa analizada utilizada por la empresa del caso de estudio. Con base en la hoja de ruta PDCA, se buscarán pautas para reducir las no conformidades. Este trabajo tiene como objetivo analizar las oportunidades de mejora para reducir las no conformidades identificadas a lo largo del proceso para garantizar la entrega de calidad y la satisfacción del cliente.

Palabras clave: Desarrollo de Producto. Gestión de Calidad. Mejora de la Producción. Proceso de Producción.

1 INTRODUCTION

Continuous improvement in production processes is essential for companies, so that their product is a differential in the market, given the competitiveness present in the market and the demand of consumers. Product development requires planning in the training of professionals and in the structural organization, in order to seek efficiency in stage, not resulting in errors that cause economic losses to the company. For the development of a product to be efficient, a systemic view of all those involved in the production line and monitoring is necessary (Neves, 2007).

Continuous improvement is a philosophy that is only possible if all areas of the company are analyzed in a structured way in order to increase production performance, integrating employees. In addition, it does not require large investments, as it is characterized by actions, identified through tools such as Ishikawa Diagram, 5W1H, PDCA cycle, among others (Furukita, 2017).

For a product to be launched on the market, a well-designed process is needed so that the idea is realized and generates a result, both economic and social, always seeking customer satisfaction. These steps are controlled by quality management.

Quality management is a process of continuous improvement, in which it analyzes the planning of activities, puts planning into practice, verifies the results generated and adjusts if there are deviations in the production line.

The objective of the research was to demonstrate the production process of plastic packaging and the quality by the PDCA methodology applied within this process, through a case study in the fictitious company EIRT9, in order to present improvements in the quality sector and reduce the number of non-conformities, consequently reducing the probability of customer complaints.

2 GOAL

2.1 GENERAL OBJECTIVE

The main objective of this work is to analyze the reduction of non-conformities in a packaging industry through the PDCA methodology. One of the premises considered was customer satisfaction.

2.2 SPECIFIC OBJECTIVES

The following specific objectives can be mentioned:

- Literature review based on the PDCA methodology;
- Verify the production process and prepare a flowchart;
- Evaluate defects and possible causes;
- Analyze possible problems and opportunities;
- Check the number of non-conformities;
- Present improvements in the production process.

3 JUSTIFICATION OF THE PROBLEM

The PDCA method is composed of four steps Plan, Do, Check and Act (Planning, Execution, Verification and Acting), being a set of tools that involve the study of causes of deviation in production in search of an action plan for the standardization of the process. The PDCA improvement method must be disclosed to all stakeholders in the organization and, therefore, it must be simple, didactic and easy to apply. Finally, the choice of this method is due to the fact that a deep analysis of the process is necessary, especially the flowchart and is low cost, as it has a simple structure, thus bringing great potential for results.

Therefore, the present study proposes to evaluate the potential of applying continuous improvements in a packaging company in order to reduce defects in the production of products, increasing efficiency and customer satisfaction.

4 LITERATURE REVIEW

According to Bessant et al. (1994), in continuous improvement a process involves the entire corporation around a broad innovation process, being a simple concept with low investment, but with great cultural difficulties for implementation and maintenance. It is an essential tool for the longevity of companies, with the character of continuous improvements that, if maintained, will give references to companies. (apud Juran, 1995).

Gonzalez and Martins (2007) say that whether structured or not, any continuous improvement must bring rapid changes to companies, so that they can have reactions to the different scenarios of socio-economic changes (apud Kaplan et al, 1996).

According to Alencar (2008), the PDCA Cycle (Plan, Do, Check, Action), also known as the Shewhart Cycle or Deming Cycle, is a simple technique that aims to control the process (Figure 1).

Figure 1

PDCA Cycle



Source: Bezerra (2014).

According to Neves (2007), the PDCA method is usually used as departmental goals or in individual cells to achieve the company's strategic goals, always bringing cost, quality and productivity advantages to the company. (Figure 2).

Figure 2

PDCA Framework

PDCA	FLUXO	ETAPA	OBJETIVO
P	1	Identificação do problema	Definir claramente o problema e reconhecer sua importância.
	2	Observação	Investigar as características específicas do problema com uma visão ampla e sob vários pontos de vistas.
	3	Análise	Descobrir as causas fundamentais.
	4	Plano de ação	Conceber um plano para bloquear as causas fundamentais.
D	5	Ação	Bloquear as causas fundamentais.
C	6	Verificação	Verificar se o bloqueio foi efetivo.
	?	(Bloqueio foi efetivo?)	
A	7	Padronização	Prevenir contra o reaparecimento do problema.
	8	Conclusão	Recapitular todo o processo de solução do problema para trabalho futuro.

Source: (Campos, 1992).

According to Aguiar (2012), PDCA must be directed to three forms of management in order to achieve the company's survival goals, as follows:

- Maintenance of quality, to be able to provision the company's results;
- Quality improvement, so that with the existing methods you can always have a continuous improvement in the company's results;

The tools that will be covered are: brainstorming, cause and effect diagram, 5W1H and flowchart.

4.1 BRAINSTORMING

According to Santos, Ceccato and Michelin (2011), brainstorming can be defined as a storm or rain of ideas. It is a group technique where people can present ideas freely, it is not advisable for there to be criticism and it needs to occur in a way that does not spend too much time.

4.2 CAUSE AND EFFECT DIAGRAM

According to Costa (2003), this diagram was created in 1943 by Ishikawa, which is why it is known as the Ishikawa Diagram or fishbone because of its shape, it was developed to be used by quality circles to study the problems identified as priorities by the Pareto analysis, which represent the relationship between the "effect" and all the possible "causes" that can contribute to this effect.

4.3 5W1H "ACTION PLAN"

According to Maiczuk and Júnior (2013), 5W1H is used in order to inform and certify a cluster of action plans, diagnose a problem and design actions.

According to Campos (1998), 5W1H comes from English and means: What; Why; How; Who (who will be responsible); When (when, establishes the deadline for execution); Where (where it will be held).

4.4 FLOW CHART

Neves (2007) says that the flowchart graphically demonstrates the steps to be followed in the process, in order to know its sequence. In this way, it becomes essential for the standardization and understanding of it. After its completion, it can be analyzed with what is achieved in practice in order to achieve improvements.

5 METHODOLOGY USED

The scientific research developed is of an applied nature, exploratory objective, combined approach, with bibliographic character and the method through a case study, using various bibliographic sources such as books, academic publications, internet, standards, among others.

The methodology used is divided into three stages: The first stage is related to the Bibliographic Review, in which quality management topics are addressed, such as continuous improvement, PDCA methodology, with a theoretical foundation about the project. Then, a packaging company and its quality management system are studied and analyzed, elaborating a Discussion of Results, displaying the values and benefits of the PDCA methodology in the company. In the last phase, the benefits of using continuous improvement in the product production process are presented. In the end, it is concluded that the search for quality is now a concern of all companies, which has become a priority for every organization

6 QUALITY MANAGEMENT: PDCA METHODOLOGY IN A PACKAGING INDUSTRY

The first contact that the consumer has with the product is through the packaging, and the relationship with the consumer is established.

The company's flowchart is divided into three steps. The first step in the packaging production process is printing, where the virgin transparent BOPP reel is inserted into an 8-color flexographic printer, these printers are high-tech equipment, which result in productivity, agility and excellent print quality ranging from the simplest to the most sophisticated packaging.

The second step is the lamination process, which is the process used for packaging of more than one layer, called laminated packaging. The laminator in its lamination process is able to join two different or equal structures in the same film, without the use of solvent and free of odors, which is an important factor for food packaging. The last step is the trimming and cutting of coils in the sizes and patterns desired by customers, where the operator performs the cutting, eliminating product non-conformities.

And finally, the packaging production process is completed by finishing, where the reels are packaged and palletized to be delivered to the customer.

6.1 STRATEGIC MANAGEMENT OF PRODUCTION AND OPERATIONS

MISSION: To provide high-reliability packaging for the food industry.

VISION: To be a reference as a Brazilian packaging supplier.

VALUES: - Efficiency;

-Technology;

-Reliability;

Table 1

SWOT analysis

FORCES - Strategic vision of the business - Technical qualification of the team	WEAKNESSES - Market entrant - High cost of machinery
OPPORTUNITIES - Low number of competitors - Huge market in the country	THREATS - Unstable economy in the country - Competitors with large structures

Source: The author.

The quality process monitors the entire production, so that the appearance of non-conformities in the product is avoided.

Quality control identified through the SAC (customer service), a problem with one of the batches of packaging that the company produces, where the defect found was printing failures and bubbles in the packaging. Upon learning this, the responsible sector opened an RNC (Non-Conformity Report). In view of this, the possible causes of the problems were raised:

- Printer being shut down when the operator is away
- Unskilled labor
- Wear of rubber rollers in the lamination process
- Factory Layout

These causes will be exposed in more detail in the cause and effect diagram where the objective is to identify in the tool the causes and sub-causes of the problem presented.

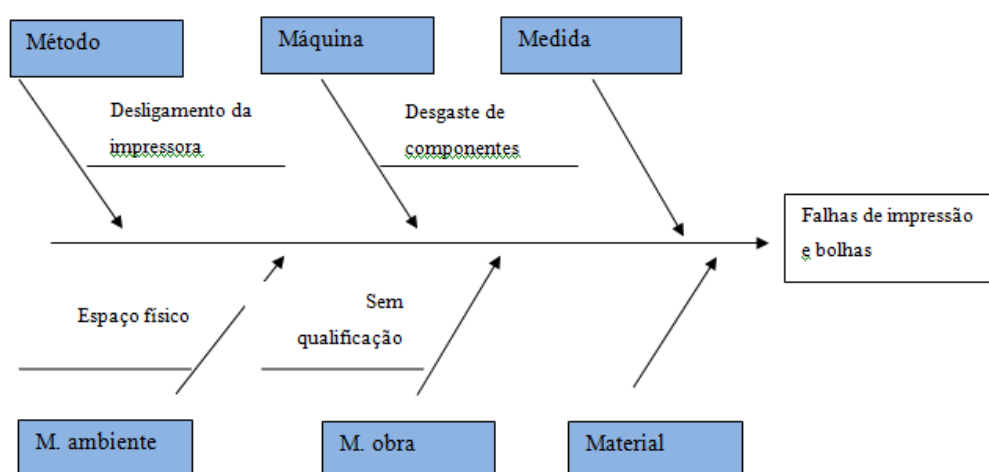
6.2 STUDY AND OPTIMIZATION OF THE PRODUCTION PROCESS

6.2.1 Cause and Effect Diagram

In this tool, the quality sector decided to treat the causes of the problem of printing failures and bubbles in the packages, presenting sub-causes (Figure 4). These suggestions were obtained through a brainstorming session, in which they guided the planning stage.

Figure 4

Cause and Effect Diagram/Print Defect and Bubble Analysis



Source: The author.

The observation carried out by the quality sector identified in the execution method factor a cause related to the central problem, due to the printer operator having to be absent from his workstation during lunch hours and to perform his needs he turns off the printer, thus causing printing failures in the packages.

As far as the machines are concerned, the causes found were the wear and tear of printer components and also the wear of the rubber rollers in the laminator, thus causing printing failures and bubbles in the packaging.

In the environmental factor, a disorganization was noticed in the positioning of equipment and inputs used in the processes, where the inks were far from the printers and the rewinder far from the finishing process, causing unnecessary displacement of operators and loss of time in the production process.

In the labor factor, the lack of training in the operation of printing and laminating equipment and also in the execution of equipment maintenance was noticed.

6.2.2 5W1H Action Plan

After the analysis, the commission concluded that the defects in the product batch occurred due to the lack of corrective and preventive maintenance on the equipment, printing operator having to be absent from the equipment and disorganized layout of the factory.

Therefore, the 5w1h model action plan was created to mitigate the cause of the failures, as shown in the following table (Table 2. Table 5W1H).

Table 2

Table 5W1H

Table 1 - Action plan					
WHAT	WHERE	BECAUSE	HOW	WHO	WHEN
Hire Printing Assistant	Printing industry	Operator support in handling paints	Through resume evaluation	HR Sector	30/05/2020
Perform corrective maintenance	At the factory	Component wear	Replacing Worn Components	Production	15/05/2020
Create preventive maintenance schedule	For all production process equipment	Maintain the smooth operation of the factory	Component Inspection & Replacement	Production	30/05/2020
Schedule training	Training Center	Equipment maintenance	Schedule training	HR	10/06/2020

Source: The author.

6.3 VIABILITY

Cycle analysis for each phase of the process is essential to avoid wasting resources on any project. Basically, this analysis is verified under the strategic aspects of the company and is constantly updated (Araújo et al, 2013).

Because it is carried out at the time of planning, production waste is minimal, since, once the failure is identified, production is immediately improved. The economic viability of this methodology is simple, since there are investments only in the organization of planning and training of employees.

7 RESULTS AND DISCUSSIONS

The results generated for the company were not immediate, as the paradigm shift goes through a period of implementation, so little by little the results came out and knowledge of

the learning process of new methodologies was added by the company. Prior to the program, defects that represented an average of 1.6% of production, with the month of December 2019 as a reference and were concentrated in printing failures, representing 31% of discarded products.

After this identification, the printing machines were studied and it was found that of the five printers, only a certain equipment accounted for 55% of the failures.

The quality method implemented for the analysis of batches that presented manufacturing defects made a series of managerial controls that did not exist in the company very simple. These controls are the basis for new continuous improvement efforts.

The fact of adopting a printing assistant, creating a schedule of preventive maintenance of the equipment and training of professionals exceeded the financial return on investment, as the company started to have more reliability of its products before customers. Soon the company started to offer a higher quality product to its customers, with a significant increase in its sales. This difference between the production before the PDCA methodology (December) and after (from January) can be seen in the comparison below, representing a loss decrease of 45%.

8 FINAL CONSIDERATIONS

This work aimed to present possible waste reduction within the packaging production cycle through the PDCA cycle and its tools in search of continuous improvement. Because it is easy to develop and understand, this methodology is widely used by companies in any field.

However, despite being easy to apply, some proposals were not properly executed, since it is difficult to break some of the company's paradigms.

These initial project barriers were overcome throughout the process and after proper training of employees, a significant reduction in packaging waste and, especially, raw material can be perceived.

Non-conforming products were separated for analysis and mapping of defects so that failures could be mitigated, continuously improving the production process.

With this waste reduction, the company can increase its profit margin without having to reduce its quality or increase its sales price, being a great differential in the market.

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AUTHENTICITY AND POWER: RECONNECTING WITH MARGINALIZED ASPECTS OF THE FEMININE

AUTENTICIDADE E PODER: A RECONEXÃO COM OS ASPECTOS MARGINALIZADOS DO FEMININO

AUTENTICIDAD Y PODER: RECONEXIÓN CON ASPECTOS MARGINADOS DE LO FEMENINO

 <https://doi.org/10.56238/sevened2025.036-027>

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ABSTRACT

The present study aims to provide a critical analysis of the historical marginalization of the three feminine powers — cyclicity, ancestry, and sexuality — and their impact on female subjectivity, as they directly influence the construction of women's identity, self-esteem, and autonomy. The central question of this research is: How does the historical marginalization of cyclicity, ancestry, and sexuality affect the construction of women's identity, self-esteem, and autonomy, and in what ways can the conscious integration of these three powers promote empowerment and authenticity? The hypothesis that supports this study is that, through self-knowledge, women achieve authenticity and liberation in the process of self-occupation by re-signifying individual and collective experiences. To substantiate the critical analysis, the theoretical concepts of Audre Lorde (2019), who problematizes power as erotic and self-expression as resistance, are used; Brené Brown (2019), who discusses vulnerability and courage; Chimamanda Ngozi Adichie (2014), with her contributions on the danger of a single story, feminism, and the social construction of femininity; Clarissa Pinkola Estés (1992), on ancestral archetypal feminine wisdom; Michel Foucault (1983; 1986), on biopower and subjectivation; Silvia Lane (1999), from the perspective of critical social psychology; and Zygmunt Bauman (2001), in his reflections on identity in liquid modernity. This bibliographic research seeks to integrate these authors to broaden the understanding of the phenomenon, highlighting how the conscious reclaiming of these three powers can serve as a path to personal and social transformation. The analysis aims to demonstrate that self-occupation — understood as the capacity to recognize oneself and lead one's own life — is strengthened when women reconnect with their ancestry, embrace their natural cycles, and express their sexuality and creativity.

Keywords: Female Subjectivity. Self-knowledge. Cyclicity. Ancestry. Sexuality. Authenticity.

RESUMO

O presente estudo tem como objetivo trazer uma análise crítica sobre a marginalização histórica dos três poderes femininos — ciclicidade, ancestralidade e sexualidade — e seu impacto na subjetividade feminina, ao influenciar diretamente a construção da identidade, da autoestima e da autonomia nas mulheres. A questão central da pesquisa é: Como a marginalização histórica da ciclicidade, ancestralidade e sexualidade impacta a construção da identidade, autoestima e autonomia de mulheres, e de que forma a integração consciente

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desses três poderes pode promover empoderamento e autenticidade? A hipótese que sustenta este estudo é a de que, por meio do autoconhecimento, promove-se autenticidade e libertação às mulheres na ocupação de si mesmas ao ressignificar experiências individuais e coletivas. Para fundamentar a análise crítica, são utilizados os conceitos teóricos de Audre Lorde (2019), que problematiza o poder como sendo erótico e a autoexpressão como resistência; Brené Brown (2019), ao abordar vulnerabilidade e coragem; Chimamanda Ngozi Adichie (2014), com suas contribuições sobre o risco da história única, feminismo e construção social do feminino; Clarissa Pinkola Estés (1992) sobre sabedoria arquetípica ancestral feminina; Michel Foucault (1983; 1986), sobre biopoder e subjetivação; Silvia Lane (1999), a partir da psicologia social crítica e Zygmunt Bauman (2001), ao refletir sobre identidade na modernidade líquida. A pesquisa aborda uma metodologia bibliográfica, buscando integrar esses autores na compreensão do fenômeno, evidenciando como o resgate consciente desses três poderes pode atuar como caminho de transformação pessoal e social. A análise busca revelar que a ocupação de si, entendida como a capacidade de se reconhecer e liderar a própria vida, é potencializada quando a mulher se reconecta com sua ancestralidade, compreende seus ciclos naturais e expressa sua sexualidade e criatividade.

Palavras-chave: Subjetividade Feminina. Autoconhecimento. Ciclicidade. Ancestralidade. Sexualidade. Criatividade. Autenticidade.

RESUMEN

Este estudio tiene como objetivo proporcionar un análisis crítico de la marginalización histórica de los tres poderes femeninos (ciclicidad, ascendencia y sexualidad) y su impacto en la subjetividad femenina, influyendo directamente en la construcción de la identidad, la autoestima y la autonomía de las mujeres. La pregunta central de investigación es: ¿Cómo impacta la marginalización histórica de la ciclicidad, la ascendencia y la sexualidad en la construcción de la identidad, la autoestima y la autonomía de las mujeres, y cómo puede la integración consciente de estos tres poderes promover el empoderamiento y la autenticidad? La hipótesis subyacente a este estudio es que, a través del autoconocimiento, se promueve la autenticidad y la liberación de las mujeres en su autoocupación al redefinir las experiencias individuales y colectivas. El análisis crítico se apoya en los conceptos teóricos de Audre Lorde (2019), quien problematiza el poder como erótico y la autoexpresión como resistencia; Brené Brown (2019), quien aborda la vulnerabilidad y el coraje; Chimamanda Ngozi Adichie (2014), con sus contribuciones sobre el riesgo de una sola historia, el feminismo y la construcción social de lo femenino; Clarissa Pinkola Estés (1992) sobre la sabiduría femenina arquetípica ancestral; Michel Foucault (1983; 1986) sobre el biopoder y la subjetivación; Silvia Lane (1999), basada en la psicología social crítica; y Zygmunt Bauman (2001), quien reflexiona sobre la identidad en la modernidad líquida. La investigación utiliza una metodología bibliográfica, buscando integrar a estos autores en la comprensión del fenómeno, destacando cómo la recuperación consciente de estos tres poderes puede actuar como un camino hacia la transformación personal y social. El análisis busca revelar que la autoocupación, entendida como la capacidad de reconocer y liderar la propia vida, se potencia cuando las mujeres reconectan con su ascendencia, comprenden sus ciclos naturales y expresan su sexualidad y creatividad.

Palabras clave: Subjetividad Femenina. Autoconocimiento. Ciclicidad. Ascendencia. Sexualidad. Creatividad. Autenticidad.

1 INTRODUCTION

Throughout history, the feminine has been subjected to systematic processes of silencing, control, and marginalization that have profoundly impacted the way women build their identity and relate to themselves and society. The patriarchal structure, based on power relations, established norms that defined the social roles attributed to women, as well as the limits of their subjective experiences. Michel Foucault (1983; 1986) points out that bodies are targets of disciplinary technologies that, at the same time that they produce knowledge, impose restrictions and configure specific modes of subjectivation. In the case of women, this disciplining is expressed in the control of sexuality, reproduction, emotional expression, and identity.

Among the elements most affected by this process are three fundamental dimensions of the female experience: cyclicity, ancestry, and sexuality/creativity. These dimensions, which could constitute sources of power, autonomy and authenticity, have historically been devalued and associated with fragility, irrationality or transgression. Marginalization occurred in conjunction with a historical-cultural movement aimed at maintaining patriarchal hierarchy. As Bauman (2001) observes, in a liquid modernity characterized by identity fluidity, women are encouraged to constantly reinvent themselves, but without the support of solid bonds of belonging, which intensifies subjective fragmentation and the feeling of insecurity.

In this context, the demand to conform to social standards — related to beauty, fashion, motherhood, professional performance and relationships — deepens a cycle of permanent demand. Often, the more women sacrifice themselves to meet external expectations, the more they are socially valued, perpetuating a logic of recognition conditioned to the renunciation of themselves. As Lorde (2019) points out, patriarchy is not limited to institutions, but also crosses the way women perceive themselves and relate to the world. This internalization of patterns often results in feelings of inadequacy, shame, and self-sabotage, as evidenced in the so-called Impostor Syndrome (CLANCE; IMES, 1978; BROWN, 2019).

Cyclicity, linked to biological and emotional rhythms, was disregarded in a culture that favors linearity and continuous productivity. Ancestry, which refers to the transmission of knowledge between generations, has been weakened by modern individualism and the devaluation of women's collective histories. Sexuality, also understood as vital energy and creativity, was subjected to processes of moral control, limiting the full expression of the body and desire. In this sense, Audre Lorde (2019) defends eroticism as a creative and

transformative force, often distorted by patriarchy and reduced to repression or the satisfaction of others:]

When I speak of the erotic, then, I speak of it as an affirmation of the vital force of women; of that strengthened creative energy, the knowledge and application of which we now claim in our language, our history, our dance, our loves, our work, our lives. (LORDE, 2019, p. 70)

Chimamanda Ngozi Adichie (2015) also emphasizes the importance of narratives in the construction of the feminine, showing how repeated stories shape beliefs and behaviors. For the author, recognizing the plurality of voices is essential, as she says, "what the discovery of African writers did for me was this: it saved me from having a unique story about what books are" (ADICHIE, 2015, p. 9). When narratives are crossed by silencing and oppression, they not only perpetuate inequalities, but also limit the possibilities for transformation. Thus, revisiting cyclicity, ancestry and sexuality means rescuing individual and collective dimensions, creating conditions for the strengthening of women in their processes of self-knowledge and emancipation.

Given this scenario, the present study aims to investigate how the historical marginalization of these three dimensions impacts female subjectivity and how their conscious rescue can promote empowerment and authenticity. It is based on the hypothesis that, through self-knowledge, it is possible to resignify experiences, deconstruct internalized patterns and expand the occupation of oneself, allowing women to constitute themselves as active agents in the construction of their own narratives.

For the development of this proposal, a bibliographic research was carried out based on authors such as Audre Lorde (2019), Brené Brown (2019), Chimamanda Ngozi Adichie (2015), Clarissa Pinkola Estés (1992), Michel Foucault (1983; 1986), Silvia Lane (2000) and Zygmunt Bauman (2001), whose contributions allow an interdisciplinary analysis of power, identity, subjectivity and transformation.

Thus, this article seeks to contribute to academic and social debates about the awakening of female consciousness, offering theoretical subsidies to understand how the reconnection with these three powers can be configured as a path of liberation and authenticity in the face of contemporary challenges.

2 SILENCING OF THE FEMININE: POWER, CONTROL AND FRAGMENTATION OF SUBJECTIVITY

The marginalization of the feminine, as a historical process, is not limited to the exclusion of women from formal spaces of power. It involves, above all, the construction of control devices over their bodies, emotions and narratives. In this sense, Foucault (1983; 1986) points out that power is not only exercised in a repressive way, but also in a productive way, that is, it creates knowledge, norms and practices that shape behaviors and subjectivities.

In the case of women, this mechanism is manifested through what the author calls biopower, in which the body becomes a privileged target of social and political regulation. The medicalization of the menstrual cycle, the normalization of motherhood and the control of female sexuality exemplify how society disciplines and organizes women's bodies to meet the interests of a patriarchal order.

This discipline, however, is not only established by explicit laws or prohibitions, but also by seemingly banal daily practices, which guide how women should think, feel and relate to themselves and others. From childhood, discourses are transmitted that teach which behaviors are considered "appropriate" or "acceptable". The result is the construction of a process of internal surveillance, which leads to self-policing. As Foucault (1983; 1986) observes, women themselves begin to reproduce and reinforce these norms unconsciously, perpetuating structures of oppression.

Female subjectivity, in this context, is built on a terrain of restrictions, marked by the repression of desires, the denial of female ancestral knowledge and the absence of self-recognition. It is no coincidence that, although all human beings are born of a woman, we still live in a society marked by machismo, misogyny, and systematic criticism of female behaviors, desires, and ambitions.

With the arrival of liquid modernity, as analyzed by Bauman (2001), these control mechanisms take on new forms. If before society was structured in rigid and predictable norms, today the scenario is characterized by fluidity and instability.

For women, this new context represents both opportunities and challenges: on the one hand, it creates space to question old patterns; on the other hand, there is a constant pressure for reinvention, performance and adaptation to unattainable ideals. As the author points out, identity is continuously reconstructed, never finalized or stable, which generates a permanent state of anxiety.

Consider, for example, the contradiction of self-constituted identities that must be sufficiently solid to be recognized as such and at the same time flexible enough not to impede the freedom of future movement in constantly changing and volatile circumstances. Or the precariousness of human partnerships, now burdened with higher expectations than ever, but poorly institutionalized (if institutionalized), and therefore less resistant to the additional burden. (BAUMAN, 2001, p. 52)

In this scenario, the three powers of the feminine — cyclicity, ancestry, and sexuality — are further stifled. Cyclicity, which invites the recognition of natural and internal rhythms, clashes with the capitalist productive logic, sustained by linearity, constancy and continuous growth. The female body, in this process, is reduced to a machine, disregarding its physiological and emotional variations.

The menstrual cycle, for example, is often medicalized or made invisible, producing a rupture between the woman and her biological processes. This separation weakens the ability to self-perceive and respect one's own limits, resulting in physical and emotional exhaustion.

Contemporary culture imposes unrealistic standards of productivity and perfection on women, symbolized by the figure of the "Bionic Woman": impeccable body, domesticated emotions and constant availability. This expectation generates physical and emotional overload, resulting in exhaustion, frustration, or paralysis in the face of the fear of not meeting social demands. The pressure for performance and belonging intensifies in liquid modernity (Bauman, 2001), in which identities become unstable and continuously reconfigured.

The recognition of cyclicity allows women to align their activities with their own internal rhythms — creation, planning, execution, review and rest — promoting autonomy, energy preservation and a fuller experience. However, historically, this cyclical power has been invisible, medicalized, or pathologized (Illich, 1976; Emily Martin, 1987), creating a disconnect between the woman and her body. Cyclicity, which reflects natural rhythms of bodily and emotional wisdom, is often perceived as instability, fragility, or an obstacle to the linear productivity required by capitalism.

Ancestry, a central element for the sense of belonging and identity, also suffers marginalization. In the liquid society, community bonds are weakened, and knowledge transmitted orally by elderly women — such as practices of care, spirituality and resistance — is devalued (Bauman, 2001; Gonzalez, 1984; Anzaldúa, 1987). This historical erasure limits the recognition of a lineage of feminine strength and creativity, while the hegemony of androcentric scientific knowledge delegitimizes non-formalized knowledge. Women lose solid

references and are often compelled to adapt to external narratives about what a woman "should be", reinforcing insecurity and disconnection with herself.

Control over the body intensifies with medicalization and techno-scientific science, which impose norms on food, health, and aesthetics (Ortega, 2003; Haraway, 1991). Perfect health becomes an ideal to be displayed continuously, configuring itself as a new social utopia, while the circulation of digital information, paradoxically, contributes to misinformation and anxiety (Bauman, 2021).

Sexuality, understood by Audre Lorde (2019) as vital and creative energy, constitutes a deeply controlled field. Female eroticism, a source of personal and collective power, is historically silenced, repressed, and devalued in patriarchal societies. When associated with guilt or danger, it restricts not only pleasure but also creativity and authentic expression.

As Lorde (2019) observes, naming experiences and breaking silence is an essential political act "In the name of silence, each of us evokes the expression of our own fear [...] But most of all, I think we fear visibility that we can't really live without." (LORDE, 2019, p. 53)

The fragmentation of these three powers—cyclicity, ancestry, and sexuality—produces a subjectivity marked by disconnection, low self-esteem, anxiety, and difficulty in self-confidence (Lane, 1999; Brown, 2019). Female identity, shaped by limiting roles and hegemonic discourses, becomes restricted, reinforcing the internalization of patriarchal norms (Beauvoir, 1949; Butler, 1990).

The rescue of these powers involves self-knowledge and practices of collective resistance. Reconnecting to cyclicity can involve body awareness, taking care of one's own rhythms, and valuing emotional experience; ancestry is rescued through women's circles, oral histories, community rituals, and intergenerational dialogues (Julieta Paredes; Gonzalez, 1984; Anzaldúa, 1987); sexuality can be celebrated as a creative and transformative energy, breaking taboos and resignifying female pleasure and creativity (Lorde, 2019).

In addition, the deepening of the analysis requires an intersectional perspective: black, indigenous, and peripheral women face specific forms of marginalization that articulate gender, race, and class (hooks, 2000; Ribeiro, 2017; Lugones, 2008). Recognizing these multiple layers of oppression is essential to understanding the diversity of experiences and strategies of resistance of the feminine.

In this context, self-knowledge is not just an individual exercise, but a political and transformative act. It allows the identification and questioning of internalized norms, reconstructing one's own narratives, and integrating individual and collective history,

promoting authenticity, freedom, and creativity (Lane, 2000; Brown, 2019). When women know each other deeply, they are strengthened not only personally, but collectively, inspiring others and opening paths to a more just and egalitarian society, in which female subjectivity can flourish in its entirety.

2.1 THE DOMESTICATED FEMININE AND THE FRAGMENTATION OF SUBJECTIVITY

Female subjectivity was historically constructed from unequal power relations, which shaped behaviors, desires, and ways of being over time. Silvia Lane (2000) argues that psychological phenomena cannot be understood in isolation, as they emerge from social, cultural and historical contexts. The feelings of inadequacy, anxiety or low self-esteem that many women experience are not only individual, but reflections of internalized collective processes, which cross their histories, bodies and social relationships.

To be or not to be? It is the great moral question. What will be its ethical equivalence? 'Why are we what we are?' And the answer lies in the conception of the human being that we have adopted: we can be mere creatures at the mercy of superior forces, or we can become subjects of the History of our society, that is, capable of deciding on which ethical values will guide our actions and interactions. (LANE, 2000, p.68)

Oppression over the feminine also acts through silencing. Audre Lorde (2019) emphasizes that when women do not have space to express emotions, desires, or narratives, they internalize symbolic violence and distance themselves from their creative force. The imposed silence is not neutral; It serves as a mechanism for maintaining patriarchal power, reinforcing external norms and expectations that domesticate the feminine. For Lorde, transforming silence into language and action constitutes a revolutionary act, essential for the reconstruction of women's identity and personal power.

The fragmentation of subjectivity is, therefore, a structural phenomenon. It is not just about individual experiences of self-criticism or insecurity, but about an ongoing process of domestication of the feminine, in which women are shaped to correspond to external standards and demands, often internalized as obligatory or natural. This internal disconnection makes the woman perceive herself mainly through the eyes of the other, constantly seeking external validation and moving away from her own authenticity and autonomy (Brown, 2019; Butler, 1990).

In addition, fragmentation is intensified by historical and cultural factors that devalue cyclicity, ancestry, and sexuality. Women are taught, from an early age, to suppress

emotions, regulate behaviors and meet linear expectations of productivity, beauty and sociability, while ancestral knowledge, care practices and creativity are relegated to silence (Anzaldúa, 1987; hooks, 2000). This configuration contributes to the construction of a subjectivity that does not fully recognize its creative, ethical, and relational potential, making it difficult to integrate experiences and form a solid and autonomous identity.

Understanding female subjectivity as the result of social and historical processes of domination is fundamental to think about strategies to rescue authenticity, autonomy and internal power. Breaking the cycle of silencing and domestication requires, in addition to self-knowledge, collective and cultural practices that value the expression, creativity, and ancestry of the feminine, enabling each woman to recognize herself as a full subject and agent of her own history (Lorde, 2019; Ribeiro, 2017; Lugones, 2008).

2.2 THE LIQUID SOCIETY AND THE (PRE)OCCUPATIONS OF CONTEMPORARY LIFE

Nowadays, there is a social model characterized by the fluidity and instability of relationships, in which individuals are constantly pressured by external and internal expectations. According to Bauman (2001, p. 25), "The individual submits to society and this submission is the condition of his liberation."

The author describes this context as liquid modernity, in which bonds, values, and identities are fragile, transitory, and constantly reconfigured. In this scenario, women face specific challenges: they are called upon to play multiple roles — professional, maternal, marital, social — that are often contradictory, which causes inadequacy, anxiety and emotional exhaustion. This overload is intensified by historical patriarchal structures, which have shaped gender roles and limited the full expression of female subjectivity (Lorde, 2019; Lane, 2000; hooks, 2000).

The construction of female identity, therefore, is deeply rooted in historical, economic, and political conditions. Understanding gender oppression only as an individual experience is insufficient; it is necessary to recognize its collective dimension. Feelings of inadequacy, perfectionism, and self-criticism are largely products of systems that legitimize inequalities, not women's personal failings.

In this context, many women live in a constant state of (pre)occupation — occupied in advance — either with past pain, which feeds resentment or depressive states, or with anxieties projected into the future. The absence of full presence in the "here and now" makes

it difficult to connect with one's own authenticity and strengthens patterns of self-sabotage and extreme demand. Lane (2000, p. 66) points out:

In everyday life, emotions should be repressed, as they disturb rationality and psychological health. Conscience was saved. Talking, demonstrating, convincing, should be the invincible weapons of the human being.

This dynamic is closely linked to historical and cultural structures that define gender roles and shape female identities to serve the other rather than herself. As Bauman (2001) observes, class and gender significantly influenced the options available to each person; breaking through these barriers was not much simpler than challenging the assigned position in the 'divine hierarchy of being' prior to modernity. Thus, for all intents and purposes, class and gender were considered 'natural aspects', and the mission of many individuals was to 'adjust' to the assigned space, acting in accordance with others who were there.

The risk of the "single story", as Chimamanda Ngozi Adichie (2014, p.13) warns, reinforces this precariousness of identity:

I realized that I had been so immersed in the media coverage of Mexicans that they had become one thing in my mind: the abject immigrant. I had believed in the unique story of the Mexicans and I was ashamed of it. This is how a unique story is created: show a people as one thing, one thing, without stopping, and that is what this people becomes.

When only one narrative about what it means to be a woman prevails, other ways of existing are made invisible, reinforcing the fragmentation of identity and the internalization of normative standards.

Self-knowledge, in this context, becomes a political act. Lane (2000) emphasizes that overcoming states of (pre)occupation does not occur only through individual strategies, but through a critical understanding of the social forces that produce them. Recognizing the historical and collective origin of fears, anxieties, and frustrations allows women to articulate political awareness and self-perception, promoting integration between personal experiences and social structures.

Audre Lorde (2019) reinforces that breaking with oppressive narratives and recognizing erotic power are essential strategies for resistance and identity reconstruction.

The silence imposed on women is a tool for maintaining patriarchy; transforming it into conscious action makes it possible to affirm autonomy, creativity and authenticity.

Thus, living in liquid modernity implies unique challenges for women: dealing with social fluidity, the multiplicity of roles, the demand for performance and the pressure for constant belonging. At the same time, it represents an opportunity to resignify identities, question internalized norms, and reconstruct personal and collective narratives based on self-knowledge and critical awareness (Bauman, 2001; Lorde, 2019; Lane, 2000; Adichie, 2014).

3 OBJECTIVES

3.1 GENERAL OBJECTIVE

To investigate how self-knowledge, articulated with the rescue of ancestry, cyclicity and sexuality/creativity, contributes to authenticity and liberation of female subjectivity.

3.2 SPECIFIC OBJECTIVES

1. To analyze how the historical marginalization of these three powers impacts women's self-esteem, identity, and personal power.
2. Investigate how self-knowledge practices can promote the integration of these powers, strengthening autonomy, self-confidence and authenticity.
3. Discuss symbolic and practical strategies for self-occupation, including reconnection with ancestry, cyclical rhythms, and creative/sexual expression.
4. Reflect on the relevance of collective spaces, such as women's circles, to enhance experiences of self-knowledge and autonomy.

4 METHODOLOGY

The present study was developed from a qualitative bibliographic research, with a critical and interpretative focus, aiming to understand the historical construction of female subjectivity and the impacts of the marginalization of essential aspects of the feminine, such as cyclicity, ancestry and sexuality/creativity.

4.1 JUSTIFICATION OF THE QUALITATIVE APPROACH

The qualitative approach was chosen because it enables the in-depth analysis of complex phenomena, allowing the understanding of experiences, meanings and historical processes that cannot be reduced to quantitative data. This approach is appropriate to

investigate how social, cultural, and political discourses shape women's perceptions of themselves, their bodies, and their relationships with the world, as well as allowing the identification of paths of resistance and empowerment.

4.2 CRITERIA FOR SELECTING WORKS

The selection of works considered authors who address:

- History and social construction of female subjectivity (Silvia Lane, Foucault, Bauman);
- Creative expression and sexuality as dimensions of female power (Audre Lorde, Brené Brown);
- Narratives and ancestry as elements of resistance and rescue of identity (Chimamanda Ngozi Adichie, bell hooks, Maria Lugones, Gloria Anzaldúa);
- Contemporary context and liquid modernity (Bauman, Ortega).

Priority was given to works that enable an integrated analysis between past and present, considering how historical processes influence women's individual and collective experiences in contemporary times.

The methodological procedure adopted involved:

1. Critical and systematic reading of the selected works, identifying key concepts about power, identity, subjectivity, silencing and female self-knowledge;
2. Registration and thematic organization of contents, separating information related to cyclicity, ancestry and sexuality/creativity;
3. Interpretative analysis, relating theoretical concepts to the contemporary context, with attention to the influence of cultural, social and political discourses on women's lives;
4. Critical synthesis, integrating different theoretical perspectives to build a comprehensive understanding of the impacts of the marginalization of the three powers of the feminine and the paths of rescue through self-knowledge;
5. Articulation between theory and practice, with emphasis on proposals that allow the reconstruction of female identity and the strengthening of autonomy, authenticity and self-occupation.

This approach allowed us to develop an in-depth, sensitive and contextualized analysis, respecting the complexity of women's experiences and the diversity of experiences and identities.

The study, therefore, is not limited to reflecting on the historical and social impacts on the construction of female subjectivity, but seeks to propose concrete paths for the reintegration of cyclicity, ancestry and sexuality/creativity. Self-knowledge is understood as a continuous process of liberation, expression and reconstruction of oneself, integrating individual, collective and political dimensions of the female experience.

4.2.1 Authenticity and female liberation

Social narratives that devalue central dimensions of the female experience span centuries and consolidate themselves as normative discourses that define who women "can" or "should" be. This symbolic structure, transmitted through culture, education, and institutions, acts in a way that internalizes messages of inadequacy, submission, and limitation, leading to feelings of shame, insecurity, and fragmentation. Brené Brown (2019) adds that shame is a paralyzing emotion, as it prevents the authentic expression of the self and reinforces conforming behaviors, making it difficult for women to fully live their identity.

The historical marginalization of the three feminine powers—ancestry, cyclicity, and sexuality/creativity—is not only symbolic, but also emotional, physical, and spiritual. It creates a cycle of silencing and dependence, which distances women from their creative power and the sense of belonging. This distancing reveals how power relations are inscribed in the body and in subjectivity, operating not only through explicit oppression, but also through the invisible regulation of emotions and choices.

However, the constant fluidity of social expectations can be understood as both a threat and an opportunity. On the one hand, women are pressured to conform to unattainable and changeable standards; on the other hand, this same fluidity opens gaps for transformation, as long as there is an internal support supported by self-knowledge and self-awareness. In this sense, Foucault (1983; 1986) states that knowing oneself is an act of resistance, as it means unveiling the subtle forms of power that seek to govern subjectivity. Self-knowledge thus becomes a resource for contestation and reinvention.

Brown (2019) reinforces this perspective by arguing that authenticity is not limited to seeking social acceptance, but to having the courage to show oneself vulnerable and truthful, even in the face of the risk of rejection. When women take care of themselves, they break with the imprisonment of external expectations and free themselves from narratives that do not belong to them. This liberation does not mean the absence of conflict or pain, but the ability to sustain choices aligned with one's own essence, even in adverse contexts.

In a liquid and fragmented society, as Bauman (2001) points out, authenticity becomes a revolutionary act. Finding an inner core of stability is essential to resist external pressures and maintain the integrity of one's existence. For women, this core can be strengthened by the integration of the three feminine powers, which offer a symbolic and practical basis for building a meaningful, authentic, and creative life.

At this point, Audre Lorde's reflection (2019, p. 69) broadens the debate by denouncing the logic of systems that value profit to the detriment of human needs:

The greatest horror of any system that defines what is good in relation to profit rather than human needs, or that defines human needs from the exclusion of the psychic and emotional components of those needs—the greatest horror of such a system is that it robs our labor of its erotic value. its erotic power and the charm for life and fulfillment.

Lorde introduces erotic power as a vital dimension that rescues the value of subjective experience and the joy of existing, connecting authenticity with vitality and enchantment.

Identity, in this process, must be understood as a living organism, in constant movement, which is transformed into cycles of life, death and rebirth. Silvia Lane (2000) emphasizes that identity is constituted in the social roles we play and is reinvented in the relationship with the other, because there is no "me" without "us". Thus, women can only recognize themselves in their entirety in the encounter with others — especially in collectives that legitimize their voice.

The plurality of narratives, as Chimamanda Ngozi Adichie (2015) reminds us, is fundamental to break stereotypes and expand the possibilities of existence:

Start the story with the arrows of the Native Americans, rather than the arrival of the British, and the story will be completely different. Start history with the failure of the African state, and not with the colonial creation of the African state, and history will be completely different. (ADICHIE, 2015, p.14)

This alert invites us to retell women's stories from their own references, recovering silenced voices and recognizing the multiple ways of being and existing.

Self-knowledge, therefore, emerges as the guiding thread of the occupation of oneself, understood as the ability to fully inhabit one's own existence with authenticity and autonomy. Such a process is not lonely; It is rooted in collective practices, such as women's circles,

which function as spaces for welcoming, sharing, and mutual recognition. In an exponential way, this ancestral and accessible practice allows a woman to recognize herself in the speech of the other, breaking subjective isolations and resignifying individual pains as collective experiences.

In this way, promoting self-knowledge is not only a strategy for personal development, but a political act that confronts historical structures of marginalization. By integrating ancestry, cyclicity and sexuality/creativity, women reconnect with their power, reframe their trajectory and expand the collective field of female emancipation. This reconnection not only strengthens subjectivities, but also fuels the struggle for equity and social justice, transforming the private into the political and the individual into the collective.

4.3 TAKING CARE OF ONESELF: SELF-KNOWLEDGE AS AN ACT OF LIBERATION

The concept of taking care of oneself proposes that the woman turns inwards, recognizing and inhabiting her own internal dimensions. It is not about isolation, but about reintegration, in which she becomes an active subject of her own history. This movement implies breaking with the external concerns that fragment it, recovering its presence in the here and now and rescuing the sense of authenticity.

Contemporary women, often burdened by multiple demands, find themselves torn between caring for others and maintaining tasks that are often not theirs. The romanticization of this accumulation — as if constant overcoming were proof of value — ends up displacing it from its own essence, generating feelings of loss of identity. The incessant search for recognition and love through productivity and perfection reinforces the alienation from the self.

Taking care of oneself, therefore, means ceasing to live according to external expectations and acting in line with one's internal values and desires. For Brené Brown (2019, p. 75):

We cultivate love when we allow our most vulnerable and powerful selves to be fully seen and known, and when we honor the spiritual connection that arises from that action with trust, respect, kindness, and affection.

This process is also political. Audre Lorde (2019) reminds us that self-care is not a luxury, but an act of resistance in a world that has historically devalued the feminine.

Prioritizing one's own emotional, physical, and spiritual integrity breaks with patriarchal logic, transforming the search for authenticity into a collective practice of social transformation:

For women, the need and desire to care for one another is not pathological, but redemptive, and it is in this knowing that our true power is rediscovered. (...) Only in a patriarchal structure is motherhood the only social power available to women. (LORDE, 2019, p. 136)

Lorde, a scathing critic of hegemonic white feminism, highlighted how black women have historically been excluded from the movement's central agendas. While white women struggled for political recognition and access to the market, black women never had the possibility of not working: they took care of other women's children while seeing their own being neglected. This structural inequality is still repeated today, perpetuating an invisible cycle of exploitation. In this sense, to take care of oneself is also to rescue collective memories of oppression, to claim marginalized voices, and to reconstruct historical trajectories.

From the perspective of archetypal female psychology, Clarissa Pinkola Estés (1999) describes this process as individuation: the integration of the conscious and unconscious aspects of the psyche. It is about recognizing and welcoming rejected or hidden parts, integrating them into a fuller identity.

For Estés (2007, p. 21),

a woman's soul is older than time and her spirit is eternally young." Thus, intuition, creativity and sexuality — historically repressed — need to be rescued as vital dimensions of being.

In the same direction, Foucault (1983; 1986) understands self-care as an ethical and political practice that transforms the subject into an active agent in the production of one's own life. It is not an individualistic movement, but a way of recognizing the interdependence between the self and the collective.

To take care of oneself also means to free oneself from temporal traps: resentments that imprison in the past and anxieties that project fears into the future. Mindfulness practices, for example, allow you to reduce these emotional states and strengthen well-being. Silvia Lane (2000) adds that individual transformation has collective implications: when a woman

frees herself from limiting narratives, she opens paths for others, making the personal inseparable from the political.

Therefore, taking care of oneself is a process of liberation that breaks with toxic productivity and patriarchal imperatives of perfection. Promoting self-knowledge based on the three feminine powers — ancestry, cyclicity and sexuality/creativity — reveals itself as a way to rescue authenticity and reorganize priorities for a healthy life in its biopsychosocial dimensions.

4.4 THE OCCUPATION OF ANCESTRY

Many women grew up with the feeling that their story starts from scratch, with no affective heritage, no guide and no bonds. However, female ancestry holds wisdom and strength that await to be claimed. Reconnecting to this lineage means resuming references, belonging, and continuity.

For Silvia Lane (2000), the loss of connection with ancestry contributes to feelings of alienation, low self-esteem and existential emptiness. Audre Lorde (2019) reinforces that recognizing one's own heritage strengthens identity and sustains resistance in the face of oppressive social norms.

Ancestry works, therefore, as a vital resource of wisdom, identity and resistance. It offers women a symbolic ballast that strengthens their subjectivity and guides conscious and authentic choices. In dialogue with Bauman (2001), it can be stated that, in liquid and unstable societies, ancestry acts as an anchor, helping to maintain stability and meaning in the midst of contemporary fragmentation.

Valuing ancestry is, therefore, recovering historical and cultural ties that nurture courage, creativity and authenticity. It is not a nostalgic return to the past, but a critical and vital reintegration, which strengthens autonomy and resignifies the place of women in history.

4.5 THE OCCUPATION OF CYCLICITY

Contemporary social logic associates value with linearity and constancy. Producing without pause is seen as a sign of success, but this expectation collides with the cyclical nature of the feminine. Denying this dimension leads many women to illness — physical, psychic and emotional.

Cyclicity refers to the awareness of the internal and natural rhythms of the body and mind, allowing self-regulation and emotional balance (ESTÉS, 1992). The marginalization of

female cycles — menstrual, emotional, or energetic — generates anxiety, exhaustion, and disconnection from oneself. When recognized and integrated, cyclicity allows women to harmonize their energies, make more conscious decisions, and recognize their power of choice.

This recognition goes beyond the biological dimension. It is also a question of resistance to biopower (FOUCAULT, 1983; 1986), which regulates bodies and behaviors according to standards of productivity and health. By embracing their cycles — of creation, introspection, planning, execution and rest — women resume the management of their own vital energy, defying social impositions.

The medicalization of the menstrual cycle, often celebrated as freedom, also served as a way of adapting to male constancy and the labor market. Pharmacological control, in addition to suppressing symptoms, erased the moments of introspection and recollection characteristic of the female body. This suppression reveals not only a disregard for biology, but a denial of cyclical wisdom.

Recognizing and exploring each phase of the cycle, on the contrary, can enhance health and creativity. By rescuing her cyclicity, the woman reconnects with her vital energy, strengthening processes of healing, transformation and fulfillment.

4.6 THE OCCUPATION OF SEXUALITY AND CREATIVITY

Sexuality and creativity are expressions of life force, personal power, and the ability to manifest. This energy, which symbolically pulsates in the womb, is the source of both human life and dreams and projects. When repressed, it produces emptiness, inertia, and purposelessness.

Social norms and institutions—such as family, church, and community—have historically repressed this potency, reducing sexuality to moral control and detaching it from its creative dimension. As Foucault (1986) reminds us, sexuality is crossed by strategies of power and disciplining, especially over female bodies.

Audre Lorde (2019) claims erotic power as a vital force that is often hidden or vulgarized. For her, rescuing this power means not only experiencing pleasure, but also expanding creative capacity, directing energy to the realization of projects and the transformation of reality.

The repression of female sexuality, however, is deeply associated with the maintenance of the patriarchal order: on the one hand, morality and good customs are

preached; on the other hand, freedom is associated with the vulgarization and objectification of women. This split prevents sexuality from being understood as a source of authenticity, pleasure and creation.

Reestablishing a positive and responsible awareness of sexuality is therefore fundamental for the reconstruction of female identity. Rites of passage, such as those practiced in ancestral cultures at the time of menarche, reveal how the body already contains within itself the wisdom of self-knowledge. Recovering this knowledge and re-signifying sexuality as a creative energy allows women to inhabit their own lives in a full, authentic and transformative way.

To summarize the reflections presented in chapters 6.1 to 6.4, we have prepared a comparative table that brings together the main challenges, rescue strategies and potentialities associated with the three feminine powers — ancestry, cyclicity and sexuality/creativity. The schematic organization facilitates the understanding of how each dimension, when historically silenced, impacts female subjectivity, and how, when rescued, it opens the way for the construction of authenticity and liberation.

Table 1

The three feminine powers and self-knowledge as an act of liberation

Girl Power	Historical Challenges	Rescue Strategies	Potentialities for Authenticity
Ancestry	-Rupture with the female lineage and erasure of women's history. -Invisibilization of the experiences of black, indigenous and peripheral women. -Alienation and loss of symbolic references.	-Rescue family and collective stories. -Value plural and intercultural narratives. -Reconnect with traditions, rites and knowledge transmitted by previous generations.	-Sense of belonging and continuity. -Strengthening of collective identity and resistance. -Courage and confidence to face contexts of social fragmentation.
Cyclicity	-Imposition of a linear logic of productivity. -Medicalization and suppression of natural cycles.	- Recognize body and emotional rhythms. - Practice self-knowledge through the observation of	- Harmonization of internal energies. - Improved physical, emotional, and mental health. - Ability to live

	-Stigmatization of menstruation and phases of recollection.	the cycle. -Value moments of introspection and rest as part of healthy productivity.	according to one's own rhythm, enhancing creativity and well-being.
Sexuality / Creativity	- Moral and religious repression of female sexuality. - Reduction of the female body to an object of desire and control. -Exclusion of the erotic dimension as a source of creative power.	-Resignify sexuality as vital and creative energy. - Recognize erotic power as a source of pleasure and fulfillment. - Promote emancipatory sex education and rites of passage for valuing the body.	- Reconnection with the body as a territory of pleasure, wisdom and expression. -Release of creativity and vital power. - Construction of an authentic identity based on desire, freedom and self-love.

Source: Authors.

Reading the picture allows us to observe that, although each power has specificities, they all converge to the same dynamic: patriarchal oppression has produced fragmentation and weakening of female identity, while the rescue of these dimensions strengthens autonomy, creativity and belonging.

It is also noted that the three powers mutually support each other. Ancestry provides roots and collective memory; cyclicity promotes balance between action and recollection; Sexuality/creativity drives pleasure, art, and transformative power. Integrated, they constitute a solid basis for women to occupy themselves with freedom, authenticity and resilience.

Thus, the table not only summarizes the main points, but also highlights the interdependence between the three powers, reinforcing the idea that female emancipation requires both the individual work of self-knowledge and the construction of collective practices of support and recognition.

5 FINAL CONSIDERATIONS

This study sought to understand how the historical marginalization of cyclicity, ancestry and sexuality/creativity impacts female subjectivity, limiting the construction of an authentic identity and weakening women's autonomy. The analysis of the theoretical references showed that these three powers were systematically silenced over time through social, cultural and religious structures that normalized bodies and behaviors, as discussed

by Foucault (1983; 1986). This silencing is not restricted to the collective level, but crosses emotional and psychological dimensions, producing narratives of shame, inadequacy, and disconnection, as Brown (2019) and Lane (2000) point out.

Patriarchal society has imposed a domesticated feminine standard, in which women are taught to be useful, docile and available to others, but not to themselves. We learn to care for, nurture, and sustain the dreams of others, without being allowed to recognize our own desires, limits, and needs. In this model, feminine attributes such as intuition, sensitivity, cyclicity, sensuality, and creativity have historically been associated with weakness, sin, or irrationality. In search of some social prestige, many women felt compelled to distance themselves from the feminine, trying to reproduce masculine patterns of existence.

This distancing, however, represented an internal split. As Estés (1992) states, the disconnection of one's own blood, womb and instinctive nature led to the repression of pleasure, art, intuition and creative power. The feminine has been reduced to the reproductive function or to the role of caregiver, when, in its essence, it constitutes a power of life, a portal of existence and a source of nutrition. Women were simultaneously idealized as saints or demonized as witches and wantons, but rarely recognized as whole, divine, and potent beings in their entirety.

Given this scenario, the rescue of the three powers represents a movement of reconnection and liberation. Cyclicity, when recognized, allows a more harmonious life with the rhythms of the body and emotions. Ancestry, when rescued, strengthens bonds of belonging and resignifies fragmented histories. Sexuality/creativity, when rescued, gives back to women the ability to express pleasure, desire and transformative power. The rescue of these aspects strengthens self-esteem, freedom of expression and the ability to lead one's own life. As Chimamanda Ngozi Adichie (2014) reminds us, "power is the ability not only to tell another person's story, but to make it their definitive story".

Self-knowledge emerges, in this process, as a central tool for self-occupation. To know oneself is to resist. It is to refuse the mechanisms of control and oppression that have shaped female subjectivity throughout history. Foucault (1983; 1986) argues that this movement is, in itself, a political act, as it challenges power structures. Brown (2019) adds that authenticity does not consist of pleasing or being accepted, but of assuming the vulnerability of showing oneself true, even in the face of the risk of rejection. Thus, self-knowledge is not only individual: it expands the boundaries of subjectivity and becomes social transformation.

In this sense, the collective dimension is equally fundamental. Group practices, especially women's circles, are configured as low-cost and high-power therapeutic and political spaces, in which empathetic listening, sharing and solidarity create a network of support and resignification. In this environment, each story narrated reverberates in the collective, freeing not only the woman who speaks, but also the one who listens. It is an ancestral movement of resistance, which reaffirms identity and strengthens the sense of community.

It is concluded, therefore, that the rescue of cyclicity, ancestry and sexuality/creativity is not only an individual process of self-discovery, but an act of resistance in the face of the patriarchal system that has historically marginalized these aspects of the feminine. Promoting their integration means promoting emotional health, belonging, creative power, and social emancipation.

When a woman takes care of herself, she not only transforms her own life, but becomes an agent of collective transformation, inspiring and opening paths for other women to also recognize and flourish. Thus, the reintegration of the sacred and profane, creative and instinctive, rational and sensitive feminine constitutes one of the most potent strategies of individual and collective emancipation, reaffirming that true freedom begins in consciousness and expands in the community.

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SIMPLE CONTINGENCY ANALYSIS, PARALLEL COMPENSATION, AND DETERMINATION OF THE LOADING MARGIN IN TRANSMISSION LINES**ANÁLISE DE CONTINGÊNCIA SIMPLES, COMPENSAÇÃO PARALELA E DETERMINAÇÃO DA MARGEM DE CARREGAMENTO EM LINHAS DE TRANSMISSÃO****ANÁLISIS DE CONTINGENCIA SIMPLE, COMPENSACIÓN EN PARALELO Y DETERMINACIÓN DEL MARGEN DE CARGA EN LÍNEAS DE TRANSMISIÓN** <https://doi.org/10.56238/sevened2025.037-028>**Bruna Pontes Cechinel¹, Cristiane Lionço de Oliveira², Evandro André Konopatzki³,
Filipe Marangoni⁴, Katiani Pereira da Conceição⁵****ABSTRACT**

The electrical system needs to be reliable and capable of withstanding contingencies to guarantee energy demand without overloading electrical equipment. In this research, the voltage stability of the STB-33 test system was analyzed in three situations: base case, after simple transmission line contingency simulation, and after applying parallel compensation in cases of contingency with voltage violations. The ANAREDE software was used to simulate contingencies and seek solutions using the Newton-Raphson method, discarding cases where line removal would cause isolation of network elements, resulting in 26 simulated contingency cases. Seven cases did not obtain an initial solution for the load flow, mainly in area A, which is not able to supply its demand alone, resulting in an exchange of energy with area B. As a means of forcing a solution to the load flow, three methods were used: turning off the ANAREDE controls, representing the load at 75% active power, and defining the buses that interconnect the contingency lines as a reference. The last option resulted in the convergence of all cases and the lowest severity indices. These cases were disregarded in the compensation studies due to simplifications to achieve convergence. Contingency cases with flow violations in the lines are mainly in area B, where area A imports energy due to its demand exceeding supply. Cases with voltage violations in the busbars are mostly found in area A, as the buses in this area are unable to support all their demand, resulting in voltage drops. For these cases, parallel compensation was applied, which is important for controlling reactive power in the network and improving the performance of transmission lines. Therefore, FLUPOT was used to perform the optimal power flow calculations, determining the amount of reactive power to be allocated and the buses that should receive parallel compensation. Cases 18 and 22 were chosen to receive compensation due to their high

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severity indices, where the compensation proved effective, recovering the voltages of the contingent and peripheral busbars. Voltage stability studies identify vulnerable points in the system, and a common method is the PV curve. Using the continuation method through ANAREDE to determine the PV curve and analyze the load margin of cases 18 and 22, a load increase of 0.2% was performed. Some buses did not remain stable in terms of voltage, even after compensation. These buses are considered critical because they presented undervoltage during emergencies. The base case had the highest load margin and voltage safety margin, respecting the minimum limit pre-established by ONS, of 7% for complete systems. Cases 18 and 22, after the contingency, presented a load margin and voltage safety margin below the 4% limit, which is the minimum limit for incomplete systems. After compensation, cases 18 and 22 had an increase in load and voltage indices, with a safety margin of 4.8446% for case 18 and 6.2976% for case 22.

Keywords: Electrical Power Systems. Electrical Power Transmission. Stability. Electrical Energy.

RESUMO

O sistema elétrico precisa ser confiável e capaz de suportar contingências para garantir a demanda de energia sem sobrecarga em equipamentos elétricos. Nesta pesquisa, foi analisada a estabilidade de tensão do sistema-teste STB-33 em três situações: caso base, após a simulação de contingência simples de linhas de transmissão e após a aplicação da compensação paralela nos casos de contingência com violações de tensão. Foi utilizado o software ANAREDE para simular as contingências e buscar soluções utilizando o método de Newton-Raphson, descartando casos em que a retirada da linha causasse isolamento de elementos da rede, o que resultou em 26 casos de contingência simulados. Sete casos não obtiveram solução inicial para o fluxo de carga, principalmente na área A, que não é capaz de suprir sua demanda sozinha, o que resulta em um intercâmbio de energia com a área B. Como meio de forçar a solução do fluxo de carga, foram utilizados três métodos: desligamento dos controles do ANAREDE, representação da carga em 75% de potência ativa e a definição das barras que interligam as linhas contingenciadas como referência. A última opção resultou na convergência de todos os casos e nos menores índices de severidade. Esses casos foram desconsiderados nos estudos de compensação devido a simplificações para obter a convergência. Os casos de contingência com violações de fluxo nas linhas estão principalmente na área B, onde a área A importa energia devido à sua demanda maior que o fornecimento. Já os casos com violação de tensão nos barramentos se encontram, em sua maioria, na área A, pois as barras dessa área não são capazes de suportar toda a sua demanda, resultando em quedas de tensão. Para esses casos, foi aplicada a compensação paralela, importante para controlar a potência reativa na rede e melhorar o desempenho das linhas de transmissão. Sendo assim, foi utilizado o FLUPOT para realizar os cálculos do fluxo de potência ótimo, determinando a quantidade de reativos a serem alocados e as barras que devem receber a compensação paralela. Os casos 18 e 22 foram escolhidos para receber a compensação devido aos seus altos índices de severidade, onde a compensação se mostrou eficaz, recuperando as tensões dos barramentos contingenciados e periféricos. Estudos de estabilidade de tensão identificam pontos vulneráveis do sistema, e um método comum é a curva PV. Utilizando o método da continuação através do ANAREDE para determinar a curva PV e analisar a margem de carregamento dos casos 18 e 22, foi realizado um acréscimo de carga de 0,2%. Algumas barras não se mantiveram estáveis em termos de tensão, mesmo após a compensação. Essas barras são consideradas críticas, pois apresentaram subtensão em emergências. O

caso base teve a maior margem de carregamento e margem de segurança de tensão, respeitando o limite mínimo preestabelecido pela ONS, de 7% para sistemas completos. Os casos 18 e 22, após a contingência, apresentaram margem de carregamento e margem de segurança de tensão abaixo do limite de 4%, que é o limite mínimo para sistemas incompletos. Após a compensação, os casos 18 e 22 tiveram aumento nos índices de carregamento e tensão, com uma margem de segurança de 4,8446% para o caso 18 e de 6,2976% para o caso 22.

Palavras-chave: Sistemas de Energia Elétrica. Transmissão de Energia Elétrica. Estabilidade. Energia Elétrica.

RESUMEN

El sistema eléctrico debe ser fiable y capaz de soportar contingencias para garantizar el suministro de energía sin sobrecargar los equipos. En esta investigación, se analizó la estabilidad de tensión del sistema de prueba STB-33 en tres situaciones: caso base, tras una simulación simple de contingencia en la línea de transmisión y tras aplicar compensación en paralelo en casos de contingencia con violaciones de tensión. Se utilizó el software ANAREDE para simular las contingencias y buscar soluciones mediante el método de Newton-Raphson, descartando los casos en los que la desconexión de la línea provocaría el aislamiento de elementos de la red, lo que resultó en 26 casos de contingencia simulados. En siete casos no se obtuvo una solución inicial para el flujo de carga, principalmente en el área A, que no puede abastecer su demanda por sí sola, lo que provoca un intercambio de energía con el área B. Para forzar una solución al flujo de carga, se utilizaron tres métodos: desactivar los controles de ANAREDE, representar la carga al 75 % de potencia activa y definir los buses que interconectan las líneas de contingencia como referencia. Esta última opción resultó en la convergencia de todos los casos y los índices de severidad más bajos. Estos casos se omitieron en los estudios de compensación debido a las simplificaciones necesarias para lograr la convergencia. Los casos de contingencia con violaciones de flujo en las líneas se concentran principalmente en el área B, donde el área A importa energía debido a que su demanda supera la oferta. Los casos con violaciones de tensión en las barras colectoras se encuentran mayormente en el área A, ya que las barras en esta área no pueden soportar toda su demanda, lo que provoca caídas de tensión. Para estos casos, se aplicó compensación en paralelo, lo cual es importante para controlar la potencia reactiva en la red y mejorar el rendimiento de las líneas de transmisión. Por lo tanto, se utilizó FLUPOT para realizar los cálculos óptimos de flujo de potencia, determinando la cantidad de potencia reactiva a asignar y las barras que debían recibir compensación en paralelo. Los casos 18 y 22 se seleccionaron para recibir compensación debido a sus altos índices de severidad, donde la compensación resultó efectiva, recuperando las tensiones de las barras colectoras contingentes y periféricas. Los estudios de estabilidad de tensión identifican los puntos vulnerables del sistema, y un método común es la curva PV. Utilizando el método de continuación a través de ANAREDE para determinar la curva PV y analizar el margen de carga de los casos 18 y 22, se realizó un incremento de carga del 0,2%. Algunos buses no mantuvieron la estabilidad de tensión, incluso después de la compensación. Estos buses se consideran críticos debido a que presentaron subtensión durante las emergencias. El caso base presentó el mayor margen de carga y margen de seguridad de tensión, respetando el límite mínimo preestablecido por la ONS del 7% para sistemas completos. Los casos 18 y 22, tras la contingencia, presentaron un margen de carga y un margen de seguridad de tensión inferiores al límite del 4%, que es el límite mínimo para sistemas incompletos. Después de la compensación, los casos 18 y 22 experimentaron un incremento en los

índices de carga y tensión, con un margen de seguridad del 4,8446% para el caso 18 y del 6,2976% para el caso 22.

Palabras clave: Sistemas de Energía Eléctrica. Transmisión de Energía Eléctrica. Estabilidad. Energía Eléctrica.

1 INTRODUCTION

Currently, the geographic area occupied by the country is growing rapidly and unevenly for economic and environmental reasons. The expansion of the physical structure of the National Interconnected System (SIN) does not proportionally follow the additional demand caused by the activities of a growing population. In this scenario, the electrical system, which previously operated maintaining energy transfer without loss of voltage stability, now operates at the safety limit to fully satisfy the energy needs of consumers (PINTO, 2013; COELHO, 2018).

There are several studies that allow keeping the power grid stable and in good working order, involving the management and implementation of strategies to repair disturbances in power transmission, verifying the state of operation of the grid and whether its performance is adequate. Through Submodule 23.3 of the Network Procedures, the National Electric System Operator (ONS) has responsibilities and elaborates guidelines and criteria to be implemented in electrical studies (ONS, 2018).

The system's security analysis integrates the verification of the behavior of the electrical network in the face of the loss of elements, such as busbars, generators and transmission lines (LT), detecting areas at risk of blackouts and enabling their prevention. The contingency analysis verifies situations immediately after the shutdown of one or more elements of the grid, observing changes in the operational characteristics of the Electric Power System (SEP). These contingencies can be simple, or N-1 criterion, where the analysis is made from the disconnection of a single element, or multiple, where more than one element is disconnected at the same time, and may follow N-2, N-3 and so on criteria (DELGADO, 2019).

From a contingency, there may be voltage instabilities in the system's busbars and, with this, the need for studies aimed at monitoring this parameter arises. The loading margin makes it possible to assess the imminence of voltage drops, making it possible to analyze the voltage of the system under normal operating conditions and in the face of a disturbance (ZEFERINO, 2011).

One way to analyze SEP voltage is by determining the PV curve. This method makes it possible to observe the voltage level in a bar as the active power increases, allowing the observation of voltage variation in various operating situations. The most used means to delimit this curve is the continuation method, or Continuous Charge Flow (FCC), which,

through successive load increments, makes it possible to find solutions for the flow of power at the Maximum Loading Point (PMC) (DELGADO, 2019).

Another situation that can lead the electrical system to voltage instability is the lack of control of reactive in the network. In this aspect, parallel reactive compensation becomes a more economically viable alternative, establishing a better system performance and control of operational parameters (CHAVES, 2007).

In order to improve the voltage profile of the busbars, it is sought to determine the best places for the application of compensation and the most appropriate amount of reagents to be allocated, performing analyses through the Optimal Power Flow (FPO), which is common in studies aimed at managing the operation in the face of disturbances (ONORIO, 2022). According to Dahlke (2010), the calculation of the FPO consists of obtaining the optimal operating point of a SEP, meeting a group of constraints, seeking to improve some performance index.

At the national level, the Optimal Power Flow Program (FLUPOT), developed by the Electric Energy Research Center (CEPEL), which seeks to optimize a pre-established objective function through selected controls (CEPEL, 2018), is widely used. Regarding contingency analysis, CEPEL has the Network Analysis Program (ANAREDE), which makes it possible to carry out several studies, such as simulations of the occurrence of contingencies, that is, the output of various elements of the network, seeking a new solution for the flow of power and monitoring the operational state of the simulated system (CEPEL, 2011).

Problems related to voltage instabilities can occur in highly stressed systems, where a voltage collapse can be related to a deficit in the supply of reagents or to the emergence of a contingency, with the subsequent problem being the fragility of the electrical system (KUNDUR, 1994).

Thus, starting from the initial operating point of the system, the need arises to know the PMC, as it determines if the system has the capacity to maintain its voltage levels stable. A widely used method to determine the PMC is by defining the PV curve, performing successive load increments and finding new solutions for the load flow. However, the Newton-Raphson method has problems regarding its convergence as the calculated points approach the PMC, and it is necessary to find new methods to solve the problem (PINTO, 2013; DELGADO, 2019).

In order to maintain the reliability of the system and increase the resistance against contingencies, the construction of a new TL emerges as one of the alternatives, as it would increase the robustness and redundancy of the system. However, in addition to the environmental impact that can be caused by the construction of a transmission line, building a system that is totally resistant to contingencies would require a high financial investment, thus emerging the compensation of reagents as a more financially viable and effective means (PIRES, 2005; JÚNIOR, 2019).

In order to achieve an appropriate level of reliability, the electrical system must have the ability to withstand certain contingencies in order to sustain the energy demand without overloading other equipment in the system, such as transmission lines and transformers. For this reason, the SIN is designed adhering to the N-1 reliability criterion, because when a simple contingency occurs, the system must be prepared to sustain it (JÚNIOR, 2019).

Studies focused on voltage stability become extremely important, because from them it is possible to determine vulnerable points in the system. The method of determining the PV curve is one of the most used means today when it comes to analyzing the loading margin and voltage stability of the electrical system. From power flow solutions by the continuation method, it is possible to delimit the PV curve and analyze the stability of the system under normal operating conditions and in cases of contingency (DELGADO, 2019).

In order to obtain reactive control and better performance of transmission lines, whether short, medium or long, parallel compensation methods are applied in order to obtain control over the reactive power in the grid (STEVENSON, 1986).

Often, carrying out studies focused on SEP manually can be unfeasible due to mathematical complexity when it involves systems composed of a large number of elements. In Brazil, the Department of Electroenergetic Systems (DSE) develops computer programs in order to assist in studies aimed at the planning and operation of the SEP, such as ANAREDE, which is a program aimed at SEP analysis in steady state, such as load flow and contingency analysis, and also FLUPOT, which is applied in studies such as the optimal allocation of reactive power (CEPEL, 2022).

This work carried out a voltage stability analysis study in a test system under normal operating conditions, after simulations of simple contingencies of transmission lines and the application of reactive compensation, in order to first verify and, subsequently, eliminate or reduce the impacts of contingencies. The specific objectives of this work consisted of:

- Simulate contingency cases with criterion N-1 lines in the Brazilian 33-Bar Test System (STB-33) using the ANAREDE program, disregarding cases that result in islanding;
- Simulate parallel compensation in cases that result in stress violation in the bars and present the optimal connection points, through the FLUPOT program;
- Determine the PV curves of the system members under normal operating conditions, after contingencies and after reactive compensation, presenting the analysis of the stress profile of the bars and the *ranking* of the bars according to their loading margins.

2 LITERATURE REVIEW

2.1 POWER FLOW

Stevenson (1986) conceptualizes the study of power flow as the determination of voltage, current, power and power factor or reactive power in various locations of an electrical network, whether in real or ideal operating conditions. Therefore, the study of load flow becomes necessary for the increase of the system, as it covers the effects of the interconnection of new loads, generating units, transmission lines and even other systems.

The power flow study is carried out to determine the steady-state performance of electrical grids. For a given network configuration and a given load and generation condition, it is evaluated whether the voltage levels on the busbars and the loads on the lines, transformers and other components of the network meet the pre-established criteria (ONS, 2018).

Monticelli and Garcia (2011) describe the basic formulation of power flow by associating each bar of the network to four variables, where two are provided and two are unknown, as demonstrated in the **Table 1**.

Table 1

Types of bars

Bar	Given variables	Unknowns
WHY	P_K and Q_K	V_K and θ_K
PV	P_K and V_K	Q_K and θ_K
Slack	V_K and θ_K	P_K and Q_K

Source: Adapted from Monticelli and Garcia (2011, p. 206)

Where:

- V_K : magnitude of nodal tension;

- θ_K : nodal tension angle;
- P_K : net active power generation;
- Q_K : reactive power liquid injection.

To represent the load and generation bars, the bars of the PQ and PV types are used, respectively. The reference bar, slack or V θ , has two uses: to provide the reference of voltage magnitude, which is the ground itself; and close the balance of power (Monticelli; Garcia, 2011).

Specific computational means are also used to determine the power flow. At the national level, the Network Analysis Program is the most used computer program by companies, both public and private, in the generation, transmission and distribution of energy. This is a program that aims to analyze the SEP in steady state, making it possible not only to calculate the power flow, but also the continuous power flow, contingency analysis, network equivalent, voltage sensitivity analysis and active power redispatch (CEPEL, 2022).

2.2 NEWTON-RAPHSON METHOD

When it comes to nonlinear equations, the most common method of solving is the Newton-Raphson method. Based on an unknown initial estimate and using the Taylor expansion series, this method makes a successive approximation of the desired value (SAADAT, 1999).

The obtaining of the power flow solution can be achieved through the Newton-Raphson method algorithm, which consists of (STEVENSON, 1986):

1) Through the values of nodal stress modulus and its suggested angle for the first iteration ($i = 0$), determine the value of the Equation (1) and Equation (2).

$$P_{km} = g_{km}V_k^2 - V_kV_m(g_{km}\cos\theta_{km} + b_{km}\sin\theta_{km}) \quad 1)$$

$$Q_{km} = (b_{km} - b_{km}^{sh})V_k^2 - V_kV_m(g_{km}\cos\theta_{km} + b_{km}\sin\theta_{km}) \quad 2)$$

2) Calculate and $\Delta P \Delta Q$ for each bar, which is given in the Equations (3) and (4), respectively.

$$\Delta P^{(i)} = P_k^{esp} - P_k^{calc} \quad 3)$$

$$\Delta Q^{(i)} = Q_k^{esp} - Q_k^{calc} \quad 4)$$

3) Determine the Jacobian matrix. $(J^{(i)})$

4) Solve the nonlinear system from the Equation (5).

$$\begin{pmatrix} \Delta P \\ \Delta Q \end{pmatrix}^{(i)} = \begin{pmatrix} H & N \\ M & L \end{pmatrix}^{(i)} * \begin{pmatrix} \Delta \theta \\ \Delta V \end{pmatrix}^{(i)} \quad 5)$$

5) Calculate the new values for and $\theta_K V_K$

6) Go back to item 1 and repeat the process using the new values of the modulus and angle of the tension until the values of e are equal to or less than the chosen tolerance. $\Delta P \Delta Q$

2.3 OPTIMAL POWER FLOW

In order to meet a set of constraints of equality or inequality, the FPO seeks to increase or decrease some performance index (DAHLKE, 2010). Through a series of calculations, sought to meet the operational and physical delimitations of the electrical network, the FPO becomes an important instrument, leading operators to manipulate the system within their delimited safety margins. This means that the energy demand of the electricity grid is satisfied and that the operational and physical constraints of the system are not violated (ROSAS, 2008).

Rosas (2008) represents the problem of the POF being the minimum of the objective function (Equation ((6))), subject to the equality restriction (Equation (7)) and the inequality restriction (Equation (8)).

$$\min = f(x) \quad (6)$$

s. a.

$$g(x) = 0 \quad 7)$$

$$h_{min} \leq h(x) \leq h_{max} \quad 8)$$

The Equations (1) and (2), described in subsection 0, indicate the balance of active and reactive power in the grid, composing the FPO equality constraint vector. Depending on the issue at hand, some system controls can be changed or added to existing ones, rather than being modified within a specific range. On the other hand, the inequality vector can represent the maximum load on transmission lines and transformers, maximum and minimum limits of the modulus of the voltages in the busbars, as well as maximum and minimum limits of active and reactive power generation (ROSAS, 2008; SESSA, 2013).

Through computer programs, it is possible to establish the optimal point of operation of a system based on a pre-established objective function and its constraints of equality and inequality. FLUPOT, a program developed by CEPEL, is widely used for the study of optimal power flow, with the minimization of active losses, load shedding, optimal allocation of reactive power support and maximization of active power transfer between areas or in a set of circuits.

2.4 CONTINGENCY ANALYSIS

For a better functioning of the SEP, security analyses are carried out of a cluster of contingencies most likely to occur in the network, as well as the verification of its operating and emergency limits (MONTICELLI, 1983).

The goal of operating the system is for it to be in a safe state. Under steady-state operating conditions, it is subject to load restrictions, which are related to load balance and generation; the operating restrictions that represent the limits imposed on the magnitudes of the voltages in the busbars, the apparent power flows in the transmission lines and transformers, and the reactive power injections in the generation bars; and, finally, the safety constraints that define the safe operation of the system under a list of possible contingencies, such as loss of line, generators and capacitors. (PATACA, 2012, p. 34-35).

Pataca (2012) defines contingency as the disconnection or shutdown of a system component, which can be the disconnection of transmission lines, loads, transformers and/or generators, caused by disturbances or faults. These contingencies can be single (criterion N-1), when only one component of the system is disconnected from the grid, or multiple (criterion N-2, criterion N-3...), when several outputs of system components are considered.

Through the use of computer programs, contingency analysis is carried out. By defining a point in the system and applying simulations of a series of contingencies, the impact on the network is observed and evaluated (PATACA, 2012).

According to CEPEL (2011), in order to find severe operational difficulties, ANAREDE performs the simulations by processing a sequence of contingencies, where in each case a new solution is made for the power flow and monitoring of the operational state of the simulated system.

This research will perform the analysis of simple contingencies through simulations of the shutdown of transmission lines in the STB-33 test system.

2.5 PARALLEL REACTIVE COMPENSATION

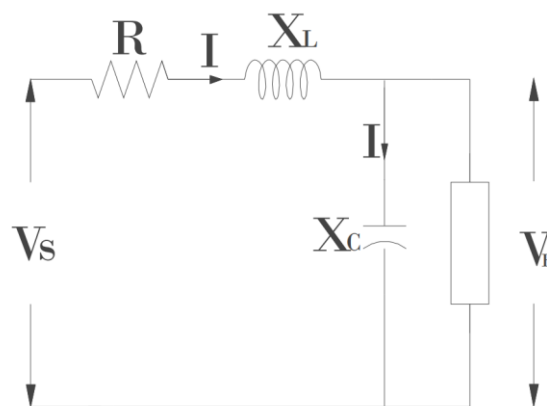
In order to obtain better performance in transmission lines, whether short, medium or long, reactive compensation methods are applied. When there is a need to supply or absorb reactivities in the network, capacitor banks or reactors are added, respectively, thus applying parallel compensation, or *shunt* (REZENDE et al., 2013).

The

Figure 1 demonstrates an equivalent circuit with capacitive parallel compensation, through a capacitor bank (JESUS; SUNTAN; COGO, 2018).

Figure 1

Equivalent circuit with parallel compensation



Source: Jesus, Tan and Cogo (2018).

Where:

- V_S : voltage at the emitting end;
- V_R : voltage at the receiving end;
- R : LT resistance;
- X_L : reactance of the LT;
- X_C : bank of capacitors in shunt.

According to Rezende *et al.* (2013), the compensation of a transmission line is directly related to the natural property of the lines, which require reactive energy in greater or lesser quantities to carry out the flow of active power. The ideal condition for the flow of energy through a line is one in which it carries an active power of value corresponding to the *Surge Impedance Loading* (SIL).

Saadat (1999) describes SIL as all reactive energy generated by the line being absorbed by it, with no losses in this line and with constant active power at the transmitting and receiving terminals. Demonstrated by the Equation ((9), where represents the nominal voltage of the line and is the characteristic impedance. $V_L Z_C$

$$SIL = \frac{|V_L|^2}{Z_C} \quad (9)$$

The lack of reactive control in transmission lines can cause two scenarios: when the active power transported by the line is lower than the SIL, therefore, the line will generate a greater number of reactive than necessary; and when the reactive power is greater than the SIL, indicating that there is a need to supply reagents to the line (REZENDE *et al.*, 2013).

Thus, this research will apply parallel reactive compensation in cases of contingencies that result in voltage violation in the busbars of the STB-33 test system.

2.6 LOADING MARGIN

In order to analyze places in the system that are more vulnerable to changes in operating conditions, studies related to voltage stability provide guidance for the control and optimal structuring of the electrical system (DELGADO, 2019). In order to assess the imminence of a voltage decrease, the loading margin is determined, defining the level of change from a disturbance in the system, which can be a variation in load and/or generation or a contingency (ZEFERINO, 2011).

From the perspective of voltage analysis, the SEP is considered stable when it is possible to maintain the voltage level in normal operating conditions or when it is subjected to some disturbance. In cases where the network suffers some gradual and disoriented loss of voltage, due to the removal of a transmission line and an increase in load, voltage instability is qualified, which can be caused, mainly, by the inability to supply reactive power (KUNDUR, 1994).

A SEP is considered safe when it has the ability to continue operating normally in the face of contingencies; however, no system is completely resistant to contingencies, because, in reality, the system is designed to sustain a finite number of generation, transmission and load contingencies (RESENDE, 2007).

Regarding voltage safety, ONS (2018) determines that studies focused on voltage stability must have the system's stability margin defined through simulations and compared with the predefined safety standards. The ONS also emphasizes a Voltage Safety Margin (MST), which is the minimum value of the stability margin that can be evaluated in a system. The MST for incomplete networks is at least 4%, and for complete networks it is 7%.

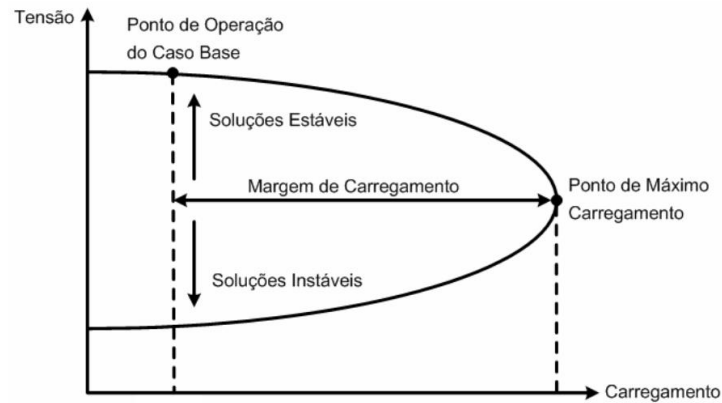
According to Delgado (2019), a complete network is one in which the original system is in normal operation, while an incomplete network occurs when there is a lack of some element of the system, such as substations and transmission lines.

2.7 PV CURVE AND THE FOLLOW-UP METHOD

One of the most used means to analyze voltage stability in SEP is through the PV curve. The PV Figure compares the voltage level in a bar as a function of the power increased in a given direction, and can analyze the proportion of variation between the system operating under normal conditions and cases of instability (DELGADO, 2019).

In **Figure 2**, it is possible to observe that the loading margin is given by the distance between the operating point of the base case and the PMC of the current case. The PMC, or critical point, is the place where the system loses the ability to retain admissible voltage levels, presenting instabilities (DELGADO, 2019).

Figure 2
PV Curve



Source: Resende (2007).

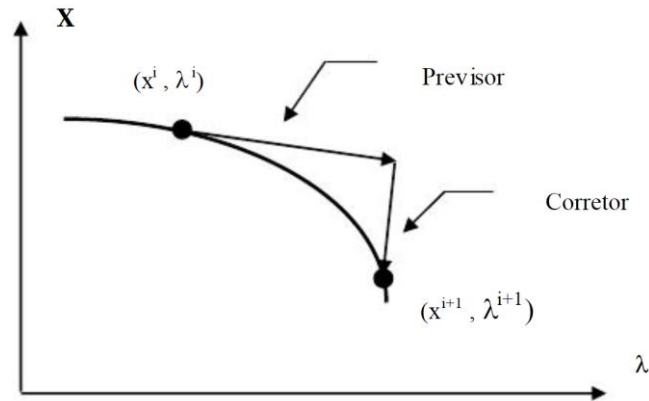
However, in order to trace the PV curve and reach solutions for the power flow in the PMC, other mathematical methods are needed, as the Newton-Raphson method becomes unusual due to the contrariety in relation to convergence when the studied points are close to the collapse point of the system (PINTO, 2013).

Soon, the continuation method, or Continuous Load Flow (FCC), emerges, which rewrites the power flow equations and, through the prediction and correction of the Figureic points, circumvents problems related to convergence, making it possible to reach power flow solutions in the PMC and draw the PV curve (DELGADO, 2019).

The **Figure 3** demonstrates the forecast-correction process used in the FCC solution, where, starting from the initial operating point, it is possible to observe the direction of load growth, from a new estimated operating condition. Thus, the resulting point is corrected by calculating the usual power flow, enabling an equilibrium point (KRAUER, 2007).

Figure 3

Predictor-broker scheme



Source: Krauer (2007).

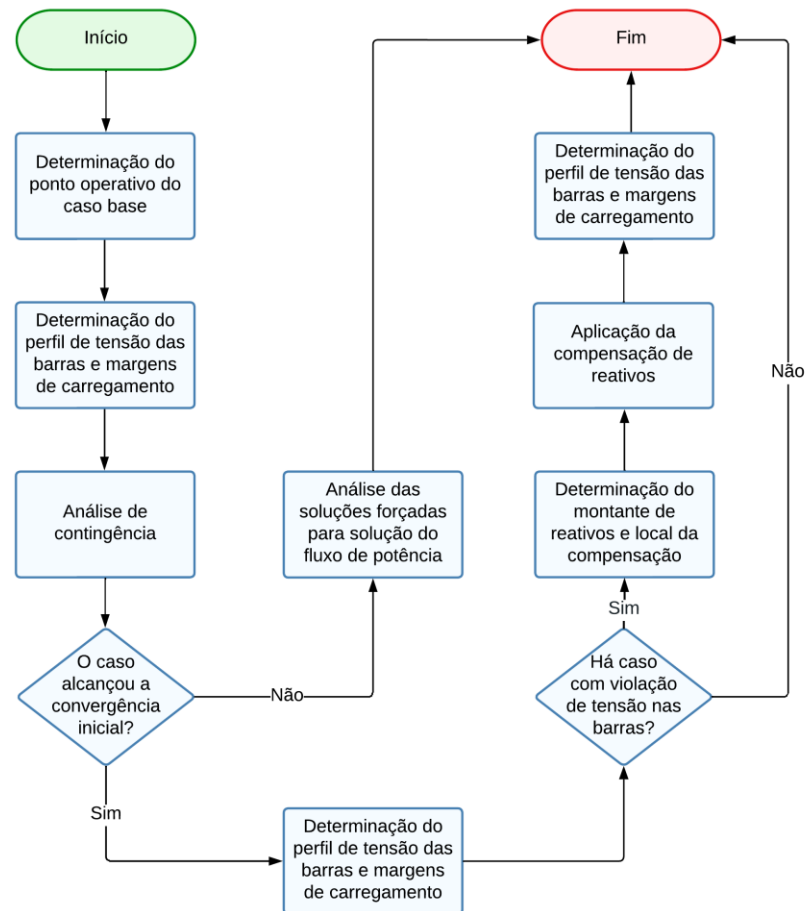
Through the determination of the PV curve by the continuation method, the present research will evaluate the loading margin of the STB-33 test system in three moments: under normal operating conditions, after contingency and after reactive compensation. In this stage, ANAREDE's Continued Power Flow Program will be used.

3 METHODOLOGY ADOPTED IN THIS STUDY

Seeking a better understanding of the methodology to be followed, the flowchart represented in the **Figure 4**, which demonstrates the step-by-step of the proposed methodology.

Figure 4

Flowchart of the research methodology



Source: The authors.

The analyses developed in this work were performed using the STB-33 test system. This and other test systems were developed by Alves (2007) through data taken from the Brazilian SEP, allowing studies through computer programs to have scenarios closer to reality, highlighting parameter violations, collapses, instabilities, oscillations, and other electrical disturbances.

To perform the calculations of the power flow, the contingency analysis and the creation of the PV curves, the *ANAREDE software* was used, which has tools aimed at the studies of the SEP in the steady regime. To carry out the studies aimed at parallel compensation, the *FLUPOT software* was used, together with *ANAREDE*, which allows the planning and allocation of reactive compensation.

Both programs are projects of the Department of Electrical Systems (DSE) and make up the group of Planning and Operation Programs for the Electrical Area of CEPEL, created

with the intention of filling the lack of computational tools aimed at the planning and operation of SEP in Brazil (CEPEL, 2022).

It should be noted that all the studies carried out in this research followed Submodule 23.3 of the Network Procedures, which dictates the guidelines and criteria for electrical studies proposed by ONS (2018).

3.1 DETERMINATION OF THE OPERATIVE POINT

The first step of this work was the determination of the operative point of the base case. For this, the calculation of the power flow was carried out through the Newton-Raphson method, through the EXLF execution code and the NEWT execution control, provided by ANAREDE. The aim was to obtain the voltage profile of the system and the load on the transmission lines to make comparisons with the results of the subsequent analyses.

3.2 SIMPLE CONTINGENCY ANALYSIS OF TRANSMISSION LINES

In order to analyze each contingency case separately, the Automatic Contingency Analysis execution code was used, provided by the Contingency Analysis Program of ANAREDE. For each contingency of a TL, the program performs a new calculation of the power flow by the Newton-Raphson method, monitoring the operational state of the network.

The contingency program provides monitoring reports that display lists of the critical busbars of contingency cases, detailing those that have violations of voltage, power flow, and reactive power generation parameters. This information is made available through the MOCT, MOCF, and MOCG options, respectively. The *software* details critical cases using the severity index, which is used to order contingency cases based on the mean square deviation in relation to the limits of each quantity that will be monitored (ONS, 2018).

ANAREDE also provides a list of controls and, based on the methodology of Alves (2007), three of them were selected:

- CAP: controls the voltage by transformer with automatic variation of TAP under load;
- QLIM: controls the limit of reactive power generation;
- CREM: Remotely controls voltage by reactive power sources.

Together with the voltage monitoring report, the emergency operating voltage levels pre-established by ONS (2018), presented in the **Table 1**.

Table 1

Permissible phase voltages at 60Hz

Rated operating voltage	Normal operating condition		Emergency operating condition	
(kV)	(kV)	(PU)	(kV)	(PU)
<230	...	0.950 to 1.050	...	0.900 to 1.050
	Pages		Pages	
230	218 to 242	0.950 to 1.050	207 to 242	0.900 to 1.050
345	328 to 362	0.950 to 1.050	311 to 362	0.900 to 1.050
440	418 to 460	0.950 to 1.046	396 to 460	0.900 to 1.046
500	500 to 550	1,000 to 1,100	475 to 550	0.950 to 1.100
525	500 to 550	0.950 to 1.050	475 to 550	0.900 to 1.050
765	690 to 800	0.900 to 1.046	690 to 800	0.900 to 1.046

Source: ONS (2018).

For contingency cases that did not obtain a solution for the power flow, that is, that did not achieve its convergence, the methodology of Alves (2007) was followed. The proposed procedure consists of three steps:

- 1) Shutdown of execution controls.
- 2) Relaxation in the load representation at 75% of the active power and 100% of the reactive power, varying with the square of the voltage.
- 3) Establishment of the bus that interconnects the contingency transmission line as a reference.

3.3 APPLICATION OF PARALLEL COMPENSATION

As a solution for the elimination of voltage violations after the contingency of a TL, the application of parallel reactive compensation was established. For this, the *FLUPOT* and *ANAREDE* software were used.

First, FLUPOT was used in order to obtain the most appropriate amount of reagents and bars for the allocation of compensation. For the objective function, Voltage Control

(CLTN) was used. This option sets a reactive adjustment based on the busbar voltage limits. DVLB and DCAQ functions were also required, which receive the data of voltage limits per bar and delimit the maximum amount of reagent injection in MVar, respectively. ANAREDE was used to carry out and evaluate the effectiveness of this compensation in relation to voltage violations in the case of contingency.

In this stage of the research, contingency cases that resulted in power flow violation in the TLs were discarded, as it was not the objective of this work to carry out studies of reactive series compensation.

3.4 DETERMINATION OF THE PV CURVE

According to ONS (2018), in order to carry out studies that cover voltage safety, it is necessary to obtain the stability margin through simulations and make comparisons in different scenarios, in which the power factor must be kept constant during the process.

In this work, through the plotting of the PV curve and the continuation method, the loading margin of the system was determined in three distinct cases: base case, after contingency and after the application of parallel compensation. For the analysis of the loading margin, the Continuous Power Flow Program was used, which allows plotting the PV curve through successive increments of loads, attributing an increment of 0.2% to both active and reactive power, which, according to Delgado (2019), ensures a constant power factor for the same curve.

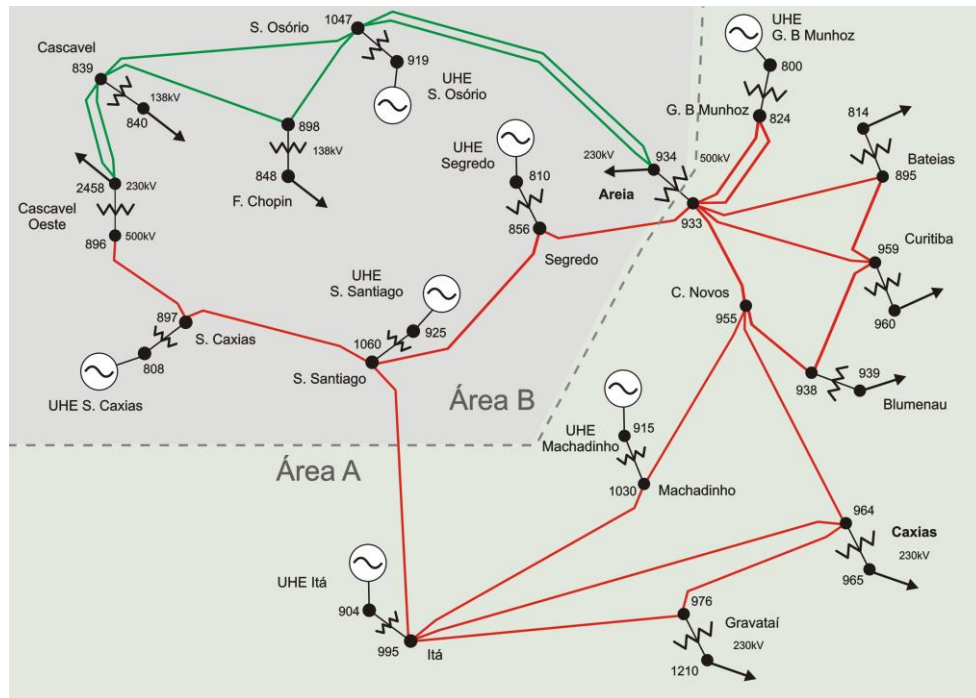
4 RESULTS AND DISCUSSIONS

4.1 SIMPLE CONTINGENCY OF STB-33 TRANSMISSION LINES

The test system chosen to receive the analyses of this work was the STB-33 test system, also known as the Reduced South System. It was prepared from data taken from the 230kV and 500kV grids of the southern region of Brazil, as can be seen in the **Figure 5**.

Figure 5

Brazilian 33-Bar Test System



Source: Alves (2007).

The system represents 33 bars and 7 large generators, totaling a maximum demand of 5.085MW and a total generation capacity of 8.912MW. The network was divided into two geoelectric areas, A and B, which are interconnected by two TLs and a transformer. Area A has a higher concentration of load and is unable to meet its demand, thus arising the need to import energy from area B.

The system has a topological characteristic of a mottled arrangement, forming a ring that connects the plants in the region. This results in a robust and structured drivetrain. Therefore, the removal of a TL does not cause the isolation of any other element of the network, resulting in 26 simulated contingency cases, as provided for in the **Table 2**.

Table 2
Contingency cases

Case	From	Towards	Name	Voltage (kV)	Circuit	Area
1	824	933	Gov. Bento Munhoz – Areia	500	1	A
2	824	933	Gov. Bento Munhoz – Areia	500	2	A
3	839	898	Cascavel – Foz do Chopin	230	1	B
4	839	1047	Cascavel – Salto Osório	230	1	B
5	839	2458	Cascavel – Cascavel Oeste	230	1	B
6	839	2458	Cascavel – Cascavel Oeste	230	2	B
7	856	933	Secret – Sand	500	1	A → B
8	856	1060	Secret – Salto Santiago	500	1	B
9	896	897	Cascavel Oeste – Salto Caxias	500	1	B
10	898	1047	Foz do Chopin – Salto Osório	230	1	B
11	933	895	Sand – Bateias	500	1	A
12	933	955	Areia – Campos Novos	500	1	A
13	933	959	Sand – Curitiba	500	1	A
14	934	1047	Sand – Salto Osório	230	1	B
15	934	1047	Sand – Salto Osório	230	2	B
16	938	955	Blumenau – Campos Novos	500	1	A
17	938	959	Blumenau – Campos Novos	500	1	A
18	955	964	Campos Novos – Caxias	500	1	A
19	959	895	Curitiba – Bateias	500	1	A
20	964	976	Caxias – Gravataí	500	1	A
21	976	995	Gravataí – Itá	500	1	A
22	995	964	Itá – Caxias	500	1	A
23	995	1030	Itá – Machadinho	500	1	A
Case	From	Towards	Name	Voltage (kV)	Circuit	Area
24	995	1060	Itá – Salto Santiago	500	1	A → B
25	1030	955	Machadinho – Campos Novos	500	1	The
26	1060	897	Salto Santiago – Salto Caxias	500	1	B

Source: The authors.

Using the Automatic Contingency Analysis function, ANAREDE performs simple contingencies of TLs, finding new solutions to the problem of power flow through the Newton-Raphson method, in view of the contingency and its interference with the parameter of voltage, power flow and reactive generation of the test system. Next, ANAREDE displays the

monitoring reports, detailing whether the contingency case has achieved its convergence and whether there have been parameter violations.

According to Alves' (2007) methodology, to facilitate the convergence process, the procedure of blocking the tap value in the first solution was adopted, deactivating the CTAP control at first, and then the analysis was carried out considering this control, but no difference was obtained in the results. The results of the simulations can be found in the

Table 3.

Table 3

Result of contingency simulations

No Violation	With violation			Non-convergent
...	Tension	Power Flow	Voltage and Power Flow	...
10	2	5	2	7

Source: The authors.

The results of the simulations can be summarized in three situations: of the 26 simulated cases, 10 did not present parameter violations, 7 cases did not reach their convergence, that is, it was not possible to find a solution for the power flow, and in 9 cases there was a violation of some network parameter. Of these, 2 resulted in voltage violation, 5 resulted in power flow violation, and in 2 cases there was voltage and flow violation. The

Table 4 details the contingency cases that resulted in voltage violations.

Table 4

Contingency cases with voltage violations

Case	From	Towards	Name	Voltage (kV)	Circ.	Area
7	856	933	Secret – Sand	500	1	A → B
18	955	964	Campos Novos – Caxias	500	1	The
Case	From	Towards	Name	Voltage (kV)	Circ.	Area
22	995	964	Itá – Caxias	500	1	The
24	995	1060	Itá – Salto Santiago	500	1	A → B

Source: The authors.

It can be observed that the busbars where voltage violations occurred are not limited only to the dams of the contingency TLs, but also to the busbars in their vicinity. All violated busbars are located in area A, as this area presents an excess of demand, resulting in

undervoltage in the critical busbars which, according to Pinto (2013), are prone to induce the entire system to a voltage collapse.

In

Table 5, the contingency cases that resulted in flow violations in the TLs are presented.

Table 5

Contingency cases with flow violations

Case	From	Towards	Name	Voltage (kV)	Circ.	Area
3	839	898	Cascavel – Foz do Chopin	230	1	B
4	839	1047	Cascavel – Salto Osório	230	1	B
7	856	933	Secret – Sand	500	1	A → B
10	898	1047	Foz do Chopin – Salto Osório	230	1	B
14	934	1047	Sand – Salto Osório	230	1	B
15	934	1047	Sand – Salto Osório	230	2	B
24	995	1060	Itá – Salto Santiago	500	1	A → B

Source: The authors.

It is possible to observe that the cases of flow violations occurred in lines that are entirely in area B and in the only two cases in which the exchange of energy between areas occurs. This is due to the fact that area A does not have enough generation to supply its loads, supplying only 52.8% of its demand, resulting in the need to import energy from area B.

Cases 7 and 24 were the only cases that resulted in the violation of both voltage and flow. By analyzing the single-line diagram of the system, presented in the **Figure 5**, it can be seen that, if one of these lines is lost, areas A and B are interconnected only by a single TL, which hinders the exchange of energy between the areas. The cases in which it was not possible to achieve initial convergence are listed in the **Table 6**.

Table 6

Contingency cases that did not converge

Case	From	Towards	Name	Voltage (kV)	Circ.	Area
9	896	897	Cascavel Oeste – Salto Caxias	500	1	B
11	933	895	Sand – Bateias	500	1	The
13	933	959	Sand – Curitiba	500	1	The
16	938	955	Blumenau – Campos Novos	500	1	The
20	964	976	Caxias – Gravataí	500	1	The

21	976	995	Gravataí – Itá	500	1	The
26	1060	897	Salto Santiago – Salto Caxias	500	1	B

Source: The authors.

The first step to find the load flow solution consisted of turning off the execution controls of ANAREDE. In this first attempt at convergence, only cases 9 and 26 were resolved; however, they resulted in high levels of violation in the parameters of voltage, reactive generation and power flow. In the second stage, a relaxation of the representation of the loads was carried out. According to Alves (2007), this measure favors convergence, because the current required by the load will be lower, reducing the voltage drop. Thus, all cases of **Table 6** reached their convergence, resulting in a violation of some parameter, with the exception of case 26, which did not converge.

The third and last attempt consisted of establishing busbars that interconnect the contingency TL as a reference, seeking to obtain the solution of the power flow, even if the voltage is corrupted. At this stage, all cases have achieved solutions for cargo flow; However, case 26 was the only one that did not present any violation in its parameters.

The

Table 7 details case 9 in the three attempts to search for the forced solution of the problem, resulting in large variations of violations of the voltage, reactive generation and flow parameters, regardless of the method.

Table 7

Case 9: Severity indices in forced load flow solutions

Forced solution	Severity Index		
	Tension	Reactive generation	Power Flow
...			
Switching off controls	502,1	120,9	9,9
Load relaxation	50,1	11,3	5,0
Reference bar	49,7	10,9	5,0

Source: The authors.

With regard to studies related to the compensation of reactives, cases that converged from the forced solution of the power flow will not be considered, due to the number of simplifications used to achieve their convergence.

4.2 PARALLEL COMPENSATION AND VOLTAGE VIOLATION CASES

After the contingency analysis, there were four cases that resulted in voltage violations, with case 18 obtaining the highest severity index. It is through the severity index that ANAREDE determines the classification of critical contingencies.

To define the appropriate amount of reactive for allocation, FLUPOT's CLTN objective function was used, which determines an adjustment in the reactive controls, in order to maintain the voltage of the busbars within the limits that were specified (CEPEL, 2018). The selection criterion for the application of reactive compensation was based on choosing the bars where the voltage violations occurred, not only those belonging to the contingency TL.

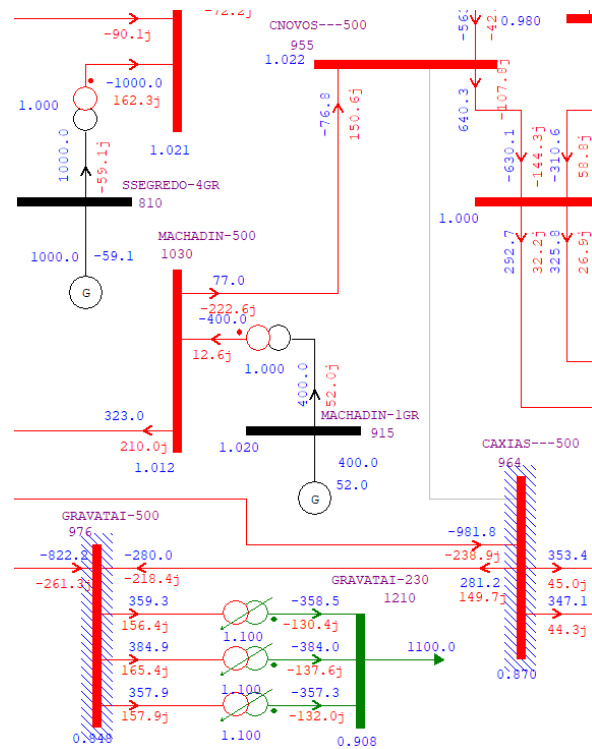
As mentioned in the section 0, for the application of parallel reactive compensation, cases that presented power flow violations were disregarded, since the objective of parallel compensation is to improve the voltage profile of the busbars of a system. Therefore, cases 18 and 22 were chosen to detail the corresponding studies.

4.3 CASE 18

The contingency of case 18 occurs due to the disconnection of the Campos Novos – Caxias line, delimited by dams 955 and 964, respectively. This line has a voltage of 500kV, is located in area A and is the only connection between these busbars. It is possible to observe in the **Figure 6** that the voltage levels of the busbars belonging to the TL and the peripheral buses are within the normal operating limits pre-established by the ONS for 13.8kV, 230kV and 500kV busbars.

Figure 7

Case 18: after the contingency



Source: The authors.

Then, the simulation of the loss of the transmission line was carried out through ANAREDE. The result of the monitoring report provided by the *software* is in the

Table 8.

Table 8

Case 18: Voltage monitoring report

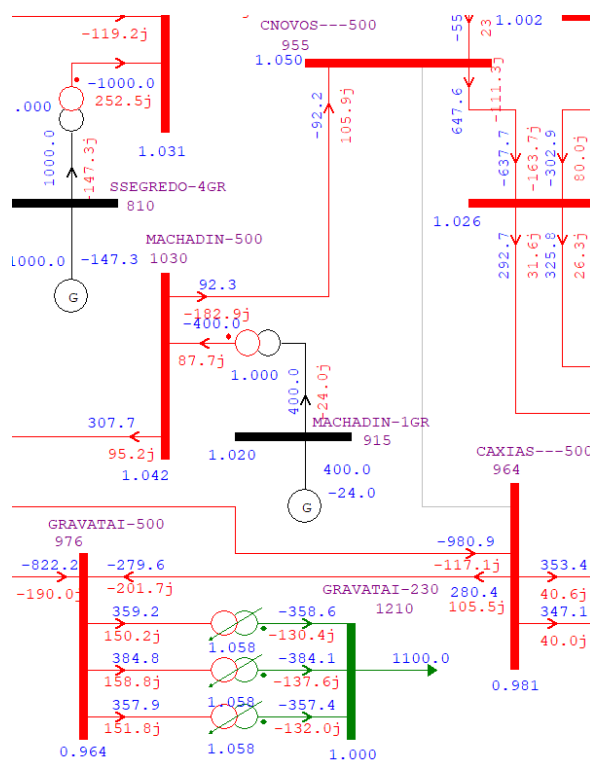
Bar	Name	Area	Voltage (PU)			Violation (pu)	Severity
...	...	...	Minim	Monitored	Maxim	...	...
964	Caxias	The	0,950	0,870	1,100	-0,080	168,0
976	Gravataí	The	0,950	0,848	1,100	-0,102	

Source: The authors.

After the contingency, voltage violations occurred in the 964 and 976 buses, both of 500kV. It is possible to observe that the Gravataí dam (976) is a neighboring element. Therefore, for this case, not only the bars belonging to the contingency transmission line were chosen to receive the compensation, but also the bar 976, as shown in the **Figure 8**.

Figure 8

Case 18: after compensation



Source: The authors.

The FLUPOT program was used to determine the appropriate amount of reagents for compensation. The

Table 9 refers to the results of the number of reagents allocated to the **Figure 8**.

Table 9

Case 18: Allocated reactive power report

Bar	Name	Allocated Power (MVar)
955	New Fields	16,63
964	Caxias	71,78
976	Gravataí	74,40

Source: The authors.

Finally, the system was compared under normal operating conditions with the two prominent situations of this case: after the contingency and after the application of parallel compensation. For such detailing, the **Table 10**, which presents the stresses of the members of the contingency transmission line and neighboring lines.

Table 10

Case 18: Voltage comparison

Bar	Name	Voltage (PU)		
		Base case	After the contingency	After clearing
...	...			
933	Sand	1,045	1,020	1,033
938	Blumenau	1,053	1,000	1,026
955	New Fields	1,082	1,022	1,050
964	Caxias	1,076	0,870	0,981
976	Gravataí	1,056	0,848	0,964
995	Italy	1,071	0,986	1,027
1030	Hatchet	1,076	1,012	1,042

Source: The authors.

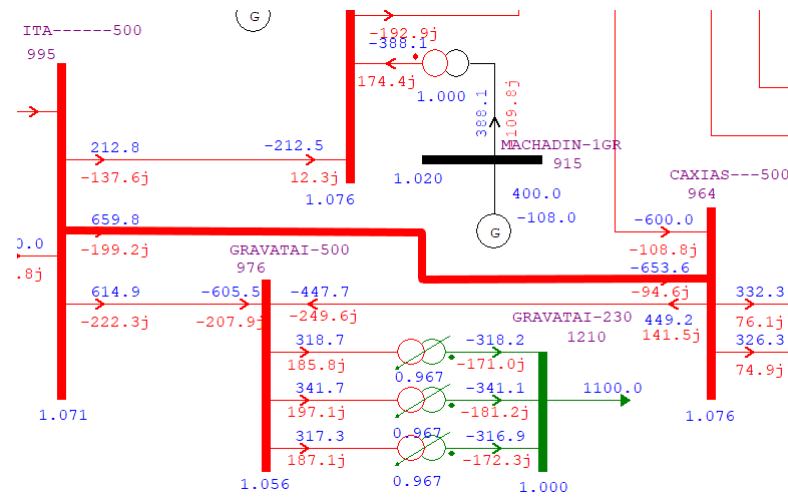
With the data presented, it is possible to observe that, after the simulation of the contingency, there was a significant voltage drop, not only in the busbars of the contingency TL, but also in the neighboring busbars. As for compensation, it proved to be effective, as the stress levels of the violated bars returned to the emergency limits stipulated by the ONS.

4.4 CASE 22

The second case studied was case 22, which addresses the analysis of the Itá (995) – Caxias (964) line, represented by the **Figure 9**. This 500kV line plays a fundamental role in interconnecting the busbars and is located in area A. In the figure, it is possible to observe the normal operation of the line, operating within the limits established by the ONS. This interconnection is extremely important to ensure the stability and reliability of the electrical system, supporting the flow of energy necessary to meet regional demand.

Figure 9

Case 22: Itá (995) - Caxias (964)



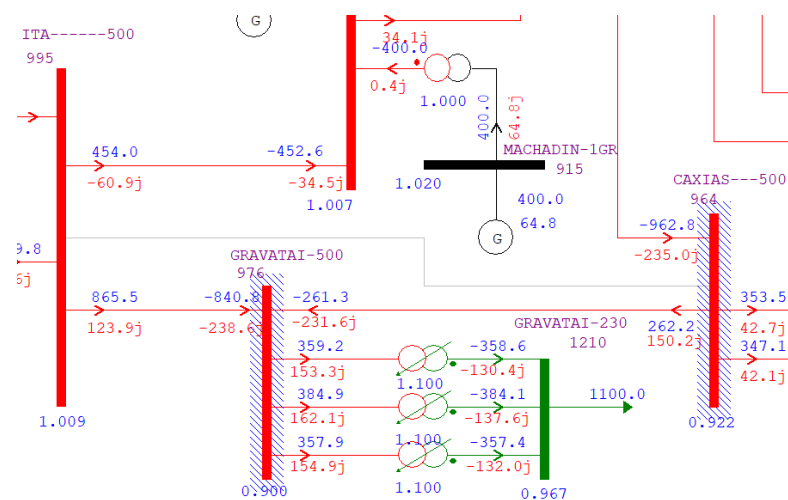
Source: The authors.

The

Figure 10 presents in detail the case studied, taking into account the disconnection of the specific line.

Figure 10

Case 22: after the contingency



Source: The authors.

The monitoring report is detailed in the

Table 11.

Table 11

Case 22: Voltage monitoring report

Bar	Name	Area	Voltage (PU)			Violation (pu)	Severity
			Minim	Monitored	Maxim		
...	...	...	0,950	0,922	1,100	-0,028	...
964	Caxias	The	0,950	0,922	1,100	-0,028	32,6
976	Gravataí	The	0,950	0,900	1,100	-0,050	

Source: The authors.

After the contingency, voltage violations occurred in the 964 and 976 buses, both of 500kV. In this case, due to the fact that the severity index was lower, only the violated bars were chosen to receive compensation and, based on the definition of the bars, FLUPOT returned the report from the

Table 12, which specifies the most appropriate amount of reactive power for compensation *Shunt*.

Table 12

Case 22: Allocated reactive power report

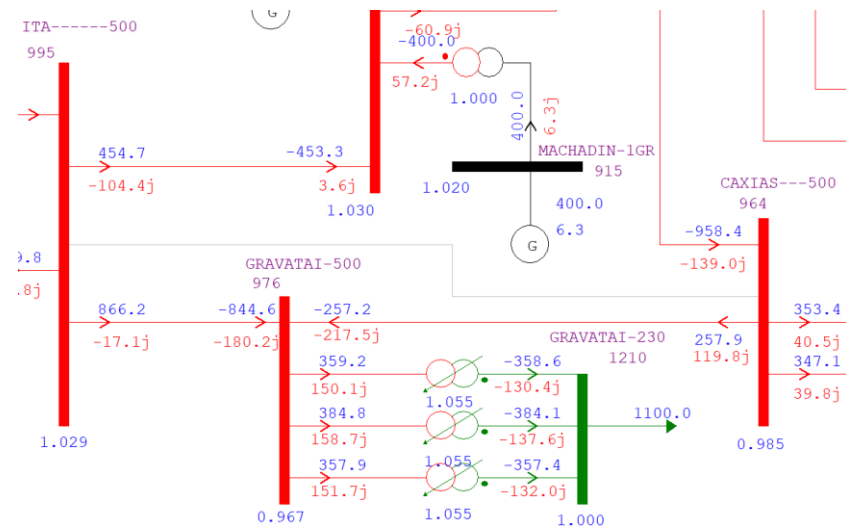
ar	Name	Allocated Power (MVar)
64	Caxias	62,99
76	Gravataí	67,15

Source: The authors.

The result of the application of the compensation can be seen in the **Figure 11**.

Figure 11

Case 22: after the compensation of reactive agents



Source: The authors.

In addition, it was detailed in the

Table 13 the comparison of stress levels in the three scenarios: base case, after contingency and after reactive compensation. It is possible to observe that, even after compensation, the voltage of the busbars did not reach the same values as in the base case, but still falls within the emergency operational limits.

Table 13

Case 22: Voltage comparison

Bar	Name	Voltage (PU)		
		Base case	After the contingency	After clearing
955	New Fields	1,082	1,000	1,029
964	Caxias	1,076	0,922	0,985
976	Gravataí	1,056	0,900	0,967
995	Italy	1,071	1,009	1,029
1030	Hatchet	1,076	1,007	1,030
1060	Salto Santiago	1,050	1,030	1,037

Source: The authors.

4.5 LOADING MARGIN ANALYSIS

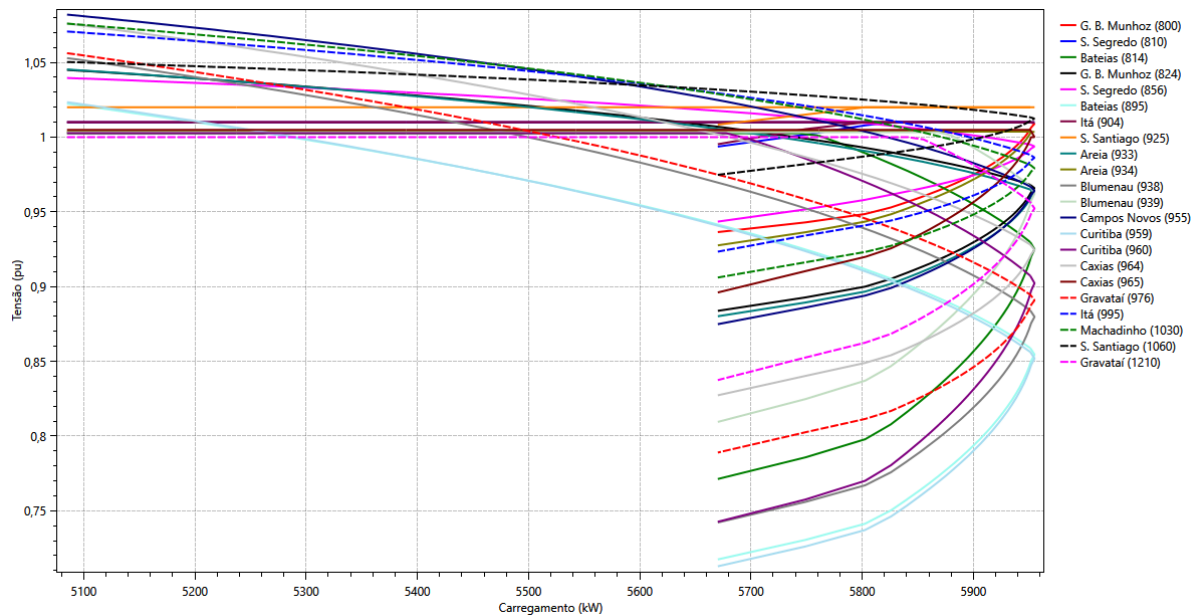
Regarding the studies related to voltage stability, the PV curves were determined using the Continuous Power Flow Program, available at ANAREDE. The program performs successive load increments, and it is possible to observe the maximum charging point (PMC) that the system can maintain safe voltage levels. For this, a load increase of 0.2% of active

and reactive power was carried out for each iteration, which, according to Delgado (2019), guarantees a constant power factor for the same PV curve.

Figure 12 shows the PV curves of the base case buses.

Figure 12

Base case: PV curves



Source: The authors.

The base case has a loading margin of 5.9550MW and a voltage safety margin (MST) of 17.1086%. The ONS (2018) determines that, for complete systems, the MST is at least 7%, which makes the test system within the accepted criteria. However, it is possible to observe that not all busbars were able to maintain voltage levels above the minimum limits established by ONS. The **Table 14** Shows the voltage levels at the maximum loading point of the complete test system.

Table 14

Base case: voltages monitored in the PMC

Bar	Name	Tension (kV)	Minimum Emergency Voltage (PU)	Tension in the PMC (PU)
800	Gov. Bento Munhoz	13,8	0,900	1,009
810	Secret Jump	13,8	0,900	1,010
814	Bateias	230	0,900	0,925
824	Gov. Bento Munhoz	500	0,950	0,966
856	Secret Jump	500	0,950	0,994
895	Bateias	500	0,950	0,855
904	Italy	13,8	0,900	1,010
925	Secret Jump	13,8	0,900	1,020
933	Sand	500	0,950	0,963
934	Sand	230	0,900	1,004
938	Blumenau	500	0,950	0,880
939	Blumenau	230	0,900	0,962
955	New Fields	500	0,950	0,964
959	Curitiba	500	0,950	0,852
960	Curitiba	230	0,900	0,902
964	Caxias	500	0,950	0,925
965	Caxias	230	0,900	1,000
976	Gravataí	500	0,950	0,891
995	Italy	500	0,950	0,986
1030	Hatchet	500	0,950	0,979
1060	Salto Santiago	500	0,950	1,012
1210	Gravataí	230	0,900	0,952

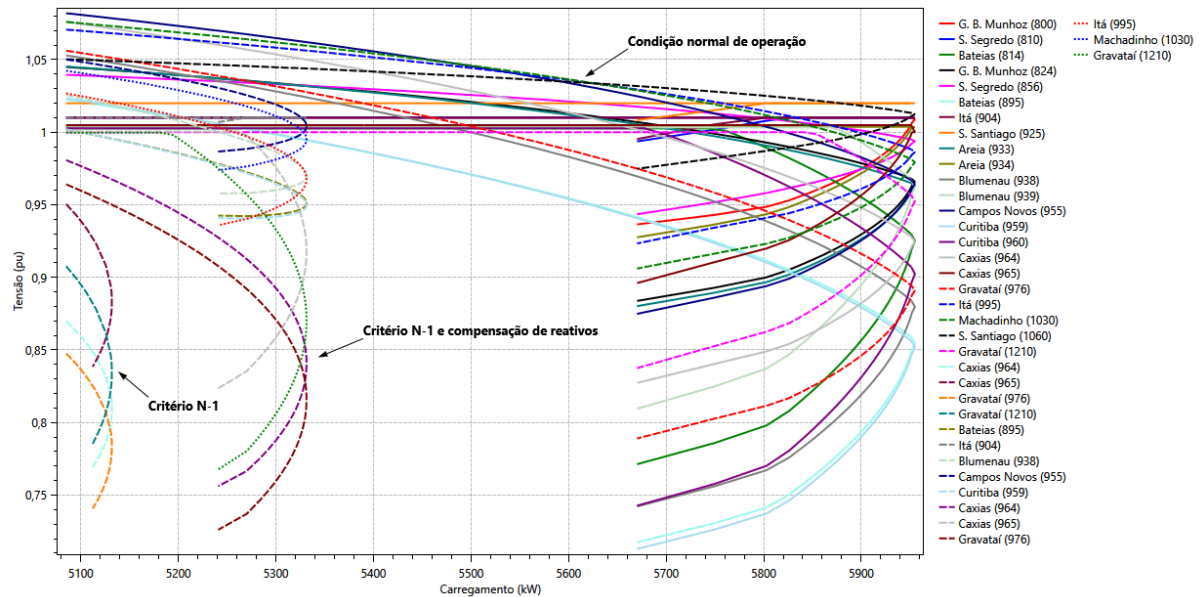
Source: The authors.

By analyzing the diagram of the test system, it is possible to observe that the bars that are unable to support the increase in load are substations interconnected to high loads. This interconnection with high demands makes such bars highly critical when confronted with events of this type.

Figure 13 shows the PV curves of the base case and of case 18, taking into account the contingency suffered and the measures adopted for the compensation of reactivities. This Figureical analysis allows a complete visualization of the effects of these occurrences and the solutions implemented to mitigate the resulting imbalances.

Figure 13

Case 18: comparison of all PV curves

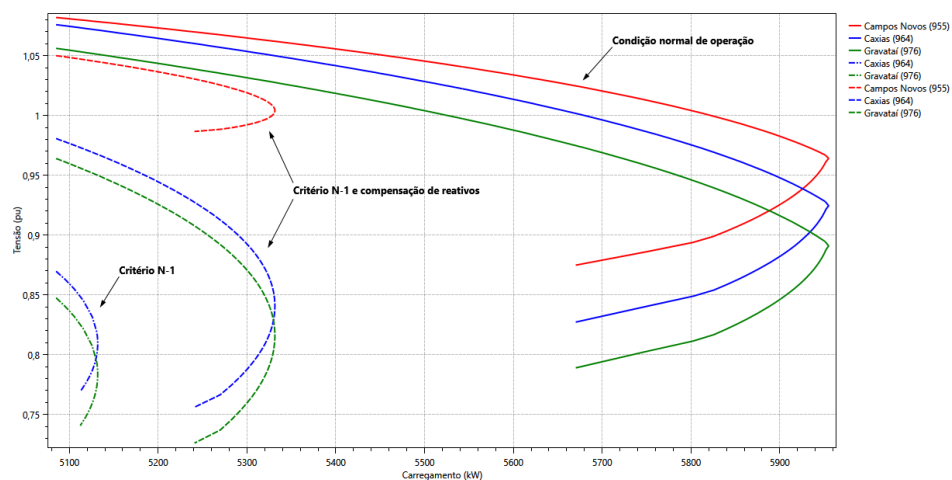


Source: The authors.

For a clearer and more objective visualization, Figure 14 was elaborated, which shows only the busbars of the contingency line of case 18 and the bar that presented the voltage violation.

Figure 14

Case 18: comparison of PV curves of bars 955, 964 and 976



Source: The authors.

The **Table 15** details the stresses on the members at the point of maximum loading in the three situations of Figures 2 and 3.

Table 15

Case 18: Tensions in the CMP after contingency and compensation

Bar	Name	Voltage (PU)		
		Base case	Criterion N-1	Criterion N-1 and Compensation
...	...			
895	Bateias	0,855	...	0,952
904	Italy	1,010	...	1,010
938	Blumenau	0,880	...	0,971
955	New Fields	0,964	...	1,005
959	Curitiba	0,852	...	0,950
964	Caxias	0,925	0,812	0,842
965	Caxias	1,000	0,886	0,920
976	Gravataí	0,891	0,786	0,818
995	Italy	0,986	...	0,969
1030	Hatchet	0,979	...	0,996
1210	Gravataí	0,952	0,837	0,872

Source: The authors.

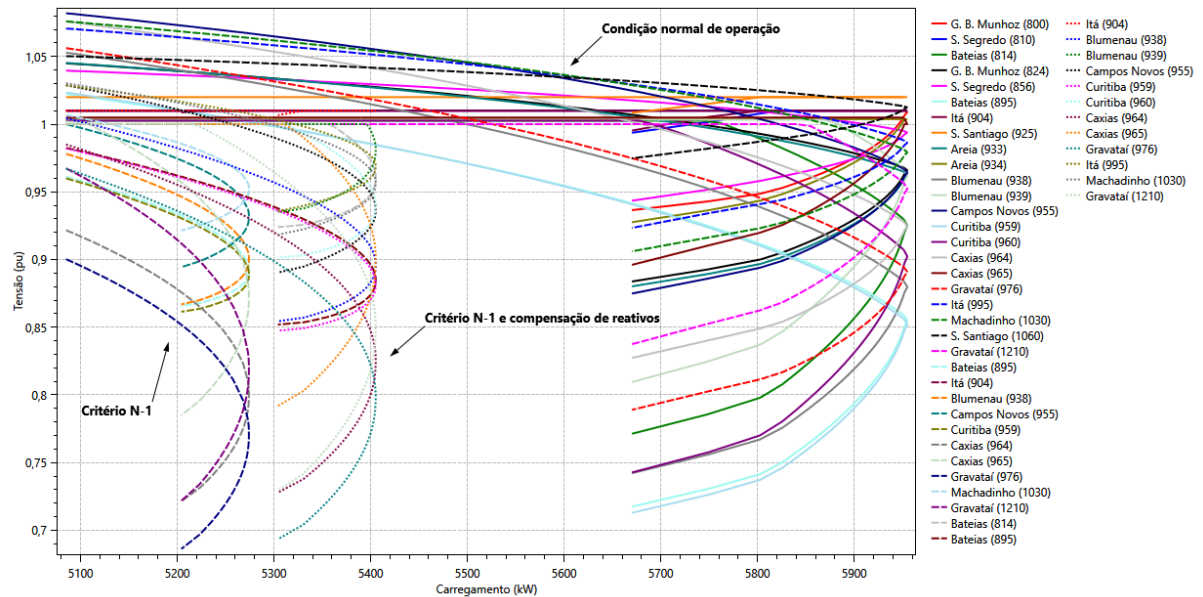
When it comes to incomplete systems, that is, after the loss of some element, the minimum margin of voltage stability established by the ONS must be 4%. Case 18 is the most critical contingency case of STB-33, obtaining a loading margin of 5.1318MW and an MST of 0.9209%, making the system unstable from the point of view of voltage stability.

After the compensation of reactivities, there was an increase in the PMC to 5.3313MW and the MST to 4.8446%, making this case within the minimum limit of 4%. However, some busbars did not reach the minimum emergency limit, because when the load is increased, the electric current in the line increases and, consequently, the voltage drop in the line increases and the voltage of the critical bus decreases.

Figure 15 presents a comprehensive set of information on the PV curves in the scenario of case 22, considering all possible simulations after the occurrence of the contingency on the Itá – Caxias line. In addition, the chart also demonstrates the bar curves after the implementation of reactive compensation. These curves offer a complete view of the changes that have occurred in the system, allowing for more in-depth analysis and a clearer understanding of the effects of contingency and compensation.

Figure 15

Case 22: comparison of all PV curves

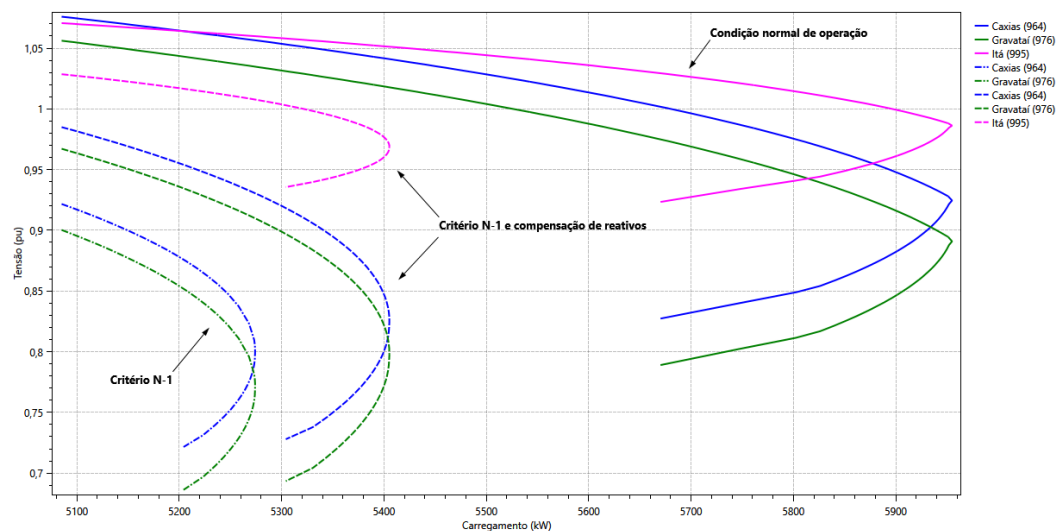


Source: The authors.

Figure 16 presents case 22 in order to detail the PV curves of the members belonging to the contingency TL, as well as the bus where the voltage violation occurred.

Figure 16

Case 22: comparison of PV curves of bars 964, 976 and 995



Source: The authors.

The PMC of case 22, after the disconnection of the line, was 5.2741MW and the MST of 3.7185%, which makes the system unstable considering the voltage stability, as the MST is less than the minimum limit of 4%. However, when parallel compensation is applied, the PMC is 5.4052MW and the MST is 6.2976%.

Table 16 that, even after the application of reactive compensation, the violated busbars remain critical, because, due to the increase in load, there was undertension in the bars close to the highest load amounts.

Table 16

Case 22: Tensions in the CMP after contingency and compensation

Bar	Name	Voltage (PU)		
		Base case	Criterion N-1	Criterion N-1 and Compensation
...	...			
814	Bateias	0,925	...	0,960
895	Bateias	0,855	0,893	0,885
904	Italy	1,010	...	1,010
938	Blumenau	0,880	0,902	0,896
939	Blumenau	0,962	...	0,981
955	New Fields	0,964	0,933	0,937
959	Curitiba	0,852	0,890	0,882
960	Curitiba	0,902	...	0,940
964	Caxias	0,925	0,802	0,825
965	Caxias	1,000	0,874	0,900
976	Gravataí	0,891	0,773	0,798
995	Italy	0,986	...	0,969
1030	Hatchet	0,979	0,953	0,957
1210	Gravataí	0,952	0,821	0,849

Source: The authors.

In order to obtain a more general view of the loading margins and MST after the contingencies, the **Table 17**. It contains the base case and the contingency cases, except for the cases that did not reach the initial convergence.

Table 17

Loading margin classification after contingency

<i>Ranking</i>	<i>Case</i>	<i>Fro m</i>	<i>Tow ards</i>	<i>Tension (kV)</i>	<i>Circ.</i>	<i>Area</i>	<i>Upload (MW)</i>	<i>MST (%)</i>
First	Base	...	...	...	...	...	5,9550	17,1086
2nd	5	839	2458	230	1	B	5,9544	17,0982
Third	6	839	2458	230	2	B	5,9543	17,0963
4th	3	839	898	230	1	B	5,9449	16,9101
5th	14	934	1047	230	1	B	5,9347	16,7090
6th	15	934	1047	230	2	B	5,9346	16,7089
7th	10	898	1047	230	1	B	5,9333	16,6833
8th	2	824	933	500	1	The	5,9321	16,6591
<i>Ranking</i>	<i>Case</i>	<i>Fro m</i>	<i>Tow ards</i>	<i>Tension (kV)</i>	<i>Circ.</i>	<i>Area</i>	<i>Upload (MW)</i>	<i>MST (%)</i>
9th	1	824	933	500	2	The	5,9318	16,6526
10th	8	856	1060	500	1	B	5,8945	15,9194
11th	23	995	964	500	1	The	5,8802	15,6387
12th	19	959	895	500	1	The	5,8359	14,7674
13th	25	1030	955	500	1	The	5,6997	12,0889
14th	12	933	955	500	1	The	5,6138	10,3991
15th	4	839	1047	230	1	B	5,4973	8,1080
16th	7	856	933	500	1	A → B	5,3145	4,5131
17th	24	995	1060	500	1	A → B	5,3024	4,2761
18th	22	995	964	500	1	The	5,2741	3,7185
19th	17	938	959	500	1	The	5,2122	2,5024
20th	18	955	964	500	1	The	5,1318	0,9209

Source: The authors.

The base case has the best loading margin and MST, as it is the complete system and is operating under normal conditions. There were contingency cases in which the system is well prepared to receive them, such as cases 5 and 6, because they are located in an area (B) where the energy demand is lower than its generation.

It is possible to observe that the most critical contingency cases, that is, those that presented the highest severity indexes, are found lower in the *ranking* indicating a lower loading margin, as well as MST. The **Table 18** presents the *ranking* with updated data from cases 18 and 22 after reactive compensation.

Table 18

Loading margin classification after compensation

<i>Ranking</i>	<i>Case</i>	<i>Fro m</i>	<i>Tow ards</i>	<i>Tension (kV)</i>	<i>Circ.</i>	<i>Area</i>	<i>Upload (MW)</i>	<i>MST (%)</i>
First	Base	...	...	...	...	...	5,9550	17,1086
2nd	5	839	2458	230	1	B	5,9544	17,0982
Third	6	839	2458	230	2	B	5,9543	17,0963
4th	3	839	898	230	1	B	5,9449	16,9101
5th	14	934	1047	230	1	B	5,9347	16,7090
6th	15	934	1047	230	2	B	5,9346	16,7089
<i>Ranking</i>	<i>Case</i>	<i>Fro m</i>	<i>Tow ards</i>	<i>Tension (kV)</i>	<i>Circ.</i>	<i>Area</i>	<i>Upload (MW)</i>	<i>MST (%)</i>
7th	10	898	1047	230	1	B	5,9333	16,6833
8th	2	824	933	500	1	The	5,9321	16,6591
9th	1	824	933	500	2	The	5,9318	16,6526
10th	8	856	1060	500	1	B	5,8945	15,9194
11th	23	995	964	500	1	The	5,8802	15,6387
12th	19	959	895	500	1	The	5,8359	14,7674
13th	25	1030	955	500	1	The	5,6997	12,0889
14th	12	933	955	500	1	The	5,6138	10,3991
15th	4	839	1047	230	1	B	5,4973	8,1080
16th	22	995	964	500	1	The	5,4052	6,2976
17th	18	955	964	500	1	The	5,3313	4,8446
18th	7	856	933	500	1	A → B	5,3145	4,5131
19th	24	995	1060	500	1	A → B	5,3024	4,2761
20th	17	938	959	500	1	The	5,2122	2,5024

Source: The authors.

Parallel compensation proves to be effective, causing cases 18 and 22 to increase their loading margins and MSTs, being within the minimum limits stipulated by the ONS and increasing their respective positions in the *ranking*.

5 FINAL CONSIDERATIONS

The electrical system needs to be reliable and able to withstand contingencies to ensure the demand for energy without overloading equipment, such as generators, transformers, and LTs. It is important to carry out voltage stability studies to identify the vulnerable points of the system, and a widely used method for this is the PV curve. The

application of parallel compensation is essential for the control of reactive power in the network and better performance of transmission lines, regardless of their length.

The objective of this research was to analyze the voltage stability of the STB-33 test system in three different situations: the base case, after the simulation of the simple contingency analysis of transmission lines and after the application of parallel reactive compensation in contingency cases that had voltage violations in their busbars, as a solution for such violations.

To perform the contingency analysis, the *ANAREDE software* was used, which seeks a new solution to the power flow problem through the Newton-Raphson method in each contingency simulation. For this stage, cases in which the removal of the TL caused the isolation of some element of the network were discarded, resulting in 26 contingency cases.

There were seven cases in which the initial solution was not found, most of them belonging to area A, where there is a greater exchange of energy with area B. Among the solutions presented, establishing the bars that interconnect the contingency TL as a reference resulted in convergence of all cases and the lowest severity indexes. It is important to understand the power flow solution to assess whether the system can maintain voltage stability during emergencies, so these cases have been disregarded from studies related to reactive compensation, due to the amount of simplification made to achieve convergence of these cases.

The contingency cases that resulted in the initial convergence of the problem, but with power flow violations on the lines, are mainly in area B of the test system. Due to the fact that area A is unable to generate enough power to meet its demand, the need arises to import power from area B. Among the four cases that resulted in voltage violations in their busbars after the contingency, two cases are entirely in area A, which has a demand greater than the power supply, resulting in drops in the magnitude of tension of the contingency bars and neighboring busbars.

Using FLUPOT and calculating the POF, the amount of reactive to be allocated and the bars that should receive parallel compensation were determined, thus avoiding a poorly dimensioned compensation. In cases 18 and 22, compensation proved to be assertive, recovering the stresses of the busbars, not only where the compensation was allocated, but also in peripheral busbars.

To determine the PV curve and to be able to analyze the loading margin, the *ANAREDE* continuation method was used. In cases 18 and 22, when the load increase is

carried out, it is possible to observe that not all busbars are considered stable from the point of view of tension, as is the case of busbars violated after contingencies. These bars, even before compensation, are considered critical, as an undervoltage occurs when placed under a state of emergency, not being able to remain stable in the face of an increase in load after compensation.

The base case obtained the highest loading margin with 5.9550MW and an MST of 17.1086%, which makes the test system above the minimum limit established by the ONS for complete systems, making it stable from a voltage point of view.

Cases 18 and 22, after the contingency, presented PMCs of 5.1318MW and 5.2741MW and MSTs of 0.9209% and 3.7185%, respectively, obtaining an MST of less than 4%, as predetermined by the ONS. After the application of the compensation, cases 18 and 22 achieved an increase in the loading and voltage indexes, where case 18 obtained a loading margin of 5.3313MW and MST of 4.8446%, and case 22 presented a PMC of 5.4052MW and an MST of 6.2976%, presenting positive results in the variables studied.

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**LAND DEGRADATION NEUTRALITY (LDN): A CRITICAL REVIEW OF
CONCEPTUAL GAPS AND CHALLENGES IN IMPLEMENTATION AND
MONITORING**

**NEUTRALIDADE DA DEGRADAÇÃO DA TERRA (LDN): UMA REVISÃO
CRÍTICA DAS LACUNAS CONCEITUAIS E DESAFIOS DE IMPLEMENTAÇÃO E
MONITORAMENTO**

**NEUTRALIDAD DE LA DEGRADACIÓN DE LA TIERRA (LDT): UNA REVISIÓN
CRÍTICA DE LAS LAGUNAS CONCEPTUALES Y LOS RETOS DE
IMPLEMENTACIÓN Y MONITOREO**

 <https://doi.org/10.56238/sevened2025.037-029>

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ABSTRACT

Land Degradation Neutrality (LDN) was proposed by the United Nations Convention to Combat Desertification (UNCCD) to curb productivity loss and socio-environmental impacts caused by terrestrial ecosystem degradation. As a recent goal, LDN remains debated regarding its conceptual clarity, methodological consistency, and applicability across regional contexts. This study, covering the period 1997–2019, aims to analyze the LDN implementation process by identifying conceptual gaps and challenges related to the use of biophysical indicators for monitoring and assessment at multiple scales. The selected timeframe encompasses the consolidation of the UN Convention to Combat Desertification and the formal inclusion of LDN within the 2030 Agenda, enabling an understanding of its conceptual and institutional evolution. The integrative and bibliometric research analyzed 54 scientific articles and 8 institutional reports from indexed databases and grey literature. Results show that although LDN has advanced as a key component of SDG 15 in the 2030 Agenda, uncertainties persist concerning baseline definition, indicator comparability, and policy effectiveness in countries with limited technical capacity. Strengthening the scientific and institutional framework of LDN requires conceptual harmonization and integration among science, governance, and sustainable financing to ensure a balanced future between land degradation and restoration.

Keywords: Land Degradation. Desertification. Land Degradation Neutrality.

RESUMO

A Neutralidade da Degradação da Terra (LDN) foi proposta pela Convenção das Nações Unidas de Combate à Desertificação (UNCCD) com o propósito de conter a perda de

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produtividade e os impactos socioambientais decorrentes da degradação dos ecossistemas terrestres. Como conceito e meta recente, a LDN ainda suscita debates quanto à sua clareza conceitual, coerência metodológica e aplicabilidade em diferentes contextos regionais. Este estudo, desenvolvido no período de 1997 a 2019, tem como objetivo analisar o processo de implementação da LDN, identificando as principais lacunas conceituais e os desafios relacionados à utilização de indicadores biofísicos no monitoramento e na avaliação da meta em distintas escalas. O recorte temporal adotado justifica-se por abranger desde a consolidação da Convenção das Nações Unidas de Combate à Desertificação até a incorporação formal da LDN na Agenda 2030, permitindo observar sua evolução conceitual e institucional. A pesquisa, de natureza integrativa e caráter bibliométrico, abrangeu 54 artigos científicos e 8 relatórios institucionais, obtidos em bases indexadas e documentos da literatura cinzenta. Os resultados evidenciam que, apesar do avanço no estabelecimento da LDN como componente do ODS 15 da Agenda 2030, persistem incertezas quanto à definição de linhas de base, à comparabilidade dos indicadores e à efetividade das políticas públicas em países com limitada capacidade técnica. Conclui-se que o fortalecimento científico e institucional da LDN depende da harmonização conceitual e da integração entre ciência, governança e financiamento sustentável, de modo a assegurar um futuro com equilíbrio entre degradação e restauração das terras.

Palavras-chave: Degradação da Terra. Desertificação. Neutralidade da Degradação da Terra.

RESUMEN

La Neutralidad en la Degradación de la Tierra (LDT) fue propuesta por la Convención de las Naciones Unidas de Lucha contra la Desertificación (UNCCD) con el objetivo de frenar la pérdida de productividad y los impactos socioambientales derivados de la degradación de los ecosistemas terrestres. Como meta reciente, la LDT sigue siendo objeto de debate respecto a su claridad conceptual, coherencia metodológica y aplicabilidad en distintos contextos regionales. Este estudio, desarrollado en el período 1997–2019, tiene como propósito analizar el proceso de implementación de la LDT, identificando las principales lagunas conceptuales y los desafíos vinculados al uso de indicadores biofísicos para su monitoreo y evaluación en diversas escalas. El período elegido abarca desde la consolidación de la Convención de las Naciones Unidas de Lucha contra la Desertificación hasta la inclusión formal de la LDT en la Agenda 2030, lo que permite observar su evolución conceptual e institucional. La investigación, de carácter integrador y enfoque bibliométrico, abarcó 54 artículos científicos y 8 informes institucionales procedentes de bases indexadas y literatura gris. Los resultados muestran que, aunque la LDT se ha consolidado como un componente esencial del ODS 15 de la Agenda 2030, persisten incertidumbres sobre la definición de líneas de base, la comparabilidad de los indicadores y la eficacia de las políticas públicas en países con limitada capacidad técnica. Se concluye que el fortalecimiento científico e institucional de la LDT depende de la armonización conceptual y de la integración entre ciencia, gobernanza y financiamiento sostenible, a fin de garantizar un futuro equilibrado entre la degradación y la restauración de las tierras.

Palabras clave: Degradación de la Tierra. Desertificación. Neutralidad en la Degradación de la Tierra.

1 INTRODUCTION

Land degradation has a profound impact on societies and nature, compromising natural resources across the planet, and is the most challenging environmental problem in drylands (MEA, 2005b). This happens because such a process affects livelihoods, biodiversity, and ecosystem services, while exacerbating climate change and ultimately affecting the well-being of 1.5 billion people worldwide (LAL et al., 2012; ELD, 2015).

The impacts of land degradation are perceived very unevenly in different regions of the planet, and may be more serious in the poorest countries, where about 40% of all land degradation is concentrated (UNCCD, 2015b). In addition, because the impacts of land degradation have direct effects on climate change and biodiversity loss (LAL et al., 2012), they can also influence the ability of nations to achieve the targets set by the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (UNCBD) (LAL et al., 2012).

As defined by the United Nations Convention to Combat Desertification (UNCCD), land degradation is characterized by the reduction or loss of biological or economic productivity and complexity of agricultural land, pastures, or forest areas in arid, semi-arid, and dry sub-humid zones (UNCCD, 2015c). This process results from a combination of factors, including unsustainable land-use systems and the aggravating effect of climate change, which reduce the land's ability to provide vital services, especially under water scarcity (CHASEK et al., 2017).

Given the urgency of reversing this trend, the concept of Land Degradation Neutrality (LDN) was introduced into the global dialogue during the United Nations Conference on Sustainable Development (Rio+20) in 2012. Member States have recognised the need for urgent action to reverse degradation, proposing to achieve a land degradation-neutral world (UNCCD, 2012). This commitment was formally established in the framework of the Sustainable Development Goals (SDGs) in 2015.

Target 15.3 of SDG 15 sets the priority target of achieving the LDN by 2030, which proposes that the global rate of land degradation should not exceed its capacity to recover, keeping the extent of degraded land stable or with minimal increase (UN, 2014; UNCCD, 2015).

Although the LDN is a globally recognized goal and fundamental for sustainable development, its implementation and practical monitoring present significant complexities, especially with regard to its conceptual basis and the biophysical indicators used. This explains the fact that the concept and, in particular, its biophysical monitoring indicators have been the

target of criticism by the scientific community in relation to its conceptual clarity, methodological consistency and effective applicability in different regional contexts.

Given this scenario and the need to guide progress towards SDG Target 15.3, the following research question arises: What are the main conceptual gaps, uncertainties, and challenges related to the LDN implementation process and the use of its biophysical indicators for monitoring and evaluating this goal in different regions of the planet?

The relevance of this study lies in its contribution to critically addressing a central theme of the global sustainability agenda. The deepening of the analysis of the LDN implementation process and the identification of limitations in the conceptual basis and biophysical indicators are crucial to guide future methodological and scientific improvements. In practical terms, this debate is indispensable to subsidize public policies that are truly effective in combating degradation and desertification. By highlighting gaps and uncertainties, this research provides an essential knowledge base for countries to adapt and strengthen their strategies, contributing more effectively to achieving the goal of a land degradation-neutral world.

In this sense, the present study aims to analyze the process of implementation of Land Degradation Neutrality, identifying the main gaps related to the conceptual basis and biophysical indicators, as well as the uncertainties and challenges found in related research to monitor and evaluate LDN in various regions of the planet.

2 THEORETICAL FRAMEWORK

Land degradation has been configured, over the last decades, as one of the most serious environmental and social challenges faced by humanity. This phenomenon compromises livelihoods, biodiversity, and ecosystem systems, intensifying climate change and affecting the well-being of an estimated 1.5 billion people worldwide (NACHTERGAELE et al., 2010; LAL et al., 2012; ELD, 2015). It is a complex and multidimensional problem, whose causes and effects transcend geographical borders and demand an integrated approach, articulating ecological, social and economic dimensions.

The conceptual discussion on land degradation is marked by the breadth and polysemy of the term "degradation", often used generically to encompass different environmental processes — such as desertification, salinization, erosion, compaction, and loss of soil fertility. This semantic generalization, although common in the literature, makes it difficult to accurately measure the phenomenon and compare it between studies (GIBBS; SALMON, 2015).

According to the United Nations Convention to Combat Desertification (UNCCD), land degradation corresponds to the reduction or loss of biological or economic productivity, as well as the ecological complexity of agricultural land, pastures, woodlands, and areas of native vegetation in arid, semi-arid, and dry sub-humid zones. At its core, this process results from unsustainable human practices and the inappropriate use of natural resources (UNCCD, 2015c; AYNEKULU et al., 2017).

The third edition of the *World Atlas of Desertification* (CHERLET et al., 2018) shows that it is not possible to deterministically map the global extent of degradation, given the complexity of the interactions between social, economic, and environmental systems. This finding reinforces the need for multiscale methodologies and integrated approaches that consider both the biophysical factors and the socioeconomic dynamics that aggravate the process.

According to the *Global Assessment of Soil Degradation* (GLASOD), about 20% of soils in dry areas of the planet are degraded, 17% have mild or moderate degradation and more than 2.5% are heavily degraded (GIBBS; SALMON, 2015). The most affected regions are Asia, with approximately 370 million hectares degraded; Africa, with about 319 million; and the American continent, with 279 million hectares. In this context, the *Food and Agriculture Organization* (FAO, 2011) warns that, if current patterns of use and occupation are maintained, by 2025 about 25% of the planet's arable land could be degraded. In arid and semi-arid regions, the picture is even more alarming, with about 69% of potentially agricultural areas suffering erosion and loss of fertility (SALVATI et al., 2009). In these fragile environments, degradation intensified by human action reaches critical levels, configuring itself as desertification (BRASIL, 2004).

The UNCCD defines desertification as the process of land degradation in arid, semi-arid and dry sub-humid regions, resulting from the interaction between climatic factors and human activities (UNCCD, 2015; MAPBIOMAS, 2018). This definition broadens the understanding of the phenomenon by including, in addition to the soil, the loss of biodiversity and the compromise of water resources. Although there are natural causes — such as climatic variations and geomorphological processes (MEADOWS; HOFFMAN, 2003; EU, 2011; WEBB et al., 2017; DHARUMARAJAN et al., 2019) —, degradation is often aggravated by inadequate anthropogenic land use and management practices (CUNHA et al., 2013; SPALEVIC et al., 2014; MATANO et al., 2015; WANJALA; KINYANJUI, 2016).

The phenomenon of desertification manifests itself in various parts of the world, especially in North and South Africa (Sahel region), south-central Eurasia (especially China),

the western portion of the Americas and Australia (ROSÁRIO, 2004). In Brazil, the most vulnerable areas are predominantly located in the Northeast region, although recent studies point to the expansion of these climatic zones to other regions of the country (MAPBIOMAS, 2018). Such evidence highlights the urgency of environmental mitigation and restoration policies adjusted to local specificities.

The conceptual breadth of the terms *land degradation* and *desertification* (ZUCCA, 2012) amplifies the controversies and makes it difficult to make precise estimates at multiple scales. The absence of a standardized global monitoring system is, therefore, one of the main obstacles to the formulation of effective public policies and to the international comparability of data (GIBBS; SALMON, 2015).

In view of the socio-environmental impacts of land degradation, the theme was incorporated into the global goals of the United Nations (UN), in 2015, in the document *Transforming our World: The Sustainable Development Agenda for 2030*. This document defined 17 Sustainable Development Goals (SDGs), divided into 169 integrated and indivisible goals, respecting the specificities and priorities of each State.

In the context of SDG 15, which deals with "protecting, restoring and promoting the sustainable use of terrestrial ecosystems, sustainably managing forests, combating desertification, halting and reversing land degradation and halting biodiversity loss", target 15.3 was approved, which determines, "by 2030, to combat desertification, restore land and degraded soil, including land affected by desertification, droughts and floods, and striving to achieve a land degradation-neutral world" (CGEE, 2016).

The concept of *Land Degradation Neutrality* (LDN) emerged in 2015, in the context of the UNCCD, defined as "a state in which the amount of healthy and productive land resources, necessary to support ecosystem services, remains stable or increases within specific temporal and spatial scales" (UNCCD, 2015). In practical terms, the LDN implies that the degradation that occurred in a given locality must be compensated by the recovery or rehabilitation of previously degraded areas.

In Brazil, research on land degradation and LDN has intensified since 2013, especially in semi-arid regions. Studies by SALGADO and OLIVEIRA (2018) and CUNHA et al. (2013) highlight the importance of integrating biophysical indicators, remote sensing, and public policies in improving environmental monitoring. Despite the advances and the country's adherence to the goals of the UNCCD, challenges related to methodological standardization and institutional articulation persist (BAPTISTA; SILVA, 2019). Such efforts, however,

constitute an essential theoretical and methodological basis for strengthening the LDN agenda in the national and regional context.

The literature on Land Degradation Neutrality (LDN) reveals the coexistence of different theoretical currents that express different conceptions about its foundations and forms of implementation. These approaches reflect tensions between ecological, technical, and institutional perspectives, demonstrating the complexity of the concept and its multiple interpretations in the field of environmental sciences.

On the one hand, authors linked to the **ecosystem and restorative** approach (ARONSON; ALEXANDER, 2013; COWIE et al., 2018) understand the LDN as a strategy for **reconciling conservation and development**, emphasizing the need to integrate mitigation and ecological restoration policies. From this perspective, neutrality represents a dynamic balance between the land's capacity to sustain ecosystem services and human demands for productivity and land use.

On the other hand, currents of **a technocratic and quantitative** nature (KUST et al., 2016; DALLIMER; STRINGER, 2018) prioritize the improvement of **biophysical indicators** and the search for standardized methodologies that ensure global comparability. This strand attributes a central role to the measurement of degradation, defending the need for universalizable models for monitoring LDN, although this standardization does not always contemplate regional and socioeconomic specificities.

There is also a **critical-institutional** aspect (CHASEK et al., 2019; GICHENJE; PINTO-CORREIA, 2019), which problematizes the political-structural limitations and inequalities of technical capacity between countries. This perspective questions the feasibility of achieving neutrality in asymmetric contexts, especially where there is institutional fragility, scarcity of resources, and dependence on international funding agendas.

This diversity of interpretations reinforces that the **conceptual gaps and methodological uncertainties** discussed in this research do not stem only from technical limitations, but reflect **epistemological tensions** between different ways of conceiving degradation, restoration, and sustainability. Understanding these theoretical divergences is essential to consolidate a **more cohesive conceptual framework**, capable of guiding comparable methodologies and consistent interpretations of the LDN within the scope of global sustainability goals.

Several factors accentuate environmental vulnerability in the face of degradation: irregular rainfall, shallow soils susceptible to erosion, fragmentation of vegetation, poverty,

unemployment and lack of social infrastructure. However, there is still no scientific consensus on which biophysical indicators are most appropriate to measure degradation or to assess progress towards neutrality.

The use of environmental indicators represents a fundamental tool to assess the state of the landscape and understand the responses to anthropogenic pressures. According to NIEMEIJER and DE GROOT (2008), environmental indicators are variables capable of describing the state of the environment, its pressures, impacts and systemic responses. For MATTALO JR. (2001), a good indicator must be meaningful, measurable, clear and sensitive to changes, reflecting future trends. Given the complexity of ecological processes, no single indicator is able to fully represent land degradation; therefore, it is recommended to use combined indicators, forming composite indices that allow comparisons between different spatial contexts (SALVATI; ZITTI, 2009).

Achieving target 15.3 of the Sustainable Development Goals (SDGs), aimed at combating desertification and restoring degraded land by 2030, requires the development of more accurate analytical models capable of identifying and measuring affected areas. This advance depends on overcoming the current limitations in the definition and operationalization of biophysical indicators, which are fundamental for the effective monitoring of land degradation.

Understanding the interrelationships between degradation processes and biophysical systems is an essential condition for the scientific and institutional strengthening of the LDN agenda. This integrated approach — which articulates science, technique, and policy — broadens the debate on sustainability, territorial planning, and rational management of natural resources, favoring the improvement of conservation and environmental governance strategies at different scales.

3 METHODOLOGY

The present research is characterized as an integrative bibliographic review associated with an exploratory bibliometric analysis, based on the principles of BOTELHO, CUNHA and MACEDO (2011). This methodological combination allowed the integration of conceptual, technical, and political dimensions of Land Degradation Neutrality (LDN), enabling a comprehensive understanding of international scientific production on the subject.

The time frame in the period 1997–2019 was defined as corresponding to the period of consolidation of the United Nations Convention to Combat Desertification (UNCCD) and

the formalization of the LDN in the 2030 Agenda for Sustainable Development, which marks the conceptual maturation and institutionalization of global policies for sustainable land management.

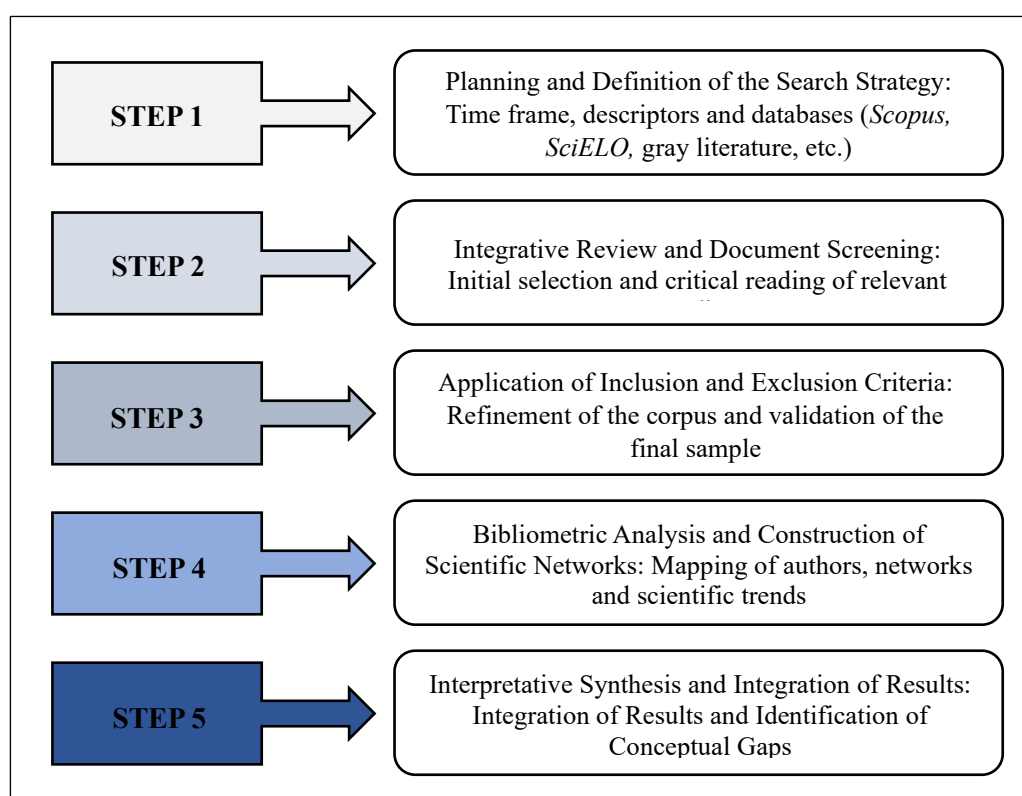
3.1 METHODOLOGICAL STRUCTURE AND STAGES OF THE RESEARCH

The methodology was structured in five sequential and interdependent stages, represented in the Methodological Diagram (Figure 1). The flowchart illustrates the iterative nature of the process, evidencing the integration between the literature review, the selection criteria and the bibliometric analysis, which supported the final interpretation of the results.

To ensure greater transparency, the exact number of documents analyzed was recorded at each stage of the methodological funnel: initially 312 records identified, reduced to 156 after the screening of titles and abstracts, of which 62 were selected in the complete reading, resulting in the final corpus of 54 scientific articles and 8 institutional reports used in qualitative and bibliometric analyses.

Figure 1

Methodological Flowchart



Source: Prepared by the authors, 2020.

3.2 STEP 1 – PLANNING AND DEFINING THE SEARCH STRATEGY

The time frame (1997–2019), the scientific bases, and the main descriptors used in the searches were established. The search was carried out in *the Scopus*, *SciELO*, *ResearchGate* and *Google Scholar databases*, complemented by consultations with the gray literature (reports from UNCCD, FAO, EEA and MMA).

The search expressions were structured with the *TITLE-ABS-KEY* command, using Boolean operators (AND, OR, NOT) to combine terms and refine the accuracy of the results. The main descriptors included: "*land degradation neutrality*", "*desertification*", "*dryland degradation*", "*biophysical indicators*" and "*sustainable land management*". The search was structured using the *TITLE-ABS-KEY* command, using Boolean operators (AND, OR, NOT) to refine the accuracy of the results.

This stage aimed to identify relevant scientific publications and institutional documents that addressed the conceptual development and evaluation mechanisms of the LDN in different regional contexts.

3.3 STEP 2 – INTEGRATIVE REVIEW AND SCREENING OF DOCUMENTS

The integrative review consisted of a systematic process of **critical reading and thematic categorization**, guided by the criteria of relevance, originality, and adherence to the scope of the LDN. Initially, **312 documents were identified**, of which **156** were kept after reading titles and abstracts. The data were organized according to the baseline variables (author, year, country, descriptors, thematic area, and type of publication).

Table 1 presents the synthesis of the databases consulted, the search parameters and the inclusion criteria used in this stage.

Table 1

Database Synthesis and Search Parameters

Database	Publication Type	Period	Search Fields	Examples of Descriptors	Inclusion Criteria
Scopus	Indexed articles	1997–2019	Title, Abstract, Keywords	"land degradation neutrality", "LDN indicators", "desertification"	Articles with ≥10 citations
SCIELO	Reviewed Articles	2000–2019	Title, Abstract	"Sustainable land	Thematic relevance

				management", "biophysical indicators"	
Google Scholar / Grey Literature	Reports and technical documents	1997–2019	Full text	"UNCCD", "2030 Agenda", "SDG 15.3"	Recognized institutional sources

Source: Prepared by the authors, 2020.

3.4 STEP 3 – APPLICATION OF INCLUSION AND EXCLUSION CRITERIA

At this stage, the documents were filtered to ensure coherence and scientific representativeness.

The inclusion criteria included:

- Publications between 1997 and 2019;
- Texts in English, Spanish or Portuguese;
- Studies on biophysical indicators, evaluation methodologies or public policies related to LDN;
- Institutional documents of international organizations.

Opinion articles with no empirical basis, studies without explicit mention of LDN or focused exclusively on agricultural degradation were excluded. Opinion articles without empirical basis, studies without explicit mention of the LDN, duplicate studies and studies focused exclusively on agricultural degradation were excluded. After applying the filters, 62 documents were analyzed in full text, resulting in the final corpus of 54 scientific articles and 08 institutional reports.

3.5 STEP 4 – BIBLIOMETRIC ANALYSIS AND CONSTRUCTION OF SCIENTIFIC NETWORKS

This stage aimed to identify patterns of production, collaboration and thematic convergence on the LDN in the delimited period, articulating quantitative data and qualitative interpretations. The metadata was previously organized, with standardization of authors, institutions, countries and keywords, ensuring the consistency and comparability of the information.

The final database was exported to the *VOSviewer 1.6.20* software, applying the "association strength" normalization model, as proposed by VAN ECK AND WALTMAN (2014), together with the modularity algorithm for the detection of conceptual clusters. This approach allowed the identification of co-authorship networks, institutional collaboration nuclei and emerging research trends.

The results of this stage enabled the formation of three *main interpretative* clusters:

- (1) Conceptualization and definition of the LDN;
- (2) Biophysical indicators and evaluation methodologies;
- (3) Uncertainties and challenges related to implementation, including governance issues, scales of analysis, and integration with environmental policies.

From these networks, it was possible to establish the empirical and conceptual basis that guided the integrated thematic analysis, developed in the next stage.

3.6 STEP 5 – INTEGRATED THEMATIC ANALYSIS AND SYNTHESIS OF RESULTS

In this stage, the correlation between the bibliometric results and the qualitative evidence extracted from the literature was carried out, in order to understand the conceptual, technical and methodological foundations of the LDN. The analytical reading of the full texts allowed the identification of excerpts that addressed the conceptual dimensions, the biophysical indicators and the operational challenges of the implementation of the LDN in different contexts.

The information was classified into three analytical macrogroups:

- 1) Conceptualization and definitions of the LDN;
- 2) Biophysical indicators and methodological integration;
- 3) Uncertainties and gaps, associated with baseline, measurement scales, governance, and financing.

Based on this categorization, an analytical triangulation was carried out between the bibliometric clusters and the thematic categories, which allowed the construction of a convergence matrix between the main conceptual trends and the empirical evidence in the literature. This matrix evidenced gaps and recurrent challenges, later systematized in **Table 2 (Results and Discussion)**, coherently integrating the quantitative and qualitative results of the research.

As a limitation, the possibility of linguistic bias is recognized, due to the predominance of publications in English, which may have restricted the inclusion of relevant studies in other languages. In addition, there is a time restriction, as the cut up to 2019 does not cover more recent methodological and institutional advances, still under development after the consolidation of the 2030 Agenda.

4 RESULTS AND DISCUSSIONS

4.1 CONCEPTUAL FOUNDATIONS OF LAND DEGRADATION NEUTRALITY (LDN)

The concept of Land Degradation Neutrality (LDN), as defined by the UNCCD (2015), represents the state in which the quantity and quality of terrestrial resources remain stable or increase over time, ensuring the maintenance of ecosystem functions and food security. This proposal aims to balance degraded and non-degraded areas, applying to all ecosystems and territorial scales (KUST, ANDREEVA and COWIE, 2017).

The main innovation of LDN lies in the requirement to restore and sustainably manage the earth's resources, so that any inevitable losses are compensated by the rehabilitation of previously degraded areas (GNACADJA and WIESE, 2016; WUNDER, 2018). This logic implies a transformation in global environmental governance, in which neutrality results from the sum of local and national goals (KUST et al., 2016; 2018).

However, conceptual and operational challenges remain. The definition of "quantity" and "quality" of land requires the use of physical and qualitative indicators, the application of which still presents methodological complexities (AKHTAR-SCHUSTER et al., 2016; 2017). The absence of standardized baselines and clearly defined spatial and temporal scales hinders international monitoring and comparability (SAFRIEL, 2017; DALLIMER and STRINGER, 2018).

In response to these limitations, the UNCCD recognizes the need to strengthen the scientific foundation and harmonize methodologies, reducing divergent interpretations. Three axes structure this guideline: maintenance of ecosystem services; integration between environmental and socioeconomic goals; and inclusive and participatory governance (UNCCD, 2015).

In summary, the LDN represents an integrative approach that articulates ecological, social and economic dimensions, guiding policies for restoration and sustainable management of soils. Its effectiveness depends on methodological standardization and

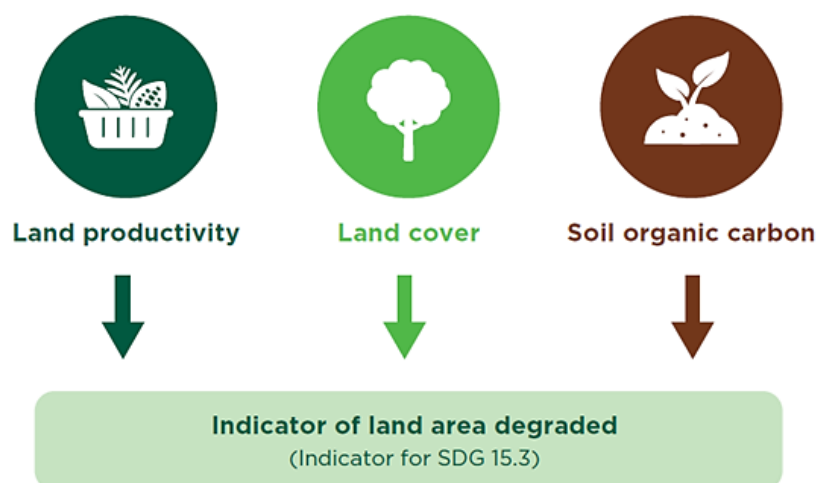
international cooperation, ensuring comparability between countries and strengthening local actions to mitigate degradation.

4.2 BIOPHYSICAL INDICATORS OF THE LDN

To monitor progress towards Land Degradation Neutrality, the UNCCD has established a minimum set of three global biophysical indicators, which are key to monitoring SDG Target 15.3 (UNCCD, 2013; 2016a; GLII, 2015). These indicators are: (1) land cover and cover changes, (2) land productivity, and (3) soil organic carbon stock (SOC). Figure 2 summarizes the model proposed by the Convention, which guides the measurement of soil degradation and restoration on a global scale.

Figure 2

The UNCCD indicators to assess trends in land degradation and achieve the LDN SDG



Source: UNCCD, 2015.

Land cover is the most sensitive indicator of anthropogenic and natural transformations, and can be monitored by remote sensing. Changes in vegetation cover indicate both degradation processes, such as deforestation and fragmentation, and recovery (CUNHA et al., 2013; EASDALE et al., 2019). Therefore, the spatial analysis of the cover must be complemented by local validation, in order to distinguish sustainable from unsustainable variations (WUNDER, 2018).

Land productivity, associated with Net Primary Productivity (NPP), reflects the capacity of vegetation to accumulate biomass and regulate energy and matter exchanges between surface and atmosphere (LIETH, 1975; BAO et al., 2017). Significant changes in NPP can

indicate anthropogenic pressure or climatic disturbances, and are therefore a useful indicator to assess the balance between degradation and restoration.

Soil organic carbon stock (SOC) is one of the most robust indicators of the health of terrestrial ecosystems, reflecting the soil's capacity to store carbon and sustain ecosystem services (UNCCD, 2016a; CHAPPELL et al., 2019). Despite its relevance, the lack of standardized data and consistent monitoring systems in various regions of the world limits the comparability of results (JONES and FALLOON, 2009).

The integration of the three indicators constitutes a relevant methodological advance, as it allows us to understand together the structural, functional and temporal dimensions of land degradation. Its effectiveness depends on robust time series, regional calibration, and articulation between scientific research and territorial management (KUST et al., 2016; GICHENJE and GODINHO, 2018). Thus, understanding the interdependence between indicators is essential for diagnosing trends and strengthening public policies aimed at sustainable land governance.

4.3 UNCERTAINTIES AND CHALLENGES FOR THE IMPLEMENTATION OF THE LDN

Table 2 summarizes the main uncertainties and challenges identified in the scientific literature on the operationalization of Land Degradation Neutrality (LDN) in different global contexts.

Table 2

The main uncertainties and challenges identified in the reference articles on LDN

UNCERTAINTIES / CHALLENGES	AUTHOR(S) / YEAR
Need for a methodology adapted to regional realities to define the baseline of the LDN (different causes and trends of land degradation, natural and socioeconomic characteristics of the territory);	UNCCD (2012, 2014a); CASPARI et al. (2015); CHASEK et al. (2015); GRAINGER (2015); STAVI & LAL (2015); KUST et al. (2018)
Consideration of environmental, economic, social, political and cultural particularities, as well as the diversity of determinant factors and processes of land degradation, among countries, which need to be considered in the formulation of LDN goals;	O'CONNELL et al. (2013); FAO (2011); NKONYA et al. (2015); KUST et al. (2018)
Balanced integration between prevention and reversal of degradation (ecosystem approach): (i) address current and	ARONSON & ALEXANDER (2013); GIROT et al. (2013);

future land degradation by avoiding/preventing/minimizing land degradation processes; and (ii) reverse past land degradation;	UNCCD (2014b, 2014c); CHASEK et al. (2015); COWIE et al. (2018)
Limits in the measurement of degradation in terms of the quantity and quality of available land: severity of degradation and area of land involved;	UNCCD (2012, 2014a); EC JRC (2014); SOLOMUN et al. (2018)
Lack of consensus on the optimal scales of application and monitoring of the status and trends of the LDN;	NKONYA et al. (2015); CROSSLAND et al. (2018); SOLOMUN et al. (2018)
Difficulty in measuring large areas due to the need for technical assistance and scientific research, especially in poorer countries;	GRAINGER (2015); COWIE et al. (2018)
Definition and standardization of national LDN indicators;	KUST et al. (2018); DALLIMER & STRINGER (2018)
The need for simple, comparable indicators based on common principles;	O'CONNELL et al. (2013); CASPARI et al. (2015); CHASEK et al. (2015); GRAINGER, 2015; TAL (2015); STAVI and LAL (2015);
Integration of LDN with biodiversity, climate (climate change), poverty, and food security	KUST et al. (2018); ARONSON AND ALEXANDER, 2013; LIU et al., 2013; IPCC, 2014; REID, 2015); OKPARA et al., 2108;
Management of <i>trade-offs</i> and synergies between different land uses for multiple benefits;	LIU et al. (2013); EC JRC (2014)
Application of the socio-ecological approach (SES) in the implementation: human beings as part of nature in the search for LDN;	OKPARA et al. (2108);
Creation of national policies and partnerships between the State (national and local governance) and the scientific community;	KUST et al. (2018); CROSSLAND et al. (2018)
Involvement and effective commitment of all stakeholders;	UNCCD (2012, 2014a); GRAINGER, 2015; GICHENJE, MUÑOZ-ROJAS & PINTO-CORREIA (2019)

High costs of implementation, evaluation and monitoring of the LDN,	DALLIMER & STRINGER (2018); DARADUR et al. (2018); CHASEK et al. (2019) CHASEK et al. (2019); GICHENJE, MUÑOZ-ROJAS and PINTO-CORREIA, (2019)
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Source: the Author, 2025.

The scientific literature shows that the implementation of the LDN faces a significant set of uncertainties and conceptual, methodological and institutional challenges, which compromise its consolidation as a global sustainability goal. The most critical point refers to the definition of baselines, which should reflect the environmental, social and economic particularities of each territory (UNCCD, 2012; CASPARI et al., 2015; KUST et al., 2018).

Another recurrent limitation is the selection of analysis scales and biophysical indicators used to measure degradation. The adoption of inappropriate scales can distort results and make comparisons between countries and biomes difficult (CROSSLAND et al., 2018; SOLOMUN et al., 2018). In addition, the lack of reliable data and the low technical-scientific support in countries with limited institutional capacity represent obstacles to the measurement and monitoring of large areas (GRAINGER, 2015).

The lack of international consensus on the standardization of LDN indicators is also a significant weakness. These indicators must be simple, measurable, and based on integrative ecosystem principles, but the multiplicity of definitions and the absence of universal parameters make comparability difficult (O'CONNELL et al., 2013; STAVI and LAL, 2015).

From a strategic point of view, the literature reinforces the need for integrated ecosystem approaches, which reconcile preventive and restorative actions, combining the mitigation of current degradation and the recovery of areas already affected (ARONSON and ALEXANDER, 2013; LIU et al., 2013; IPCC, 2014). This perspective should incorporate dimensions such as biodiversity, climate change, and food security, maximizing synergies between public policies (KUST et al., 2018; OKPARA et al., 2018).

Finally, the effectiveness of the LDN depends on favorable institutional environments and participatory governance mechanisms, with cooperation between governments, the scientific community, and civil society. The absence of robust national policies, the fragmentation of inter-institutional actions, and the high costs of implementation continue to

limit progress (DALLIMER and STRINGER, 2018; GICHENJE, MUÑOZ-ROJAS and PINTO-CORREIA, 2019).

5 CONCLUSION

The results of this research confirm the relevance of Land Degradation Neutrality (LDN) as one of the central goals of the 2030 Agenda, established by the UN. The analysis demonstrates that, although the concept represents an important advance in the integration between science, policy and environmental management, its definition remains incomplete, which limits methodological clarity and hinders the effective monitoring of degradation processes on a global scale.

It was found that the consolidation of the LDN requires the improvement of its conceptual bases and the standardization of biophysical indicators, in order to ensure comparability and effectiveness in public policies aimed at sustainable land governance. In this sense, it is essential that governments incorporate the LDN into their environmental governance agendas, establishing stable financing mechanisms and integrated institutional structures, with active participation of the scientific community and civil society in the restoration and rehabilitation of degraded lands.

From an academic point of view, this study offers a significant theoretical contribution by systematizing and critically discussing the conceptual and methodological foundations of the LDN, highlighting gaps, uncertainties, and opportunities for future research. Such a contribution reinforces the importance of interdisciplinary and multi-scalar approaches in the formulation of more precise and equitable environmental policies.

It is therefore recommended that further investigations deepen the empirical validation of the three minimum indicators proposed by the UNCCD, considering different biophysical and socioeconomic contexts. In addition, it is suggested the development of complementary indicators that are more sensitive to local dynamics, capable of strengthening the monitoring and effective implementation of the global goal of a neutral world in land degradation.

Finally, it is important that future versions of this research integrate post-2019 analyses, in order to reflect the most recent conceptual, institutional, and methodological evolution of the LDN, considering the scientific and political advances that occurred after the consolidation of the 2030 Agenda and the maturation of global neutrality strategies.

ACKNOWLEDGMENTS

To the Foundation for Research Support of the State of Bahia (FAPESB).

To the Graduate Program in Earth and Environmental Sciences (PPGM – UEFS/BA).

To Professor Rodrigo Nogueira de Vasconcelos (UEFS-BAHIA), for his guidance and support in carrying out the research.

The present work was carried out with the support of the Coordination for the Improvement of Higher Education Personnel - Brazil (CAPES) - Financing Code 001.

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SCIENTIFIC PRODUCTION ON THE CLAY MINERAL ILLITE: A BIBLIOMETRIC STUDY

PRODUÇÃO CIENTÍFICA SOBRE O ARGILOMINERAL ILITA: UM ESTUDO BIBLIOMÉTRICO

PRODUCCIÓN CIENTÍFICA SOBRE EL MINERAL ARCILLOSO ILLITA: UN ESTUDIO BIBLIOMÉTRICO

 <https://doi.org/10.56238/sevened2025.036-030>

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ABSTRACT

Clays have been present in society since the beginning of civilization, playing an important role in the early development of man. From the moment that man began to acquire knowledge about the material, in which it served him, he began to analyze its behavior and its application. However, he needed to know the raw material and that there was a difference between them in terms of the structural composition of each clay. Therefore, the objective of this work is the bibliometric survey on the illite clay mineral. The methodology was the study of art and was based on the Web of Science survey, with a time interval of 10 years (2011-2022). Within the base of the Web of Science, filters were applied for search refinement, and the term illita was inserted in the English language. Also, in addition to the year, authors with more publications and the main categories of the database were searched. After processing the data, author Zwingmann was the author with the most publications, followed by Hong and soon after Clauer, each with 29, 27 and 26, respectively. The category with the most publications was Geosciences Multidisciplinary, Geochemistry Geophysics and Mineralogy.

Keywords: Rock. Sedimentar. Genesis of Clay.

RESUMO

As argilas estão presentes na sociedade com um papel importante no desenvolvimento da civilização humana. A partir do momento que o homem começou a adquirir conhecimento sobre o material que lhe servia, passou a analisar o comportamento e sua aplicação. No entanto, era necessário conhecer a matéria-prima e as diferenças entre as argilas existentes. Portanto, o objetivo desse trabalho é o levantamento bibliométrico sobre o

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argilomineral illita. A metodologia para a determinação do estado da arte se deu com base na pesquisa na plataforma Web of Science, com intervalo de tempo de 10 anos (2011-2022). Dentro da base da Web of Science foram aplicados filtros para o refinamento de busca, com o emprego do termo illita (illite). Além do ano, foram buscados os autores com mais publicações e as principais categorias da base de dados. Após o tratamento dos dados, o autor Zwingmann foi o autor com mais publicação, seguido pelo Hong e logo em seguida Clauer, cada um com 29, 27 e 26, respectivamente. A categoria com mais publicação foi a Geosciences Multidisciplinary, Geochemistry Geophysics e Mineralogy.

Palavras-chave: Matéria Prima. Sedimentar. Aplicação Industrial.

RESUMEN

As argilas estão presentes na sociedade com um papel importante no desenvolvimento da civilização humana, . A partir do momento que o homem começou a adquirir conhecimento sobre o material que lhe servia, passou a analisar o comportamento e sua aplicação. No entanto, era necessário conhecer a matéria-prima e as diferenças entre as argilas existentes. Portanto, o objetivo desse trabalho é o levantamento bibliométrico sobre o argilomineral illita. A metodologia para a determinação do estado da arte se deu com base na pesquisa na plataforma Web of Science, com intervalo de tempo de 10 anos (2011-2022). Dentro da base da Web of Science foram aplicados filtros para o refinamento de busca, com o emprego do termo illita (illite). Além do ano, foram buscados os autores com mais publicações e as principais categorias da base de dados. Após o tratamento dos dados, o autor Zwingmann foi o autor com mais publicação, seguido pelo Hong e logo em seguida Clauer, cada um com 29, 27 e 26, respectivamente. A categoria com mais publicação foi a Geosciences Multidisciplinary, Geochemistry Geophysics e Mineralogy.

Palabras clave: Materia Prima. Sedimentaria. Aplicación Industrial.

1 INTRODUCTION

Over time, since the beginning of civilization, man sought to improve the technology of the time for better application of clays, which served man in countless ways, such as: storing groceries, water, special oils; in some civilizations, it was used to worship gods, such as in Egypt (source?).

With the advancement of science and technology, the latter from the Industrial Revolution, allowed knowledge about clays to progress and expand the areas of application. One of these areas is red pottery. Clay minerals are minerals that intrinsically define clays; Chemically, they are hydrated aluminum or magnesium silicates and in the presence of water they acquire certain properties that make technological application feasible. It was from this observation, clay became the main component of traditional ceramics in the composition of masses (ABCERAM, 2022).

Clays, therefore, are raw materials for various purposes of technological application. In addition to the use in the area of red ceramics, there are several uses in other sectors such as in the cement manufacturing industry, advanced ceramics, refractory industry, rubber, paints and paper. The modernization of technology and scientific progress have led to the use of clays in the health and cosmetics industries. In the health sector, in the manufacture of ceramic composites, blends with ceramic materials; in dentistry, in the manufacture of veneers. In the area of cosmetology, it is part of makeup products, clay masks to remove toxins and fats.

With the high variability of clay minerals, illite is one of the clay minerals with great technological application. Illite comes from the primary mineral mica that belongs to the group of phyllosilicates, making up a secondary mineral of the 2:1 type that corresponds to two sheets of silicon tetrahedron and one of aluminum octahedron. The chemical composition of illite is $(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$ and dioctahedral similar to that of

muscovite with junction of the T-O-T layer (two tetrahedral leaves and one octahedral). Generally, by majority, illites contain fewer atoms between the strata than muscovite generating a weak binding force (ERNANI, 2016; NAVARRO et al., 2017).

As a general objective of this article, a survey was carried out through a bibliometric study identifying the main authors and sectors and/or segments that use illite in the industrial process and thereby verifying the object of study, enabling its use.

2 METHODOLOGY

The bibliometric research started from the study of art with access to the list of collections available on the CAPES journal platform. The basis of the research was the Web of Science, carried out from November to December 2022. The objective of study in this survey was the clay mineral illite with its technological applications. To this end, filters were applied to refine the search based on more relevant and updated data, as shown in Chart 1.

The research began with the use of the clay mineral illite, but the Web of Science database recognizes only terms in English, and illite is used. In order to make the work more refined, the time interval applied was 11 years, from 2011 to 2021. Also, Web of Science categories and authors were searched , and the five most important articles were selected, from which the analysis of the studies of interest was generated.

The discussion of the data took place about each publication of greater importance for each author

Table 1

List of categories and authors

Filters	Data
Web of Sciences journals	<i>Geosciences</i> <i>Multidisciplinary</i> <i>Geochemistry Geophysics</i> <i>Mineralogy</i> <i>Chemistry</i> <i>Physical Energy</i> <i>Fuels</i>
Main Authors	Zwingmann, Horst Hong, Halie Clauer, Nobert Aldega, L Dai, Shifeng

Source: The author, 2022.

3 RESULTS AND DISCUSSION

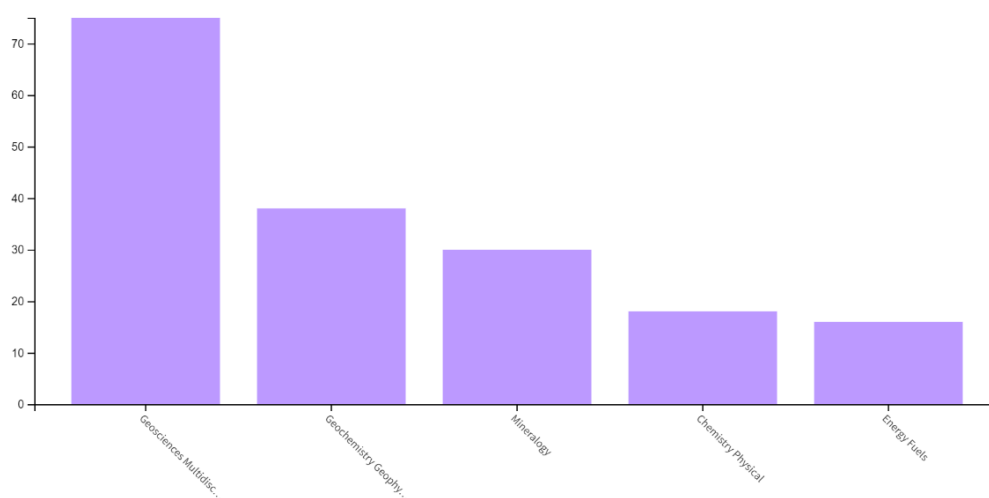
From the search filters used in this research, 126 publications were obtained. The journal with the most publications was Geosciences Multidisciplinary, with 75 papers identified, followed by Geochemistry Geophysics with 38, and then Mineralogy with 30

publications. Figure 1 shows the graph with the number of publications according to the category of the database.

Regarding the time interval employed (11 years), Figure 2 shows the number of publications. The year 2013 presented the highest number of articles with 15, followed by the years 2016 and 2017 which were tied with 14 and soon after the years 2012, 2014, 2015 and 2020, making a result of 12 published works.

Figure 1

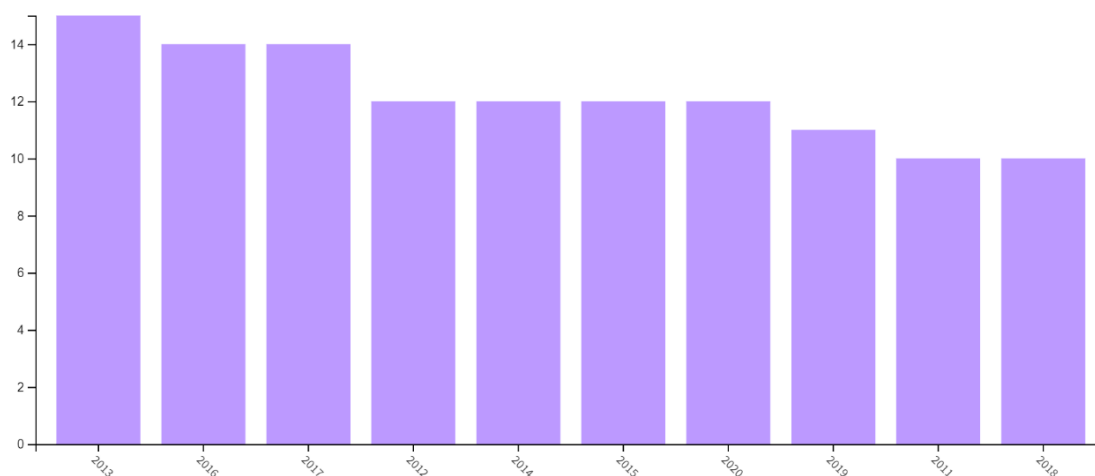
Web of Science category distribution chart



Source: Web of Science, 2022.

Figure 2

Number of publications per year



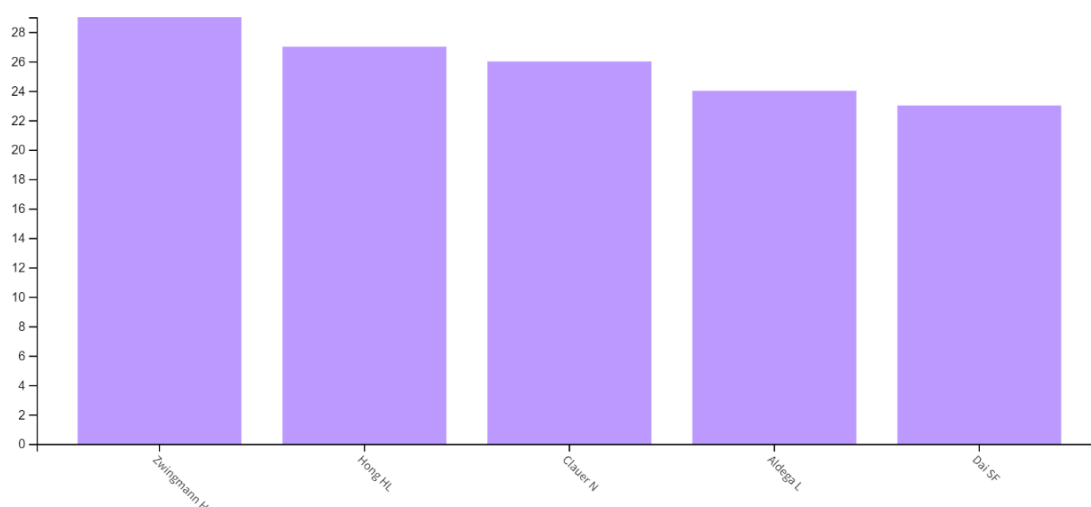
Source: Web of Science, 2022.

The author who presented the highest number of publications in the period surveyed was Horst Zwingmann, with 29 in all. After him, Halie Hong with 27 and then Norbert Clauera with 26 publications. Figure 3 shows the graph with the scientific production of the five authors who published the most.

Figure 4 shows the graph with the curve of citations and publications within the established time interval.

Figure 3

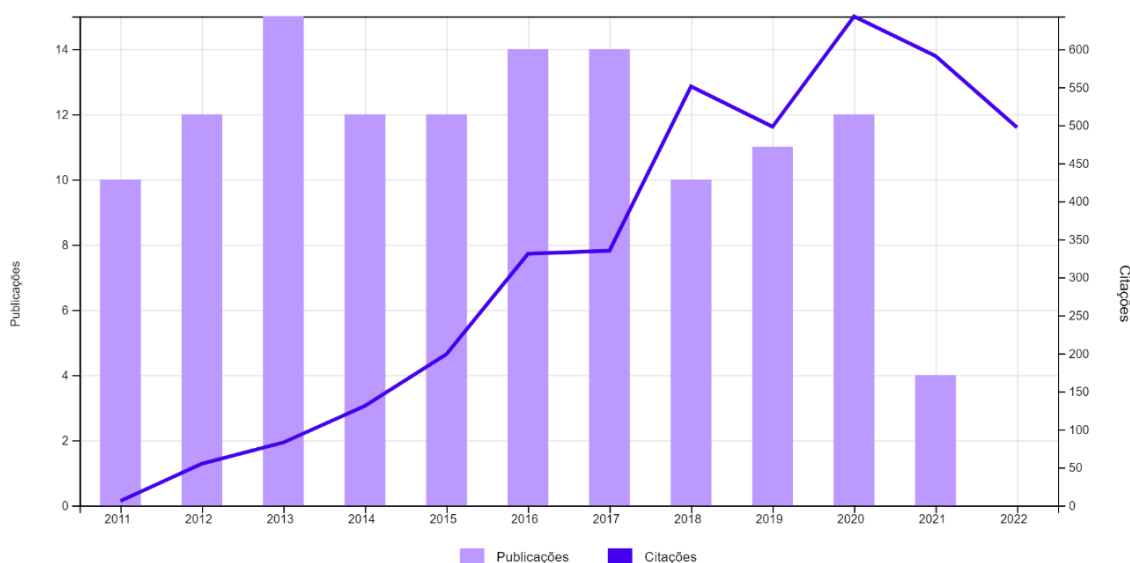
Graph with the number of publications according to each author



Source: Web of Science, 2022.

Figure 4

Graph number of citations X publication



Source: Web of Science, 2022.

According to Figure 3, Zwingmann presented 29 publications, among which Clauer et al., (2012) stand out, which aims to study two dating methods, K-Ar and $^{40}\text{Ar}/^{39}\text{Ar}$ with illite-type clay minerals. To carry out this research, the authors separated samples ranging in size < 0.2 to $40\text{ }\mu\text{m}$ originated from a set of boreholes in sandstones of the Basin in northwestern Germany. After the analyses, the authors concluded that the conventional K-Ar method is convenient and straightforward for dating clay minerals and it is possible to use this clay mineral in geochronology. This work, according to the database, is within the journal of Geosciences Multidisciplinary and has been cited 55 times, showing its value in the area of geosciences.

The study by Yin et al., (2013) brought an approach to the description of vermiculite intercalated with hydroxyl (HIV) present in the red earth profile in Jiujiang, southeastern China, aiming to understand its genesis. The site is in a subtropical zone, above sea level at around 41 m altitude. The depth of 14 m was subdivided into three sections. After processing the data, the authors concluded that the sedimentary deposit was formed in the Pleistocene period, resulting from the alteration in the HIV clays due to climatic conditions. The exchangeable cations present and the spacing break were due to the ratio of $\text{Al}/(\text{Mg}+\text{Ca})$ as AlOH acting on the HIV interlayers. The HIV clays found in this locality are products of the weathering of the illite, suggesting that the order of weathering was: illite-vermiculite-HIV. The study comprises two journals: Mineralogy, Chemistry Physical.

The author with the most publication, after Hongn, is Norbert Clauer. In total, 26 articles were identified, and their most interesting study was published in 2012. It addresses clay dating by two methodologies (CLAUER et al., 2012).

Aldega totaled 24 publications and among them the most valuable is the study developed in partnership with Rossetti et al., (2011) who proposed a hydrodynamic mathematical model for fluid flow and mineralization as well as the inference of future failures for hydrothermal flow. In addition, the description of the fluid flow mode, rock-fluid interaction and mineralogy within the environment of the extensional fault in the main hydraulic channel for thermal circulation.

The x-ray diffraction technique and the application of geochemical studies, inclusion of fluids and stable oxygen isotopes were used. As a conclusion of the study, the authors point out that the hydrological properties were influenced by the low permeability of the fault core inducing the compartmentalization of the fluid flow and the parallel flow of ascending

fault. The Web of Science category that falls under the study is Geosciences Multidisciplinary (ROSSETTI et al., 2011).

The study by Dai et al., (2011) had a high number of citations, in all 222 and aimed to describe the chemical and mineralogical compositions and possible sources of silic, mafic and alkaline tonsteins as well as magic tuffs below the Upper Permian carboniferous layers. In all, 35 samples of tonstein and 4 samples of magic tuffs from the six coal mines. The mineralogical detection was made by optical microscopy and X-ray diffraction. Therefore, the authors found that the deposits were indeed alkaline, mafic, and silicon, in which the first two correspond to the initial and final stage of the Permian and the mafic tonsteins are distributed throughout the section

Carboniferous from the late Permian. Clay minerals, in most tonsteins, belong to the kaolinite group or are composed mainly of mixed layers of illite and smectite. The presence of quartz is significant in silicon tonsteins; the alkaline and mafic ones are enriched with anatase. The presence of pyrite in all tonsteins is due to the influence of seawater. This study belongs to the category Geochemistry & Geophysics.

Regarding the development of the study, it was observed that, despite having fewer publications, the author Shifeng Dai was the most cited in the elaboration of other studies. This shows the great value of this researcher in the area of geochemistry and geophysics, as he served as a basis for the discussion of other similar studies with the intention of exploring the research area.

Another important point was the year of publication of the authors listed in Figure 3, where most of the scientific productions are from the year 2011. Among the selected works of each author, the Geosciences Multidisciplinary category was the one with the greatest coverage, while the others were only tied, except for Energy Fuels, which did not include any of the works.

4 FINAL CONSIDERATIONS

From the methodology applied, it was possible to note the importance of scientific productions, as well as the research coming from the CAFE CAPES portal, because in it there are certain ways to carry out the research, whether it is by the list of books, list of bases, search by subject or list of journals. It is worth noting that by accessing the aforementioned portal, scientific works that, in the vast majority, have to pay to have access to scientific sources, are made available free of charge due to the partnership of the Brazilian federal

government with the main scientifically based lists. Armed with this, the work presented relevant data regarding the clay mineral illite and the range of research in which it is inserted, revealing the magnitude of scientific research in the middle of society.

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ELECTROCHEMICAL SENSOR TO MONITOR LEAD IN NATURAL WATER FOR PUBLIC SUPPLY

SENSOR ELETROQUÍMICO PARA MONITORAMENTO DE CHUMBO EM ÁGUA NATURAL DESTINADA AO ABASTECIMENTO PÚBLICO

SENSOR ELECTROQUÍMICO PARA EL CONTROL DEL PESO DEL AGUA NATURAL DESTINADA AL SUMINISTRO PÚBLICO

 <https://doi.org/10.56238/sevened2025.036-031>

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ABSTRACT

Potentially toxic metals are capable of bio-accumulating in body tissues of living organisms and of having toxicological effects on both soil properties and the health of humans and animals. There are several methodologies available to quantify metals in aqueous matrices, however, these techniques are expensive, given their high cost and need of experts to manage the equipment. Accordingly, the present study introduces the application of an Au electrode, without surface modification, to analyze the presence of Pb²⁺ ions in surface water collected from Lanoso Brook, Uberaba City - MG, Brazil. The technique of anodic stripping voltammetry, without the need of sample preparation was employed. Volumetric parameters were optimized with the aid of central composite rotational design (CCRD) and method validation was carried out in atomic emission spectrophotometer. A detection limit (DL) of 0.04 ng L⁻¹ and quantification limit (QL) of 0.13 ng L⁻¹ were determined. Moreover, Pb²⁺ was found in real samples, and this finding highlighted the effectiveness of employing the Au electrode in this role.

Keywords: Environmental Electroanalyticals. Potentially Toxic Metals. Water Quality. Anodic Stripping Voltammetry.

RESUMO

Metais potencialmente tóxicos são capazes de bioacumular-se nos tecidos corporais de organismos vivos e de apresentar efeitos toxicológicos sobre as propriedades do solo e a saúde de humanos e animais. Existem diversas metodologias disponíveis para quantificar metais em matrizes aquosas; no entanto, essas técnicas são dispendiosas, devido ao seu alto custo e à necessidade de especialistas para operar os equipamentos. Assim, o presente estudo apresenta a aplicação de um eletrodo de ouro, sem modificação superficial, para

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analisar a presença de íons Pb^{2+} em água superficial coletada no Riacho Lanoso, cidade de Uberaba - MG, Brasil. A técnica de voltametria de redissolução anódica, sem necessidade de preparo da amostra, foi empregada. Os parâmetros volumétricos foram otimizados com o auxílio do planejamento composto central rotacional (CCRD) e a validação do método foi realizada em espectrofotômetro de emissão atômica. Foram determinados um limite de detecção (LD) de $0,04 \text{ ng L}^{-1}$ e um limite de quantificação (LQ) de $0,13 \text{ ng L}^{-1}$. Além disso, a presença de Pb^{2+} foi detectada em amostras reais, e essa descoberta destacou a eficácia do uso do eletrodo de Au nessa função.

Palavras-chave: Eletroanálise Ambiental. Metais Potencialmente Tóxicos. Qualidade da Água. Voltametria de Redissolução Anódica.

RESUMEN

Los metales potencialmente tóxicos pueden bioacumularse en los tejidos de los organismos vivos y tener efectos toxicológicos tanto en las propiedades del suelo como en la salud humana y animal. Existen diversas metodologías para cuantificar metales en matrices acuosas; sin embargo, estas técnicas son costosas debido a su elevado precio y a la necesidad de personal especializado para su manejo. Por consiguiente, este estudio introduce la aplicación de un electrodo de oro (Au), sin modificación superficial, para analizar la presencia de iones Pb^{2+} en agua superficial recolectada del arroyo Lanoso, ciudad de Uberaba, Minas Gerais, Brasil. Se empleó la técnica de voltametría de redisolución anódica, sin necesidad de preparación de la muestra. Los parámetros volumétricos se optimizaron mediante un diseño compuesto central rotacional (DCCR) y la validación del método se realizó en un espectrofotómetro de emisión atómica. Se determinó un límite de detección (LD) de $0,04 \text{ ng L}^{-1}$ y un límite de cuantificación (LC) de $0,13 \text{ ng L}^{-1}$. Además, se encontró Pb^{2+} en muestras reales, y este hallazgo destacó la eficacia del uso del electrodo de Au en esta función.

Palabras clave: Electroanálisis Ambiental. Metales Potencialmente Tóxicos. Calidad del Agua. Voltametría de Redisolución Anódica.

1 INTRODUCTION

Environmental contamination by potentially toxic metals is an increasingly pressing global concern, primarily driven by rapid industrialization and urban expansion. Among the various pollutants, lead (Pb) stands out due to its lack of any essential biological function and its ability to bioaccumulate in living organisms. This contaminant enters the environment through multiple anthropogenic sources, including industrial discharges, mining activities, fossil fuel combustion, and improper waste disposal. Furthermore, Pb can be present in pesticides and fertilizers, contributing to soil leaching and the contamination of both soil and water bodies. Its persistence and mobility significantly heighten environmental and public health risks.

In the environment, lead is found mainly in the form of Pb^{2+} ions or as chemically inert organic and inorganic species. Once absorbed by living organisms, Pb can cause significant biochemical disturbances, particularly affecting the nervous, hepatic, renal, and hematological systems. For this reason, monitoring Pb levels in environmental matrices is essential to prevent ecological damage and protect public health.

Given the need for sensitive and low-cost analytical techniques, electrochemical methods - especially anodic stripping voltammetry (ASV) - have shown great promise for detecting trace levels of Pb^{2+} in environmental samples. These techniques offer several advantages, including low operational cost, fast analysis, high sensitivity, and the possibility of in situ applications. In this context, the objective of this study was to evaluate the performance of an unmodified gold (Au) electrode for the electrochemical detection of Pb^{2+} ions in natural water samples intended for public supply.

2 THEORETICAL FRAMEWORK

Environmental pollution caused by potentially toxic metals is an issue of global concern. Accelerated population growth has led to several industries whose activities are the main source of release for potentially toxic metals (Latif *et al.*, 2022; Hossaini-Zahed *et al.*, 2022). Discharge of these elements into the environment can derive from such human activities as urban traffic, industrial activities, crop fertilizers and irrigation, mining, and, naturally, from soil erosion, weathering and rock cycles. Lead (Pb) stands out among possibly toxic metals as it is not an essential element and it can bio-accumulate in organisms and have permanent environmental effects (Balasubramanian *et al.*, 2020; Latif *et al.*, 2022; Chang *et al.*, 2022; Cui *et al.*, 2023).

The availability of Pb availability in soils, sediments and waterbodies frequently occurs in the form of Pb^{2+} or in its inert form, as organic or inorganic species (Kumar *et al.*, 2020). Pb can enter in contact with the environment via several pollution sources, such as smelting, mining, fossil fuels, besides inappropriate waste discharge including paint, gasoline and battery residues (Bahinting *et al.*, 2021; Latif *et al.*, 2022). Pesticides and phosphate fertilizers can also contain Pb in their formula, which can leach from soil to rivers and contaminate waterbodies (Ebrahimi *et al.*, 2020).

When in contact with the organism, Pb can cause several biochemical changes in the nervous system, kidneys and liver, besides having carcinogenic and mutagenic properties (Gnonsoro *et al.*, 2022; Nyamato *et al.*, 2022). Given its interaction with iron, lead can compromise the hematological system and cause anemia, as well as weakness and fatigue (Barroso *et al.*, 2021; Aniceto; Irazusta 2023). Symptoms attributed to exposure to lead can be light, such as burning eyes, irritation, vomiting, diarrhea, lung irritation, headaches and dizziness. However, sometimes, they can be severe and include allergic dermatitis, Painters syndrome, lung cancer, reproductive harm, kidney and liver damage (Balasubramanian *et al.*, 2020).

Lead determination in real samples is most often carried out through atomic absorption spectrometry (AAS), Microwave Plasma Atomic Emission Spectrometry (MP-AES), plasma source mass spectroscopy (ICP-MS), inductively coupled plasma optical emission spectroscopy (ICP-OES) and micro-solid-phase extraction (μ -SPE) in combination with gas chromatography–mass spectrometry (Boleji *et al.*, 2021). However, such traditional techniques require sophisticated sample preparation, longer analysis times analyses, trained technicians and high-cost equipment (Guenang *et al.*, 2020; Bahinting *et al.*, 2021). Electrochemical techniques are promising for analysis of pollutants as it is possible to reduce many of the costs. Voltammetry is an electroanalytical technique capable of providing high sensitivity in several environmental matrices in order to monitor traces of potentially toxic metals. In addition, the pre-concentration stage in anodic stripping voltammetry, can significantly increases sensitivity levels and analyte detection limits (Jovanovsk; Hrastnik 2019; Sánchez-Calvo; Blanco-López; Costa-García 2020).

Electrochemistry is an important tool to analyze reactions involving electron transfer, and a set of analytical methods based on the electric properties of analytes in the solution are available (Elgrishi *et al.*, 2018). Such techniques have been gradually more widely used due to their low operational cost, high selectivity and sensitivity to detect and quantify harmful

substances found in water bodies. Moreover, they can help studies on the formation of intermediate toxic products to both humans and the environment. Such analyses are fast, and they can be carried out in situ (Monteiro; Dos Santos Júnior; Sussuchi, 2020; Zier; Bouafia-Chergui; Chabani, 2021).

Anodic stripping voltammetry (ASV) is one of the most often used techniques to detect potentially toxic elements at low concentrations, based on using the electrochemical sensor. This device can measure the concentrations of certain molecules or analytes through redox reactions, in which electrons are transferred between analyte molecules and the electrode and consequently, a current proportional to the analyte's concentration is generated at the sensor (Nourbakhsh *et al.*, 2022).

Thus, it is worth noting that the use of unmodified gold (Au) electrodes for metal detection remains relatively unexplored in the scientific literature. Most available studies report comparatively high detection limits when measured against conventional analytical methods, which limits their applicability for trace-level environmental analysis. Therefore, investigations assessing the performance of these electrodes under real sample conditions are highly relevant, particularly when considering their simplicity, reproducibility, and potential for use in low-cost monitoring systems.

3 METHODOLOGY

3.1 REAGENT

Lead (II) chloride (Cinética, 99%) was used as the source of Pb(II) for all assays performed. All other reagents were provided by Sigma Aldrich® at analytical grade and used without further purification. Ultra-pure water (Milli-Q®) was used for solution preparation purposes (resistivity ~ 18 MΩcm). Experiments were conducted at room temperature (25°C). Hydrochloric acid solution (HCl) at a concentration of 1 mol L⁻¹ was adopted as supporting electrolyte. Lead (II) chloride stock solution (PbCl₂ - 1,000 µg L⁻¹) was prepared by diluting its solid standard in a solution of the supporting electrolyte. Solutions of sodium hydroxide (NaOH - 5.0 mol L⁻¹) and standard hydrochloric acid solutions (37 %) were used for pH adjustment purposes.

3.2 ELECTRODES

Electrodes used in the experiments were provided by Lab Solutions®. The Au electrode disc (ϕ = 1.6 mm) was pretreated by performing 15 potential sweeps in 0.1 mol L⁻¹ sulfuric

acid in the solution at range of 0.15 to 0.6 V (vs. Ag/AgCl) at a sweep-rate of 0.05 V s⁻¹. The Au electrode was also polished with suspended alumina (0.3 µm) and washed in ultra-pure water for a mirror finish. A potential of 0.33 V per 200 s was applied for cleaning after each sweep, to make sure that the metal ions were re-oxidized. A Platinum (Pt) wire (5 cm) was the auxiliary electrode and Ag/AgCl in 3 mol L⁻¹ KCl solution was the reference electrode.

3.3 EQUIPMENT

Autolab[®] potentiostat/galvanostat model PGSTAT 320N, controlled using NOVA 2.1 (Metrohm) software, was used for voltammetry procedures. Fisatom magnetic stirrer model 752A 115 V and a stirring bar (9 mm in diameter x 8 mm in height) by Merck were used in ASV. A Tecnocon pH meter, model MPA-210, was employed to determine pH values. OriginPro[®] 2019b by OriginLab was used to treat the results and to plot the graphics. Method validation was made in MP-AES 4200 Microwave Induced Plasma Atomic Emission Spectrometer, Agilent Technologies. Statistica software was used for the experimental design procedure.

3.4 CENTRAL COMPOSITE ROTATIONAL DESIGN

A Central Composite Rotational Design (CCRD) was used to optimize the parameters under study. In total, 17 experiments were carried out through CCRD 23, with 6 axial points and 3 repetitions, at the central point. Table 1 presents the codified values and the real independent variables of the CCRD.

Table 1

Codified and real values recorded for the independent variables

Variables	Code	- α	-1	0	+1	+ α
Deposition time (s)	X_1	34	100	200	300	366
Frequency (Hz)	X_2	13.5	30	55	80	96.5
Amplitude (mV)	X_3	6.9	30	65	100	123.1

Source: Developed by the authors.

3.5 VOLTAMMETRY ANALYSES

The analysis limit applied to deposition time, frequency and amplitude was established based on the proposed experimental design. After assessing studies available in the

literature, the value of 04 mV was established for scan increment. The pH was varied in the range of 0.0 to 4.0, at a 0.5 increase.

3.6 ANALYSES APPLIED TO NATURAL SAMPLES

Lanoso Brook is in the Triângulo Mineiro region, inside an environmental protection area. It is one of Uberaba River's main tributaries. Surface water samples were collected from September 2022 to February 2023, as this is the rainy period, which possibly allows more Pb^{2+} ions to leach into surface water. All samples were stored in plastic containers and kept in the dark and under refrigeration, to avoid degradation and composition changes. This process made the samples integrated over the whole collection period.

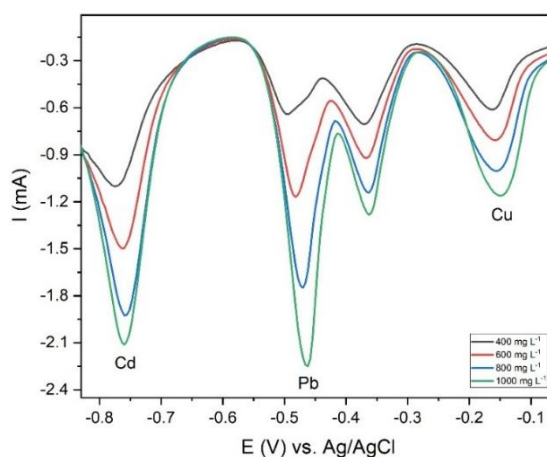
4 RESULTS AND DISCUSSIONS

4.1 EAU APPLICABILITY IN METALLIC ION ANALYSIS

Preliminary analysis of lead, cadmium and copper at an Au electrode was performed with the aim of assessing the possibility of simultaneous detection. Square wave voltammetry (SWV) was applied to at concentrations of 400, 600, 800 and 1.000 mg L⁻¹, using HCl (0.1 mol L⁻¹) as the supporting electrolyte, according to the following parameters: pulse amplitude: 50 mV, frequency: 60 Hz and scan increment: 04 mV. Figure 1 presents the voltammograms obtained during the analyses.

Figure 1

Square wave voltammogram of simultaneous detection of Pb, Cd and Cu, at concentrations of 400; 600; 800 and 1.000 mg L⁻¹ in HCl (0.1 mol L⁻¹) and pH 0.5. $f = 60$ Hz, $a = 50$ mV, $s = 04$ mV, $f = 60$ Hz, $a = 50$ mV, $s = 04$ mV



Source: Developed by the authors.

From Figure 1 it can be observed that the voltammogram presented characteristic reduction peaks for the analyzed metals with a satisfactory response to the concentration gradient. The r^2 values learned from analytical curves were 0.999, 0.995 and 0.998 for lead, cadmium and copper, respectively. Thus, it was possible to observe that, under the conditions employed, that the Au electrode was able to simultaneously determine multiple metals in solution during SWV. This finding demonstrates the potential of Au to be used in multi-elementary analysis.

4.2 CENTRAL COMPOSITE ROTATIONAL DESIGN

The Central Composite Rotational Design (CCRD) was employed to optimize three experimental variables: deposition time (34 to 366 s), frequency (13.5 to 96.5 Hz), and amplitude (6.9 to 123.1 mV). A total of 17 experiments were conducted using a Pb^{2+} concentration of $1,000 \mu g L^{-1}$ and pH 0.0. The optimized parameters obtained were a deposition time of 200 s, frequency of 81 Hz, and amplitude of 98 mV. Response surface analyses revealed that the highest current signals occurred at deposition times close to 200 s and frequencies ranging from 60 to 85 Hz, highlighting the importance of deposition time for the preconcentration of Pb^{2+} ions on the Au electrode and the consequent enhancement in detection limits.

Statistical analysis, with 95% confidence, confirmed that the optimal amplitude range was between 80 and 100 mV, and that the best analytical signals were obtained with frequencies between 60 and 100 Hz. The proposed mathematical model (Eq. 1) showed that amplitude (X_3) was the most influential variable—nearly five times more relevant than deposition time (X_1).

$$I(\mu A) = -149.20 + 0.71.X_1 - 0.002X_1^2 + 4.62.X_2 - 0.03 X_2^2 + 3.70.X_3 - 0.022 X_3^2 + 0.001.X_1.X_2 + 0.002X_1.X_3 - 0.019.X_2.X_3 \quad (1)$$

Where:

X_1 is deposition time

X_2 is frequency

X_3 is amplitude.

Additionally, it was observed that increasing frequency had a greater impact on current signal intensity compared to the other two variables, which aligns with findings by Vasconcellos *et al.* (2020).

4.3 EFFECT OF PH

The release of cations increases at lower pH values and alters the voltammetric profiles (Sun *et al.*, 2020; Król; Mizerna; Bożym, 2020). Thus, a pH study was conducted to analyze the best analytical results. After studying the literature, the following pH range was set: 0.0 to 4.0, with a 0.5 step increase.

The highest current intensity was recorded at pH 0.0, which led to the most satisfactory analytical signal. Therefore, this value was used as the standard pH for the analyses applied to natural samples to obtain the highest sensitivity for the electroanalytical method.

4.4 LEAD ANALYTICAL CURVE

After assessing several articles and analyzing the laboratory conditions adopted in the studies by Munoz & Angnes (2004), Zhu *et al.* (2014), Vasconcellos (2020), Yaman *et al.* (2021), it was possible to observe that the best scan increase for the present study was 4 mV. Accordingly, parameters were established to find the best analytical signal for the Pb²⁺ analytical curve.

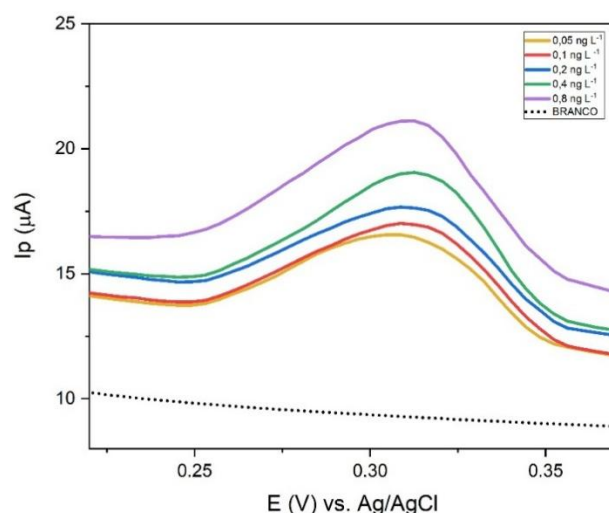
All assays used hydrochloric acid (HCl 1 M) as supporting electrolyte. Thus, some exploratory voltammograms were performed to determine the oxidation potential of Pb under the conditions set for these analyses. Pb undergoes oxidation at values close to 0.33 V. Therefore, during the analyte pre-concentration stage at the Au electrode, a potential of -0.33 V, for 200 s, was applied.

Equation 2 shows the reaction taking place at deposition stage, which involves Pb²⁺ reduction to metallic lead (Pb⁰) at the working electrode after applying a potential of -0.3 V. Subsequently, anodic stripping occurs, which makes the lead deposit at the electrode oxidize and form Pb²⁺ (Eq.3) in solution. Thus, a positive scan was performed, and resulted in Pb oxidation at concentrations 0.05, 0.1, 0.2, 0.4 and 0.8 ng L⁻¹, as depicted in Figure 2.



Figure 2

Anodic stripping voltammogram at concentrations 0.1, 0.2, 0.4 and 0.8 ng L⁻¹ Pb²⁺ in HCl (1 mol L⁻¹) and pH 0.0. Deposition time = 200 s, $f = 81$ Hz, $a = 98$ mV, $s = 04$ mV



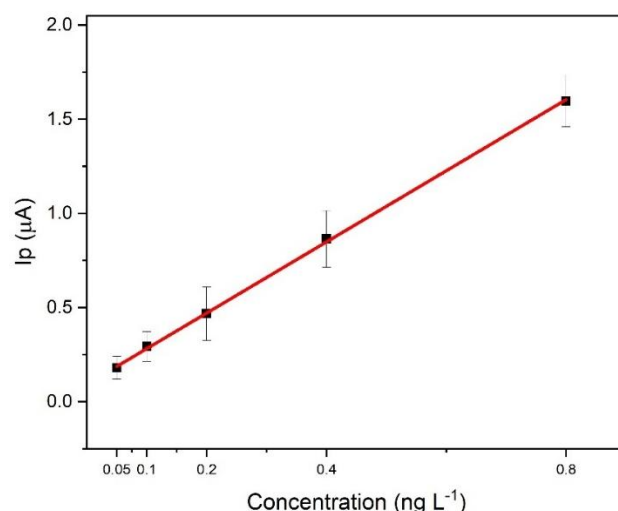
Source: Developed by the authors.

Linearity, in the analytical method, is an intrinsic property that allows analytical responses to be directly proportional to the concentration of the analyte in the study (Ribani *et al.*, 2004). Therefore, it is possible to observe (Figure 2) the Pb analyses at different concentrations conducted in triplicate, as well as the gradual increase in peak current as analyte concentration increases.

Based on Figure 3, the analytical curve displays satisfactory association between Pb²⁺ concentration and current peak. The current increased as concentration also increased. Thus, the linear equation is given by $I_p (\mu A) = 1.88952 \cdot 10^{-6} + 9.27194 \cdot 10^{-8} \cdot C_{\text{lead}}$.

Figure 3

I_p association with Pb^{2+} concentration (0.05, 0.1, 0.2, 0.4 and 0.8 $ng\ L^{-1}$). Deposition time = 200 s, $f = 81\ Hz$, $a = 98\ mV$, $s = 04\ mV$



Source: Developed by the authors.

The results display a satisfactory linear response between concentration and peak current ($r^2 = 0.999$). The proposed method, based on the application of an Au electrode, and ASV, presented a detection limit (DL) of $0.04\ ng\ L^{-1}$ and quantification limit (QL) of $0.13\ ng\ L^{-1}$.

4.5 ELECTROANALYTICAL DETERMINATION OF LEAD (II) IONS IN NATURAL WATER

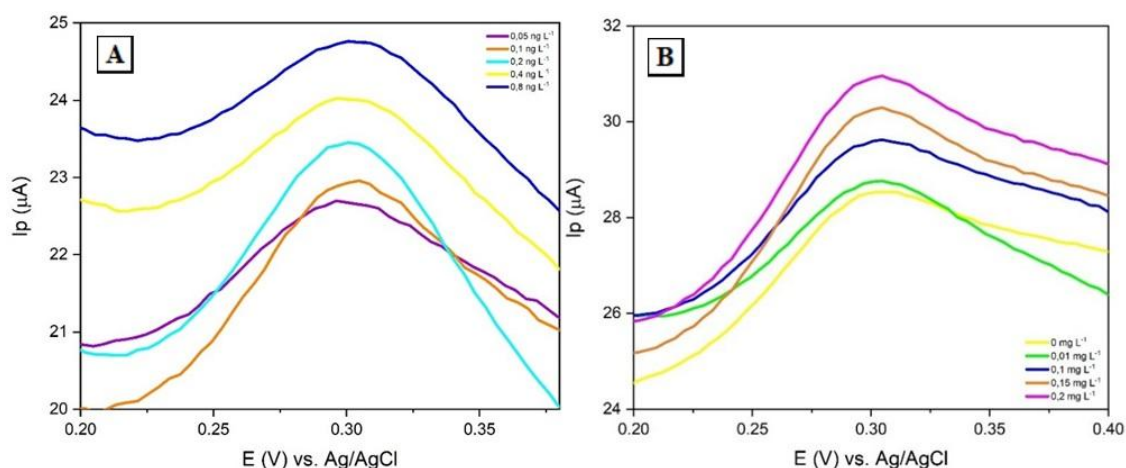
Tests were performed with surface water samples collected from the Lanoso Brook, Uberaba City – MG, Brazil. Figure 4a presents the characteristic voltammogram of analyses applied to concentrations 0.05, 0.1, 0.2, 0.4 and $0.8\ ng\ L^{-1}$ adopted to compare the analyses performed under laboratory conditions. The process was performed for concentrations of 0.0, 0.01, 0.1, 0.15 and $0.2\ mg\ L^{-1}$ (Figure 4b), which is in the detection range of microwave induced plasma atomic emission spectroscopy.

Characteristic current peaks were observed at 0.3 V, without significant peak displacement and with variations in anodic stripping voltammetry, based on voltammograms of Pb^{2+} oxidation in natural samples, at the two concentration limits. These fluctuations likely occur due to the presence of organic pollutants, organic matter and dissolved inorganic matter, because these are complex samples; this process could lead to slight changes (Kobielska *et al.*, 2018; Nourbakhsh *et al.*, 2022).

Nevertheless, interaction with organic matter can form stable complexes with metallic ions and compete for electrode surface sites in deposition or redissolution. This reduces signal intensity or allows the presence of interfering signals (Monteiro *et al.*, 2018).

Figure 4

Anodic stripping voltammetry applied to natural samples at different Pb²⁺ concentrations, expressed in HCl 1 mol L⁻¹ (pH 0.0). Concentrations were A) 0.05, 0.1, 0.2, 0.4 and 0.8 ng L⁻¹ and B) 0.0; 0.01; 0.1; 0.15 and 0.2 mg L⁻¹. Deposition time = 200 s, $f = 81$ Hz, $a = 98$ mV, $s = 04$ mV



Source: Developed by the authors.

4.6 ELECTROCHEMICAL METHOD VALIDATION

Microwave Plasma Atomic Emission Spectrometry (MP-AES) was applied to validate the proposed method adopted to detect Pb²⁺ ions in natural samples. Table 2 presents the comparison between MP-AES and ASV in natural water samples for lead detection purposes. These results show similarities between the two techniques employed to detect Pb²⁺ ions. Interestingly, the ASV technique was capable of detecting Pb²⁺ in natural water samples.

Table 2

Comparison of results recorded for natural water samples

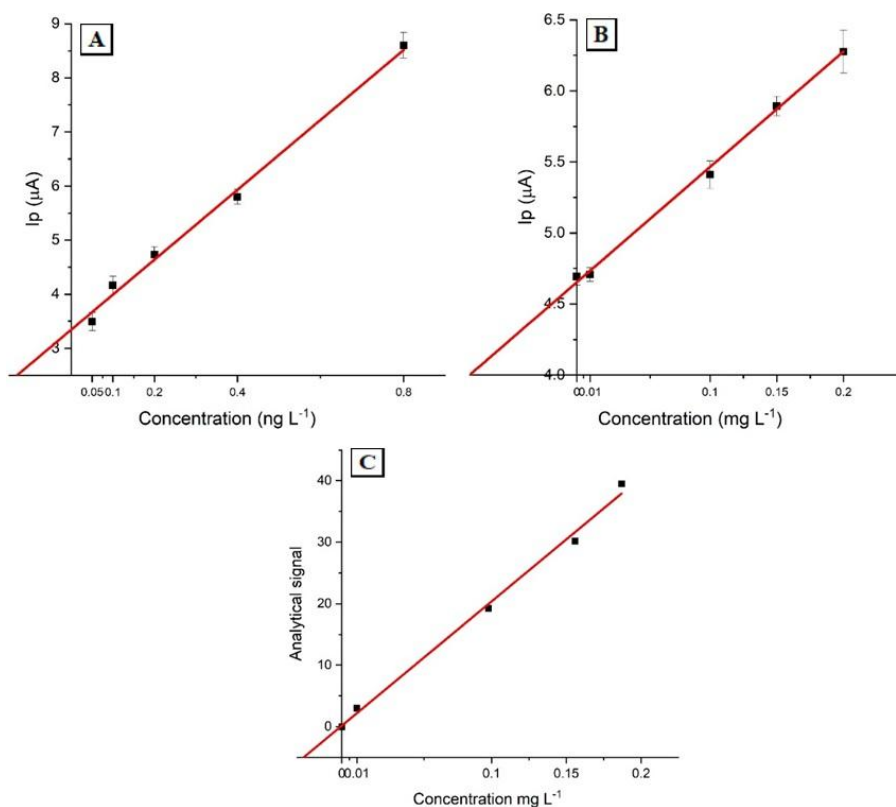
Added concentration (mg L ⁻¹)	Concentration found in MP-AES (mg L ⁻¹)	Concentration found in ASV (mg L ⁻¹)
0.000	< QL	0.005 ± 0.062
0.010	0.010 ± 0.001	0.007 ± 0.090
0.100	0.098 ± 0.002	0.093 ± 0.031
0.150	0.156 ± 0.010	0.153 ± 0.044
0.200	0.187 ± 0.020	0.199 ± 0.093

Source: Developed by the authors.

Figure 5 (a and b) depicts the concentration curves plotted for concentrations expressed in ng L⁻¹ using ASV at the concentration of ng L⁻¹ ($r^2 = 0.990$) and at mg L⁻¹ ($r^2 = 0.996$), respectively. Figure 5(c) contains the data obtained using MP-AES analysis ($r^2 = 0.995$).

Figure 5

Analytical curve plotted for lead in natural samples expressed in A) and B) ASV concentrations ng L⁻¹ and mg L⁻¹, respectively. Deposition time = 200 s, $f = 81$ Hz, $a = 98$ mV, $s = 04$ mV and C) MP-AES 4200 analysis



Source: Developed by the authors.

The t test was performed to statistically compare results recorded through MP-AES analysis and ASV, at concentrations expressed in mg L^{-1} . The value obtained was -0.02386 and indicated a lack of evidence of significant differences between the observed results.

4.7 RECOVERY TEST

Recovery values recorded for both electrochemical techniques employed for lead detection purposes were calculated and they are given in Table 3. This was done to assess the accuracy of the analyses carried out with natural water samples.

Table 3

Total lead recovery in natural water

Analytical method	Total recovered concentration (mg L^{-1})	% Recovery
MP-AES	0.451	98
ASV	0.457	99

Source: Developed by the authors.

The standard addition method was chosen to minimize the matrix effect. The matrix effect, in its turn, can interfere with the analyses (Ribani *et al.*, 2004). These results recorded 98% recovery through MP-AES and 99% recovery through ASV. The t value was 0.79046, at a 95% significance level. This finding shows that there is no evidence of significant differences between results provided by ASV, based on the use of Au electrodes, and MP-AES.

The Au electrode was effective both in terms of costs and of detection and quantification limits obtained in the analyses. The Au electrode does not need pre-treatment of its surface and reached detection levels of ng L^{-1} . Thus, the proposed method, in combination with the electrode, emerged as an efficient alternative to quickly detect low Pb^{2+} concentrations in natural water samples.

5 CONCLUSION

The Au electrode proved itself to be effective and promising for detection of Pb^{2+} without any surface modification or pre-treatment, through ASV, applied to natural water samples collected from Lanoso Brook, Uberaba City – MG, Brazil. The methods were validated through MP-AES and ASV with $r^2 = 0.995$ and $r^2 = 0.996$, at recovery rate of 98% and 99%, respectively. This result was statistically confirmed through the t test, which demonstrated the lack of substantial differences between the analytical procedures.

It was possible to that any future application of the methodology proposed would employ printed electrodes. This would be required to reduce the time of electrode cleaning. Therefore, the electrochemical method proposed here, based on using Au electrodes without pre-treatment, has emerged as feasible alternative for Pb^{2+} detection in natural water samples. The methodology makes in situ analysis feasible and allows for real-time analyses to assess and monitor surface water used for public supply.

ACKNOWLEDGEMENTS

Thanks to CAPES, CNPq and FAPEMIG for the financial resources that made this research possible. We also extend our special thanks to Professor Dr. Geoffroy for his invaluable support throughout the development of this work.

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UNIFIED HEALTH SYSTEM (SUS) IN ITS DICHOTOMY OF VARIABLES: THE CHALLENGES OF THE CITY OF TUPÃ AS AN EMERGENCY CARE REGION

SISTEMA ÚNICO DE SAÚDE (SUS) NA SUA DICOTOMIA DE VARIÁVEIS: OS DESAFIOS DA CIDADE DE TUPÃ COMO REGIONAL DE PRONTO ATENDIMENTO

SISTEMA ÚNICO DE SALUD (SUS) EN SU DICOTOMÍA DE VARIABLES: LOS DESAFÍOS DE LA CIUDAD DE TUPÃ COMO ÁREA REGIONAL DE ATENCIÓN DE EMERGENCIAS

 <https://doi.org/10.56238/sevened2025.036-032>

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ABSTRACT

This paper analyzes the creation and importance of the Unified Health System (SUS) in Brazil. Before its establishment, formalized by the 1988 Federal Constitution, the country's health system was fragmented and unequal. The SUS was established with the goal of guaranteeing universal, free, and equal access to health care for the entire population. Its implementation represented a substantial advance, promoting the decentralization of services and a focus on primary care, prevention, and health promotion. This principle reflects the vision that "health is a right for all and a duty of the State," as emphasized by Paulo Capel Narvai (2022, p. 103). Despite notable achievements, such as expanded access to treatments and preventive programs, the system faces challenges that compromise its ability to fully serve the population. Problems such as underfunding, regional inequalities, and the social perception that health actions and services are not rights, but commodities (NARVAI, 2022) persist. However, it is concluded that the SUS continues to be one of the country's greatest social achievements, essential to guarantee the well-being of millions of Brazilians.

Keywords: Challenges. Dichotomy. Health. SUS. Tupã-SP.

RESUMO

Este trabalho analisa a criação e a importância do Sistema Único de Saúde (SUS) no Brasil antes de sua instituição, formalizada pela Constituição Federal de 1988, visto como um sistema de saúde do país outrora fragmentado e desigual. O SUS foi estabelecido com o objetivo de assegurar acesso universal, gratuito e igualitário à saúde para toda a população. Sua implementação representou um avanço substancial, promovendo a descentralização dos serviços e o enfoque na atenção primária, na prevenção e na promoção da saúde. Esse princípio reflete a visão de que "a saúde é direito de todos e dever do Estado", conforme destacado por Paulo Capel Narvai (2022, p. 103). Apesar de conquistas notáveis, como a

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ampliação do acesso a tratamentos e a programas preventivos, o sistema enfrenta desafios que comprometem sua capacidade de atender plenamente à população. Problemas como o subfinanciamento, as desigualdades regionais e a percepção social de que ações e serviços de saúde não são direitos, mas mercadorias (NARVAI, 2022) persistem. Contudo, conclui-se que o SUS continua sendo uma das maiores conquistas sociais do país, essencial para garantir o bem-estar de milhões de brasileiros.

Palavras-chave: Desafios. Dicotomia. Saúde. SUS. Tupã-SP.

RESUMEN

Este artículo analiza la creación y la importancia del Sistema Único de Salud (SUS) en Brasil antes de su establecimiento, formalizado por la Constitución Federal de 1988. El SUS se consideraba un sistema de salud fragmentado y desigual. Se estableció con el objetivo de garantizar el acceso universal, gratuito e igualitario a la atención médica para toda la población. Su implementación representó un avance sustancial, promoviendo la descentralización de los servicios y un enfoque en la atención primaria, la prevención y la promoción de la salud. Este principio refleja la visión de que «la salud es un derecho de todos y un deber del Estado», como lo enfatizó Paulo Capel Narvai (2022, p. 103). A pesar de logros notables, como la ampliación del acceso a tratamientos y programas preventivos, el sistema enfrenta desafíos que comprometen su capacidad para atender plenamente a la población. Persisten problemas como la falta de financiación, las desigualdades regionales y la percepción social de que las acciones y los servicios de salud no son derechos, sino bienes (NARVAI, 2022). Sin embargo, se puede concluir que el Sistema Único de Salud (SUS) sigue siendo uno de los mayores logros sociales del país, esencial para garantizar el bienestar de millones de brasileños.

Palabras clave: Desafíos. Dicotomía. Salud. Sistema Único de Salud (SUS). Tupã-SP.

1 INTRODUCTION

The present research, developed in the city of Tupã, São Paulo, is dedicated to the analysis of the performance and administration of the Unified Health System (SUS) in the municipality, with the purpose of examining its relevance as a regional center of emergency care. To this end, a qualitative methodological approach was adopted, which was based on a bibliographic review and an interview with the nurse in charge of the Santa Casa de Misericórdia de Tupã Hospital, Diego Zutin Vassoler. The study aims, therefore, to identify and discuss the positive and negative aspects of the system, with particular attention to the issue of maintaining its resources and their respective consequences for the institution and local community.

2 THEORETICAL FRAMEWORK

Public health in Brazil has undergone several transformations over the centuries, reflecting in social, political, and economic changes. Its trajectory comes from the colonial period, in which medical care was practically non-existent, so many resorted to healers and shamans, to the creation of the Unified Health System (SUS), which is present today. The main leader of the proposal to create a universal health system, Sérgio Arouca, stated with all the letters: "The SUS is a civilizing project" (NARVAI, Paulo Capel. *SUS: A Revolutionary Reform to Defend Life*, 2022, p. 172), a process that was marked by inequalities and gradual advances (SUMMIT SAÚDE, 2024).

With the arrival of the Portuguese Royal Family, in 1808, characterized as the Johannine period, there were advances in the area of health, such as the creation of the first medical schools and sanitary improvements in the ports, in order to strengthen commercial ties with the British. However, these initiatives were not enough to meet the needs of the general population, making them vulnerable to endemics and epidemics due to the lack of basic sanitation, high population density in urban centers, and the absence of effective public policies for the control of communicable diseases (WIKIPEDIA, 2024).

During the Old Republic (1889-1930), Brazil went through an intense process of urbanization, especially in Rio de Janeiro, which aggravated sanitary problems. The population faced frequent outbreaks of diseases such as yellow fever, smallpox, and bubonic plague. In response to this crisis, the government implemented the Health Reform led by Oswaldo Cruz, which promoted mandatory vaccination campaigns and measures to combat disease vectors. However, these actions generated strong popular resistance, culminating in

the Vaccine Revolt in 1904. Despite the difficulties, this period marked the beginning of a more structured approach to confronting epidemics in the country (DMS UFPEL, 2024).

During the military period (1964-1985), the National Institute of Social Security (INPS) and the National Institute of Medical Assistance (INAMPS) centralized health services, however, they favored large urban centers, leaving smaller localities with precarious care. It was then that the economic crisis of 1986 highlighted the problems in force in this area, boosting the Movement for Health Reform. It was through the VIII National Health Conference (1986) and the Federal Constitution of 1988 that Law No. 8,080 was consolidated, regulating the SUS and, this time, establishing health as a right for all (DMS UFPEL, 2024).

In the Federal Constitution (BRASIL, 1988, art. 198, II) it is stated that:

[...] the SUS is based on the principles of universality, integrality and equity, aiming to meet the needs of all citizens. One of its guidelines is "comprehensive care, as a priority for preventive activities, without prejudice to care services". According to Sérgio Arouca (2022, p. 172), the main leader of the proposal to create a universal health system, "The SUS is a civilizing project [...]".

Thus, in contemporary times, the SUS is based on the principles of universality, integrality and equity, aiming to meet the needs of all citizens. One of its guidelines is "comprehensive care, as a priority for preventive activities, without prejudice to care services" (BRASIL, 1988, art. 198, II).

2.1 FIGURES

Figure 1

Students from Colégio Objetivo de Tupã together with nurse Diego Zutin Vassoler posing in front of the entrance of the Santa Casa de Misericórdia de Tupã Hospital



Source: Aloísio Cássio dos Santos, 2nd Human Itinerary, August 20, 2025.

Figure 2

Students from Colégio Objetivo at the entrance of the Santa Casa de Misericórdia de Tupã hospital together with the students to Nurse Diego Zutin Vassoler



Source: Amanda Frigulio Amaral, 2nd Human Itinerary, August 20, 2025.

3 METHODOLOGY

The work was developed by students of the 2nd year of High School at Colégio Objetivo de Tupã -SP with a focus on the study and performance of the Unified Health System (SUS) of the municipality and its region of coverage, in which it used a qualitative methodological approach to deepen the understanding of the theme.

The study is based on a documentary analysis of the work "SUS: a revolutionary reform to defend life", by Paulo Capel Narvai, and on the content analysis of an interview with nurse Diego Zutin Vassoler, technical manager of the Santa Casa de Misericórdia de Tupã Hospital. Data collection and analysis were organized in two stages: first, a bibliographic survey and a critical analysis of the historical context of the Brazilian health system, covering the pre- and post-implementation periods of the SUS, were carried out. In a second moment, the administration of the SUS in the city of Tupã was investigated from the perspective of a professional in the area.

Thus, this work intends to provide a significant contribution to a debate on the impact of the SUS in Brazil, with special emphasis on the local reality of Tupã, in addition to encouraging a reflection on the fundamental importance of the public health system for Brazilian society.

4 RESULTS AND DISCUSSIONS

From the theoretical analysis, data collection and group discussions, it was possible to raise relevant information that contributes to the critical understanding of this public health system. In this section, the main results obtained are presented and discussed, relating them to the current reality and to the objectives proposed at the beginning of the study.

The information obtained through the realization of this work, including a field research at the Santa Casa de Misericórdia (Tupã-SP), accompanied by the advisor professor Aloísio Cássio dos Santos, interviews with a technical professional Diego Zutin Vassoler, in parallel with bibliographic research (SUS: A Revolutionary Reform to defend life - Book by Paulo Capel Narvai and the Federal Constitution of 1988) and media (Health Policies in Brazil - Documentary by Renato Tapajós), In relation to the proposed theme, we show that the results of this study demonstrate that the Unified Health System (SUS) is a historical advance in the consolidation of the right to health, acting in turn as a fundamental instrument of equity and social inclusion. The field research reiterated the revolutionary dimension by establishing a public and universal model of care for the community that concomitantly confronts social

inequalities. The practical experience observed in the municipality of Tupã, reported by the professional Diego Zutin Vassoler, conveys the idea that despite the particular challenges preeminent to the municipality, such as the poor management of resources in part of the health units, such as the non-availability of these within the hospital itself, the lack of properly interested professionals and the difficulty of working in an environment where many patients and companions do not show respect for the professionals acting at times with aggressiveness or devaluation. For him, in addition to efficient management, it is essential that the population recognizes the effort of the team, which even with limitations, is dedicated daily to saving lives. Respect and appreciation of the work of these professionals are essential for a more humane and effective service.

In short, it is concluded that the SUS, even in the face of persistent structural and financing challenges, constitutes a Brazilian social asset, whose role is indispensable in the defense of life and in the promotion of human dignity, which makes it imperative to recognize its relevance and strengthen its policies in ensuring comprehensive and quality care for the entire population.

5 CONCLUSION

The Unified Health System (SUS) is configured, as evidenced by this study, as one of the greatest social assets in Brazil, reflecting its relevance and effectiveness. The detailed analysis of the operations and results of the SUS demonstrated, unequivocally, that, despite the financial and structural challenges, the system is fundamental for the promotion of equity, the universalization of access and the guarantee of the constitutional right to health for all citizens.

The survey also revealed that the SUS has achieved international recognition, particularly in areas such as immunization programs and transplants, solidifying its position as a model of public health policy. These successes not only underscore the system's ability to make significant advances in public health, but also reinforce the need for its continued strengthening and maintenance.

In summary, the SUS, even in the face of the complexities of its implementation and the obstacles in fully fulfilling its constitutional role, has established itself as a pillar of social justice and an essential instrument for the reduction of inequalities. Its existence is indispensable for the construction of a more just and solidary society, serving as concrete proof of its vital role in guaranteeing Brazilian citizenship.

ACKNOWLEDGMENTS

We thank, first, God, for the strength, inspiration and wisdom granted during the realization of this work. We also express our gratitude to our families and friends, for their unconditional support, patience and encouragement throughout the process. We also recognize the fundamental role of our professor and advisor, Aloísio Cássio dos Santos, whose dedication and knowledge were essential for the development of the research.

Finally, we thank the academic community and the institutions that, directly or indirectly, contributed to the realization of this study.

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**CHARACTERIZATION OF VIOLENCE AGAINST WARAO GIRLS AND WOMEN
IN BELÉM, PARÁ**

**CARACTERIZAÇÃO DE VIOLÊNCIAS CONTRA MENINAS E MULHERES
WARAO EM BELÉM DO PARÁ**

**CARACTERIZACIÓN DE LA VIOLENCIA CONTRA LAS NIÑAS Y MUJERES
WARAO EN BELÉM, PARÁ**

 <https://doi.org/10.56238/sevened2025.036-033>

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ABSTRACT

Violence against women is a historical and cultural problem, resulting in social inequalities and power imbalances among individuals. For example, consider violence against indigenous girls and women, such as the Warao. The objective of this study was to analyze violence against Warao girls and women from 2017 to 2023 in the municipality of Belém. This is a descriptive, exploratory, and quantitative study. Data collection and analysis were based on records from the Deputy Secretariat of Intelligence and Criminal Analysis of the State of Pará, as well as bibliographic research. The violence perpetrated against the victims was independent of age group, with 37.50% under 18 years of age and 62.50% over 18 years of age. Regarding education, 45.45% were illiterate and 54.55% did not complete primary education. Of the victims, 100% were women, 50% were single, and the majority were homemakers. The most prevalent type of violence was against sexual dignity (39.40%), with the majority (91.30%) of victims suffering violence in their collective housing, funded by the public sector, predominantly at night (39.13%), and on all days of the week. The research concluded that it revealed the sociodemographic profile of violent crimes against Warao girls and women in the municipality of Belém, Pará, and the results contribute to reflections on the topic, as well as to actions for prevention, assistance, and policies guaranteeing rights by the public authorities, especially for improving public services provided to them.

Keywords: Human Rights. Violence. Girls. Women. Warao.

RESUMO

A violência contra a mulher é um problema histórico e cultural, resultando em desigualdades sociais e poder entre os indivíduos. Tomando como exemplo, a violência contra meninas e mulheres indígenas, tais como as Waraos. O objetivo do estudo foi analisar as violências contra meninas e mulheres Warao, de 2017 a 2023, no município de Belém. Trata-se de um

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estudo descritivo, exploratório e quantitativo. A coleta e análise de dados foram com base nos registros da Secretaria Adjunta de Inteligência e Análise Criminal do Estado do Pará, além de pesquisa bibliográfica. As violências praticadas contra as vítimas independeram de faixa etária, sendo 37,50 % menores de 18 anos de idade e 62,50 % maiores de idade, com relação a escolaridade 45,45 % analfabetas e 54,55 % sem ensino fundamental completo, de 100% de mulheres, 50% são solteiras, na sua maioria da ocupação do lar. O tipo de violência mais predominante foi contra a dignidade sexual em 39,40 %, na sua maioria, 91,30%, as vítimas sofreram a violência em suas moradias coletivas, custeadas pelo poder público, com preponderância no horário noturno, 39,13 %, e em todos os dias da semana. Concluiu-se que a pesquisa evidenciou o perfil sociodemográfico do crime de violência contra as meninas e mulheres Warao no município de Belém do Pará e os resultados auxiliam em reflexões sobre o tema, bem como para ações de prevenção, assistência e políticas de garantia dos direitos pelo poder público, especialmente para melhoria dos serviços públicos a elas dispensados.

Palavras-chave: Direitos Humanos. Violência. Meninas. Mulheres. Warao.

RESUMEN

La violencia contra las mujeres es un problema histórico y cultural que genera desigualdades sociales y desequilibrios de poder. Un ejemplo de ello es la violencia contra las niñas y mujeres indígenas, como las warao. El objetivo de este estudio fue analizar la violencia contra las niñas y mujeres warao entre 2017 y 2023 en el municipio de Belém. Se trata de un estudio descriptivo, exploratorio y cuantitativo. La recopilación y el análisis de datos se basaron en registros de la Subsecretaría de Inteligencia y Análisis Criminal del Estado de Pará, así como en investigación bibliográfica. La violencia ejercida contra las víctimas fue independiente del grupo de edad: el 37,50 % eran menores de 18 años y el 62,50 % mayores de 18 años. En cuanto a la educación, el 45,45 % eran analfabetas y el 54,55 % no habían completado la educación primaria. El 100 % de las víctimas eran mujeres, el 50 % eran solteras y la mayoría se dedicaban al hogar. El tipo de violencia más frecuente fue la que atentaba contra la dignidad sexual (39,40%), y la mayoría (91,30%) de las víctimas sufrieron violencia en sus viviendas colectivas, financiadas por el sector público, principalmente durante la noche (39,13%) y todos los días de la semana. La investigación concluyó revelando el perfil sociodemográfico de los delitos violentos contra niñas y mujeres warao en el municipio de Belém, Pará, y los resultados contribuyen a la reflexión sobre el tema, así como a las acciones de prevención, asistencia y políticas que garanticen los derechos por parte de las autoridades públicas, especialmente para mejorar los servicios públicos que se les prestan.

Palabras clave: Derechos Humanos. Violencia. Niñas. Mujeres. Warao.

1 INTRODUCTION

Violence against women is a historical and cultural problem, by which the male gender is presented as superior to the female, resulting in serious problems of inequalities, with repercussions on social and power relations between individuals (Souto; Diotto, 2018; Lima, 2016).

According to the World Health Organization (WHO), violence against women is a public health problem (WHO, 2013), being a violation of basic human rights, configuring itself as a great dilemma for humanity in the twenty-first century (Granja; Medrado, 2009).

This situation is old, occurring in all social strata, and is constantly observable in the daily lives of women, under different forms of ideological representations, social classes, races and ethnicities (Barreto, 2007), but it had gained its own contours in recent history, which was evidenced in which girls and women began to enjoy rights previously exclusive to boys and men and became bearers of human rights. Even in the face of this, violence against indigenous girls and women, such as the Warao, is still little investigated, and it seems that general public security policies aimed at the populations are already contemplating them.

In addition, there is the problem pointed out by Pontes and Nascimento (2021) that the social organization of the Warao ethnic group is little known, based on the studies of Garcia-Castro (2006) and Rios and Carvalho (2016). Thus, little is known whether any violence by the partners and other family members of the Warao women came to the attention of the public authorities and whether they were really treated as violence. In a manner of speaking, there is a scientific gap in the studies of violence against indigenous girls and women, including those of the Warao ethnic group.

Likewise, the study is restricted to police occurrences made by them, which reduces the dimension of violence, since not all of them can be recognized, in this format, under a broad aspect of exclusion and discrimination of gender and race, including institutional violence, practiced by State agents, aggravated by the situation of "migrant in a situation of vulnerability", understood in the following terms by the UN, in a report published in 2016: (a) vulnerability related to the reasons for leaving their country; b) vulnerability related to the situation encountered by migrants on the way, at the borders and in the context of their reception; c) vulnerability related to a specific aspect of the person's identity or circumstance (Yamada *et al.*, 2018, p. 377). With the objective of analyzing violence against girls and women, in the period from 2017 to 2023, in the municipality of Belém, the research revealed how harmful the institutional shelter policy carried out by the public authorities in Belém do

Pará, through collective housing, was, considering that most crimes against the sexual dignity of victims occurred in these spaces.

2 METHODOLOGY

This is a descriptive and documentary research, with a quantitative approach. Data collection and analysis were based on records from the Secretariat of Intelligence and Criminal Analysis of the State of Pará (SIAC). Descriptive research orders, analyzes and deciphers the data without the researcher interfering or manipulating them, seeking to discover the frequency with which the phenomenon occurs, its origin, characteristics, causes and relationships with other phenomena.

As for the technical procedures, the research was documental, using materials that have not yet been analyzed, or even, according to the objectives of the study, they can be reformulated and their sources are diversified and dispersed. The quantitative approach, on the other hand, uses quantification both in the collection and treatment of information, using statistical techniques, aiming at results that avoid possible distortions of analysis and interpretation, enabling a greater margin of safety, using statistical techniques from the simplest to the most complex (Gil, 2008; Diehl, 2004; Prodanov; Freitas, 2013).

The data cataloguing was carried out with the Assistant Secretariat of Intelligence and Criminal Analysis SIAC of the State of Pará (SIAC/PA), based on the database of police occurrence records of crimes against Warao girls and women, in the municipality of Belém, state of Pará, Brazil, from 2017 to 2023.

The total number of records analyzed was 9,278, with 4,169 records in 2018, 3,851 records in 2019, and in the 1st half of 2020, 1,258 records. In this study, only occurrences against females of all ages were included.

Data collection was carried out between November 2022 and February 2024. The data were stored in an electronic spreadsheet and the analysis was performed by descriptive statistics elements. The Exploratory Data Analysis technique was used, whose analysis organizes and synthesizes the collected data through tables and graphs, which facilitate the obtaining of results in a fast, accessible and simple to interpret way, giving a systemic view of the data, obtained with calculations of statistical measures, summarizing the information achieved (Bussab; Morettin, 2017).

The variables used include age group (in years: 0 to 17; 18 to 24; 25 to 29; 30 to 34; 35 to 64 and $\geq$ to 65), level of education (illiterate, incomplete elementary school, complete

elementary school, incomplete high school, complete high school, incomplete higher education, complete higher education, and graduate studies); marital status (single, stable union, married, divorced/separated, widow); profession/occupation (the most cited domestic; type of violence (psychological violence, physical violence, moral violence, sexual violence and property violence), presumed cause (hatred or revenge, jealousy, alcoholism, drunkenness, ambition, narcotics, malpractice, recklessness, negligence, debauchery, alienation and others), means employed (without instrument, blunt weapon, cutting or piercing weapon, firearm and other means), place of occurrence (private residence, public road, condominium/hotel/pension, entertainment, educational establishment, public transport and others), day of the week (Sunday; Monday; Tuesday; Wednesday; Thursday; Friday and Saturday) and shift (dawn; morning; afternoon and night).

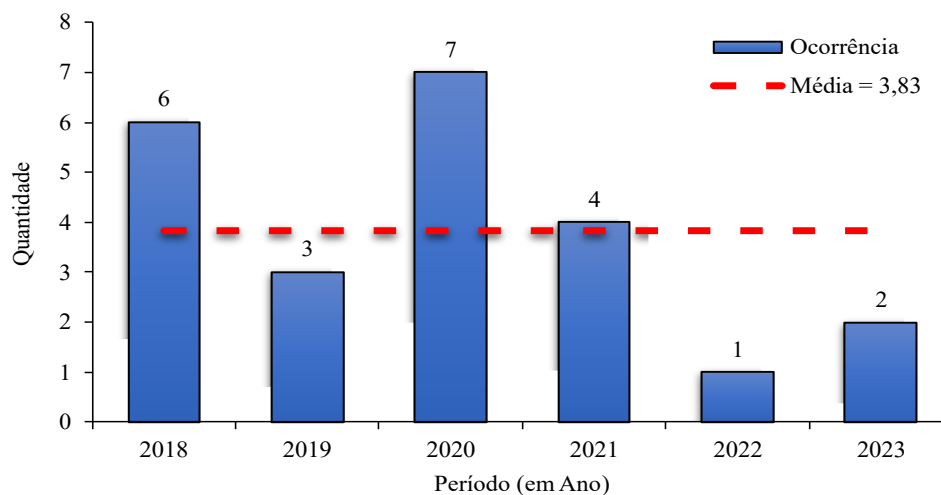
3 RESULTS

3.1 DESCRIPTIVE ANALYSIS

Based on SIAC data, provided by the Public Security Secretariat of the State of Pará (SEGUP/PA) on crimes against Warao girls and women, from 2017 to 2023, it was found that in 2017 no occurrences were recorded, only in the others, with a higher number in 2020, and in total there were 23 occurrence records. However, from a global perspective, they represent few, which may demonstrate the possibility of underreporting of crimes against this population. The highest numbers were of sexual violence, in the places they used as housing, which reveals a greater face of vulnerability, since they were not safe in these places.

Figure 1

Graph of the number of Occurrences per year of Crime against Warao girls and women. Belém, PA, Brazil, 2017 to 2023



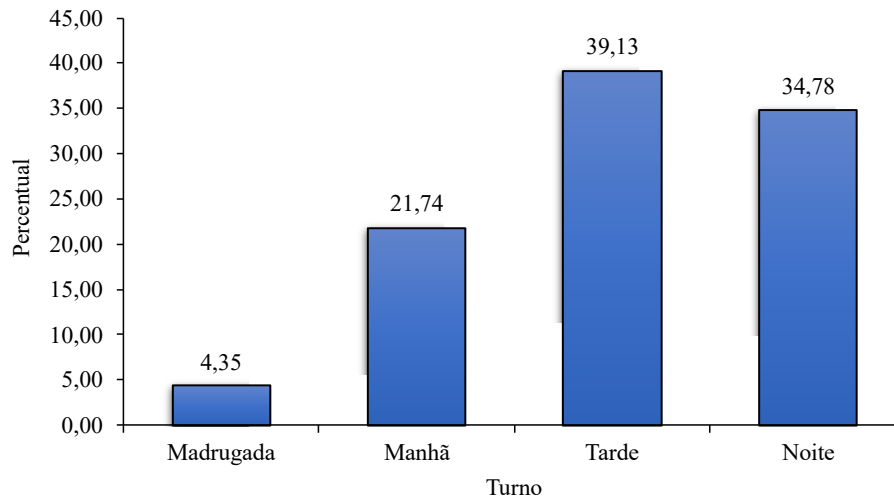
Source: Prepared by the author based on SIAC (Mar. 2024).

The other graphs demonstrate the dynamics of these crimes, which reveal very useful data, since they keep a relationship about their spatialities and temporalities and positions of the victims and perpetrators at the scenes of occurrences.

Figure 2 shows that Warao girls and women were more susceptible to violence during the rest period, from night to dawn, although they were not safe at any time.

Figure 2

Percentage Graph by Shift of Crime against Warao Girls and Women. Belém, PA, Brazil, 2017 to 2023

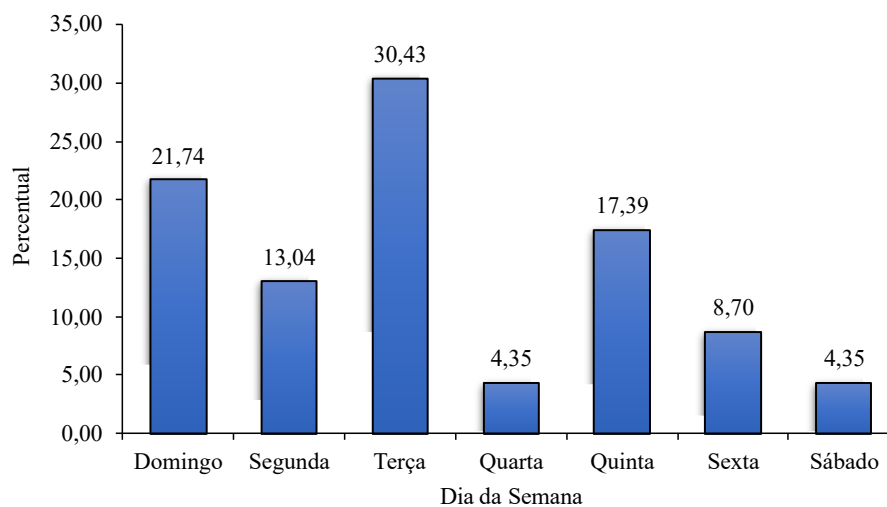


Source: Prepared by the author based on SIAC (Mar. 2024).

Figure 3 shows that girls and women were susceptible to violence during all days of the week, and on Sundays and Tuesdays there was an increase in occurrences, and it cannot be said that they were safe on the other days.

Figure 3

Percentage chart by Day of the Week of crime against Warao girls and women. Belém, PA, Brazil, 2017 to 2023



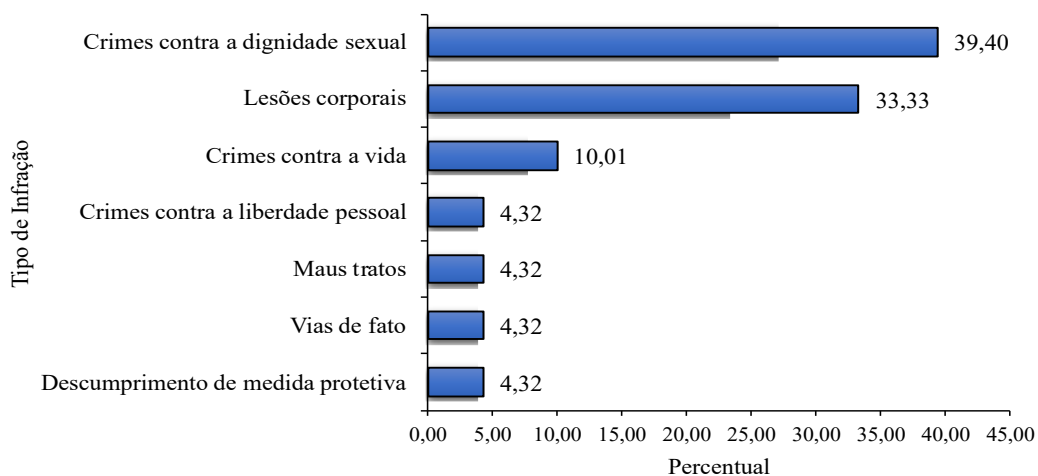
Source: Prepared by the author based on SIAC (Mar. 2024).

Figure 4 shows that Warao girls and women were more susceptible to sexual violence, according to the group of violence, being more victims of crimes of this nature. See, which does not mean that violence itself is watertight and unrelated, as stated by Souza and Adesse (2005) that gender violence refers to an alarming social phenomenon that includes several aspects and factors, the most serious being sexual violence:

Violence against women and girls includes situations of physical, sexual, psychological, and economic aggression. The two most common forms of violence against women, whose perpetrators are intimate partners of the victim, are: physical aggression, which is commonly characterized by the crimes of bodily injury and threat, also called domestic violence; and coercion to sex, called sexual violence, which most often includes the crimes of rape and violent indecent assault. Sexual violence can be exercised in the domestic space (home) or in the public space (street). Physical aggression is almost always accompanied by psychological aggression and, from a quarter to half of the time, it is related to situations of sexual violence, such as marital rape. (Souza; Adesse, 2005, p. 37).

Figure 4

Percentage chart by type of Penal Code Offense against Warao girls and women. Belém, PA, Brazil, 2017 to 2023



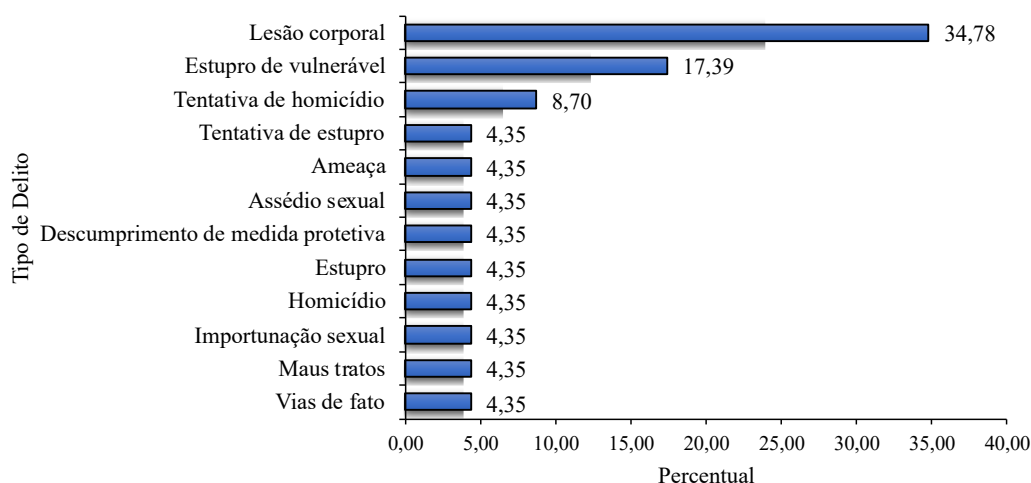
Source: Prepared by the author based on SIAC (Mar. 2024).

Figure 5 shows that Warao girls and women were more susceptible to sexual violence, by type of crime, considering that the sum of crimes of rape of a vulnerable person, rape, attempted rape, sexual harassment and sexual harassment surpass that of bodily injury,

which is in first place. Also, drawing attention in these data that children and adolescents were the ones who suffered the most sexual violence (rape of a vulnerable person).

Figure 5

Percentage chart by type of Crime against Warao girls and women. Belém, PA, Brazil, 2023



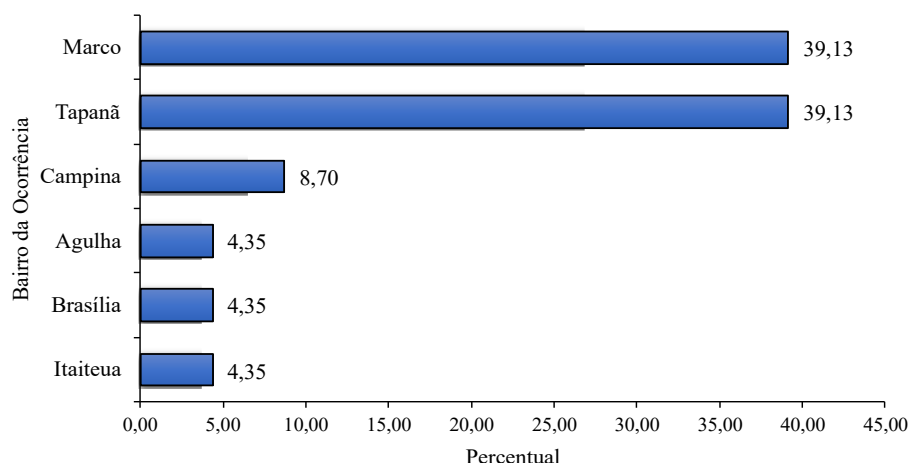
Source: Prepared by the author based on SIAC (Mar. 2024).

On this point, this data is in correspondence with the Brazilian Yearbook of Public Security (Brasil, 2019, p. 118) which, when analyzing the data on rape, found that the majority, 63.8%, were committed against vulnerable people. This rate increased in 2021, according to data recorded in the Brazilian Yearbook of Public Security (Brasil, 2022, p. 187), which went from 63.8% to 75.5%. And that, in 2022, 61.4% were at most 13 years old, according to the Brazilian Yearbook of Public Security (Brasil, 2023, p. 156).

Figure 6 shows that the Warao girls and women suffered violence in the neighborhoods of Belém where they lived, drawing a lot of attention to these data, since they corroborate the others obtained.

Figure 6

Percentage graph by neighborhood of occurrence of crime against Warao girls and women. Belém, PA, Brazil, 2017 to 2023



Source: Prepared by the author based on SIAC (Mar. 2024).

In this regard, in line with national data, according to the Brazilian Yearbook of Public Security, 2022, in the study "A decade and more than half a million victims of sexual violence" (Brasil, 2022), which note that the profile of victims of sexual violence remains: in 88.2% of cases they are women; and, for the most part, minors under 14 years of age and/or adults incapable of consenting.

In view of this, it is urgent that measures be taken due to the consequences for the lives of the victims:

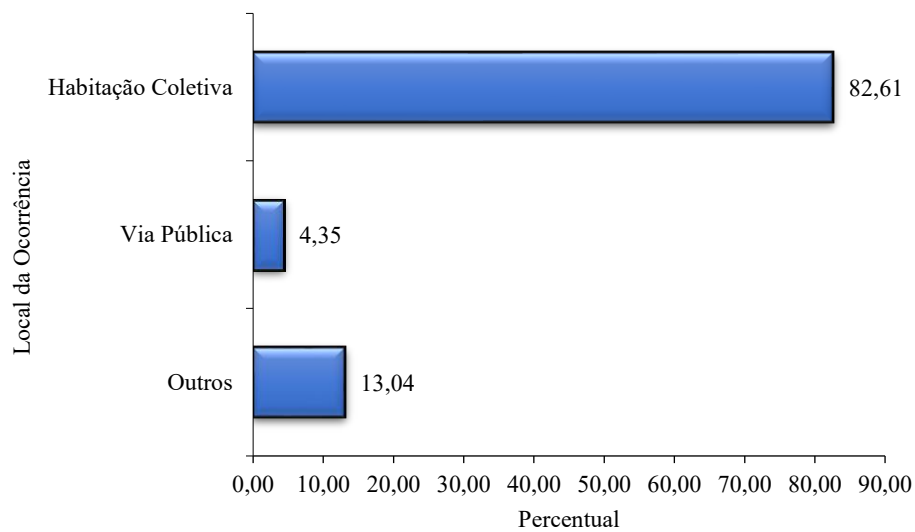
Among the impacts on the lives of survivors, the most visible and immediate effects are unwanted pregnancy, physical injuries and sexually transmitted diseases. Less visible effects, but well documented by the literature, show that victims of sexual violence often suffer from post-traumatic stress disorder (PTSD), depression, anxiety, eating disorders, sexual and mood disorders, a greater tendency to use or abuse alcohol, drugs and other substances, impaired satisfaction with life, with the body, with sexual activity and with interpersonal relationships, as well as suicide risk. (Brazil, 2022, p. 9).

Figure 7 shows that the Warao girls and women suffered violence in the homes in Belém where they lived, most of which were subsidized or paid for by the government, meaning that they were not safe in these places. In addition, another piece of data corroborates this dangerous situation, since 100% of the women who registered occurrences declared themselves as domestic workers, that is, not necessarily house workers, but who

spent most of the time in their homes, considering that children cannot live in a stable union. Table 1 below indicates these places, for a better understanding.

Figure 7

Percentage graph by place of occurrence of the crime against Warao girls and women. Belém, PA, Brazil, 2017 to 2023



Source: Prepared by the author based on SIAC (Mar. 2024).

Table 1

Location of the crime against Warao girls and women. Belém, PA, Brazil, 2017 to 2023

Location of the Occurrence	Quantity	Percentage
Tapanã Institutional Reception Space	9	39,13
Domingos Zahluth Transit Service Unit	8	34,78
Public Road	1	4,35
Hospital	1	4,35
Itaiteua Community	1	4,35
Monitored Self-Management House	1	4,35
Hotel	1	4,35
Private Residence	1	4,35
Total	23	100,00

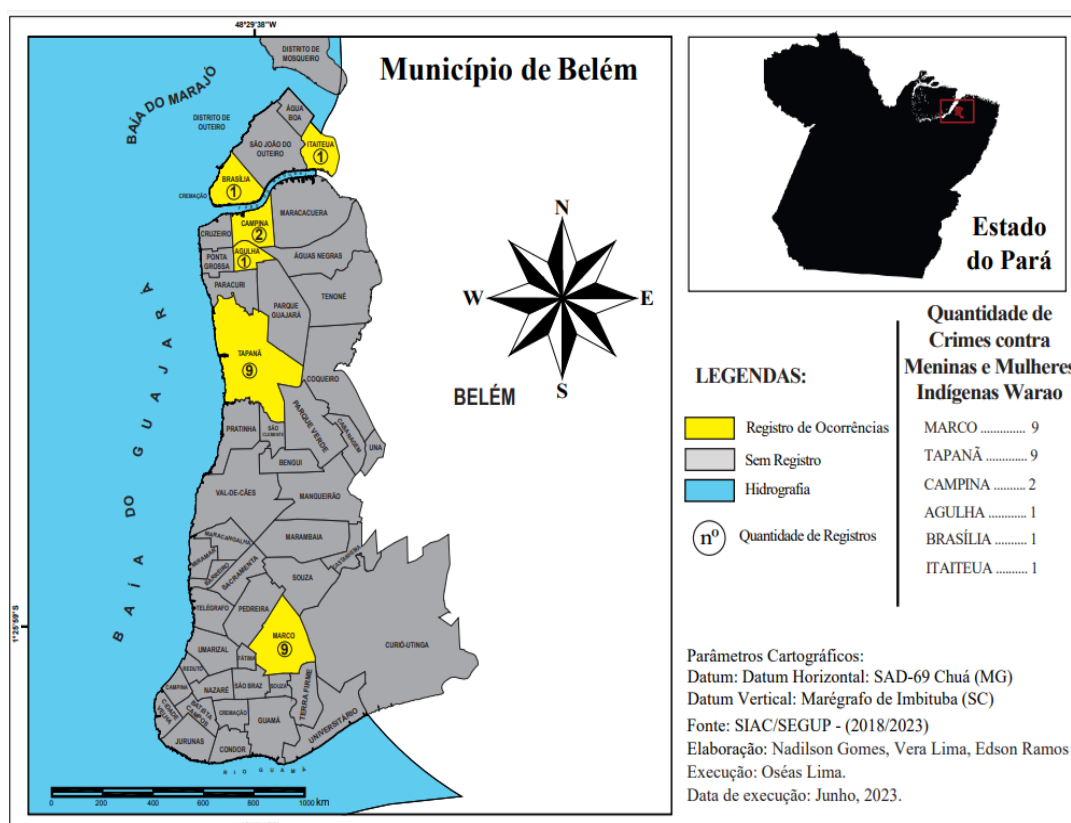
Source: Prepared by the author based on SIAC (Mar. 2024).

The results of the statistical data show that the policies to prevent and confront violence practiced against them should have as one of their spaces of execution their homes, where the most common crimes occur, especially those of a sexual nature.

In addition, the study showed that the crimes against these Warao girls and women occurred in these territorial spaces where they lived, generally peripheral (Bairro do Marco, Tapanã, Campina, Agulha, Brasília and Itaiteua), as shown in the map below.

Figure 8

Map by neighborhood of the occurrence of crime against Warao girls and women. Belém, PA, Brazil, 2017 to 2023



Source: Prepared by the author based on SIAC (Mar. 2024).

Periphery is understood as what Trindade Junior *et al.*, (2009, p. 29) called lowlands: "Segregated, socially excluded spaces, with deficiencies and insufficient urban and community facilities".

The configuration of peripheral spaces is characterized by neighborhoods not only far from the central area of the city, with the exception of Campina, but also because they are places with a low structure of urban services and because they are abandoned by the government or are in the process of changing their territorial destination. In addition, the neighborhood of Campina has changed its profile to commercial space, with a deterioration of it to housing. In this aspect, these spaces are characterized by the absence of urban and

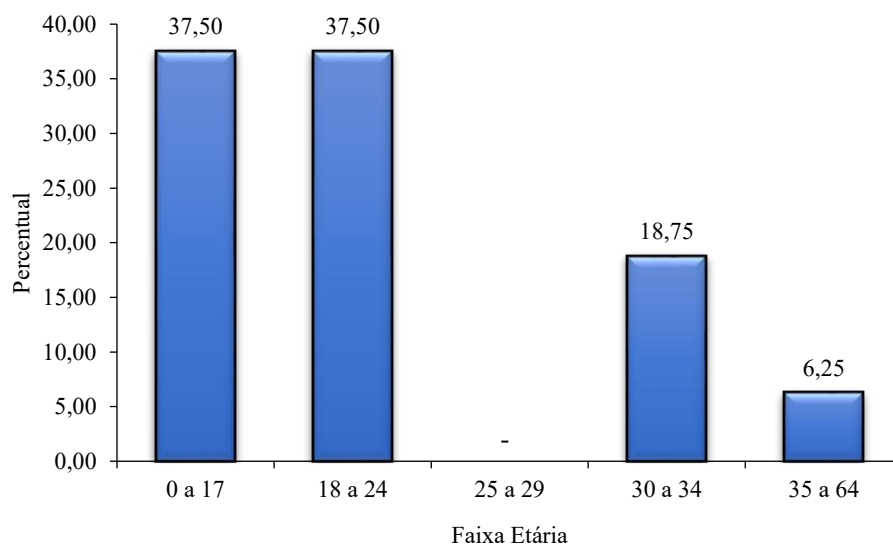
environmental planning, caused by the lack of public policies in such a way that the population with low purchasing power occupies the spaces in a disorderly way and even areas of risk in an evident situation of socio-spatial segregation (Rodrigues, 1996, p.267; Santos, 2009, p.10; Trindade Jr, 1998, p. 60).

A peculiar aspect is that the Warao began to influence the territorial formation of the municipality of Belém, often occupying areas previously without the presence of indigenous people and unoccupied land, such as in Outeiro, so to speak, creating "indigenous territories" within the city.

In turn, Figure 9 shows that women, regardless of their age, were susceptible to crimes, with 37.50% of victims under 18 years of age and 62.50% of whom were older.

Figure 9

Percentage graph of occurrences by Age Group of the victims, girls and Warao women. Belém, PA, Brazil, 2017 to 2023

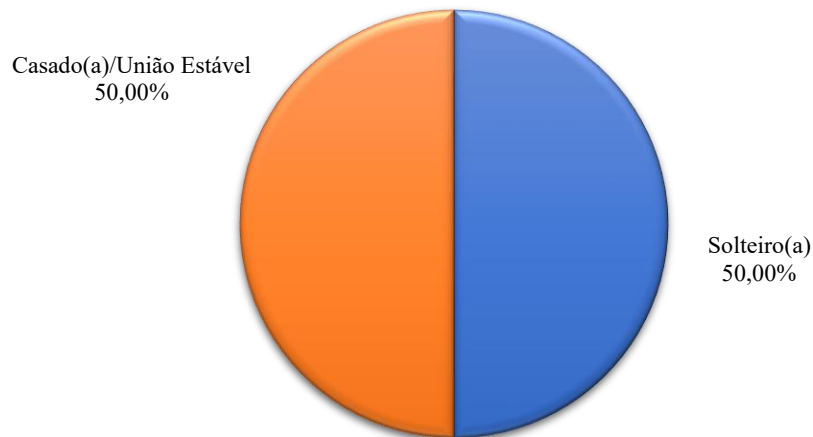


Source: Prepared by the author based on SIAC (Mar. 2024).

Figure 10 shows that women, regardless of their marital status, were susceptible to crimes.

Figure 10

Percentage graph by marital status of the victims, Warao girls and women. Belém, PA, Brazil, 2017 to 2023

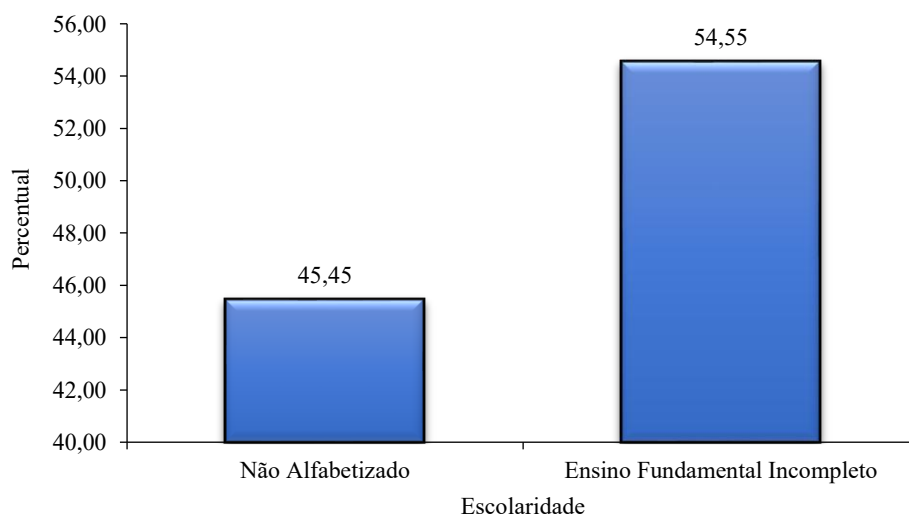


Source: Prepared by the author based on SIAC (Mar. 2024).

Regarding the level of education, according to Figure 11, it was shown that these victims had a low level of education, most of them were illiterate and did not finish elementary school, which alerts much more to the need for prevention and repression.

Figure 11

Percentage graph by schooling of victims, girls and women Warao, Belém, PA, Brazil, 2017 to 2023

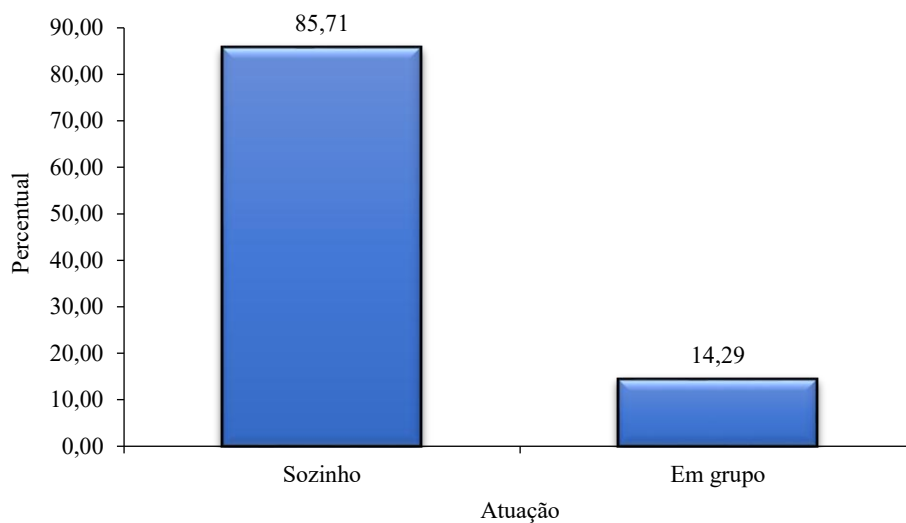


Source: Prepared by the author based on SIAC (Mar. 2024).

It is also worth noting that, according to Figure 12, most of these aggressors acted alone, thus preliminarily refuting that the practices of violence against girls and women is a collective cultural practice, accepted by the Warao community residing in Belém do Pará, so much so that the police records were made by them or those responsible.

Figure 12

Percentage graph Number of aggressors of Warao girls and women, Belém, PA, Brazil, 2017 to 2023



Source: Prepared by the author based on SIAC (Mar. 2024).

In addition, it should be noted that 100% of the aggressors were male, which is in line with data from the 2022 Brazilian Public Security Yearbook, as for the characteristic of the criminal, it remains the same: male (95.4%) and acquaintance of the victim (82.5%), with 40.8% being fathers or stepfathers; 37.2% siblings, cousins or other relatives and 8.7% grandparents. And the place of violence also remains the same: 76.5% of rapes happen inside the home (Brasil, 2022).

Although, the relationship with the victim of the aggressor was a partner" in 100% of the records. At this point, it is assumed that there have been errors in the records, given that it is not possible for children to live in a stable union.

All victims were female, evidencing gender inequality. These data highlight the situation of vulnerability in which this group of women finds themselves, which involves precarious spaces and opportunities for work (domestic in their own homes) and low socioeconomic and educational indexes.

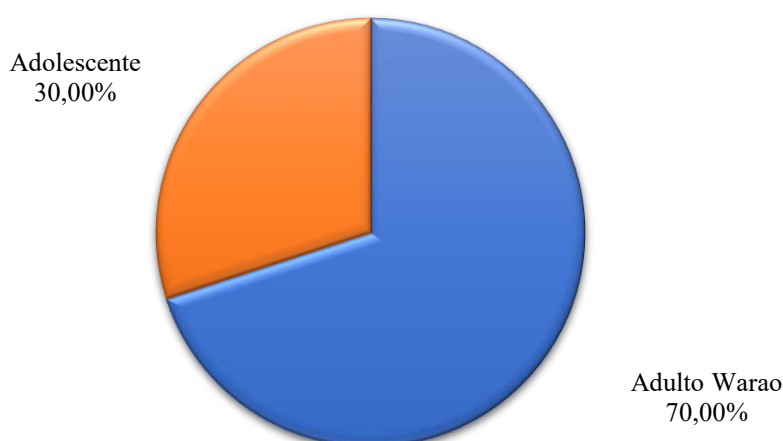
Even so, in cases of violence against Warao adult women, it is worth further study whether the violence occurred due to affective relationships and/or the end of the relationship or for another cause.

A very relevant point, which must be taken into account, is the collective violence practiced against these women and girls in Belém, according to Furlan:

From the theoretical framework studied and the reports of violence suffered by Warao migrant women from Venezuela in Belém, we conclude that intersectionality evidences the processes of vulnerability that affect these women, from the intersection of the markers of race, gender and ethnicity, and that the vulnerabilities to which these women are subjected are not exclusively individual, but they occur collectively. Finally, we believe that intersectional studies on migration must be carried out, in order to combat this scenario of exclusion and multiple oppressions. (Furlan, 2022, p.5).

Figure 13

Percentage graph by Age of Aggressors of Warao girls and women, Belém, PA, Brazil, 2017 to 2023



Source: Prepared by the author based on SIAC (Mar. 2024).

Figure 13 reveals that 100% of the aggressors were male, 70% of whom were Warao adults and 30% were adolescents, including individuals of the Warao ethnic group or not.

4 DISCUSSION

The data collected reveal a facet of the violence practiced against these girls and women, which were mostly practiced by people close to them and, mainly, inside their homes, greatly contributing to the territorial isolation that had been imposed on them.

There is no way not to relate violence and spatiality in this context, as the format of welcoming them prioritized the format of collective housing, including individuals who had never had contact before or did not belong to the same family or who did not live together in "rancheria" houses, in a misunderstanding of the Warao people's way of being, existing and organizing. In addition, the choices made by the government or by the conditions that were pressed resulted in a dynamic already known in the Amazon region for indigenous peoples, expelling them to urban agglomerations or to peripheral areas, causing part of them to live in the misery of the favelas and underoccupation (Martins, 2009).

Domestic violence is a serious social problem arising from historical inequalities promoted by the patriarchal system, which placed women in a position of subordination, promoting differences between male and female roles within society (Silva, 2017).

The survey data ratify a picture of violence against girls and women in a global scenario where they are more victims. And, what is worse, when it comes to sexual violence, they are also the biggest victims, regardless of their age for the aggressors, marital status, occupations and ethnicities, meaning that being female is dangerous in our society.

The configuration of the dynamics of sexual violence was also confirmed for these Warao victims, a fact generally committed by close people and family members, in secret, in deserted places, far from witnesses and, sometimes, they leave no trace, which has been ratified by official statistics. Likewise, related to the fact that most aggressors are known and often have access to the victim's domestic environment or live in it, we realize that the characteristics of most sexual violence committed in Brazil are not related to sudden aggressions committed by groups of strange men, but that they are done by the action of family members, neighbors and friends who have previous contact with their victims (Brasil, 2019, 121).

It is worth mentioning that the records analyzed were only those made in the SIAC database, not including the phenomenon called "black crime figure",⁴ or "hidden crime figure" ("dark number" or "ciffre noir"), which are the quantities of crimes that do not come to the

⁴ Here is the record of our disagreement with the use of this scientific term because we consider it racist (emphasis added).

attention of the State, often due to lack of confidence in the penal system, for fear of revenge or even for the feeling of impunity. In this sense, the problem can be even worse, as the criminal statistics, which serve to support public security policies, end up not demonstrating reality because of this (Penteado Filho, 2017). In addition, the search was carried out using the descriptors "Warao", "Warao indigenous" and "Venezuelan Warao" to search for data from crime records, since the ethnicity or the item "skin color" is usually non-existent or is not filled out in the identification forms (Almeida; Pereira, 2012).

As most of the violence committed against the Warao victims was of a sexual nature, it is important to point out that Ishida's lesson, so that because they are indigenous their sexual dignity does not bear relativization:

Human beings have the right to self-determination and freedom in the conduct of their own lives, and must be protected by the Law and its norms, as a measure of recognition of their own essence and condition as a human being. Sexual dignity, in this context, represents the values that must be respected in the sexual sphere with a view to self-determination and freedom. (Ishida, 2009, p.345).

Furthermore, violence committed against children and adolescents, who are unable to validly consent to the sexual act, in addition to their conditions as indigenous and migrants, deserve special attention from the public authorities in the sphere of public security due to the overlapping of vulnerabilities.

5 FINAL CONSIDERATIONS

Violence against Warao women, whether adult or not, is a relevant issue for the whole of society, as it constitutes an unprecedented public health and security problem, much more so for the most invisible categories of women such as indigenous women, including the Warao, where violence against them is treated as something of their cultures, in a way of concealing and justifying the inaction of the public power and the people themselves. Thus, the present research proposed to present the results of the sociodemographic profile of Warao girls and women who experienced the situation of violence, as well as the characteristics of this type of crime in the municipality of Belém do Pará. The limitations of the study are the lack of analysis of other variables such as alcohol and drug consumption, or even perspectives from the perpetrators of violence and other family members, such as children, to have a broader view of the phenomenon.

In addition, it is noted that, as it is a documentary research, with secondary data, it was observed that much information, such as in relation to the chosen variables, was incomplete in the database, which hindered the real quantification of the results of the investigation.

It is recommended for future work that the phenomenon of violence against these victims be analyzed more broadly under other intersectoral and multidisciplinary aspects, directed to the care of men, families and professionals or people in the victims' support networks, offering elements for the development of new forms and strategies of coping, thus carrying out interventions in different social sectors and contributing to the creation of public policies on the Thematic. And not only that, a new way of acting aimed at preventing violence for indigenous female victims, according to each ethnic group and population in migration, in a dynamic of facilitation/availability of care, reception, support and support.

In addition, it is necessary that studies be carried out to deepen whether these violences committed against girls and women Warao also come from historical inequalities promoted by the patriarchal system, which places women in a position of subordination, promoting differences between male and female roles within society (Silva, 2017).

It is also essential to discuss violence against Warao women not only from a gender perspective, but also from a race perspective, that is, to seek intersectionality in this discussion, understanding that gender discrimination intensifies in their lives (children, adolescents and adults), so the public power must promote policies to confront social inequalities caused by the issue of gender and racism, unfortunately still present in society.

Finally, it is believed that the data of this study add to the existing field of knowledge, to evidence and/or unveil the indicators of violence against Warao girls and women for the adoption of forms of confrontation, to confront the prejudices related to the theme, mainly due to the lack of knowledge and the lack of instrumentalization of the professionals who deal with the different facets or forms of violence against these Venezuelan Warao indigenous victims.

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BETWEEN LAW AND FEAR: HOW THE TCU NEUTRALIZES THE LINDB AND THE NLLC

ENTRE A LEI E O MEDO: COMO O TCU NEUTRALIZA A LINDB E A NLLC

ENTRE LA LEY Y EL MIEDO: CÓMO LA TCU NEUTRALIZA A LA LINDB Y A LA NLLC

 <https://doi.org/10.56238/sevened2025.036-034>

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ABSTRACT

The article investigates why the LINDB (Law 13,655/2018) and the NLLC (Law 14,133/2021) have yielded limited practical effects in public management, with emphasis on the external control exercised by Brazil's Federal Court of Accounts (TCU) and on repercussions for administrative decision-making, especially in municipal contracting and urban policies. It adopts a critical documentary review (2018–2025) of TCU rulings and regulations, Supreme Federal Court decisions, opinions from the Office of the Attorney General, and academic literature, selected through explicit criteria. Findings indicate incipient use of a precedent technique, normative and applicative variations concerning limitation periods, irregular application of LINDB art. 28, underuse of consensual instruments, and centralizing effects that compress subnational decision margins. The article argues that low predictability and weak consideration of context intensify decision retrenchment (“pen paralysis”). It proposes guidelines for stating theses and distinctions, parameters for gross error, risk assessment, and the adoption of commitments with monitoring and publicity. The implications point to gains in legal certainty and governance of urban contracting, while preserving liability for intent or gross error.

Keywords: LINDB (Law of Introduction to the Norms of Brazilian Law). New Public Procurement and Contracts Law (Law 14,133/2021). Federal Court of Accounts (TCU). Gross Error (LINDB art. 28).

RESUMO

O artigo investiga por que a LINDB (Lei 13.655/2018) e a NLLC (Lei 14.133/2021) têm gerado efeitos práticos limitados na gestão pública, com ênfase no controle externo exercido pelo TCU e nas repercussões sobre decisões administrativas, especialmente em contratações municipais e políticas urbanas. Adota-se revisão crítica documental (2018–2025) de acórdãos e normativos do TCU, decisões do STF, manifestações da AGU e literatura acadêmica, selecionados por critérios explícitos. Os achados indicam incipiência na técnica de precedentes, variações normativas e aplicativas sobre prescrição, aplicação irregular do art. 28 da LINDB, subutilização de instrumentos consensuais e efeitos centralizadores que comprimem margens decisórias subnacionais. Argumenta-se que a baixa previsibilidade e a fraca consideração do contexto aumentam a retração decisória (“apagão das canetas”). Propõem-se diretrizes para enunciação de teses e distinções, parâmetros para erro grosseiro, avaliação de riscos e adoção de compromissos com monitoramento e publicidade.

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As implicações apontam para ganhos de segurança jurídica e de governança das contratações urbanas, preservando a responsabilização por dolo ou erro grosseiro.

Palavras-chave: LINDB. Nova Lei de Licitações e Contratos (Lei 14.133/2021). Tribunal de Contas da União (TCU). Erro Grosseiro.

RESUMEN

El artículo investiga por qué la LINDB (Ley 13.655/2018) y la NLLC (Ley 14.133/2021) han generado efectos prácticos limitados en la gestión pública, con énfasis en el control externo ejercido por el Tribunal de Cuentas de la Unión (TCU) y en las repercusiones sobre la toma de decisiones administrativas, especialmente en las contrataciones municipales y las políticas urbanas. Adopta una revisión documental crítica (2018–2025) de acórdãos y normativas del TCU, decisiones del Supremo Tribunal Federal, manifestaciones de la Abogacía General de la Unión y literatura académica, seleccionadas mediante criterios explícitos. Los hallazgos indican uso incipiente de la técnica de precedentes, variaciones normativas y aplicativas en materia de prescripción, aplicación irregular del art. 28 de la LINDB, subutilización de instrumentos consensuales y efectos centralizadores que comprimen los márgenes decisorios subnacionales. Se sostiene que la baja previsibilidad y la escasa consideración del contexto incrementan la retracción decisoria (“apagón de las plumas”). Se proponen directrices para enunciar tesis y distinciones, parámetros de error grave, evaluación de riesgos y adopción de compromisos con monitoreo y publicidad. Las implicaciones apuntan a ganancias de seguridad jurídica y de gobernanza de las contrataciones urbanas, preservando la responsabilidad por dolo o error grave.

Palabras clave: LINDB (Ley de Introducción a las Normas del Derecho Brasileño). Nueva Ley de Licitaciones y Contratos (Ley 14.133/2021). Tribunal de Cuentas de la Unión (TCU). Error Grave (art. 28 de la LINDB).

1 INTRODUCTION

The Brazilian Public Administration has sought to increase efficiency and results in a context of increasing decision-making complexity. Authors such as **Braga (2017)**, Ribas and Marques (2024) and Charles (2024) maintain that a pattern of control persists that tends to favor punishment and the standardization of understandings, often with low consideration for the concrete circumstances of the cases. This pattern impacts daily contracting and management decisions and affects the autonomy of subnational entities in the federative pact (Mohn, 2010; Sundfeld, 2014; Braga, 2017; Binenbojm, 2023).

The **Law of Introduction to the Rules of Brazilian Law (LINDB)**, amended by Law No. 13,655/2018, introduced parameters for administrative and control decisions to consider obstacles and real difficulties of the manager and limit liability to cases of intent or gross error. The New Bidding and Contracts Law (NLLC), Law No. 14,133/2021, reinforced guidelines for planning, risk management, and consensual mechanisms (*Brasil, 2022; Brazil, 2024a; Brazil, 2024b*). However, recent studies and institutional documents indicate a dissociation between the normative design and its application in the arena of control, with effects on legal certainty and on the willingness of the public agent to decide (FGV, 2021; AGU, Federal Attorney General's Office, 2024; Brazil, 2024; Ribas and Marques, 2024; Pereira and Garrido, 2025).

The central hypothesis of this article is that the practical ineffectiveness of the LINDB and the NLLC stems less from failures of the rules themselves and more from the culture of control that guides the performance of the Federal Court of Accounts (TCU). The literature indicates that interventions persist that do not always consider the real conditions in which the manager decides and that there is still low predictability in sensitive issues, such as gross error and prescription (Braga, 2017; Naves, 2019; AGU – Federal Attorney General's Office, 2024; Brazil, 2025a; Brazil, 2025b;).

In this environment, the literature describes relevant behavioral effects among managers: decision-making retraction, increased transaction costs, and prioritization of defensive strategies, a phenomenon referred to as "pen blackout" (Charles, 2024; Ribas and Marques, 2024). These effects can reduce adherence to the NLLC and discourage the use of consensual solutions provided for in the LINDB and subsequent acts (Faria, 2022; Eidt, 2024; Oliveira and Moreira, 2024; Tce/SE, 2025; Jota, 2025).

At the federative level, the understanding of "general norms" (national guidelines) and the limits to subnational normative competence **has generated recurrent interpretative disputes**. The theme is central to the autonomy of states and municipalities in public

procurement and to the compatibility between standardization and the ability to adapt to local contexts (Mohn, 2010; Sundfeld and Câmara, 2011; Binenbojm, 2023). Without **predictability** and **coherence** in the performance of external control and without clear incentives for context analysis, the division of competences tends to operate in a centralized manner, with low margin for local innovations and consequent loss of effectiveness of the NLLC, because its planning, risk management and local adaptation instruments are no longer exercised autonomously.

In terms of liability, recent empirical literature suggests that article 28 of the LINDB still finds oscillating application when it comes to qualifying the "gross error", with repercussions on the manager's willingness to decide (Kammers, 2024; Pereira and Garrido, 2025). The unpredictability about the incidence of "gross error", added to alternating understandings about prescription and duties of result, accommodates incentives for administrative inaction.

The analysis takes as its object the tension between the normative efforts of responsible flexibility (LINDB and NLLC) and the persistence of a punitive and unpredictable control culture within the TCU. The focus is not only to describe the effectiveness of the rules, but to explain why they have been ineffective in producing the environment of legal certainty and efficiency in public management that they promise. The contribution lies in articulating the institutional diagnosis of control with the federative and managerial implications for public procurement, proposing practical criteria to qualify the performance of external control and mitigate decision-making fear.

It seeks to demonstrate, based on the selected bibliography, how the TCU's performance has produced low predictability and limited consideration of the manager's decision-making context in central themes (precedents, prescription and gross error); explain the behavioral effects of this pattern of control on management, especially the decision-making retraction and the so-called "blackout of the pens"; and to propose criteria, derived from the LINDB and the NLLC itself and from institutional documents contained in the bibliography, to reinforce predictability and contextual analysis in the performance of external control, without removing the duty of accountability in cases of intent or gross error.

The organization of the text is as follows: Section 2 discusses bureaucracy and federalism, focusing on competencies and general norms. Section 3 analyzes the "administrative law of fear", the unpredictability and the application of gross error by the TCU. Section 4 examines LINDB and consensuality, including accountability, unavailability of

public interest, and self-composition chambers. Section 5 presents a synthesis, recommendations and research agenda.

2 BUREAUCRACY AND FEDERALISM IN BRAZIL: COMPETENCIES AND "GENERAL NORMS"

The 1988 Constitution distinguishes competences and reserves to the Union the edition of **general rules** in matters such as bids and contracts, and it is up to states and municipalities to **complement and adapt** procedures. Mohn (2010) describes the division of competences and the function of general norms in the federative arrangement; Moreira Neto (1988) examines the **conceptualization** of general norms and their limits; Sundfeld and Câmara (2011) analyze the **control of competences** by the Courts of Auditors and its reflections on the autonomy of the entities; Amorim (2022) discusses **federative autonomy** in the face of Law No. 14,133/2021; and Binenbojm (2023) resumes the debate on the **delimitation** of general rules in public procurement, arguing that this division usually generates controversies about the measure of the local conformation space and the scope of general rules in the daily life of contracting (Moreira Neto, 1988; Mohn, 2010; Sundfeld and Câmara, 2011; Amorim, 2022; Binenbojm, 2023). This background is decisive for the theme of this article because the way in which control interprets "general norms" influences the degree of effective autonomy of subnational entities. Since, when the interpretation of general norms is overly broadened and control demands **rigid uniformity**, the legitimate space for local conformation is reduced and the possibility of adjustments to different institutional realities is restricted.

2.1 LEGAL FETISHISM AND NORMATIVE MAXIMALISM

Amorim's analysis (2020; 2022) reveals a criticism of what he calls "legal fetishism", that is, the institutional tendency to attribute to the legal norm a role of absolute solution in public procurement. This posture generates an excess of formalism and bureaucratic imprisonment, resulting in the proliferation of procedural requirements that do not always contribute to administrative efficiency or effectiveness. **Braga (2017) observes that, in this environment, control tends to prioritize document compliance and discourage innovative choices. Dallari (2021) notes that, although Law No. 14,133/2021 intends to rationalize the regime, its reception has occurred with regulatory additions capable of reproducing the normative excess. In this context, rigid normative maximalism (the**

option to **exhaustively regulate** public procurement, with **detailed rules, rigid steps, and detailed prohibitions**, seeking to anticipate almost all possible situations) **reduces responsible discretion, shifting the focus from administrative merit to the fear of administrative sanctions, and increases the pressure for standardized decisions, regardless of differences in context.**

"**Legal fetishism**" appears as excessive reliance on the increase of rules to solve management problems, with detail that compresses the **manager's responsible discretion** (Amorim, 2020; 2022). In this environment, **rites and documents** become worth more than **analysis of results**, which reinforces formal and defensive behaviors (Sundfeld, 2014). In public procurement, this pattern coexists with **control pressures** that favor **standardized compliance** by control bodies and discourage innovative choices (Braga, 2017), leading managers to **follow uniform controls**, with **little adaptation** to local capacities, contexts, and risks. Even with Law No. 14,133/2021, the practical reception may be accompanied by **regulatory additions** that reconstitute the criticized complexity (Dallari, 2021). In a federalism with unequal capacities, exacerbated maximalism tends to push entities and entities of the administration, including state-owned ones, when subjected to the same compliance requirements, to **replicate federal models**, reducing adaptation to local contexts.

Maximalism also feeds on the way control operates. According to Braga (2017), the TCU's performance tends to emphasize the rigor of procedural compliance, which, paradoxically, can discourage creative solutions in public management. Naves (2019) notes that the limited use of administrative precedents contributes to the instability of interpretations, making it difficult to predict control decisions. The TCU's compendium (Bids & Contracts: guidelines and jurisprudence) (Brazil, 2024) summarizes understandings and disseminates standardizing standards of compliance. The combination of detailed laws and standardizing guidelines produces an environment in which the manager operates focused on following the **verification scripts**, with less room for contextual motivation, risk management and adaptation to local capacities.

2.2 DIVISION OF COMPETENCES AND THE SELF-REPORTED CONTROL PERFORMANCE

Regarding the 1988 Constitution, Mohn (2010) describes the division of competences and the role of the Union in the edition of general rules in bids and contracts, preserving

space for states and municipalities to complete and adapt procedures. Moreira Neto (1988) examines the conceptualization and limits of general norms, indicating that excessive enlargements compress local conformation.

Sundfeld and Câmara (2011) analyze the control of competences by the Courts of Auditors and the effects of this action on the autonomy of the entities, especially when understandings of control operate as if they were general rules. Amorim (2022) and Binenbojm (2023) return to the topic in the context of Law No. 14,133/2021, emphasizing the need to preserve the subnational space of conformation. When there is self-reported control action, that is, the application of internal understandings with little consideration for the context, the result in practice tends to be the reduction of local autonomy.

In the practice of hiring, the line between guideline and detail narrows when statements and understandings of the TCU start to guide administrative action as if they were general (binding) parameters. Braga (2017) indicates a discouraging effect on differentiated arrangements; Naves (2019) points to incipient use of precedents, which reduces predictability; Mohn (2010) and Moreira Neto (1988) outline that general norms should preserve space for local conformation; Amorim (2022) and Binenbojm (2023), in the context of Law No. 14,133/2021, emphasize the need to safeguard the subnational margin. When the administration is compelled to follow control guidelines as if they had general normative force, the practical autonomy of states and municipalities is reduced and adaptation to the context is compromised.

In the context of Law No. 14,133/2021, Amorim (2022) and Binenbojm (2023) reinforce the need to preserve space for local conformation, while Dallari (2021) points out risks of reconstituting regulatory excess. If the dominant interpretation and the self-reported control action expand the practical scope of the general rules, the division of competences centralizes administrative practice, reduces adaptation to local contexts and limits the use of the planning and risk management tools provided for in the NLLC.

3 METHODOLOGY

This is a critical documentary review based exclusively on the bibliography and institutional documents listed in the References section, focusing on the period 2018–2025 (post-Law No. 13,655/2018 and effectiveness of Law No. 14,133/2021). Scientific articles, dissertations, chapters and institutional acts/reports (AGU/PGF, TCU, MGI), as well as selected legal journalistic material (JOTA), all included in the bibliography, were included.

The sources were classified into analytical axes: (i) precedents and predictability; (ii) statute of limitations; (iii) gross error (article 28 of the LINDB); (iv) consensuality (art. 26 of the LINDB and NLLC); and (v) federalism and "general norms". The collection of judgments and regulations was done in **the TCU Public Survey** (official portal), with persistent records on the respective pages of the acts.

A thematic analysis of the texts was carried out by axis, with extraction of evidence (excerpts and conclusions of the authors/agencies themselves) and cross-comparison between academic and institutional sources, in order to explain why the practical application of the LINDB/NLLC has been limited in the context of the control exercised by the TCU. Limitations: the analysis is restricted to the corpus listed in the References; it does not cover an exhaustive jurisprudential survey beyond the judgments and compendia cited; Inferences remain tied to the selected material.

4 THE ADMINISTRATIVE LAW OF FEAR: PUNITIVE EXTERNAL CONTROL AND LEGAL UNCERTAINTY

4.1 THE GENESIS OF FEAR IN PUBLIC MANAGEMENT

Even after the amendment of the LINDB by Law No. 13,655/2018, the permanence of these behaviors indicates a disharmony between the legal command of contextual analysis and the practice of control.

The expression "administrative law of fear", coined by Santos (2020), translates the perception of a legal-institutional environment in which the fear of severe and sometimes unpredictable sanctions leads public managers to decision-making paralysis. Ribas and Marques (2024) call this retraction the "blackout of pens", illustrating the fear of making decisions in the face of the risk of multiple responsibilities. Charles (2024), when mapping the phenomenon, associates this inhibition with the performance of control bodies that disregard, in many cases, the contextual particularities (the concrete case that designed the possible solution in the context) of administrative decisions. Santos (2020) associates fear with the combination of personal accountability and decision-making uncertainty. In everyday life, this uncertainty stems from three recurring factors in the literature: (i) limited predictability of control decisions, with incipient use of precedents (Naves, 2019); (ii) oscillating attribution of gross error, with low consideration of the real difficulties faced by the manager (Kammers, 2024; Pereira and Garrido, 2025); and (iii) variable interpretations of the statute of limitations in accountability, which is the subject of recent normative adjustments (Jota, 2023; AGU –

Federal Attorney General's Office, 2024). When the manager realizes that, even after completing all the steps and registering justifications, the possibility of *ex post accountability* with unstable criteria remains, he tends to restrict discretionary decisions and prioritize defensive routes, fueling the "blackout of the pens" described by Ribas and Marques (2024) and mapped by Charles (2024).

At the organizational level, fear translates into defensive routines: postponement of decisions, preference for verification scripts, and replication of standardized solutions, even when the context would recommend alternatives (Santos, 2020; Charles, 2024; Ribas and Marques, 2024).

The amendment to the LINDB sought to induce context analysis and delimitation of liability (articles 22 and 28), but the practical application remains irregular, with incipient use of precedents and oscillation in the qualification of gross error (Naves, 2019; FGV, 2021; Kammers, 2024; Pereira and Garrido, 2025). The proposal of lines of defense intends to rationalize access to control and order decision-making flows, but it does not eliminate the fear when stable criteria are lacking (Palma, 2024). As long as signs of unpredictability and low consideration of the circumstances of the case persist, managers will tend to restrict discretionary decisions and prioritize self-protection, fueling the "blackout of pens".

As pointed out by Fundação Getúlio Vargas (2021), the provisions of the LINDB that require the consideration of the factual context and the qualification of gross error have not yet been fully incorporated into the TCU's decisions. The Attorney General's Office (2024) also shows instability in the criteria related to the statute of limitations, which has motivated recent normative changes. In the same sense, Kammers (2024) notes the low effectiveness of the application of article 28 of the LINDB in the jurisprudence of control. In view of this scenario, Pereira and Garrido (2025) propose a doctrinal systematization that allows greater uniformity in the analysis of gross error, contributing to predictability and legal certainty. Naves (2019) points to incipient use of precedents, with effects on predictability. Without stable precedents, clear criteria for prescription and consistent application of article 28, managers tend to restrict choices and **minimize personal risks**, even at the expense of efficiency and innovation.

Thus, it is evident that the culture of control and defensive behaviors can reduce the practical effectiveness of the LINDB and NLLC commands: the legal requirement of context analysis and the limitation of liability to intent or gross error are not consolidated when there is a lack of stable precedents, clear prescription criteria and consistent adherence to article

28 (Naves, 2019; AGU – Federal Attorney General's Office, 2024; FGV, 2021; Kammers, 2024; Pereira and Garrido, 2025). As long as control operates with low predictability and little consideration of the real conditions of decisions, the manager will continue to restrict choices and minimize personal risks, even at the expense of efficiency and innovation.

4.2 TCU, PRECEDENTS AND PREDICTABILITY

The limitation in the adoption of administrative precedents, as evidenced by Naves (2019), compromises the consolidation of a stable jurisprudence within the TCU. In addition, Braga (2017) points out that this uncertain environment can generate a deterrent effect on innovative practices in public management. The TCU/FGV Observatory (2021) also pointed out the restricted application of the LINDB rules regarding the contextualization of decisions. In response to these interpretative weaknesses, the Court published, in 2024, a compendium of jurisprudence and guidelines with the aim of fostering greater standardization and clarity in control practices. These reports show that without a consistent use of precedents, with clear identification of the thesis applied and distinction of cases, guidelines fluctuate and predictability decreases, increasing the incentive for defensive decisions even when there is technical justification for different solutions.

Regarding the issue of the statute of limitations in accountability, there have been recent normative adjustments within the scope of the TCU (Resolutions 344/2022 and 367/2024, and IN 98/2024) (STF, 2020). The Referential Statement of the AGU – Federal Attorney General's Office (2024) systematizes the milestones and guides the practical application of these acts; the journalistic material of Jota (2023) points out that Resolution 344/2022 sought to increase predictability in the judgment of the statute of limitations. Successive changes in the TCU's statute of limitations, followed by the need to adjust processes already in progress to the new requirements, increase compliance work and maintain operational doubts (Brasil, 2022; Brazil, 2024a; Brazil, 2024b). In this situation, managers tend to opt for low-risk and more standardized decisions (Jota, 2023; AGU – Federal Attorney General's Office, 2024).

Naves (2019) points out that the *administrative stare decisis* in the TCU (idea of following precedents, understandings already established) is still incipient, with little explicit identification of the applied thesis and *distinguishing* (distinction of precedent) when the facts diverge (because the **concrete case has relevant** factual and legal differences in relation to the paradigm). The TCU/FGV Observatory (2021) recorded the limited application of the

LINDB commands on context analysis, which reduces the prospective usefulness of judgments to guide future decisions. Braga (2017) indicates that, in this scenario, control action discourages innovation. Without a consistent technique of precedents (enunciation of the thesis, distinction and eventual overcoming) and without a clear examination of the circumstances of the case, managers are unable to anticipate the control judgment and tend to opt for standardized and lower-risk solutions, even if less adjusted to the concrete problem.

Differentiating administrative guidance from precedents is central to predictability. The compendium *Bids & Contracts: guidelines and jurisprudence of the TCU* brings together useful understandings for practice, but does not replace the technique of precedents with an identified thesis, consistent application and explicit distinction when the facts diverge (Naves, 2019; Brazil, 2024). The report by the TCU Observatory (FGV, 2021) recorded limited application of the LINDB commands on context analysis, which reduces the ability of judges to guide future decisions. Without the formalization of theses and the distinction of cases, compiled guidelines tend to operate as decontextualized standardization, with less prospective value for the manager (Naves, 2019; FGV, 2021; Brazil, 2024).

The recent normative adjustments on the statute of limitations, **TCU Resolution No. 344/2022**, **TCU Resolution No. 367/2024** and **IN-TCU No. 98/2024**, have consolidated milestones and procedures aimed at preventing the statute of limitations in accounts and in the TCE (Brasil, 2022; Brazil, 2024a; Brazil, 2024b). The production of subsequent rulings indicate a movement of updating, but also reveal the need for methodological stabilization: applying theses in a coherent manner and justifying distinctions when appropriate (AGU – PGF, 2024; Brazil, 2025a; Brazil, 2025b). Even with regulatory changes, predictability depends on the technique of precedents and the examination of the context provided for in the LINDB; Without this, operational uncertainty persists. This normative movement meets, in part, the guideline set by **Theme 899** of the STF (STF, 2020).

In terms of decision-making behavior, limited predictability and incipient use of precedents increase the incentive for defensive choices, already described as pen blackout (Ribas and Marques, 2024). When it is not possible to predict, based on clear and replicable theses, how the control will assess analogous cases, managers reduce the use of discretionary solutions and prioritize verification scripts and low-risk decisions (Naves, 2019; FGV, 2021; Ribas and Marques, 2024).

4.3 (DIS)APPLICATION OF GROSS ERROR (ART. 28 OF THE LINDB)

Article 28 of the LINDB conditions the liability of the public agent to intent or gross error and requires that control decisions consider real obstacles and difficulties of management (in dialogue with article 22). The TCU/FGV Observatory (2021) records limited application of these contextual analysis commands in the Court's decisions. Naves (2019) points to incipient use of precedents, which affects the predictability of the criteria applied. Pereira and Garrido (2025) offer a new perspective for the TCU's jurisprudence on gross error. Kammers (2024) identifies low adherence to the legal parameters of article 28 in judgments analyzed. When stable criteria and explicit examination of the conditions of the case are lacking, the space for accountability for "gross error" expands in an uncertain way, reinforcing defensive behaviors.

The oscillating treatment of gross error impacts decision-making. Kammers (2024) identifies low adherence to the parameters of article 28 of the LINDB. Pereira and Garrido (2025) propose criteria to qualify serious fault; The TCU/FGV Observatory (2021) records limited application of context analysis. Without stable parameters and an explicit examination of the manager's real difficulties, defensive choices prevail: postponement of decisions, adoption of rigid verification scripts, replication of standardized solutions, and priority to alternatives with lower exposure, even when the case recommends different arrangements (Sundfeld, 2014; Braga, 2017; Santos, 2020; Ribas and Marques, 2024).

The interaction between gross error and prescription has a direct impact on the predictability of control. The AGU – Federal Attorney General's Office (2024) systematizes recent changes on prescription (TCU Res. 344/2022; 367/2024; IN 98/2024), while Kammers (2024) and Pereira and Garrido (2025) deal with the criteria for qualifying gross error, the TCU/FGV Observatory (2021) records limited application of context analysis. When the statute of limitations is adjusted and, at the same time, the qualification of the gross error remains oscillating, the temporal and material horizon of liability becomes uncertain; This combination increases the incentive for defensive decisions. The production of recent rulings (TCU 949/2025; 1,071/2025) is part of this updating movement and should be read in conjunction with the normative acts on prescription.

The proposal of "lines of defense" attempts to order decision-making flows and rationalize access to control, distributing roles between management, internal control, and external control (Palma, 2024). When, however, precedents are incipient, the prescription criteria fluctuate, and the qualification of gross error lacks stable application, these lines tend

to function as additional procedural layers, without reducing decisional uncertainty (FGV, 2021; AGU – Federal Attorney General's Office, 2024; Kammers, 2024; Pear tree; Garrido, 2025;). In these terms, the "lines of defense" do not replace the need for context analysis required by the LINDB (articles 22 and 28) nor do they resolve, by themselves, the incentive to defensive decisions; Without predictability and coherence in the performance of control, management tends to prioritize verification scripts and solutions with lower risk, even if it does not reach the highest quality or standard for the specific case.

5 LINDB AND CONSENSUALITY: LEGAL CERTAINTY AND "GOOD BUREAUCRACY"

5.1 LIMITATION OF THE AGENT'S LIABILITY (ARTS. 22 AND 28)

Articles 22 and 28 of the LINDB guide that administrative and control decisions consider real management obstacles and difficulties and that the liability of the public agent is limited to intent or gross error. The TCU/FGV Observatory (2021) records limited application of these commands in the Court; the Referential Statement of the AGU – Federal Attorney General's Office (2024) systematizes the practical effects of these parameters, including in interface with the statute of limitations; Kammers (2024) identifies low adherence to the criteria of art. 28; and Pereira and Garrido (2025) propose technical parameters to qualify serious fault. Without consistent examination of the context and stable criteria for gross error, the protective effect of arts. 22 and 28 are weakened, and the manager tends to restrict discretionary decisions for fear of accountability (*STF, 2020; BRAZIL, 2022; BRAZIL, 2024a; BRAZIL, 2024b*).

To give practical consequence to arts. 22 and 28 it is necessary to connect accountability to the reality of the concrete case. The effectiveness of this regime depends on control decisions that explain (a) which real obstacles and difficulties of management were considered; (b) why the conduct examined is intentional or qualifies as a gross error; and (c) how the conclusion harmonizes with the applicable prescription frameworks. In the database consulted, the TCU/FGV Observatory (2021) recorded limited application of context analysis; Kammers (2024) identifies low adherence to the legal parameters of art. 28; Pereira and Garrido (2025) propose technical criteria to qualify serious fault; and the Reference Statement of the AGU – PGF (2024) systematizes the recent adjustments to the statute of limitations (TCU Res. 344/2022; 367/2024; IN 98/2024), relevant to the coherence of decisions.

To give evidentiary support to arts. 22 and 28, the manager's conduct must be accompanied by contextual motivation and demonstrable diligence: planning compatible with

the NLLC, registered risk analysis, explanation of obstacles and real difficulties (resources, deadlines, technical constraints), comparison of alternatives considered, technical-legal opinions and justifications proportional to the problem faced. These elements allow the control to reconstruct the decision-making context and distinguish ordinary failures from gross error, in line with the parameters discussed by the TCU/FGV Observatory (2021), by Kammers (2024) and by Pereira and Garrido (2025), in addition to the guidelines on prescription systematized by the AGU – PGF (2024).

On the control side, the application of arts. 22 and 28 requires a consistent decision-making method: (i) enunciate the thesis applied and, when applicable, distinguish the case from precedents (Naves, 2019); (ii) examine the contextual motivation produced by management (FGV, 2021); (iii) expressly qualify the conduct as intent or gross error based on technical criteria (Kammers, 2024; Pereira and Garrido, 2025); and (iv) make the conclusion compatible with the current statute of limitations (AGU – PGF, 2024). When these steps are observed, predictability increases and the incentive for defensive conduct is reduced (Santos, 2020; Ribas and Marques, 2024).

5.2 CONSENSUALITY AS A MANAGEMENT TOOL (ART. 26 OF THE LINDB AND NLLC)

Article 26 of the LINDB allows the execution of commitments to resolve administrative controversies, reduce uncertainty and avoid litigation, including with conditions and counterparts appropriate to the case. Eidt (2024) exposes the reasons for incorporating appropriate methods of conflict resolution into public management; Oliveira and Moreira (2024) discuss the legitimacy and control of these instruments under the regime of Law No. 14,133/2021; Amorim (2022) examines negotiation agreements aimed at the conditional removal of sanctions.

The journalistic material in Jota (2025) records the growing adoption of mediation and arbitration in the Administration. The usefulness of these instruments increases when the control recognizes the contextual motivation, the mapped risks and the agreed counterparts; When unpredictability and context-sensitive reading prevail, the use of commitments tends to be residual, for fear of future liability.

Faria (2022) interprets the unavailability of the public interest as a prohibition on the arbitrary waiver of rights, not as an absolute impediment to composition; agreements are admitted when they demonstrate public advantage and protection of the protected interest. Eidt (2024) justifies the insertion of consensual methods as long as the commitment has a

delimited object, contextual motivation, evidentiary basis, and performance metrics. Oliveira and Moreira (2024) support the legitimacy of these instruments under the regime of Law No. 14,133/2021, conditioning them to control criteria (planning, risk analysis, economic-legal evaluation, and monitoring).

The scope of article 26 covers the resolution of administrative disputes and the prevention of litigation, with limits: prohibition of disproportionate concessions, requirement of economic equivalence, verifiable counterparts, monitoring and publicity clauses; at the institutional level, materials from the TCE/SE (2025) indicate the need for standardization and awareness so that the Courts of Auditors evaluate such commitments with attention to the context and results.

Eidt (2024) justifies the adoption of administrative chambers to structure the consensual settlement of disputes with a delimited object, contextual motivation, evidentiary basis, and monitoring metrics; Oliveira and Moreira (2024) deal with the legitimacy and control of these instruments under the regime of Law No. 14,133/2021, conditioning the execution to planning, risk analysis, economic equivalence, and publicity. TCE/SE (2025) indicates that effectiveness depends on internal standardization and awareness for attentive evaluation of the context and results. Pinto (2025) analyzes experiences and points out the need for clear procedures and monitoring; Santana (2025) describes current practices in the Federal Public Administration. Jota (2025) reports on the strengthening of mediation and arbitration in the Administration. The operationalization of the chambers requires a minimum design: regulations, admissibility criteria, registration of motivation, execution plan with verifiable counterparts, monitoring and publicity clauses, in order to allow subsequent control and reduce decision-making uncertainty about the validity of the commitments.

5.3 UNAVAILABILITY OF THE PUBLIC INTEREST: MEANING AND LIMITS

Faria (2022) interprets the unavailability of the public interest as a prohibition on the arbitrary waiver of rights and the unfounded transfer of public advantages, not as an absolute prohibition on settling conflicts. The composition is admissible when it demonstrates public advantage, protects the protected interest and is anchored in contextual motivation and evidentiary basis. Under the regime of Law No. 14,133/2021, Oliveira and Moreira (2024) recognize the legitimacy of consensual arrangements, conditioning them to control criteria (planning, risk analysis, economic-legal evaluation, and monitoring). Eidt (2024) emphasizes

that the commitment needs a delimited object, technical justification, and performance metrics to measure results.

In the light of these works, unavailability functions as a rule of prudence: it admits transactions on available property rights and conditional solutions (verifiable counterparts, economic equivalence, monitoring and publicity) whenever the public advantage is demonstrable. In cases that touch on interests that are not available, the consensual route requires specific legal authorization and reinforced safeguards (dense motivation, result controls, and transparency). For external control, the examination must verify these requirements instead of rejecting the composition in advance, aligning the performance with arts. 22, 26 and 28 of the LINDB and the governance design provided for in the NLLC.

5.4 SELF-COMPOSITION CHAMBERS AND CONSENSUAL PROCESSES

Eidt (2024) proposes that structured administrative chambers with defined competence, standardized procedures, and monitoring metrics should raise the quality of consensual solutions. Oliveira and Moreira (2024) argue that the performance of these chambers should observe planning, risk analysis, and economic-legal evaluation, with publicity of acts and results-oriented control. Pinto (2025) reports experiences that highlight the importance of clear procedures and monitoring; Santana (2025) describes practices in the Federal Public Administration. TCE/SE (2025) indicates that effectiveness depends on internal standardization and awareness so that the Courts of Auditors evaluate the commitments with attention to the context and results. A minimum design includes: regulations with competence and attributions, admissibility criteria (object, evidence, risk, alternatives considered), execution plan with verifiable goals and counterparts, monitoring and publicity mechanism, preferably with the possibility of deferred publicity when there is a concrete risk to the negotiation.

Eidt (2024) proposes that the establishment of commitments should involve a technical opinion from the requesting area and a legal opinion with an analysis of risks and alternatives; Oliveira and Moreira (2024) defend the submission to the self-composition chamber with an execution plan, verifiable counterparts and monitoring; TCE/SE (2025) highlights the importance of internal standardization and publicity of acts; Pinto (2025) and Santana (2025) describe monitoring and systematic recording practices. Palma (2024) articulates this design to the lines of defense: management and internal control must prevent and treat conflict before external control is triggered.

A minimum chain, technical instruction, legal-economic analysis, deliberation in the chamber, manifestation of internal control, approval by the authority and publicity (with justification for possible deferred disclosure) favor the context analysis required by the LINDB and offer external control a verifiable record of the decision-making process, reducing the incentive for defensive decisions.

Eidt (2024) and Oliveira and Moreira (2024) point out that valid commitments require contextual motivation, evidentiary basis, economic equivalence between concessions and an execution plan with verifiable goals and monitoring mechanisms. Faria (2022) links validity to demonstrable public advantage and the protection of the protected interest; TCE/SE (2025) highlights standardization, systematic registration and publicity as guarantees for control. A minimum validation protocol includes: (a) technical justification with risks and alternatives considered; (b) measurable counterparts and equivalence criteria; (c) compliance metrics and schedule; (d) documented monitoring and reporting of results; (e) publicity of the acts, with the possibility of deferred publicity when there is a suitable reason; and (f) legal opinion on legality and adherence to the LINDB/NLLC. Once these requirements are met, the commitment offers ballast for the control to verify the rationality of the solution and reduces the incentive for defensive decisions.

6 CONCLUSIONS

Recent normative production (LINDB amended by Law No. 13,655/2018 and NLLC) established commands for context analysis, limitation of liability to intent or gross error, and encouragement of consensual forms of dispute resolution. The basis consulted indicates, however, limited application of these parameters in the control action: incipient use of precedents (NAVES, 2019), variations on prescription (AGU – PGF, 2024) and low adherence to the criteria of article 28 of the LINDB (Kammers, 2024; Fundação Getulio Vargas, 2021; Pear tree; Garrido, 2025). At the same time, the federative design that reserves to the Union the edition of general rules continues to demand safeguards of local autonomy (Moreira Neto, 1988; Mohn, 2010; Sundfeld and Câmara, 2011; Amorim, 2022; Binenbojm, 2023).

BRAGA (2017) describes discouragement to innovation when control action favors standardized compliance. The result is an environment of decision-making retraction, already qualified as a "blackout of the pens" (Santos, 2020; Ribas and Marques, 2024), with underuse

of the planning, risk management, and consensuality instruments provided for in LINDB and NLLC.

6.1 PROSPECTS FOR "GOOD BUREAUCRACY"

Amorim (2020; 2022) proposes to overcome legal fetishism with a focus on responsible discretion, planning, and results. Sundfeld (2014) criticizes defensive formalism and links good management to proportional justifications and evaluation of consequences. In the field of liability, Kammers (2024) and Pereira and Garrido (2025) defend clear parameters for gross error, compatible with arts. 22 and 28 of the LINDB; The TCU/FGV Observatory (2021) records the need for context analysis in judgments. In consensus, Eidt (2024) and Oliveira and Moreira (2024) base arrangements with planning, risk analysis, economic equivalence and monitoring; Faria (2022) interprets unavailability as a rule of prudence, not an absolute prohibition of composing. Naves (2019) points out that stable precedents increase predictability; Palma (2024) articulates lines of defense to rationalize flows; the AGU – PGF (2024) systematizes statute of limitations.

A "good bureaucracy" combines: (a) contextual motivation and risk management; (b) decision-making method with identification of thesis, distinction and coherence with the LINDB; (c) consensus with metrics and control; and (d) minimum stability in prescription and gross error to reduce pen blackout (Santos, 2020; Ribas and Marques, 2024).

6.2 RECOMMENDATIONS

Structured application of arts. 22 and 28 of the LINDB: control decisions must explain the real obstacles and difficulties considered, qualify the conduct as intent or gross error based on technical criteria, and make the result compatible with the current statute of limitations (AGU – PGF, 2024; FGV, 2021; Kammers, 2024; Pereira and Garrido, 2025;). This organization must observe procedural schedules compatible with the statute of limitations defined in **Topic 899** (STF, 2020)

Precedent technique in the TCU (in accordance with the binding precedent of **Topic 899** (STF, 2020): clear identification of the thesis applied, *distinguishing* when there are material differences and, if necessary, reasoned overcoming, to increase predictability (Naves, 2019).

Standardized contextual motivation in management: require, in sensitive acts, a plan, risk analysis, considered alternatives, technical-legal opinions, and result metrics, allowing

the reconstitution of the context (Amorim, 2020) ensuring temporal predictability and legal certainty **in alignment with Topic 899** (STF, 2020).

Consensuality with governance: establish chambers with criteria of admissibility, economic equivalence, and monitoring, ensuring publicity (with the possibility of deferred publicity when justified) and results-oriented control (Oliveira and Faria, 2022; Eidt, 2024; Moreira, 2024; TCE/SE, 2025). Consensual instruments must contain schedules for compliance and monitoring of statutes of limitations, **in line with Topic 899** (STF, 2020)

Integration with the "lines of defense": strengthen internal control and advisory services to filter conflicts and qualify evidence before the activation of external control (Palma, 2024) including systematic control of the statute of limitations **defined in light of Topic 899** (STF, 2020).

Prescription stabilization: coherently apply recent resolutions and normative instructions, with operational guidelines for ongoing cases (*Brasil, 2022*; AGU – PGF, 2024; *Brazil, 2024a*; *Brazil, 2024b*).

The set reduces uncertainty, shifts the focus from the rite to the motivated merit and mitigates defensive behavior, without removing liability for intent or gross error (Santos, 2020; Ribas and Marques, 2024).

6.3 SUGGESTIONS FOR FUTURE RESEARCH

Three empirical fronts can deepen the topic based on its agenda: (a) longitudinal monitoring of TCU rulings on gross error and context analysis after 2024, to assess adherence to arts. 22 and 28; (b) evaluation of the results of commitments signed based on article 26 of the LINDB (fulfillment of goals, economic equivalence and incidence of subsequent controversies); and (c) comparative studies between entities with different administrative capacities to verify whether contextual motivation and risk management reduce the incidence of liability without prejudice to control.

ACKNOWLEDGMENT

The author thanks the **Brazilian Institute of Teaching, Development and Research (IDP)** for the environment of excellence that stimulates scientific production and critical debate on contemporary public administration.

In particular, it expresses its gratitude to **Professor Victor Aguiar Jardim de Amorim**, for the exchange of knowledge, academic excellence and for the constant encouragement to reflect and write this article.

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NURSING CARE DURING THE PARTNER'S PRENATAL PERIOD: A LITERATURE REVIEW**ASSISTÊNCIA DE ENFERMAGEM NO PRÉ-NATAL DO PARCEIRO: UMA REVISÃO BIBLIOGRÁFICA****CUIDADOS DE ENFERMERÍA DURANTE EL PERÍODO PRENATAL DE LA PAREJA: UNA REVISIÓN DE LA LITERATURA** <https://doi.org/10.56238/sevened2025.036-035>**Tarciana Maria Fragoso da Silva¹, Simoni Furtado da Costa², Fabiana Ferreira Koopmans³****ABSTRACT**

Prenatal care is a fundamental step in the prevention and/or early detection of problems during pregnancy. Historically, prenatal care has been built from the perspective of promoting the health of women and children. However, as new ways of thinking about health advance, changes are also observed in the implementation of public policies such as: norms, legislation, among others, whose approach has been gaining emphasis on the inclusion of the partner in prenatal care and in other stages of the pregnancy to birth process. The objective of this research is to discuss, through scientific literature, nursing care for the partner during prenatal care. The aim is to contribute to encouraging greater male participation in healthcare within the scope of Primary Care. Method: This is a descriptive and exploratory bibliographic review study with a qualitative approach. Data were collected from physical and virtual collections. For the search of virtual material, a consultation of the Health Descriptors (DeCs) was carried out to select specific terms to guide data collection in the database. Database: Virtual Health Library (BVS). The time frame for the final analysis of the publications covered the last five years. The results show data that align with the National Policy for Comprehensive Health Care (PNAISH) of the Ministry of Health, which emphasizes the inclusion of the topic of fatherhood and care, through partner prenatal care, in debates and actions focused on reproductive planning as essential strategies to improve care during pregnancy and childbirth in public health services. The evidence suggests a favorable context for the inclusion of men in partner prenatal care; however, the effective participation of men depends on various factors such as legislation, institutional commitment to humanized childbirth, and other aspects. Conclusion: For greater achievements, it is necessary to adapt the infrastructure of health units, promote actions to minimize barriers to access for the male population, especially in the processes of preparation and monitoring during prenatal care, and promote awareness among the health team to welcome this population. It is suggested that innovative strategies be designed for the recruitment, onboarding, and education of men and women, implementing a gender perspective focused on masculinities, considering issues that also involve the inclusion of this debate within the context of training.

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Keywords: Nursing Care. Prenatal Care. Partner. Health Education.

RESUMO

O pré-natal é uma etapa fundamental da prevenção e/ou detecção precoce de problemas no percurso da gestação. Historicamente, o pré-natal foi se construindo sob a perspectiva da promoção à saúde da mulher e da criança. No entanto, conforme avançam novas formas de pensar a saúde, também se percebe alterações na implementação de políticas públicas como: normas, legislações, entre outras, cuja abordagem vem ganhando ênfase na inclusão do parceiro no pré-natal e em outras etapas do percurso da gestação ao nascimento. O objetivo desta pesquisa é discutir, através de literatura científica, a assistência de enfermagem ao parceiro no pré-natal. Com a finalidade de contribuir para o incentivo à maior adesão dos homens no atendimento à saúde no âmbito da Atenção Básica. Método: Trata-se de um estudo de revisão bibliográfica, de natureza descritiva e exploratória, com abordagem qualitativa. Os dados foram coletados através de acervos físicos e virtuais. Para a busca do material virtual foi realizada consulta aos Descritores em saúde (DeCs) para a seleção de termos específicos para nortear a coleta de dados na base de dados. Base de Dados Biblioteca Virtual em Saúde (BVS). O recorte temporal das publicações para a análise final foi dos últimos cinco anos. Os resultados trazem dados que vêm caminhando na mesma direção da Política Nacional de Atenção Integral à Saúde do (PNAISH), do pelo Ministério da Saúde, os quais apostam na perspectiva da inclusão do tema paternidade e cuidado, por meio do pré-natal do parceiro, nos debates e nas ações voltadas para o planejamento reprodutivo como estratégias essenciais para qualificar a atenção à gestação e ao nascimento, nos serviços públicos de saúde. As evidências sugerem que há um contexto favorável para a inclusão dos homens no pré-natal do parceiro, no entanto, a participação efetiva dos homens decorre de diferentes fatores como a legislação, o compromisso institucional com o parto humanizado, entre outros aspectos. Conclusão: Para maiores conquistas, é preciso adequação da infraestrutura das unidades de saúde, promover ações a fim de minimizar as barreiras de acesso da população masculina, sobretudo, nos processos de preparação e acompanhamento no pré-natal e promover a conscientização da equipe de saúde para o acolhimento desta população. Sugere-se desenhar estratégias inovadoras de recrutamento, acolhimento e educação de homens e mulheres, implementando uma perspectiva de gênero voltada para as masculinidades, considerando as questões que envolvem também a inclusão do debate no âmbito da formação.

Palavras-chave: Assistência de Enfermagem. Pré-Natal. Parceiro. Educação em Saúde.

RESUMEN

La atención prenatal es un paso fundamental en la prevención y/o detección temprana de problemas durante el embarazo. Históricamente, la atención prenatal se ha centrado en la promoción de la salud de las mujeres y los niños. Sin embargo, a medida que avanzan nuevas concepciones de la salud, también se observan cambios en la implementación de políticas públicas, como normas y legislación, entre otras, cuyo enfoque ha cobrado mayor importancia en la inclusión de la pareja en la atención prenatal y en otras etapas del proceso de embarazo y parto. El objetivo de esta investigación es analizar, a través de la literatura científica, la atención de enfermería a la pareja durante la atención prenatal. Se busca contribuir a fomentar una mayor participación masculina en la atención sanitaria dentro del ámbito de la Atención Primaria. Método: Se trata de un estudio de revisión bibliográfica descriptivo y exploratorio con enfoque cualitativo. Los datos se recopilaron de colecciones físicas y virtuales. Para la búsqueda de material virtual, se consultó el Descriptor de Salud

(DS) para seleccionar términos específicos que guiaran la recopilación de datos en la base de datos. Base de datos: Biblioteca Virtual en Salud (BVS). El periodo para el análisis final de las publicaciones abarcó los últimos cinco años. Los resultados muestran datos que concuerdan con la Política Nacional de Atención Integral a la Salud (PNAISH) del Ministerio de Salud, la cual enfatiza la inclusión del tema de la paternidad y el cuidado, a través de la atención prenatal en pareja, en los debates y acciones centrados en la planificación reproductiva como estrategias esenciales para mejorar la atención durante el embarazo y el parto en los servicios públicos de salud. La evidencia sugiere un contexto favorable para la inclusión de los hombres en la atención prenatal en pareja; sin embargo, la participación efectiva de los hombres depende de diversos factores como la legislación, el compromiso institucional con un parto humanizado y otros aspectos. Conclusión: Para lograr mayores avances, es necesario adaptar la infraestructura de las unidades de salud, promover acciones que minimicen las barreras de acceso para la población masculina, especialmente en los procesos de preparación y seguimiento durante la atención prenatal, y fomentar la sensibilización del personal de salud para acoger a esta población. Se sugiere diseñar estrategias innovadoras para la captación, la integración y la formación de hombres y mujeres, implementando una perspectiva de género centrada en las masculinidades, considerando también la inclusión de este debate en el contexto de la formación.

Palabras clave: Cuidados de Enfermería. Cuidados Prenatales. Pareja. Educación para la Salud.

1 INTRODUCTION

Pregnancy is a complex experience with different aspects for each woman, in addition to the biological dimension, it is a social process that involves the collective, mobilizing the family and the environment in which the woman is inserted. Therefore, in order for health promotion, disease prevention, and early detection of risk situations to occur safely, the involvement of women, their partners, their families, and health services is important (LUCENA, 2024).

In view of this, it is necessary for pregnant women to start the first prenatal consultation early, preferably until the initial 120 days of pregnancy, to have at least six prenatal consultations, which can be medical interspersed with nursing and that take place in the reference service, educational actions with the pregnant woman and her family during the period of her pregnancy (BRASIL, 2016, BRAZIL, 2017).

Prenatal care in Brazil is governed by the guidelines of the Program for the Humanization of Labor and Birth (PHPN), established by the Ministry of Health (MS) in 2000, which is based on the humanization of care as a condition for adequate monitoring of pregnancy, childbirth and puerperium, seeking complete quality, qualified and humanized care, becoming fundamental for maternal and neonatal health with a view to prevention. Care during pregnancy needs to be permeated by scientific knowledge, humanization of care and respect for women as active subjects in this process (BRASIL, 2012).

Prenatal care precedes the birth of the baby, that is, it is a set of actions aimed at the individual and collective health of women in the gestational period. It is up to the health team from the first contact with the pregnant woman to seek to identify the meanings of pregnancy for her and her family members. Knowing that the history of each pregnancy is an important factor for the individual to develop in a healthy way. In view of this, prenatal care aims to welcome the pregnant woman and her family in its entirety, from the beginning of pregnancy to the changes that occur in the body, as well as her emotional. Pregnancy is a moment of transition in a woman's life, so such transformations can trigger doubts, fears, fantasy, anguish or questions about what happens inside her (TEIXEIRA; ADAM; MAGALHÃES, 2010).

Adequate prenatal coverage, associated with quality care, is essential for a good evolution of pregnancy and birth. The objective of this follow-up is to ensure the safe development of pregnancy, allowing the delivery of a healthy newborn, without impact on maternal health, including addressing psychosocial aspects and educational and preventive activities (BRASIL, 2012).

Low-risk pregnancies can only be confirmed at the end of the gestational process. The dynamic process and the complexity of the functional and anatomical changes that occur in the gestational cycle require continuous and specific evaluations in each period (BRASIL, 2012).

The actions developed with pregnant women begin with the diagnosis of pregnancy carried out through history, physical examination and laboratory tests. The main suspicion of pregnancy reported by women is menstrual delay in amenorrheic women with an active sexual life. In the context of public health, after confirmation of pregnancy, the woman must be accompanied by the health system in her area of coverage to start prenatal care (SOUSA; MARIE; TORRES, 2012).

Health actions should be aimed at covering the entire target population in the area covered by the health unit, ensuring at least six prenatal consultations (BRASIL, 2017). In addition, the continuity of care, monitoring and evaluation of the impact of these actions on maternal and perinatal health must be guaranteed (BRASIL, 2012).

In the context of prenatal care, nurses emerge as professionals qualified to monitor low-risk pregnancies, due to their technical-scientific training. This professional masters the propaedeutic methods for monitoring pregnancy, scientific knowledge for interpreting signs, symptoms and exams, as well as intellectual capacity to guide this woman on important issues and care, preparing her to experience this phase (**ERRICO et al., 2018**)

It is extremely important that during their work, nurses use, in addition to their techniques, scientific and social knowledge, special, empathetic and facilitating care in the face of the emotional sensitivity that these women are in, thus ensuring humanized and qualified care for pregnant women. This is an action guaranteed through public health policies, by the Women's Health Program, in places where the Family Health Program is inserted, it is recommended that this monitoring be carried out by the Inter-professional team, which allows the exchange of knowledge and a broad view of the patient (TEIXEIRA; ADAM; MAGALHÃES, 2010).

It should be emphasized that low-risk prenatal care can be performed by nurses, obstetricians or not, supported by the Law of Professional Nursing Practice (Law No. 7,498, of June 25, 1986), since this law ensures the legality of nursing consultations, nursing prescriptions, and care for parturient and puerperal women (**ERRICO et al., 2018**).

During the prenatal consultation, the nurse carries out the nursing care plan, based on the perceived and prioritized needs, guidelines, interventions and referrals are determined, in order to promote the interdisciplinarity of medical, nutritional, dental and psychological services (TEIXEIRA; ADAM; MAGALHÃES, 2010).

For low-risk prenatal care to occur in pregnant women, the variables (blood glucose, BP, BMI, history of the pregnant woman) are extremely important for the patient to have a faster recovery until the baby is born (**FERREIRA et al, 2015**)

During pregnancy, important changes occur in maternal metabolism to create an environment that allows embryogenesis, fetal growth, maturation, and survival; Thus, a nutritional reserve is favored at the beginning of gestation to meet the increase in maternal-fetal demands in the more advanced stages of gestation and lactation. A normal pregnancy is characterized by being a diabetogenic state, due to the progressive increase in postprandial glucose concentrations and the decrease in cell sensitization to insulin in the late stages of pregnancy. Inadequate prenatal care can lead to complications such as gestational diabetes (MIRANDA, 2008).

Prenatal care is a fundamental step in the prevention and/or early detection of problems in the course of pregnancy. Some pathologies, both maternal and fetal, can be detected in a timely manner, enabling, in many cases, a healthy development of the baby and reducing the risks of the pregnant woman. Information about the different experiences should be exchanged between women and health professionals (BRASIL, 2016).

The importance of participation and male support helping the partner helps to tolerate pain, doubts and anxiety related to labor, reduces the time of labor, number of cesarean sections and the use of medications. Therefore, in this way, the inclusion of men during the gestational process, childbirth and postpartum increases the bond between the trinomial (JARDIM; PENNA, 2012).

Prenatal care in Brazil is one of the most opportune moments for different forms of approach to health, as it is considered a service with good coverage in the Unified Health System, as shown in the research by Viellas *et al.* (2014). The study showed that prenatal coverage in Brazil was high at 98.8%, with 75.8% of women starting prenatal care before 16 weeks of gestation and 73.1% with six or more consultations. Prenatal care was performed mainly in primary health care units (89.6%), public health care units (74.6%), by the same professional (88.4%), mostly physicians (75.6%), and 96% received the prenatal care record in hand (VIELLAS *et al.*, 2014).

Historically, prenatal care has been built from the perspective of promoting women's and children's health. However, as new ways of thinking about health and the implementation of policies, norms, and legislation advance, other approaches have been gaining emphasis, such as the inclusion of the partner in prenatal care (COSTA & TAQUETTE, 2017).

It is in this process that there is the possibility of exchanging experiences and knowledge between professionals and families, and it is considered the best way to promote the understanding of the pregnancy process as a strategy to reduce the risk of maternal and neonatal mortality (BRASIL, 2016).

The Ministry of Health considers that prenatal care should be organized in such a way that it can meet the needs of the population of pregnant women, requiring the use of scientific technical knowledge, adequate and available means and resources (BRASIL, 2011; BRAZIL, 2016).

In view of these points, equity is one of the principles that best suits the topic under discussion, as it is directly related to equality. Thus, it is understood that partners must be fully involved in everything related to reproductive decision-making, from the choice to be a father to solidary participation in pregnancy, childbirth, care and education. It is from this perspective that this study discusses the theme of nursing performance on the partner's prenatal care. This work Its objective is to investigate the partner's prenatal nursing care.

2 METHOD

The bibliographic review aims to build a contextualization for the problem and analyze the possibilities existing in the literature consulted (VOSGERAU; ROMANOWSKI, 2014). According to Andrade (2010, p.112), descriptive research consists of "the facts observed, recorded, analyzed, classified and interpreted, without the researcher interfering in them". In other words, the main objective of exploratory research is to delimit the problem, formulate hypotheses or identify new approaches for the study to be developed, and its main objective is to delimit the problem, formulate hypotheses or identify new approaches for the study to be developed (GIL, 2008).

. It is emphasized that "through exploratory research, the possibility of developing good research on a given subject is evaluated" (ANDRADE, 2010, 2012).

According to Polit and Beck (2011, p.90), "in qualitative studies, researchers mainly collect qualitative data, that is, narrative descriptions."

The content survey was carried out between September 2021 and November 2022, the search took place through the physical and virtual collections. The virtual database used was the VHL (Virtual Health Library). The following descriptors were used in DeCS (Health Sciences Descriptors) databases: Nursing care, prenatal care, partner, health education, using the Boolean operator AND.

The inclusion criteria for the selection of contents were the choice of productions, which fit the following aspects: article published in the period of five years, articles that were

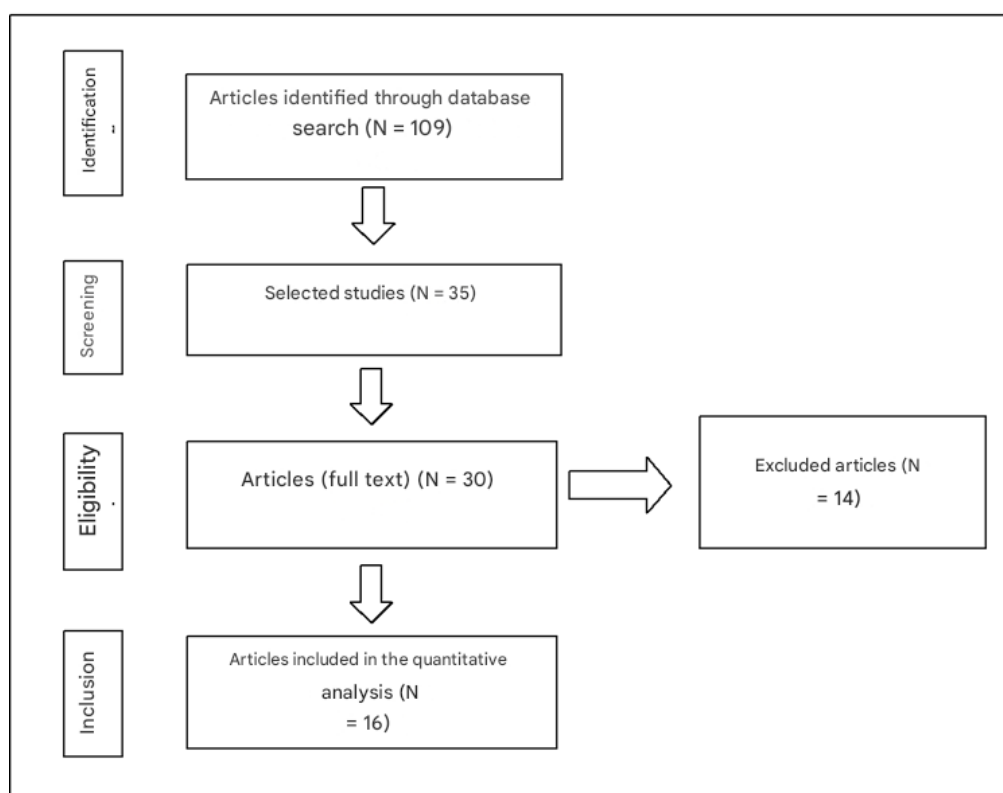
repeated and did not have full texts were used as exclusion criteria. The titles, indexes, abstracts and chapters were read - when it was thesis, policies and books, as shown in **Figure 1**.

The Portuguese language and the five-year time frame (2017 to 2021) were used as filters. As inclusion criteria, theses, dissertations, books, articles published in journals with an editorial policy of peer review, articles with titles, abstracts and keywords, . As exclusion criteria, articles that did not answer the research question, that is, not related to the research theme, and duplicate publications.

Next, the material was organized in a synoptic table according to the type of publication (Table 1). From the contents found, the categories that guided the discussion of the study emerged.

Figure 1

FlowTable of the researched articles



Source: (The authors, 2025).

3 RESULTS AND DISCUSSION

From the literature review and analysis of the studies indexed in the databases, on the proposed theme, 109 scientific studies were found, 35 were selected, 30 met the inclusion criteria, 14 of them did not focus on the theme in question or did not have the full text, and combination with descriptors in the last 05 years between 2017 and 2022, leaving

only 16 articles to compose the analysis. In table 1, we describe the selection strategies for articles on the theme, as shown in the flowTable below:

Table 1 describes the strategy for selecting articles on the topic in question. Table 1 - Scientific literature on the importance of the partner in prenatal care (- 2017-2021).

Table 1

Scientific literature on the importance of the partner in prenatal care (- 2017-2021)

Quadro 1. - Literatura científica sobre a importância do parceiro no pré-natal (2014-2021).					
Título	Autor/data	Objetivo	Tipo de estudo	Revista	Resultados
Atenção à gestante adolescente na rede sus - o acolhimento do Parceiro no pré-natal	Costa & Taquette (2017)	Verificar o acolhimento e a participação de parceiros de gestantes adolescentes no pré-natal da rede SUS.	Estudo descritivo de abordagem qualitativa	Rev. Enferm.UFPE	Houve o desejo do parceiro de acompanhar as consultas de pré-natal, mas este desconhece seu direito de participar. Há limites pessoais e institucionais para efetivar a participação dos parceiros.
Característica do relacionamento entre a mulher e seu parceiro na ocorrência de gravidez não planejada	Parcer et.al.(2017)	descrever características do parceiro e do relacionamento com a companheira na ocorrência de gravidez não planejada	Estudo transversal exploratório	Rev.bahiana.enferm	Os parceiros apresentaram idade média de 28 anos, predominando raça/cor negra, sem religião, baixo nível de escolaridade e baixa renda. A situação conjugal casada/união estável e o tempo de união apresentaram alta significância estatística para a ocorrência da gravidez não planejada.
Prática de cuidado realizadas pelo companheiro na perspectiva da gestante	Martello et al.(2017)	Compreender como a mulher percebe a participação do homem no processo gravídico	Estudo qualitativo	Rev.Enferm.UFPE	Foram identificados tipos de cuidados prestados pelos companheiros às gestantes, relacionados principalmente à preocupação com o bem-estar delas e do bebê, participação nas consultas, alimentação e sexualidade. As gestantes consideram importante a participação do companheiro, e isso tem
Estratégias para identificação e enfrentamento de situação de violência por parceiro íntimo em mulheres gestantes	Marques et al. (2017)	Conhecer as estratégias utilizadas por enfermeiros de Unidades de Estratégias de Saúde da Família para identificação e enfrentamento de situação de violência por parceiro íntimo em mulheres gestantes.	Estudo descritivo com abordagem qualitativa	Rev.Gaúcha Enferm.	Ações de identificação e enfrentamento da violência por parceiro íntimo em mulheres gestantes. As lesões físicas foram o principal indicativo de violência identificada na consulta pré-natal. As estratégias de enfrentamento foram os encaminhamentos a serviços especializados e discussão conjunta com a equipe de saúde.
A inclusão paterna durante o pré-natal	Henz;Medeiros;Salvador(2017)	Investigar a participação paterna durante o pré-natal em um Centro de Atenção à Saúde da Mulher	Estudo qualitativo	Rev.Enferm.APS	A limitação da oferta de horários de atendimento, que coincidem com os de trabalho dos homens, dificulta a participação paterna. Destacou-se a importância de as gestantes encorajarem o seu parceiro a participar das atividades do pré-natal.
A visão da gestante acerca da participação do homem no processo gestacional	Caldeiras et al. (2017)	Analisar a visão das gestantes quanto à participação do homem durante o processo gestacional e as consultas de pré-natal	Estudo qualitativo	Rev.Enferm.Cent-Oeste	A pesquisa apontou o apoio ofertado em âmbito familiar como essencial para a gestante e a ausência do homem durante a consulta foi entendida e justificada pelo horário de trabalho do companheiro, na maioria das vezes.
Influência da participação do companheiro no pré-natal: Satisfação de primíparas quanto ao apoio no parto	Holanda et al. (2018)	Correlacionar a satisfação de primíparas quanto ao apoio e à utilidade do companheiro durante o processo de parto com a sua presença e capacitação no pré-natal.	Estudo correlacional	Texto & Contexto	A variável presença do companheiro no pré-natal esteve estatisticamente associada à satisfação da puérpera com o apoio ($p=0,0004$) e com a utilidade do apoio ($p=0,007$) durante o trabalho de parto, enquanto a variável capacitação do companheiro no pré-natal esteve estatisticamente associada à satisfação com o apoio ($p<0,00001$) e à utilidade do apoio ($p<0,001$; $p<0,00001$ e $p=0,006$) prestado pelo companheiro durante todas as fases avaliadas (trabalho de parto, parto e pós-parto imediato).
O comportamento paterno na consulta de pré-natal	Cavalcante et al. (2018)	Conhecer a experiência do homem como acompanhante na consulta de pré-natal.	Estudo qualitativo	Rev.Paul.Enferm.	Ainda que o atendimento pré-natal seja destinado aos cuidados com a mulher grávida, a experiência do homem na atenção pré-natal – o objeto social – é uma inserção masculina no universo feminino. Esta experiência pode beneficiar a ambos na vivência do período gestacional.
Gestantes adolescente e seu sentimento acerca do apoio familiar	Nune et al. (2018)	Identificar o sentimento em relação às principais fontes de apoio para mulheres que vivenciaram a gestação na adolescência	Estudo qualitativo, exploratório e descritivo	Rev.Enferm.UFSM	A participação e apoio dos pais dos bebês e da figura materna no contexto da gravidez na adolescência,pareceu primordial no enfrentamento da situação de tornar-se mãe.

Continua...

(Cont. **Quadro 1**)

Título	Autor/data	Objetivo	Tipo de estudo	Revista	Resultados
Pais de primeira viagem: demanda por apoio e visibilidade	Trindade et al. (2019)	Reforçar um aspecto já identificado em outros estudos, a deficiente atenção (social, familiar e institucional) aos homens ao longo de sua construção social e afetiva como pais, este estudo, investigando o posicionamento de pais de "primeira viagem" sobre ações de apoio advindas de sua rede social e de profissionais da saúde	Estudo descritivo e analítico	Saúde & Sociedade	Indicaram que elementos tradicionais de representações sociais sobre homem e pai interferem na proximidade dos participantes com a gestação e no reconhecimento de suas necessidades por apoio durante esse período. Evidenciou-se também o distanciamento do homem do atendimento por profissionais de saúde e a necessidade de cumprimento de políticas públicas na saúde e inserção da perspectiva de gênero nas políticas e práticas de saúde e educação, visando a formação de profissionais sensíveis para atuar com os homens, contribuindo para a promoção de modos de vida mais igualitários e benéficos para o homem-pai.
Presença do acompanhante durante o processo parturição e nascimento	Anjos & Geremias(2019)	Analisar a prática da presença do acompanhante durante o processo de parturição	Estudo transversal	Rev.Enferm.UERJ	A informação sobre o direito do acompanhante foi mais frequente no Centro Obstétrico e Internação Obstétrica. Não houve relação significativa entre o conhecimento da Lei de Acompanhante e o número de consultas pré-natal. Onde houve menor frequência de acompanhante foi na sala de recuperação pós-parto, devido à ausência do acompanhante e à não permissão. O companheiro foi o acompanhante mais frequente. Não houve significância quanto à presença do acompanhante e realização de analgesia, o tipo de parto e o Apgar.
A presença do genitor no pré-natal: um estudo de representações sociais com gestantes	Couto et al.(2020)	Analisar as representações sociais da presença do genitor no pré-natal para as mulheres gestantes	Estudo descritivo e qualitativo	Rev.Enferm.UERJ	A análise aponta a palavra "não" como a mais latente no sistema cognitivo das gestantes, sendo percebida a alta frequência no Dendograma de Classes, presença no eixo de intersecção entre as ordenadas e abscissas no Mapa Fatorial de Correspondência, além de ser central e fazer as maiores forças de conexidade com as demais palavras na árvore máxima de similitude.
Transição para a paternidade no período pré-natal: um estudo qualitativo	Silva; Pinto e Martins (2021)	Compreender as vivências dos homens na transição para a paternidade durante o período pré-natal.	Estudo qualitativo, exploratório, descritivo, transversal e retrospectivo	Ciência & Saúde Coletiva	Evidenciam o período pré-natal como momento chave da transição para a paternidade, marcado pela enorme exigência psíquica e emocional e afigurando-se como motor do desenvolvimento da identidade paterna.
O pré-natal do parceiro sexual: importância para a saúde do homem e da gestante-	Vitoretti et.al (2021)	Avaliar a saúde dos parceiros sexuais de gestantes, bem como a sua importância para a evolução da gestação.	Estudo transversal	Rev.Eletrônica . Acervo Saúde	Considerando a participação do parceiro ou não durante o pré-natal, não houve mudanças estatísticas significativas em relação a progressão esperada da gestação bem como as complicações mais comuns dessa fase. Em relação a saúde do parceiro o fator de maior preocupação foi a média de IMC classificada como sobrepeso.
Percepção e participação do parceiro na assistência pré-natal e nascimento	Marques et.al (2022)	Compreender a percepção do parceiro sobre sua experiência e participação na assistência pré-natal e nascimento.	Estudo qualitativo	Rev.Pesqui	Emergiram três categorias as quais mostram que eles tiveram pouca participação nas consultas de pré-natal e que desconhecem o "pré-natal do parceiro". Em geral, demonstram gratidão pela assistência durante o parto, mas poucos relataram ter recebido informações relacionadas à educação em saúde.

(As autoras,2025)

(Conclusão)

4 NURSING CARE IN THE PARTNER'S PRENATAL CARE

According to Ordinance GM/MS No. 1,944, of August 27, 2009, it is foreseen that the health monitoring of the male population in the unified health system will be ensured, with primary care as a gateway, especially in the partner's prenatal care, and this monitoring is extensive in childbirth and immediate postpartum. The same must be done by qualified professionals, as recommended by law.

The assistance includes an assessment of the health status of the pregnant woman during pregnancy. Take care of any existing health problems; prevention of other health problems; health promotion. Each patient should have an equal or better health status at the end of pregnancy than at the beginning and give birth to a strong and healthy child.

It is of paramount importance that health professionals have a qualified listening and that they seek to understand what the couple has in terms of knowledge, opinions and rights about prenatal care. Therefore, it is essential that nurses hold groups aimed at pregnant couples, so that there is an exchange of experiences among the participants. Understand the anxieties for low inclusion of men in health services, always encouraging and promoting their early inclusion in the unified health system (ANJOS & GEREMIAS 2019).

According to Vitoretti (2021), the partner's participation in prenatal care did not influence the pregnant woman's clinical complications for the determinism of childbirth, but it was possible to identify changes in the partner's own health that deserve guidance, control, and treatment. Thus, it can be seen that men's prenatal care reduces the morbidity and mortality rate.

The aim of the 2016 WHO antenatal care model is to provide pregnant women and their partner with respectful, individualised and person-centred care in all contacts, and to ensure that each is supported by effective and integrated clinical practices (interventions and tests), relevant support and timely information and to offer psychosocial and emotional support by professionals with good clinical and interpersonal skills in a well-functioning health system. Given the evidence pointing to an increase in perinatal mortality in women with only four antenatal visits and that an increase in the number of antenatal contacts, regardless of country, is associated with higher maternal satisfaction, WHO recommends a minimum of eight contacts: one contact in the first trimester, two in the second trimester and five contacts in the third trimester, (TAVARES *et al.*, 2019).

For Silva, (2021) the prenatal period is like a key moment in the transition to fatherhood, marked by enormous psychic and emotional demands and appearing as an engine for the development of paternal identity.

Thus, it is of fundamental importance to become the visible partner in prenatal consultations so that he can report on his fear or anguish in relation to fatherhood.

To meet the objectives of prenatal care, the nursing team must base its actions on a continuous process of learning situations, whose purpose will be to reaffirm or achieve changes in the attitude or behavior of the pregnant woman and the family nucleus. The educational actions that Nursing performs in the Areas of Outpatient Clinics, Inpatient Rooms (Prepartum and Delivery Rooms, pregnancy and puerperium), could be operationally divided into incidental education and systematic education. Incidental education is understood to be that which is carried out during the development of daily work, where appropriate situations that arise are used to teach through casual conversation. Systematic education is that which is carried out in a formal way, with work methodology and planned time, with explicit objectives and purposes (Cavalcante et al., 2018).

4.1 PARTNER PARTICIPATION

The role of men in pregnancy and in protecting maternal health has generated growing interest in recent years. Despite this, their exclusion and marginalization persist in relation to these processes, traditionally considered as a women's issue. Male involvement in these environments is poorly understood and little researched compared to other areas of sexual and reproductive health (HORTA, 2017).

The intersection of gender, health, and reproductive rights highlights the need to analyze men's reproductive experiences. Men can be made visible in reproductive spaces, while reproduction has been feminized in disciplinary discourses, in everyday language, and in the discourse of public policies (SILVA et al., 2020).

Men's participation in care is decisive for gender equality. Men's weak approach to care is reinforced by the dominant forms and roles of fatherhood that relate to the sexual division of labor. Sexual difference and the hegemonic models built from this difference end up excluding what it means to "be a man" and "to be a woman", causing and legitimizing inequality. In gender learning, such as men and fathers, stereotypes centered on values such as strength, responsibility, and conformity are usually constructed, from which expectations,

actions, and forms of relationship considered typical of masculinity and fatherhood are created (SANTANA; DA SILVA GONÇALVES, 2020).

The importance of male participation in reproductive health and its benefits for gender equality has been highlighted in widely accepted international agreements, emanating from the International Conference on Population and Development and the Fourth World Conference on Women, and in the Sustainable Development Goals, one of the key points is to meet the needs of the actors involved in their fulfillment (HORTA, 2017).

The interest in addressing the phenomenon of male participation in pregnancy lies in being able to listen to the voices of men. Therefore, spaces are created to learn about their experiences and their constructions as caregivers, and reflections are generated in the institutional sphere in relation to prenatal programs, in view of the importance of male participation. In this way, attachment strategies are promoted for men (SILVA *et al.*, 2020).

In this context, participation is understood as the process in which people want to do more than just contemplate: they want to get involved, intervene and carry out actions that result in change, managing to do so constantly. In this way, the participation of men contributes significantly to maternal health, facilitating the acceptance of pregnancy, favoring timely access to prenatal programs, promoting the physical and emotional stability of pregnant women and self-care actions (SANTANA; DA SILVA GONÇALVES, 2020).

Likewise, the participation of men during pregnancy facilitates early adherence to prenatal care, reduces maternal stress and risk behaviors and, in the future, ensures male participation in paternal functions. The participation of couples in the reproductive processes favors the humanization of care for pregnant women, but, despite these benefits, their participation in pregnancy is still scarce (HORTA, 2017).

In addition to health system recommendations to improve the quality and use of antenatal care, the 2016 WHO antenatal care recommendations address interventions in four other categories: nutrition, maternal and fetal assessment, preventive measures, and treatment of birth defects (SILVA *et al.*, 2020).

The most common concerns that exist in men during the pregnancy of their companion were evaluated: what it is to be a father, how it should behave and whether he will be able to promote what is necessary for his child and family. The future birth will cause the present father to evoke or elaborate memories of his childhood and his relationship with his own parents (ANJOS & GEREMIAS, 2019).

Many fathers-to-be feel ambivalence about pregnancy: anxiety about their own maturation (because becoming a father means ceasing to be a teenager) and expressing internal conflicts related to the role of father. Even when on the conscious level you are very happy with the prospects of being so, it is common for there to also be anxiety and fear of the future. In the man who has had a difficult relationship with his own father, the challenge is how he can become so. There may also be feelings of competition towards the fetus. Societal expectations and uncertainty are additional stressors; many men are confused about what is expected of them during pregnancy (MENDES; SANTOS, 2019)

In primary studies and literature reviews, it has been pointed out that the follow-up of the father during pregnancy and/delivery has positive effects on the emotional relationship of the father with the mother and the newborn, increasing maternal well-being during delivery and although it does not affect mortality, it improves obstetric outcomes. For women, the presence of the father is valued, and greater paternal participation in the care of the newborn is observed when he is actively involved in the delivery activities by the health team (ANJOS & GEREMIAS, 2019).

The prenatal period is considered in the literature as a propeller for the development of paternal identity, in which the monitoring of the gestational process promotes the physical and psychological adjustment necessary to face the new role and deep reflections on the parental model that parents want for the future of their children. The collective discourse also revealed that, during the evaluations, the men were sure about their maternal and child health conditions, through the monitoring of auscultation of the heartbeat, uterine height and cardiac evaluations and techniques (MENDES; SANTOS, 2019).

Therefore, these processes allow a better understanding of the changes that occurred with the woman, obtaining information and reducing insecurity and anxiety resulting from doubts in the development of care. Thus, paternal participation in childbirth and puerperium can be determined by the different experiences lived during prenatal care, in which the monitoring of procedures such as ultrasound and fetal movements are positive, as they influence the acceptance of pregnancy, the recognition of paternity, and the strengthening of titles (ALVES *et al.*, 2021).

The inclusion of fathers in prenatal care favors access to nursing consultations, to meeting their demands and the form of exams and immunization, a proposal widely recommended by the Ministry of Health, based on encouraging the implementation of male prenatal care. The political strategy called "male prenatal care" aims to encourage fathers to

make frequent visits to health services in a preventive manner, developing a greater affective bond between him, his partner and his child, in addition to tracking infectious diseases and expanding access to health services.

5 RELATED FACTORS THAT INTERFERE WITH THE EFFECTIVE PARTICIPATION OF MEN IN PRENATAL CARE

Although the Ministry of Health recognizes the presence of a companion as one of the rights of women, some factors interfere directly or indirectly with male participation in prenatal care. The issue of lack of space, due to the pregnant woman's own decision to be alone, lack of knowledge and socioeconomic difficulties can be mentioned.

In prenatal care, the information made available in the consultations provides the partner with the conditions to understand the changes that occur with the woman during this period and also to guide them on the right to accompany the pregnant woman in prenatal consultations and childbirth, a right guaranteed by Law No. 11,108/2005 (FERREIRA et al., 2014; FIELDS; SAMPAIO, 2015).

However, it is still possible to find natural obstacles and resistance in this process, since it involves a change in paradigms and new ways of working, both on the part of managers and health workers and by a significant portion of the male and female population with regard to men's engagement in this issue (BRASIL, 2016).

Not every father is aware of his responsibility in the prenatal process. The lack of involvement and willingness to accompany in this stage is not always a matter of interest, but because it does not measure the importance of its presence in this process, This fact comes from values passed on by a patriarchal culture and society, predominantly sexist, which defends the maintenance of rigid gender roles for women and men. Often, including the perception that pregnancy and child care are exclusively the responsibility of women (BRASIL, 2016).

The hegemony of the patriarchal model is still maintained: the man is only the material and moral provider of the family, opposing the need for his presence in the pregnancy process.

6 FINAL CONSIDERATIONS

Paternal participation during the pregnancy-puerperal period is still poorly understood, because even if it is stimulated by health professionals, it also depends on cultural, family

and labor aspects. The participation of the partner provides emotional, economic, affective support and strengthening of the bond between the family, the community and the health professionals.

Despite the changes in the way men participate in consultations, there is still low adherence to health services. Therefore, it is of great relevance that health professionals are qualified about their partner's prenatal care, carry out activities related to men about fatherhood, promote actions and strategies to expand the opening hours of health units, so that they can meet the demand with quality and problem-solving capacity and clarifying that men also have rights to preventive practice, as recommended by PNAISH.

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INDUSTRIAL ARCHITECTURE IN BRAZIL

A ARQUITETURA INDUSTRIAL NO BRASIL

ARQUITECTURA INDUSTRIAL EN BRASIL

 <https://doi.org/10.56238/sevened2025.036-036>

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ABSTRACT

To understand the development of industrial architecture in Brazil, it is necessary to know the historical process of industrial implementation, from the first and limited initiatives during the colonial regime to the expansion into diverse regions starting in the 19th century. After a long period of adaptation in rudimentary constructions, brought by foreign professionals and companies, Brazilian industrial architecture reflects, despite the chronological lag compared to European countries like England and France, the models and typologies established after the Industrial Revolution, in the functional designs and in the choice of construction systems and materials used in the works, as well as in the implementation of the factory layout within the territory. The text will address how the first manufacturing initiatives took place in Brazilian territory until the opening of the first factories, in different phases, from the period of prohibition, through the government incentives that benefited investors, to industrial development in the 20th century. Regarding the establishment of factories, the configuration of the factory space and the consolidation of the industrial typology as a new architectural typology in Brazil will be analyzed. Subsequently, the analysis will focus on the implementation of industrial establishments and the architectural styles employed in Brazilian industrial architecture, as well as an analysis of common construction techniques and systems, in addition to influential projects of national industrial architecture, whose authors stood out for the innovative solutions used in the buildings that properly characterize the modality of industrial architecture in Brazil.

Keywords: Industrial Architecture. Brazilian Industrialization. Industrial Typologies. Construction Techniques and Systems. Projects and Architects.

RESUMO

Para compreender o desenvolvimento da arquitetura industrial no Brasil, é necessário conhecer o processo histórico da implantação industrial, desde as primeiras e restritas iniciativas no regime colonial, até a expansão nas mais diversas regiões a partir do século XIX. Após um longo período de adaptação em construções rudimentares, trazida por profissionais e por empresas estrangeiros, a arquitetura industrial brasileira reflete, apesar da defasagem cronológica em relação a países europeus como Inglaterra e França, os modelos e tipologias estabelecidos a partir da Revolução Industrial, nos projetos funcionais e na escolha dos sistemas construtivos e dos materiais empregados nas obras, como também na implantação da planta fabril no território. No texto será abordado como se deram as primeiras iniciativas de manufatura em território brasileiro até a abertura das primeiras

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fábricas, em diferentes fases, desde o período de proibição, passando pelos incentivos governamentais que beneficiaram os investidores, até o desenvolvimento fabril no século XX. Com relação ao estabelecimento das fábricas, será analisada a configuração do espaço fabril e a consolidação da tipologia industrial como nova tipologia arquitetônica no Brasil. Na sequência, a análise sobre a implantação do estabelecimento industrial e os estilos arquitetônicos empregados na arquitetura industrial brasileira, como também a análise sobre as técnicas e sistemas construtivos comuns, além de projetos influentes da arquitetura industrial nacional, cujos autores se destacaram pelas soluções inovadoras utilizadas nas edificações que caracterizam propriamente a modalidade da arquitetura industrial no Brasil.

Palavras-chave: Arquitetura Industrial. Industrialização Brasileira. Tipologias Industriais. Técnicas e Sistemas Construtivos. Projetos e Arquitetos.

RESUMEN

Para comprender el desarrollo de la arquitectura industrial en Brasil, es necesario conocer el proceso histórico de establecimiento industrial, desde las primeras y limitadas iniciativas durante el periodo colonial hasta la expansión a diversas regiones a partir del siglo XIX. Tras un largo periodo de adaptación en construcciones rudimentarias, introducidas por profesionales y empresas extranjeras, la arquitectura industrial brasileña refleja, a pesar del desfase cronológico con respecto a países europeos como Inglaterra y Francia, los modelos y tipologías establecidos desde la Revolución Industrial, tanto en los diseños funcionales como en la elección de sistemas y materiales constructivos empleados, así como en la implantación de la planta fabril en el territorio. Este texto abordará cómo se produjeron las primeras iniciativas manufactureras en territorio brasileño, hasta la apertura de las primeras fábricas, en diferentes fases: desde el periodo de la prohibición, pasando por los incentivos gubernamentales que beneficiaron a los inversores, hasta el desarrollo de las fábricas en el siglo XX. En cuanto al establecimiento de las fábricas, se analizará la configuración del espacio fabril y la consolidación de la tipología industrial como una nueva tipología arquitectónica en Brasil. La siguiente sección analiza la implementación de establecimientos industriales y los estilos arquitectónicos empleados en la arquitectura industrial brasileña, así como las técnicas y sistemas constructivos comunes. Además, se presentan proyectos influyentes en la arquitectura industrial nacional, cuyos autores se destacaron por las soluciones innovadoras utilizadas en los edificios que caracterizan la modalidad de la arquitectura industrial en Brasil.

Palabras clave: Arquitectura Industrial. Industrialización Brasileña. Tipologías Industriales. Técnicas y Sistemas Constructivos. Proyectos y Arquitectos.

1 INTRODUCTION

The study entitled "Industrial Architecture in Brazil" is part of the final report of the Post-Doctorate in Architecture and Urbanism with the Graduate Commission of the Faculty of Architecture and Urbanism of the University of São Paulo (CPG FAUUSP) entitled: "The architecture and industrial archaeology of the Central Mills and Power Plants in France and Brazil: recovery of the architectural memory of the Central Mill of Piracicaba", under the supervision of Prof. Dr. Beatriz Mugayar Kühl. The purpose of this research is to analyze the formation, development and consolidation of Brazilian industrial architecture, understanding it as a concrete expression of the economic, technical and social transformations that accompanied the process of national industrialization. It is based on the understanding that industrial architecture goes beyond the functional and technological dimension of factories: it constitutes a historical and cultural document, capable of revealing the relationships between territory, work, modernization and identity.

The proposed approach seeks to situate industrial architecture in the broader context of the country's modernization dynamics, showing that factory buildings are direct products of production processes and, simultaneously, agents of transformation of urban space. Factories and industrial complexes have contributed to shaping new landscapes and ways of life, establishing physical and symbolic landmarks in cities. In this sense, industrial architecture is understood as a specific form of expression of technical advancement and social organization, but also as an instrument for reading the urban and territorial history of modern Brazil.

Throughout the work, the historical path of Brazilian industrialization is described, from the colonial period, when manufacturing activities were prohibited, to the consolidation of the large manufacturing complexes of the twentieth century. Each stage of this path is linked to different economic and political contexts, such as the coffee cycle, European immigration, the advent of railroads and the industrial incentive policies of the governments of Getúlio Vargas and Juscelino Kubitschek. The main objective is to identify and understand the architectural typologies, construction systems, forms of implementation and technical agents that contributed to the constitution of industrial architecture in the country.

It seeks to demonstrate that, although marked by technological and financial dependence on European countries, Brazilian industrialization was able to generate its own architectural solutions, the result of a process of appropriation and creative adaptation of external models to local conditions of climate, materials and labor. Thus, national industrial

architecture is interpreted not as a mere reproduction of foreign paradigms, but as the result of a dialogue between tradition and modernity, between imported technique and regional constructive knowledge.

The research is justified by the conviction that industrial architecture constitutes a cultural heritage of high relevance, still little recognized in the field of preservation. Such buildings represent material testimonies of a period of profound transformations in the Brazilian territory, when manufacturing production began to order new forms of urban occupation and to redefine the role of medium-sized and inland cities. The factories, warehouses and workers' villages configure complex cultural landscapes, in which memory, technology and social life are intertwined.

Understanding this architectural heritage is essential for reading the process of national modernization and also for valuing the material expressions of work and production. In this sense, the study seeks to contribute to the expansion of the recognition and preservation of the Brazilian industrial heritage, affirming it as an important integral part of the collective memory and as a fundamental component of the urban, economic and cultural history of the country.

2 METHODOLOGY

The research was conducted through a historical-analytical approach, which combines bibliographic survey, documentary study and typological analysis. It is based on fundamental authors, such as: Santos (2006), Azevedo (2009; 2010), Maffei (1982), Padin (2009) and Rufinoni (2004), to reconstitute the context of industrialization and the architectural models that served as a reference for Brazilian factory constructions. At the same time, comparative readings of buildings and industrial complexes were carried out, considering the implantation, materials, techniques and formal language. This methodology allowed the correlation of the technical and spatial aspects to the territorial and social dynamics of each period.

With this approach, we sought to articulate history, technique and territory, treating industrial architecture not only as a product of engineering and economics, but as a symbolic expression of the country's modernization. Thus, the study proposes a critical reflection on the cultural value of the Brazilian industrial heritage and reinforces the need to integrate it, in a more systematic way, to the preservation policies and the construction of the national collective memory.

3 RESULTS

3.1 HISTORY OF BRAZILIAN INDUSTRIALIZATION

Since the beginning of the colonization process of the Brazilian territory by the Portuguese in the sixteenth century, Portugal's economic interests were related to the extraction of minerals and vegetable raw materials, such as brazilwood, and later to the acclimatization of sugarcane for export production. Thus, after a long period of prohibition on factory production, Brazilian industrialization officially began a century later than the Industrial Revolution, however, in the same period of implementation as Portugal, also backward compared to England and France.

Santos (2006) observes that the implementation of industries in Brazil has always involved political control, since the Portuguese colonial system dominated by British mercantilism, which did not accept initiatives that represented some competition in the market. Thus, the Brazilian economic subjugation meant the occurrence of an industrial architecture that was technically and chronologically outdated, in comparison with the development of the industrial system in England and the United States.

Authors dedicated to the study of industrialization establish periods or time frames to characterize different technical and sociocultural conjunctures, with each period representing a proposal for understanding the ruptures in the social and economic structure, as well as the type of energy and technical innovations used (SANTOS, 2006).

Azevedo (2010) understands the Brazilian industrialization process in four main periods, which make it possible to perceive the advances and setbacks in production, and also in industrial architecture. The first period, between 1785 and 1808, is known as the 'Prohibition' phase; the second period, from 1808 to 1930, is called the 'Implantation' period; the third period, between 1930 and 1956, is called the phase of the 'Brazilian Industrial Revolution'; while the fourth period, after 1956, is called the stage of the 'internationalization of the Brazilian economy'. The author also considers that, from the 1980s onwards, a process of deindustrialization began in Brazil.

The initial period, between 1500 and 1808, is known as the "Prohibition", because there was a restriction on the development of industrial activities in Brazil, with only small factories of spinning, footwear and containers for internal consumption being allowed, justified by the distance between Portugal and the colony. In this sense, Azevedo (2010) states that soon after the Portuguese discovered the Brazilian territory, an extremely open economy developed, oriented to the production and export of sugar to Europe, where a new

and respectable surge of urbanization was occurring, demanding greater demand for this product. For the author, the rupture related to the dominant functioning of the economy at that time is important, initiating the transformation of the subsistence economy and food assistance to the Kingdom, to an economy aimed at mercantile profit; and consequently integrating Brazil as a new production space (AZEVEDO, 2010).

On the other hand

the structuring of this sugar economy is already associated with the emergence and increase of conflicts of interest - namely, the trend towards monoculture, on the one hand, and the needs of diversified agriculture, on the other; the regulation of the export trade by the king and, with a tendency to oppose it, the liberal desire of the big merchants - which configures the capitalist dynamics that are beginning to emerge in other parts of Europe (AZEVEDO, 2010, p. 20).

The first isolated experiences occurred in the Northeast, however only with the implementation of the Captaincy of São Vicente, by its donee Martim Afonso de Souza, favorable conditions were created for the installations and proper functioning of the first mills on the south coast of the country. from 1532².

One of the first three sugar mills in Brazil - Engenho do Governador - was built in 1533, on the initiative of Martim Afonso de Souza, together with Jan Van Hielst, Francisco Lobo and Vicente Gonçalves, constituting the Sociedade Armadores do Trato³. It was strategically located at the foot of Morro Nova Cintra, to be supplied with water from the north slope by a channel that disappeared in a landslide. Later, in 1557 it belonged to Erasmo Schetz and Sons, from Antwerp in Belgium, when it was renamed São Jorge dos Erasmos (figure 267) and had its period of greatest sugar production in the place, until at least 1580. From the beginning of the seventeenth century, the mill suffered the effects of the decline of the sugar culture in Brazil, being under the administration of Schetz's heirs until 1603. However, around 1615, the mill would have been destroyed by a fire caused by the Dutch pirate Joris Spilbergen, reduced to ruins since then⁴.

² VOICES OF THE MILL. Available at: <<http://www.engenho.prceu.usp.br/vozes-do-engenho/>>. Accessed on 21 Jan. 2021.

³ Contrary to what is commonly thought, the Engenho dos Erasmos is the third built where the city of Santos is currently located. The first was the Engenho de Madre de Deus (1532), by Pero de Góes; and the second was the Engenho de São João (1533) by José Adorno, near Morro de São Bento (ENGENHO DOS ERASMOS (1). Available at: <<http://www.pimentel.jor.br/santos/fotos114.htm>>. Accessed on 21 Jan. 2021).

⁴ The ruins of the old mill were donated Octávio Ribeiro de Araújo in 1958 to the University of São Paulo, which restored the best preserved unit (LICHTI, Fernando Martins. **One of the first mills**. Available at: <<https://www.novomilenio.inf.br/santos/h0133g.htm>>. Accessed on 21 Jan. 2021 and ENGENHO DOS ERASMOS (1). Available at: <<http://www.pimentel.jor.br/santos/fotos114.htm>>. Accessed on 21 Jan. 2021).

Figure 1

Ruins of the Erasmos Mill



Source: <http://condephaat.sp.gov.br/benstombados/ruinas-do-engenho-dos-erasmos/>

In addition to the Erasmos Mill, Melo (2009, p. 9) points out that in 1534, six mills operated on the coast of São Paulo, rising to 11 units in 1557. However, in the first two centuries of Portuguese colonization, production and export farming did not prosper in São Paulo.

The development of sugar production in the North of the Colony led to the decline of Vincentian production, as its mills were reduced to four in 1585, and were deactivated at the beginning of the seventeenth century.⁵

The first mills implanted in the Northeast region were initially concentrated in two locations: in Pernambuco, from Olinda, developing to the south, to Penedo and to the north, to Goiana, going to Paraíba and Rio Grande do Norte; and in Bahia, from Salvador to the entire Recôncavo Baiano (Andrade, 2007, p. 15). The result of the sugarcane expansion is known as the "sugar civilization", as it determined the forms of implantation and development of the settlement of rural and urban centers in this region.

During the seventeenth century, the Captaincy of Pernambuco had a considerable production, in about 150 mills, representing most of the sugar production of the entire colony, enough to fill between 80 and 90 large vessels per year, from the port of Recife to Europe (Menezes, Muniz and Silva, 2012). Thus, since the sixteenth century, a production considered pre-industrial was configured in Brazil, in which the productive scale no longer refers to the small dimensions imposed by its previous artisanal character (AZEVEDO, 2010).

According to Hardman and Leonardi (1982),

[...] during the first three centuries of our history, industrial activities (here understood

⁵ QUEIROZ, Suely Robles Reis de. Some notes on the sugar plantation in São Paulo in the colonial period. *Annals of the Paulista Museum*, Volume XXI. São Paulo, 1967, pp. 112-117.

in the generic sense of the term) were practically reduced to the manufacture of sugar in the mills and to mining. The techniques used in both cases were quite rudimentary, with little difference between the process of making sugar and brandy in the sixteenth century and the beginning of the nineteenth century [...]. During the long colonial period, a series of other artisanal and manufacturing industrial activities were developed here, but all of them with an accessory activity, occupying a secondary role in the economy as a whole (HARDMAN and LEONARDI, 1982, p. 24).

In summary, the few primitive manufacturing enterprises were dedicated to extractive activities, with the function in the production chain, of supplying the raw material, that is, various ores and vegetables such as Pau-Brasil, as well as semi-processed agricultural products, especially sugarcane (SANTOS, 2006).

In the second half of the eighteenth century, some iron and fabric industries developed, and began to compete with the court trade, threatening to make the colony financially and politically independent, leading D. Maria I to extinguish in 1785, all textile manufactures in the colony, except for that of thick cloths, which were used by slaves and workers (AZEVEDO, 2010).

The second period, between 1808 and 1930, is called "Implantation", when the Portuguese royal family moved to Brazil, and Brazilian ports were opened to foreign trade, with a rate of 24% for imported products and 16% for the Portuguese. With the establishment of 15% for English products in 1810, local industrial development became minimal as a result of competition from imports from England, which predominated in the Brazilian consumer market. At that time, Azevedo (2010) recalls, slavery was still in force and there were few free and salaried workers to consolidate a consumer market. Furthermore, the investing elite of the coffee market was not yet willing to invest in industrial activity.

Considered the first factory installed in Brazil, the Real Fábrica de Ferro Ipanema (figure 268), was created by Royal Charter in 1810, starting to operate in 1811, located in the dense forest of Morro de Araçoyaba (current Ipanema National Forest), in Iperó, region of Sorocaba. "Europeans, especially Spaniards and Portuguese, at the head of indigenous people and mamluks, removed from ovens a pasty and incandescent mass that was taken to the mallet and transformed into bars" (TOMAZELA, 2007, A 29 apud PADIN, 2009, p. 48).

Figure 2

Real Ipanema Iron Factory in Iperó, SP



Source: <http://www.ipatrimonio.org/ipero-real-fabrica-de-ferro-de-sao-joao-de-ipanema/#!/map=38329&loc=-23.425597000000014,-47.59790254,17>

In addition to the Royal Iron Factory of São João de Ipanema, in the Province of São Paulo, the Prata Iron Factory (1812), the Morro do Pilar Factory (1812) and the São Miguel de Piracicaba Factory (1827) were also created, these in Minas Gerais (CORREIA et al, 2006).

Coffee growing became the main Brazilian economic activity from 1840 onwards, constituting a source of accumulation of the capital necessary to promote industrial activities (SANTOS, 2006), including those related to the export of coffee such as the production of cloth bags for the storage of beans.

In this sense, the textile industry received tax incentives in 1846 and, in the following year, raw materials in general also received it. However, the local industry was not yet able to develop in a country with a slave regime, with scarce availability of free and salaried workers, also representing a timid consumer market (PADIN, 2009).

Brazilian industry, dependent on the import of capital goods, mainly machinery, still had unqualified labor. In 1850, the Eusébio de Queirós Law prohibited the slave trade, causing important consequences for industrial development, especially the availability of capital, previously used in the purchase of slaves, in the industrial sector (AZEVEDO, 2010).

According to Padin (2009), Brazil's entry into the industrial market, with development of significant proportions, occurred only from the 1850s onwards, remembering that, in addition to Great Britain, even in 1880, the Industrial Revolution had not yet reached many countries, such as Germany and Portugal, which entered the industrial stage in 1870, and the United States during the years following 1860, achieving a firm structure only at the end

of the century⁶.

Santos (2006) considers that in São Paulo, the inaugural moment of its modern industrialization occurred in 1866, from the inauguration of the São Paulo Railway - SPR, the future Santos-Jundiaí Railroad, also a milestone in São Paulo's urbanization. Until then, coffee exports were carried out via the port of Rio de Janeiro, the capital of the Empire, from where coffee extended from the end of the eighteenth century to the Paraíba Valley of São Paulo in the nineteenth century. from where the product was sent to the main importer, the USA. However, the political and economic frameworks changed, elevating the capital of São Paulo to the center of capital, infrastructure and labor force and, later, the most dynamic Brazilian industrial center (SILVA, 1986; SANTOS, 2006).

Reis Filho (1990, p.6) describes the period between the 1860s and 1890s as the time of the establishment of the first large factories in the State of São Paulo, therefore before the occurrence of the great migratory currents. In that period, the textile sector was the one with the highest growth, partially favored by the growth of cotton cultivation, due to the lack of the American product in the market, while the Civil War occurred in the United States between 1861 and 1865. Thus, the North American conflict stimulated cotton production in the province of São Paulo since the 1860s and, in turn, the abundance of this raw material instigated its industrialization, and by the end of that decade, the first textile industries were already installed in the interior of the province and, in the capital of São Paulo, in the following years (PADIN, 2009; AZEVEDO, 2010).

Along these lines, Santos (2006) considers that the factories installed in Brazil reached the technical level defined from the First Industrial Revolution in Europe, only since the last three decades of the nineteenth century, still in the Imperial period. After the development of an economy basically supported by agriculture, mainly for the production of sugar and coffee, the industrialization of São Paulo was made possible by the profits obtained from the commercialization of coffee in the foreign market (AZEVEDO, 2010).

Dean (1971, p.10) points out that coffee production initiated the monetary economy, the first prerequisite of an industrial system. With the surplus money added to the export of coffee, fundamental improvements for industrialization were funded, such as railways, trams and electricity and gas networks, in addition to promoting social transformation.

⁶ FORBES, Robert James. Energy until 1850. In *The Invention of the Steam Engine*. São Paulo, 1972, p.73.

The coffee agroindustry, in full development⁷, needed labor, stimulating considerable European immigration, which brought new techniques of manufacturing production, being the first salaried (organized) labor force in Brazil. Immigrants established an effective consumer market essential to industrial development, in addition to a specialized workforce (AZEVEDO, 2010).

The immigration policy instituted by the government also boosted the coffee culture in the first republican period, with the demographic growth and productive capacity of São Paulo, in rural and urban areas, conquering a significant domestic market. São Paulo also asserted itself as a commercial and financial center of great influence, when a considerable part of the coffee elite began to reside in the capital, diversifying its business, investing in commercial and manufacturing activities, through Corporations, mainly in the textile and food sectors, also linked to the coffee complex (SINGER, 1977; SANTOS, 2006).

Maffei (1982, p.13-14), in turn, points out that 1870 was the year of the beginning of the implantation of industry in the State of São Paulo and divided the phases of Industrial expansion of São Paulo into five periods, comprising, respectively, up to the decade in which his research is inserted: first period, from 1870 to 1920; second period, 1920 to 1940; third period, from 1940 to 1955; fourth period, from 1955 to 1965; and fifth period, from 1965 to 1980. According to the author, the initial period consisted of the textile, leather and skin, wood, metallurgy, ceramics, chemical products, food, clothing and furniture industries.

In this context, the textile industry is considered by Arantes Santos (2011) to be responsible for the pioneering spirit of modern industry in Brazil. The first weaving company in São Paulo was the Companhia Industrial, founded in 1874 by Major Diogo de Barros. The factory employed 400 workers and had about 150 looms and a generator that produced electric lighting inside from 1880 onwards, allowing night work - a solution later adopted by the large factories in São Paulo (REIS FILHO, 1990, p.6).

Azevedo (2010) points out that the first industrial boom in Brazil occurred in the 1880s, when the number of establishments went from 200 factories in 1881 to 600 units in 1889, inaugurating the process of import substitution. Reis Filho (1990, p.6) also observes that:

[...] It was after 1889, with the establishment of the Republic, that it became simpler to create companies and multiplied the workshops and industrial facilities. From that moment on, small businesses, founded by immigrants, gained importance (apud

⁷ Funded by coffee, the School of Law (1830) was founded and, before the First World War, the schools of Engineering, Commerce, Medicine and Biology (Dean, 1971 in Padin, 2009).

PADIN, 2009, p. 50).
For Padin (2009) this idea

it comes from the fact that between 1890 and 1900 the city of São Paulo had its population composed of 50% immigrants and in some factories 90% of the workers were Europeans. In the first decades, however, the factories were created by the richest families, linked to mercantile activities and coffee production. Among the most important names are: Silva Prado, Aguiar de Barros, Penteado or Lacerda Franco, Rodovalho or Pacheco Jordão, Souza Queiroz and Souza Aranha. The first immigrants of equivalent weight then appeared at the end of the century: Matarazzo, Crespi, Scarpa and Siciliano (PADIN, 2009, p. 50).

However, at the end of the nineteenth century, while the Second Industrial Revolution was developing in Europe, as a result of the inclusion of scientific knowledge in industrial techniques, creating new technologies, Brazil was still a century behind, compared to industrially developed countries, due to the absence of significant foreign investments in industrial production, with exceptions in the sugar industry. until the end of the nineteenth century (SANTOS, 2006, p. 26; PADIN, 2009).

In the period between 1880 and 1930, the installation of light industries of non-durable consumer goods predominated, giving rise to Brazilian industrial capital, from national mercantile capital, directly linked to the agro-export sector. Santos (2006) considers industrialization as typical of the republican period, especially after the 1930s, when the agro-export economic model based on coffee cultivation went into decline with the crisis of the New York Stock Exchange, installed in 1929. This condition was accentuated due to the difficulties in importing industrialized products during the two World Wars, stimulating factory production to supply the domestic market, especially in Rio de Janeiro and São Paulo, and for export (SINGER, 1977; CANO, 1995; SANTOS, 2006).

Between 1920 and 1940, the second period highlighted by Maffei (1982) developed in different ways in the two decades. In the first decade, growth was slow due to the lack of a tendency towards the concentration and organization of associations controlling prices and production; while in the second decade, exports expanded and growth accelerated. It was in 1939, in this period, according to the author, that the value of industrial production exceeded that of agriculture by 30%.

The sectors that grew the most were cotton, cement and iron fabrics, among the sectors of execution of

mineral products, vegetable products, metallurgical, mechanical, transformation of non-metallic ores, wood and related products, paper and cardboard, rubber, vegetable oils and greases, hides and skins, pharmaceutical chemicals, hair and feathers, textiles, clothing and footwear, food products, beverages and stimulants, civil construction, electricity products, publishing and printing (MAFFEI, 1982, p. 14).

The Third Period, from 1940 to 1955, according to Maffei (1982) was marked by the Second World War, which hindered imports, directing the material possibilities to domestic production, with the objective of meeting the expanding domestic market.

For Azevedo (2009), the phase known as the Brazilian Industrial Revolution comprises the years from 1930 to 1956, marked by the Revolution of 1932 and by the internal policies of the Vargas government that operated changes in order to remove from the power of the State, the traditional oligarchies that represented agrarian-commercial interests. The federal government adopted an industrializing policy, promoting the replacement of immigrant labor by national labor, formed in states in the Southeast, such as Rio de Janeiro and São Paulo, Minas Gerais, and also in Rio Grande do Sul, due to the rural exodus resulting from the decadence of coffee, in addition to migratory movements from the Northeast. The author reinforces that Vargas made investments in industrial infrastructure by implementing basic industry and increasing energy generation; even creating the National Petroleum Council - CNP, the National Steel Company - CSN, the Vale do Rio Doce Company and the São Francisco Hydroelectric Company.

Azevedo (2010, p. 16) points out that it was characteristic of many of the industries created after the First World War, to only assemble parts produced and imported from abroad, being subsidiaries of foreign headquarters. Later, at the beginning of World War II, growth slowed as a result of the impossibility of importing equipment and machinery, highlighting the importance of the Capital Goods Industry. "Despite this, our exports continued to be maintained, leading to an accumulation of foreign exchange. The national raw material replaced the imported one. By the end of the war, there were already industries with national capital and technology, such as auto parts."

While in the first decades of the twentieth century there was a predominance of the consumer goods industry, other types of industrial activity that required technological apparatus began to develop in the 1940s, such as minerals, metallurgy and steelmaking, including the production of steel by CSN from 1946 onwards, which expanded the industrial development of the country, as steel is the basis for several industrial branches (AZEVEDO, 2010).

Serious problems hindered Brazilian industrial development from 1950 onwards, such as the lack of energy⁸, low oil production and deficiencies in the transport and communication system. However, Azevedo (2010) points out that in the second Vargas government (1951-1954), developmental projects based on state capitalism, through public investments in the extinct Brazilian Coffee Institute - IBC, in 1951, in addition to the BNDES, among other agencies, left important subsidies for Juscelino Kubitschek's Plan of Goals, with the high cost of internationalization of the Brazilian economy (AZEVEDO, 2010).

Santos (2006) considers that one of the characteristics that best defines this historical moment is the use of Technology, that is, the incorporation of scientific knowledge into industrial techniques and processes, as well as the administration and organization of work. The invention of the combustion engine and the use of electric energy in machines made it possible to expand production capacity, in addition to the application of knowledge of modern Physics and Chemistry to the transformation process (SANTOS, 2006).

As a result, new productive sectors were asserted, such as petrochemicals and automobiles. According to Santos (2006) also

The Economy of Scale was set up, which, in the face of the phenomenon of accelerated urbanization, consolidated mass consumption and planetary coverage. Associated with mass consumption, the Cultural and Entertainment Industry emerged, applications of mechanisms and inventions related to the mechanical production of images and sound records (SANTOS, 2006).

The fourth period, from 1955 to 1965, according to Maffei (1982) is characterized by the manufacture of production goods: machinery, equipment, motor vehicles and heavy raw materials. New sectors of activities were created: automotive, plastics, heavy chemicals, petroleum products, petrochemicals, machinery and tools, heavy boilermaking, electronic equipment and household appliances.

In this sense, the fourth period, according to Azevedo (2010) is recognized as a phase of internationalization of the Brazilian economy, due to the policies of the Kubitschek government's Plan of Goals, which from 1956 onwards began to dedicate two thirds of the resources to stimulate the energy and transportation sectors. It was at this time that the road sector developed intensely and the production goods industry also grew, from 37% to 63% in relation to the consumer goods area, with reflection, mainly in the steel, metallurgy

⁸ According to Azevedo (2010), in order to correct these problems, the São Francisco Hydroelectric Company was founded, among others.

(automobiles), chemical, pharmaceutical, and shipbuilding sectors (implemented in Rio de Janeiro in 1958).

Azevedo (2010) points out that in this phase the internationalization of the Brazilian economy grew, based on the actions of multinationals, whose foreign capital was attracted by exchange, tariff and tax incentives offered by the government. However, the political crisis in the early 1960s, after the resignation of Jânio Quadros (1961), was prolonged by the political pressures faced by his successor, João Goulart (1961-1964), in the face of the economic reforms provided for in the Triennial Plan. In addition, political unrest and inflation, combined with a favorable international political circumstance, led the country to the coup d'état in 1964⁹ (SANTOS, 2006; AZEVEDO, 2010).

The fifth period, from 1965 to 1980, for Maffei (1982) was characterized by enormous industrial expansion with the doubling and diversification of production, with total opening of the economy to foreign capital, combined with the enormous investment of multinationals from Japan, the United States, Germany, Italy, France, Great Britain, Holland and Sweden.

In the military government, as for the economic model, there was not a break with developmentalism, but a peculiar stage of the process of industrial updating, which had been initiated by Vargas and remained in the Dutra and JK governments. The military continued to implement heavy industry and infrastructure, such as the production of electricity, steel, petrochemicals; necessary for the formation of sectors producing intermediate goods, consumer goods and capital, in addition to the opening of highways, in order to ensure the conditions for the expansion or growth of its business to the private sector (CANO, 1995; SANTOS, 2006; AZEVEDO, 2010).

After the initial recessionary period (1964-1967), the military government was strengthened related to the Latin American geopolitical context in the international circumstances of the Cold War, which guaranteed to associate national and international capital, sponsored by the public power with various actions that created public and state-owned companies and also encouraged the installation of transnational corporations with investments in infrastructure (transport, telecommunications and energy). Such actions¹⁰ were translated into the 'Brazilian Miracle' or 'Economic Miracle' (1968-1974), as a product of

⁹ The coup triggered a military dictatorship in 1968, with Institutional Act No. 5 (AI 5), which closed the National Congress, ending legislative activities. The military regime only ended 20 years later, economically and politically exhausted, like the developmentalism that sustained it (Santos, 2006).

¹⁰ The 'Brazilian Miracle' is related to two plans drawn up during the military governments with the objective of guiding economic development and correcting imbalances in the adopted model: the first and second National Economic Development Plan (PND I and PND II), implemented from 1972 to 1979 (SANTOS, 2006).

economic restructuring (CALDEIRA, 1997 in SANTOS, 2006, p. 30).

Maffei (1982, p. 22) informs that in the 1970s

There was a great expansion of some sectors that until then were implanted in the Greater São Paulo region, and with the need for expansion created new factories outside the Rio-São Paulo hub, São José dos Campos, Pindamonhangaba, Taubaté and other municipalities in the Paraíba Valley. They also expanded to the coast, along the Anchieta-Imigrantes complex and occupying the remaining areas of the municipalities of São Bernardo, Santo André, São Caetano, Diadema and Rio Grande da Serra up to the dams at the beginning of the Serra do Mar.

In that period, the durable and non-durable consumer goods industry expanded, with the production of sophisticated products such as airplanes, computers, calculators, microprocessors, as well as steel, iron, cement and oil. The export of manufactured products was also stimulated through government incentives. In 1979, exports of industrialized and semi-industrialized products surpassed exports of primary goods, such as agricultural products, minerals, and raw materials (MAFFEI, 1982; AZEVEDO, 2010).

Direct and indirect investments by foreign capital grew in Brazil, but this growth was proportional to the progressive indebtedness, causing a slowdown in the initial growth, added to the exhaustion of the authoritarian regime, with an inflationary process and external indebtedness (SANDRONI, 1999 in SANTOS, 2006, p. 31).

After a period of rising inflation, with the military already out of command of the State, the Cruzado Plan, which although it had implicit electoral objectives, was launched on February 28, 1986, by the Sarney government, and was characterized as an attempt to promote the growth of Brazilian economic production without going through the painful fiscal and monetary austerity that would be the trademark of the Real Plan. in 1994. However, the customs protection that existed at the time, restricting imports, led to shortages, especially of basic necessities, promoted by oligopolized sectors of the economy, which condemned the economic plan to failure, despite their policy of keeping the exchange rate frozen and, with the real interest rate low, the GDP had experienced an unprecedented bubble of internal consumption in its history (AZEVEDO, 2010).

According to Azevedo (2010), the adjustment of public accounts after the Real Plan and the adoption of political and legal measures to support micro and small industry, as well as the entry of foreign capital attracted by the privatization programs of state-owned companies, made venture capital investment in the industrial sector attractive. The author

considers that the desired stability in the rules of the economy during the mandates of Fernando Henrique Cardoso and the decision of his successor, Luís Inácio Lula da Silva, to maintain the same rules of the economy also contributed to this (AZEVEDO, 2010).

3.2 INDUSTRIAL TYPOLOGIES IN BRAZIL:

From the industrialization process initiated since the Industrial Revolution in Europe, new architectural typologies were developed with the aim of meeting the needs of the new factories. In Brazil, the first initiatives followed the traditional patterns arising from the old manufacturing facilities, until there was a need to import large machinery, which brought with it the requirement for adequate projects for the construction of manufacturing buildings according to the various production chains.

With regard to the typological analysis of Brazilian industries, there is a great variety of factory types that distinguish them in time and space. Arantes Santos (2011) recognizes as conditioning factors for the development of industrial buildings, the political, economic and technological moments, in terms of the priorities of a given time and the conditions that the country offered for technological innovation (Arantes Santos, 2011).

As for the typological aspects, according to Hardman and Leonardi (1982), it is possible to recognize two precursor typologies of industrial architecture in Brazil, which served as a model for the construction of several manufacturing centers in the territory of São Paulo. The first typology developed was called 'Brazilian colonial', in which the façade is configured in a similar way to that of a large farmhouse for the production of sugar or coffee, characteristic of the first mills.

According to Azevedo (2009), the configuration of the primitive sugar factories in Brazil was basically the result of technological factors of production, which did not show much variation throughout the colonial period. As an example, the Engenho São Jorge dos Erasmos, one of the first three built in Brazil in 1533 which, according to Luís Saia's report to the DPHAN in 1966, had an architectural design of the Azorean model, of the real type (powered by water), with successive platforms to overcome differences in level, with porch access, and all facilities arranged below the same roof, in an agglutinated party¹¹. Saiah's hypothesis (1966) is confirmed in a document dated 1548, belonging to the 'Archives

¹¹ It was donated in 1958 to the University of São Paulo (CONDEPHAAT. *Ruins of the Engenho dos Erasmos*. Available at: <<http://condephaat.sp.gov.br/benstombados/ruinas-do-engenho-dos-erasmos/>>. Accessed on 21 Jan. 2021).

Généraux du Royaume de Bruxelles'¹² and, translated by prof. Eddy Stols, about this device:

[...] a very large house of 6 flights and a slave quarters with a blacksmith shop, all provided with bastions, and also two houses covered with tiles, very good and strong [...] all these houses rise at one height and all together and close together in such a way that no farm is so strong for the opposites¹³.

About the operation of the primitive São Paulo mills, archaeological records found at the site of the Engenho dos Erasmos, such as the stone millstone and the shapes of sugar loaf are the main remaining evidence, according to archaeologist Margarida Andreatta, responsible for the excavations¹⁴.

The millstone is a wheel about one meter in diameter that made the axles rotate with which the sugarcane was crushed to obtain the juice. It was driven by animals or slaves.

Another important piece for the historical reconstruction of the mill are fragments of the sugarloaf molds, which the researchers are trying to reconstruct. These molds - cones with a hole at the end - received the boiled sugarcane juice and stored it for 45 days, after which the 'bread' (block of hardened sugar) was removed. The 'bread' was cut by the slaves so that the 'noble' parts of the sugar - intended for export - were separated from the part that mixed the sugarcane bagasse and impurities - intended for the slaves' food. The noble part of the 'bread' was lighter and was deposited in the top layer of the sugar block. At the bottom, darker brown sugar was deposited¹⁵.

As for the installations, a niche embedded in one of the walls indicates the probable location of the chapel of the mill; five stone thresholds, one of which has marks in the shape of a half semicircle, indicating the movement of the doors of one of the rooms of the probable house of the lord of the mill. Also, in the remaining walls, there are vertical rectangular holes - the 'arrows' that served so that the occupants of the room could observe occasional external threats and shoot enemies without being hit by those who were outside¹⁶.

The Engenho dos Erasmos is considered the only remnant in the world of the Azorean-style mills, coming from the Azores Archipelago, where the Portuguese developed their sugar

¹² LICHTI, Fernando Martins. *One of the first mills*. Available at: <<https://www.novomilenio.inf.br/santos/h0133g.htm>>. Accessed on 21 Jan. 2021.

¹³ SIQUEIRA, Fausto. *The first factory in Brazil*. (1996). Available at: <<http://www.pimentel.jor.br/santos/h0133f.htm>>. Accessed on 21 Jan. 2021.

¹⁴ FOLHA AGENCY. *Dutch pirate destroyed mill*. (1996). Available at: <<http://www.pimentel.jor.br/santos/h0133f.htm>>. Accessed on 21 Jan. 2021.

¹⁵ FOLHA AGENCY. *Research finds sugarloaf pan*. (1996). Available at: <<http://www.pimentel.jor.br/santos/h0133f.htm>>. Accessed on 21 Jan. 2021.

¹⁶ Ibid..

industry. In comparison, the northeastern mills, after that of the Erasmos, built their buildings separately for each function, in a typology specific to the Brazilian mills¹⁷.

The architecture of the buildings did not undergo major changes until the imperial period, when, from the incorporation of new construction techniques, the introduction of the steam engine and new purging processes, the area and the floor shape of the manufacturing spaces underwent some changes, with the adaptation to the new productive capacity of the mills, although the architecture of the traditional mill was not essentially altered (AZEVEDO, 2009).

Azevedo (2009) cites as an example the Bahian mills of the first half of the nineteenth century, whose main architectural characteristic is the factory in the shape of a shed, with a rectangular plan configured by three or more naves, covered by only one hipped or four-pitched roof, which is supported by masonry supports or pillars. The central nave was generally supported by wooden scissors with a span of up to 12m, while the lateral ones were supported by beams or half-scissors, overcoming spans of up to 6m. In addition

Many factories had balconies on one or two sides of the shed. It is worth mentioning that these constructions appeared in the Recôncavo as early as the eighteenth century, but only became widespread in the following century. The scissors in the central span were generally of the pig yoke type, formed by two legs connected at mid-height by a tie rod. The thrust produced by these imperfect scissors was absorbed by the side ships (AZEVEDO, 2009, p. 117).

Also in Bahia, most of the mills located in the Jaguaripe River basin have an integrated party, with the big house and the factory in the same construction. However, in other cases, all the factory functions are brought together in a single space and the mill house remains isolated, in many cases, also fulfilling other functions (AZEVEDO, 2009).

The sugar production facilities were divided into two or even three independent buildings where milling, cooking and purging were carried out, since the sixteenth century. Azevedo (2009) understands that apparently the solution with the milling house and boiler together and the separate purge house predominated, whose scheme prevailed in the nineteenth century, in the traditional sugar production area of the Recôncavo Baiano, and generally, the two constructions were arranged parallel to each other or forming an 'L', when combined.

¹⁷ FOLHA AGENCY. *Dutch pirate destroyed mill.* (1996). Available at: <<http://www.pimentel.jor.br/santos/h0133f.htm>>. Accessed on 21 Jan. 2021.

Azevedo (2009) highlights the introduction of the in-line furnace, ending in a chimney, known as the Jamaican train¹⁸, among the modernization elements that influenced the reformulation of the factory space in the nineteenth century:

This new type of furnace, in addition to the advantages it brought in the broth cooking stage, contributed to the reduction of the area of the old milling house and boilers, enabling better working conditions and compatibility with the purging activity, since it did not emit as much smoke and heat. Due to the ease of location, compared to previous furnaces, the equipment also allowed greater flexibility of the internal space (AZEVEDO, 2009, p. 120).

Steam¹⁹, which replaced the water wheel and animals as a driving force in the first half of the nineteenth century, is considered another important element introduced in traditional mills, serving mainly to drive the mills and as a heat transfer vehicle for the cooking of the juice. Its installation initially occurred in the milling houses, not requiring the reformulation of the factory space (AZEVEDO, 2009).

The spatial configuration of the mills was linked to the sugar manufacturing process, which basically consisted of three main stages: sugarcane grinding, juice cooking and purging, and each stage of sugar production was reflected in the architecture of the factories, specifically aimed at making sugar production viable; while the main house fulfilled the function of housing and the church, of a space of religious worship (MENEZES, MUNIZ and SILVA, 2012).

In addition to the traditional built complex, the mills had very complex structures, involving various functions related or not to sugar production. In this sense, sugar began to be produced in the mill - the building that housed the mill - responsible for extracting all the juice from the sugar cane and in the boiler house, where the juice was cooked (Menezes, Muniz and Silva, 2012).

Apart from the mill itself, several other buildings participated in the manufacturing process, such as the purge house, where the molasses resulting from the cooking of the broth rested for several days, until it was transformed into sugar. For the operation of the mill (figure

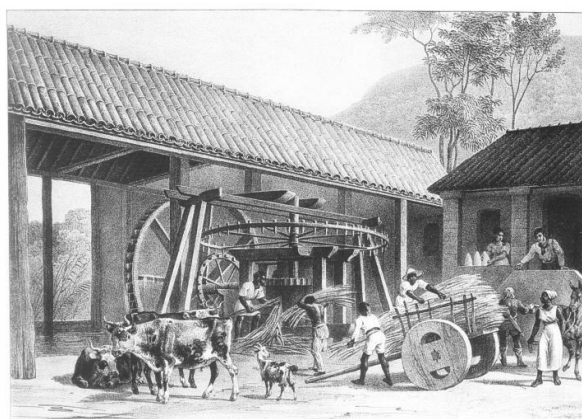
¹⁸ At the beginning of the nineteenth century, the Cuban sugar manufacture expanded the Jamaican train by adding two or three clarifiers, consisting of large cast iron vessels (1.75 m to 2 m in diameter), where the sugarcane juice was heated, without boiling, and lime was added for clarification. In the system, the solid elements of the juice were separated from the liquid by decantation (FRAGINALS, Manuel Moreno. *O Engenho. Cuban Sugar Social Economic Complex*. v.3. p. 215).

¹⁹ To obtain a vacuum in the closed cooking pans and in the equipment for drying the sugar, the pneumatic device patented by John Hagnes (FRAGINALS, Manuel Moreno. *O Engenho. Cuban Social Economic Complex of Sugar*. v.3. p. 215.).

272), it was necessary to have the support of pottery, carpentry, carpentry, among others, in appropriate places. As well as warehouses, to preserve equipment and the sugar produced, as well as sugarcane bagasse, used to feed the furnaces (MENEZES, MUNIZ and SILVA, 2012).

Figure 3

Sugar mill



Source: Rugendas (1835).

The banguê-type mills were moved by human or animal traction (trapiche mill) or by water wheels (royal mill). They produced brown sugar (demerara), which was then subjected to a bleaching process using clay, being destined for export. On the other hand, the mills that produced rapadura for the domestic market were called contraptions²⁰. According to Coelho de Souza (1970, p. 37; 38):

In the Banguês, at harvest time, the activity is intense. The reeds, brought by the carreiros in their oxcarts or by the money changers in their donkeys, go to the wooden mills. The juice, collected in large tanks, is taken to the boilers to be cooked over a raw fire. It goes, after cleaning, to the copper pots where it is thickened and beaten. Taken to the purging house, the molasses is placed in clay, wood or iron molds that, placed on perforated boards, let the honey drain that can be used for the manufacture of sugar de retame, or for the distillation of brandy in copper or clay stills.

In this way,

This produces an inferior type, raw sugar, which can be dried or molasses, purged, brown or retam. They are the same processes, the same routine and backward

²⁰ MUSEUM OF THE UMA. **Engenhos**. Available at: <<http://www.museudouna.com.br/engenho.htm>>. Accessed on: 21 jan. 2021.

methods that, through centuries, still persist in the primitive sugar industry of the Banguês. The decadence of these mills was not long in coming, overcome by the ever-increasing technique and industrialization (COELHO DE SOUZA, 1970, p. 37).

Beyond the Banguês

Others work, moved by water, with the three variants: "cupbearer", "covilhete" or "half cupbearer" and "rasteiro", depending on the place where the liquid falls on the wheel of the mill. Finally, the steam engines. In general, in the humid Northeast the colonial "banguês" and the large modern mills coexist (COELHO DE SOUZA, 1970, p. 37).

As for the housing segment, the owner of the mill and his family lived in the main house (or used it in seasons), which fulfilled the political and administrative function of the factory complex, in addition to being a symbol of the power and authority of the plantation owner (figure 274). Azevedo (2009) believes that it is possible that the older mill houses were very simple, since most of the investments were intended for the manufacture of sugar (AZEVEDO, 2009).

The enslaved labor lived in slave quarters and there were also houses for salaried employees. According to Simonsen (2005, p. 118), depending on the size, the mill could be similar to a small village, with the displacement of a large number of people to a given region, favoring the population increase in Brazilian lands based on its growth.

The mill represented a true village, requiring the use not only of many hands, but also the necessary lands of sugarcane fields, bush, pasture and supplies. In fact, from the mill house, the house of housing, slave quarters and infirmaries, it was necessary to have about a hundred settlers or slaves, to work in about twelve hundred massapê tasks (of nine hundred square fathoms), in addition to pastures, fences, vessels, utensils, iron, copper, oxen and other animals.

Figure 4

Megaípe de Baixo Mill



Author: José Wasth Rodrigues. Source: <https://www.behance.net/gallery/94554113/ENGENHO-MEGAÍPE>

In São Paulo, in the first phase of installation classified by Maffei (1982) between 1870 and 1920, the manufacturing facilities were still small and rudimentary, configured as small workshops.

As the space requirement due to the equipment was small, and they did not have problems of pollution or excessive noise, they worked in mansions, which were 2-story buildings with the same solution used for commercial houses, that is, at street level the workshops worked and on the upper floor, the office and sometimes, the owner's house, as is the case of the National Hat Factory on the street where Ladeira do Ouvidor is today, in the historic center of São Paulo, and the Schritzmeyer and Co. Hat Factory, on Quirino de Andrade Street, which began its activity in 1853 (MAFFEI, 1982, p. 28).

Following the European model of the first modern industries, recurrent to the already established, of a residential nature, simplified and adapted to its scale and the operation of the machinery, generally for factories founded in the Empire, the textile factory installed in buildings similar to rural manor houses (SANTOS, 2006). It had cotton cultivation on its own land, and manufacturing was configured as a kind of extension of agricultural activity with industrial capital originating from farmers, such as: the São Luiz Factory (figure 276) in Itu²¹ (1869) and the São Bento Factory in Jundiaí²² (in the period between 1874 and 1908, prior

²¹ The São Luiz Fabric Factory in Itu was the first steam factory in São Paulo and the second installed in the country, with machinery from the USA and England. Built in three distinct moments, the first part has colonial characteristics on the façade. The second, in greater proportion, added classicist elements such as the full arches; while the third part was built following the Manchesterian model (ESPAÇO FÁBRICA. Available at: <<https://espacofabrica.com.br/>>. Accessed on 26 Jan. 2021).

²² Companhia Fiação e Tecidos São Bento S/A was the first weaving company in Jundiaí, founded by Antônio de Queirós Teles as Companhia Jundiahyana de Tecidos e Cultura S/A, in 1874, being the first industry in the city, which became the national center of the fabric industry in the first half of the twentieth century. and name

to the reforms and expansion that correspond to the control of the company by French bankers) and the Votorantim Factory (Cachioni, 2013).

Figure 5

São Luiz Fabric Factory in Itu, SP



Source: <https://biblioteca.ibge.gov.br/biblioteca-catalogo.html?id=447266&view=detalhes>

Another industrial typology found in the Brazilian territory, according to Hardman and Leonardi (1982), is the one known as 'British Manchesterian' (factories created at the beginning of the twentieth century): in this pattern, the typical façade of exposed masonry, sober and heavy structure and symmetry of planes was common, presenting a modern system of factories fully implemented and manifesting the separation of agrarian capital and subordination to international capital (FAUSTO, 1977).

In this way, the 'Manchester factory system', characterized by the concentration of a productive mode in a single place, became the most expressive organizational model, as it provided the conditions for technology to become the priority element of capitalist accumulation, responding more adequately to the needs of the market (DECCA, 2004, p.70).

Miranda (2003) observes that varied typological solutions were built in the Brazilian industrialization in formation, in the early decades of the twentieth century: horizontal buildings for spinning and weaving; or vertical parts, for mills and grain processing plants. The implementation of these factories varies between peripheral to the lot or in line, with a program organized in only one building or in parts, and can be structured in iron, brick or concrete, whose lighting was usually provided by side openings with the help of *sheds*, skylights and lanterns (MIRANDA, 2003).

changes (S/A Industrial Jundiaense, São Bento, and Têxtil L'Affit S/A, ended its activities in 1989 (TECELAGEM SÃO BENTO. Available at: < https://pt.wikipedia.org/wiki/Tecelagem_S%C3%A3o_Bento>. Accessed on 26 Jan. 2021).

According to Miranda (2003), most of the factories built until the First World War were stripped, with modular markings on the structures, or a few frames with o'its and platbands. For the author, in the case of spinning and weaving, mainly, there are clear English and North American influences, disseminated through industrial catalogs of the early twentieth century, which suggested standardization of façade treatment solutions and spatial arrangements for floor plans, where the machinery would be installed. "In this picture, 'Manchesterian' influences are observed, where the brick was the seal and also the finishing of the building" (MIRANDA, 2003, p. 27).

In this line, according to Maffei (1982) the projects executed followed calculation standards and American projects, and the assemblers of metal structures copied American or English drawings, repeating without any alteration, structures made in England more than 50 years ago. Still, Miranda (2003, p. 30) states that

The organization of the volumes took place according to production: in line, in the alignments of the land with the central courtyard or even another structure of occupation of the lot, but characteristics such as free plan, modulation, high ceilings and standardization of the openings were almost constant. The vast majority of buildings of this period were defined in pavilions in sheds, with one or two floors structured in iron and perimeter walls of masonry.

Examples of this type of influence are the Nossa Senhora da Ponte de Sorocaba Factory (1881), the Votorantim Factory (1893), the Mariângela Factory of São Paulo (1907), the Società Per l'Expostazione e Per l'Industria Ítalo-Americana de Salto - Brasital²³ (from the expansion and transfer of the corporate name to this firm in 1904); the São Bento Factory after association with international financial capital in 1908; and the Francisco Matarazzo Industries in Água Branca in São Paulo (1920)²⁴, Santa Rosália Spinning and Fabric Factory (figure 281) in Sorocaba (1890), Santa Adélia Factory (figure 282) in Tatuí (1908), and Crespi Cotonificio (1897), among others (MIRANDA, 2003; CACHIONI, 2013).

²³ Brasital was formed by the merger of the old textile mills Jupiter (1895-97) and Fortuna (1898), and the paper mill (on the left bank of the Tietê River) purchased by the Italian company 'Società Ítalo-Americana per Importazione e Esportazione' in 1904. Its mills also boosted the industrial profile in the city. The Italian-American Factory was renamed Brasital, by combining the names Brazil and Italy, in 1919 (Valderrama and Oliveira, 2008).

²⁴ Indústrias Reunidas Francisco Matarazzo in Água Branca in São Paulo. In the early 1920s, they diversified the group's production, until then concentrated basically in flour and fabrics, in Brás. The railway branch integrated into the industry project improved the production transport system. Little remains of the old factory, as many buildings were demolished or abandoned, leaving practically the Boiler House (<http://www.ipatrimonio.org/?p=137#!/map=38329&loc=-23.525214999999996,-46.678043,17>).

Figure 6

Santa Rosália Spinning and Fabric Factory in Sorocaba. Built in 1890



Photo: Philip Gunn, 2001. Source: https://www.scielo.br/img/revistas/anaismp/v19n1/html/a02fig16a_20.htm

Figure 7

Santa Adélia Factory in Tatuí. Founded in 1908



Photo: Philip Gunn (2001). Source: https://www.scielo.br/img/revistas/anaismp/v19n1/html/a02fig16a_20.htm

Miranda (2003) informs that mills and silos, industrial types very common in Brazil, were built in smaller proportions than their North American counterparts, since the flour was still mostly imported. Between the end of the nineteenth century and the beginning of the twentieth century, based on foreign machinery, the activity of the mills often determined that their project was also carried out by foreign technicians, as well as in the central sugar mills. For this reason, the author points out that European standards used in the construction of mills adapted to Brazil were common, such as the 'Manchesterian' pattern, which is common in English factories, with facades in exposed brick masonry, a sober and heavy structure, with symmetry of planes (MIRANDA, 2003, p. 30, 31).

The acquisition of machinery from European companies was often accompanied by the assembly project of the factory, which also included the design of the building carried out

by production engineers who designed the plan of the building, in a functional character, following the established typology, and the facades according to models of treatises by authors such as Blondel.

Generally, according to Miranda (2003, p. 31) the mills and grain processing mills were built in a multi-plant system, with an external structure in brick masonry that is reduced as the efforts decrease with the elevation of the pavements.

The internal grate was made of iron pillars and beams with wooden interfloors, since this material was at the time more efficient in drying grains. Facades often had a modulated marking of the masonry reinforcement and the standardized openings in iron. The internal organization was basically divided into three zones: pre-cleaning and cleaning (where the silos and grain elevators were) and the milling sector, always imposing vertical conceptions of party.

As examples of this industrial typology, the author cites the Antonina Mill in Antonina - PR, the Rio-Grandense Mill in Porto Alegre - RS and the Rio-Grandense Mill in Rio Grande - RS (MIRANDA, 2003).

Thus, from the final decades of the nineteenth century, through the architecture produced by the factories, the constitution of a cultural landscape typical of the industrial environment is identified in the Brazilian territory. Correia (2010) points out that in this period, the manufacturing centers became important expressions of Brazil's transformation into an industrial society:

not only because of their origins, uses, functions and social conflicts, but also because of the formal characteristics that many of these places have assumed when referring to values, materials and symbols of the manufacturing world. In the architecture of some of these villages and manufacturing centers, a typically industrial aesthetic emerged, based on notions of economy, efficiency, utility and functionality (CORREIA, 2010 apud CACHIONI, 2013, p.464).

According to Santos (2006, p. 26), as a result of the creation of the assembly line by Henry Ford in 1912 and the incorporation of scientific knowledge into factory production and management, profound transformations occurred in industrial production, which required greater performance of the industrial space. In this sense:

Horizontality was necessary to house machines and assembly lines, extensive and sequential due to rationalization, which implies the economy of displacements. It also needed vast constructions for storage (raw materials and products), control and

administration. Mechanization and the use of electricity have increased the production systems and the internal conditioning of the buildings, making it possible to break with the traditional typology, the factory of warehouses with shed roof. [...] The factory of rationalist design, ground floor or floor, with a flat roof, transparent or even totally closed with artificially controlled lighting, humidity and temperature is established.

In addition

The administrative sector was expanded, which, like the new 'utilities' (synthetic raw materials and packaging equipment), required specific facilities, as well as social services (the 'facilities'), such as medical care, housing, health and leisure for employees (SOBRINO, 1996 in SANTOS, 2006, p. 26).

The factories of the Second Industrial Revolution required more space as a result of the increase in technical production capacity and the international proportions adopted by the markets. With the use of metal structures and reinforced concrete, large spans became generalized with continuous and versatile spaces in open plan, allowing varied arrangements (SANTOS, 2006). However, the incorporation of the technical standards typical of this phase in Europe and the USA only occurred again with a delay in Brazil, more than 50 years later and

[...] we began it between 1933-1955 in a restricted and incipient way and in a more decisive way in the periods 1956-1962 and 1968-1980, when we completed the installation of the sectors producing durable consumer goods, intermediate goods and capital (CANO, 1995, p. 23 apud SANTOS, 2006).

Moreira (2007) points out that these models were initially disseminated at the national level, through the importation of the machinery necessary to install the first factories in the country. However, the author considers that difficulties in carrying out the construction of the first factory buildings, related to the scarce guidelines and specifications for the installation of those enterprises, combined with the lack of specialized labor and the lack of the necessary means of transportation, often made the installation of factories in Brazil unfeasible (MOREIRA, 2007).

According to Maffei (1982), in the 1920s, based on the construction of large-scale industries and the diversification of the type of product, industrial buildings in São Paulo began to be settled in remote neighborhoods, such as Brás, Belenzinho, Água Branca and Mooca, which were transformed into areas with characteristics of industrial use accompanied

by low-income labor, especially Italian, Spanish and Portuguese immigrants. The first buildings built with the objective of housing equipment and machines were characterized as large sheds where more than 200 workers worked, and due to industrial requirements, they had spans of more than 15 meters and a ceiling height of more than 6 meters. The author points out that most were exposed masonry walls, with small side windows for lighting and roofing with wooden scissors and imported French tiles.

At the end of the 1920s and during the 1930s, with the importation of equipment for the electrical, metallurgical and weaving industries, in addition to the injection of English capital, imported metal structures were installed, constituting the main part of the industrial sheds, usually in type I laminated profile or two-inch iron profile lattice pillars, welded or screwed. Maffei (1982, p. 30) points out that

The roof structure was made of metal tresouros, in welded or screwed iron profile, shed type, with a roof of imported slate tiles. Some roofs, as in the case of metallurgical industries, a type of ventilation was used with a lag in the roof, forming a lantern. The side closure was made with a brick wall up to the roof, following the design of the roof.

The sheds then formed a set very similar to the English industrial complexes of the mid-nineteenth century, with large brick chimneys (MAFFEI, 1982).

Only in the 1940s, after the installation of large steel mills, such as CSN, did metal structures begin to be produced in Brazil. In the 1950s, with the implementation of auto parts industries and vehicle assembly plants in the USA and Germany, the projects of Brazilian buildings were copies of those built in the USA in the 1930s and 1940s, transferring the machinery, equipment and design of the buildings to São Paulo. Thus, according to Maffei (1982, p. 30),

[...] in the landscape of the Presidente Dutra Highway or Via Anchieta, the large metal sheds, with lateral closure and roof in ficrocement tiles or corrugated metal sheets, and the façade facing the highway, in red ceramic brick masonry up to the top to hide the roof and give it a rectilinear, horizontal shape. This type of architecture is limited by industrial companies with national capital, aiming to have the same status as the industries of multinational groups.

According to Maffei (1982), the only project of that period that escaped the standards of imported warehouses was the Duchen Factory, at the beginning of Via Dutra, designed by Oscar Niemeyer, using concrete arches and slabs.

In the 1960s, Maffei (1982) informs that the possibility of using new materials, in addition to the competitive price of concrete, allowed new proposals for structures for industrial warehouses in aluminum, concrete shears, precast concrete, among others. In the 1970s, new materials, solutions and construction techniques were consolidated, when sophisticated industries of electromechanical and electronic equipment were built that needed pressurized or air-conditioned sectors, as well as pharmaceutical or chemical industries, which introduced in the country the "sealed factories", which did not need natural ventilation, adopting a flat roof with electromechanical ventilation.

3.3 THE IMPLEMENTATION OF THE BRAZILIAN INDUSTRIAL ESTABLISHMENT:

Like the European factories, Brazilian industrial establishments were implemented in various ways in the most varied territories, according to the manufacturing requirements, mainly in relation to watercourses and the supply of raw materials and, later, in proximity to the railways.

Regarding the implementation of the productive space, Santos (2006, p. 18) proposes morphological categorization distinguishing three architectural configurations of industries: isolated works, industrial complexes and factory complexes. The author identifies as an "isolated work" the monospatial manufacturing unit where all the equipment, stages and transformation activities are in a single environment in the building - isolated works typical of the eighteenth century. The "industrial set" is characterized by the grouping of buildings, according to the need to dismember activities into specific buildings, determining the grouped organization according to a product or the planning adopted for its production, involving constructions for concierge, warehouses, offices, workers' village, among others. Finally, more recently, the "factory complex" corresponds to the gathering of manufacturing groups for reasons of a corporate or technical nature (equal or complementary raw material), often formed by different companies, manufacturing processes and products, recurrent in modern manufacturing units (SANTOS, 2006).

The geographical space particularly offers support to the history of Brazilian factories with information referring to the most prosperous places, such as the capitals and more developed cities. In this sense, initially the factories were located in areas far from urban centers, mainly due to the generation of energy, which required the construction of buildings in the vicinity of water resources, whose situation has been maintained since the invention of the steam engine in 1776, but allowing the proximity of industrial activities to the cities

(ARANTES SANTOS, 2011).

In the first industrial experiments carried out in colonial Brazil, there is an archaeological record proving that the Engenho de São Jorge dos Erasmos in Santos was formed following the Azorean model, with all its facilities arranged in a building, in an agglutinated part, configuring a morphology characterized as an isolated work. Still as isolated works, the first experiences of installing sugar mills in the Brazilian pre-industrial period were practiced. According to Gomes (1996, p. 118) the proximity to water resources represented an important conditioning factor for the location of the mills.

From a more organic implantation, the buildings of the mills were arranged on the ground in a more rational way, probably following French models. As all arrangements and buildings were always independent of each other, the construction systems were not necessarily the same for all units of the same mill. Of the set of buildings that made up the mill, four stand out for their permanence: the *mill* itself, also called *the factory* or *bush*, the *main house*, the *slave quarters* and the *chapel*. The latter was always built with the most durable materials - stone or brick masonry - indicating its symbolic value to overcome the vicissitudes of the plantation owners. All other buildings could be temporary and this was shown even in the materials with which they were built.

For Gomes (1996, p. 118) "The image, therefore, of fortresses that was sought to spread in analogy with the big houses of the Pernambuco mills applies only to a few and exceptional cases".

For the industrial complexes, the proximity to the water resources remained a condition when the central steam-powered mills were installed, whose mills depended on the channeling of water from tributary streams of the rivers that also served as a means of transport to transport the production. In the same way, for the pioneer weaving mills, it was also important to implant them in the vicinity of river waterfalls, where hydroelectric plants could be installed to supply energy for the electric looms.

With respect to the implementation of the industry, it was common to have a close link with the railroads, with facilities subordinated to the need for railroad branches for loading and unloading. According to Rufinoni (2004, p. 52) "[...] the whole set, finally, shows the formation of a complex productive network, where the existing urban structure was developed in response to the needs of the industrial complexes installed there, in full activity in the first decades of the twentieth century" (RUFINONI, 2004, p. 52).

In the city of São Paulo, railroads were installed on the banks of the rivers, with the objective of minimizing difficulties caused by the relief of the plateau where the urban fabric

is established. Padin (2009, p. 53) considers that, for this reason, many plots of land where industrial buildings were installed are in areas with humid soil.

In many cases, such as in the warehouses of Indústrias Matarazzo, located in the Jaguaré neighborhood, in São Paulo, the foundations were executed with pine piles. Constantly moistened wood does not rot or lose its mechanical resistance properties (PADIN, 2009).

These areas in the strip of floodplains and river terraces, which are bordered by the railroad roads, were much sought after by commercial establishments, which intended to maintain their headquarters in the capital of São Paulo. At first, the industries were attracted by the proximity to the railway stations and, later, they began to occupy the intermediate stretches intensively, where large warehouses or warehouses were also installed in large lots (BARDESE, 2011, p. 33).

Rufinoni (2004) points out that many of the large lots determined by the occupation of industrial complexes still remain, in areas where the development of other activities caused the division of lots and the dismemberment of industrial complexes, whose original characteristics are still perceived. "The 'block-lots' formed by the large industrial complexes, even if officially dismembered among several owners, still mark the landscape as continuous blocks - often compact - of built mass" (RUFINONI, 2004, p. 43).

On the other hand, workers' villages were implanted next to the industrial complexes, in small lots, usually single-family, distinct from the occupation of the industries. Housing was granted to workers by paternalistic industrialists, as a way of obtaining the worker's loyalty to the factory. Generally, the villas were built in a row or semi-detached, aligned with the sidewalk, and may have small backyards or common patios inside (CACHIONI, 2013).

Factory complexes were built close to water resources, also having their own railway line, which connected to the branches of the main railways. In the sugarcane sector, close to the sugar and alcohol mills, other factories were installed that also processed sugarcane derivatives, such as the production of paper. Next to the production complex, in addition to the workers' villages, schools, a library, a Catholic church, a community center, an outpatient clinic, a cinema, a ballroom and a dry goods warehouse were built by paternalistic entrepreneurs, constituting new neighborhoods far from urban centers.

3.4 CONSTRUCTION TECHNIQUES AND SYSTEMS OF INDUSTRIAL ARCHITECTURE IN BRAZIL

The repertoire of techniques, systems and stylistic and constructive elements used in pioneering industrial buildings in Brazil, is similar to that used in European countries such as France, England and Italy, as well as in the USA, justified by the fact that many of the constructive elements were imported from Europe, including the metallic structural system and the tiles, which were allied to mud bricks, which were already produced in Brazil.

In addition to the preponderant choice of exposed masonry highlighted by authors such as Rufinoni (2004) and Padin (2009), whose device can vary between English, Flemish or traditional, depending on the need for greater or lesser thickness to support roof structures, full and depressed arches composed of ceramic elements specially produced for this purpose are identified, constituting models of classicist and Romanesque inspiration. According to Padin (2009, p.52) the choice of brick masonry probably induced the option for solutions for door and window openings in depressed arches, high and with narrow lintels, as well as ornaments made from the careful rigging of bricks.

Bardese (2011) points out that until the installation of railroads and the foreign repercussion on the employment of salaried labor and also on imported taste and techniques, brick masonry was still little used in São Paulo constructions. According to Toledo (1983, p. 13) "[...] Until the advent of the railroad, São Paulo was a city of clay." ²⁵ In fact, according to Silva Bruno (1954), at the end of the 1850s, there were only nine small tile and brick factories in the city, which were mainly used for paving, and the first large brick factory was only inaugurated in 1859, in Bom Retiro²⁶.

From the installation of the railroads, the architecture of São Paulo underwent significant changes, with the presence of English technicians and the importation of machinery accompanied by the construction techniques used in the process of expansion of the railroad lines. According to Bardese (2011), associated with the phenomenon of immigration, the railway stations and factories promoted the dissemination of the use of brick masonry in constructions, albeit slowly, introducing a construction system little used in São Paulo until that moment, which allowed the realization of wider spaces, meeting the new programs of activities of this historical period. The author points out that the factories and railway stations built in exposed brick masonry and metal structures demonstrate the great

²⁵ TOLEDO, Benedito Lima de. **São Paulo: three cities in a century**. São Paulo: Duas Cidades, 1983, p.13.

²⁶ Silva Bruno (1954, p.470) in Bardese (2011, p. 64).

influence of English industrial architecture (BARDESE, 2011, p. 64), called by Hardman and Leonardi (1982) as British Manchesterian.

From then on,

The walls were usually built of brick and lime masonry. This modification, so simple, implied a significant increase in precision: the measurement errors, which with the use of traditional techniques could almost always be evaluated in decimeters, were now reduced to centimeters. The walls, with a uniform width, allowed the mechanized production of doors and windows (REIS FILHO, 1995, p. 159).

And

[...] The adoption of industrially produced construction elements and formal standards capable of assimilating them, within traditional solutions, meant, under these conditions, at the same time an advance in technology and the reinforcement of colonial-type ties (REIS FILHO, 1995, p. 183).

Mainly through the immigrant European labor, the bricks that were initially used in a special way in railway stations, industries and warehouses, became popular and enabled the accelerated growth of the city of São Paulo, as the main construction material. Bardese (2011, p. 64) attributes the success of bricks to the fact that "[...] Its low cost and ease of transportation by railroads provided faster and safer construction, especially in relation to the frequent rains, in addition to meeting the growing demand for the new programs". In addition, from the 1870s onwards, the City Council began to demand the replacement of rammed earth as a construction technique in 1873²⁷, which was highlighted by the provisions of the Code of Postures of 1875.

Bardese (2011) exposes that

The municipal and ecclesiastical government itself was gradually eliminating from the city its provincial and traditional aspects and customs, hiding or replacing any non-European trace of its streets, houses and customs, just as these new residents, influential in political and economic life, began to aspire to a city at their height, eliminating the vestiges of their provincial past (BARDESE, 2011, p. 64).

Brick masonry was the construction system used for the construction of chimneys, and there are also examples made up of various materials, such as stone masonry and metallic

²⁷ MORSE, 1970, p.255.

material. However, exposed brick masonry was more widespread due to its lower cost, ease of maintenance and resistance to heat, and can be erected with circular, rectangular or prismatic section. In addition to their functional origin, chimneys also served as an aesthetic component in the formation of the industrial landscape, considered by Arantes Santos (2011, p. 37) as an "element that configures a distinct meaning in industrial construction". For the author,

More than that, the chimney was a strong support for the memory of the place, the company, the community and those who in some way are or were part of the daily life of the industry. Sometimes, they even received ornaments that could not even be seen in the body of the building itself, so that their presence in the factory scenario could be remarkable.

In this sense, Bach (2009, p. 17) considers that:

The image of the chimney, an icon of the industrial city, also appears in the rural scenario, and is presented as a major vestige of this industrial activity that moved the region in the period analyzed and, at the time in which this production occurred, it was also a distinctive element of economic progress for the company it represented (apud ARANTES SANTOS, 2011, p. 37).

Regarding the factory buildings, Rufinoni (2004, p.43) points out that the technique used, as well as the architecture adopted, did not present significant variations in the construction of the first factories in São Paulo.

The large buildings - which could occupy an entire block - were usually built with exposed brick masonry and cast iron or steel structure. Metal or wooden roofs were the most common solution; in sheds or in two successively repeated gables side by side.

According to Padin (2009, p. 53), from the constructive point of view, all industrial buildings in São Paulo from this period have the same characteristics.

All are simple casings in brick, wood and iron. Internal productions develop as a function of their better rationality and productivity, however, at this time they still define the building little. In fact, the construction system used was based on the construction knowledge of the time and the availability of materials. The difference in relation to the profusion of decorative elements in the eclectic buildings of the same period lies in the fact that they had many of their components and construction materials imported, which made construction more expensive, and was not interesting in the case of

industrial architecture.

In several industrial buildings, the main structure was made of brick masonry, while the cast iron pillars had only the function of supporting the internal part of the roof structure. In turn, the use of iron in constructions also enabled constructive innovations not allowed by wood, such as the São João Market (1890), the Chá (1892) and Santa Ifigênia (1913) viaducts (PADIN, 2009; BARDESE, 2011).

Furthermore, Rufinoni (2004, p. 158) identifies in the industrial complex built in the Mooca neighborhood in São Paulo,

use of advanced architectural techniques, such as iron and steel structures, which were quite versatile for the construction of the free spaces and high ceilings that the factory facilities so badly needed. It is, therefore, the search for design solutions appropriate to specific functions, a fact that corroborates its importance for the history of architecture and contributes to the formal coherence generally achieved.

In this sense, Rufinoni (2004, p.52) concludes that

The vast majority of the buildings analyzed have the same construction system: bones made with a metallic structure, cast iron or steel, and solid brick masonry sealing. Sometimes the use of load-bearing masonry is noticeable and the metallic elements are restricted to the support of the roof structure, also metallic or wooden. The frames generally adopted are made of iron, in a few exceptions, made of wood. The ornaments of the pots - exquisite details of bricks arranged sometimes longitudinally, sometimes transversely - repeat the theme in curious and peculiar variations.

Padin (2009) informs that most of these buildings were built on the ground floor, but there are examples of vertical construction, such as the Cotonificio Crespi (1897), designed by Giovanni Batista Bianchi. The metal structures of many sheds were imported, among them, *sheds* sealed by glass to allow zenith lighting, which can open to allow ventilation (PADIN, 2009).

The need for natural lighting and ventilation forced the creation of openings and the movement of the lateral and roof fence planes, creating open windows, lanterns, mansards and finally the *shed* - openings in the roofs with the objective of offering lighting, before the use of electric light -, which made it possible to create "a basic module for the multiplication of the factory space", according to Santos (2006, p. 21). Anyway

It made it possible to open the side or air to ventilate and illuminate the internal space, as well as its expansion through the addition of other modules and in all directions. Complementary architectural solutions, such as the gutter system and devices for the control of light and undesirable winds, allowed for the improvement of this typology (SANTOS, 2006).

The use of *sheds* conditioned the design of the factory building and configured a top line known as "sawtooth roofs", which is striking for the formal understanding of the units. The development of this model, according to Moreira (2007, p. 125), "made it possible, in the first decades of the twentieth century, to apply the concept of the production line that revolutionized industrial production" (apud Arantes Santos, 2011, p. 38; 39). And, according to Santos (2006), the sequence of the shed roof combined with the chimneys of the steam boilers, composed the image of the modern factory, the typical factory architecture of the First Industrial Revolution (SANTOS, 2006).

Also imported from European countries were metal structures such as trusses and purlins, which were generally equipped with rafters and wooden slats and; ceramic tiles usually brought from France, known in Brazil as Marseille type tiles (PADIN, 2009).

In addition to the metal structures,

The development of European industry made it possible to supply, under advantageous conditions, tinplate and copper, for the assembly of flashings, rails, conductors and finishing pieces in general. Cast iron conductors and gutter clamps with decorative designs were common (Reis Filho, p. 1995, p. 162).

It is worth remembering that

Intended for all sectors of construction, they ranged from structural parts such as beams and columns, to secondary finishing resources such as garden ornaments, fountains and railings, not to mention stairs, window and door fittings. pipes, bathroom pieces and stoves (Reis Filho, p. 1995, p. 164).

Bruna (2002, p. 35) adds that

In Brazil, these elements are strongly present in all nineteenth-century architecture. Not only were hollow columns and beams in cast or wrought iron (as it was also called) imported, but also finishing pieces and ornaments for gardens, such as fountains, benches and railings imitating tree trunks.

For Maffei (1982, p. 33) there has always been a great interrelationship between the

type of building in terms of space, construction system and materials, with the type of product manufactured, as well as the manufacturing process, depending on the type of equipment and machinery. That is:

The evolution of industrial architecture has not only followed the evolution of construction technique, materials and aesthetic concepts (plastic-formal) that are inherent to architecture itself, but also of the type of industry as a function of the industrial production process (with all the inherent needs) and the type of product manufactured (with all the implications of transport, handling, areas, etc).

3.4 PROJECTS AND ARCHITECTS OF BRAZILIAN INDUSTRIAL ARCHITECTURE

The projects of industrial buildings built in Brazil from the 'Implementation' phase have varied origins, justified by several factors. As verified in the previous chapters, depending on the productive branch, the project was contracted together with the machinery, and was often developed by the mechanical engineers responsible for assembling the imported equipment. The catalogs of the machinery industries, which instructed the assembly of the equipment, provided general guidelines for the construction of buildings, according to production needs. There are also several records of constructions carried out by engineers and contractors, based on treaties and construction manuals, which allowed the application of their rules and practical examples in industrial buildings. However, despite the numerous factories designed by civil and mechanical engineers, based on manuals and catalogs, relevant architects in Brazil were also hired for the development of factory projects.

According to Maffei (1982), Brazilian industry, due to its technological dependence and the origin of capital, obeys imported parameters, always prevailing from the beginning, the design coming from abroad. In the evolution of the history of industrial buildings, the fundamental element to understand the solutions adopted is the origin of the capital, considering that the national capital was partial and, in some industrial sectors, came from some family groups that passed the capital that had been invested in the agricultural or import sector to the industrial sector.

The so-called "Captains of Industry" were mostly people with European training, and the little "know-how" they had was imported, acquired along with the machinery and equipment. Thus, our industry, due to its technological dependence and the origin of capital, obeyed imported parameters and always followed the design that came from abroad (MAFFEI, 1982, p. 33).

Maffei (1982) states that the evolution of the architecture of industrial buildings not only followed the evolution of aesthetic concepts, materials and construction techniques, inherent to architecture itself, but also developed as a function of the industrial production process and the manufactured product. The author considers that the physical characteristics of industrial buildings built with foreign capital are similar to those found in their country of origin, including the project, which was imported along with the equipment and the production system. "In some cases, even the metal structure was imported, and a model of architecture from the time of the European industrial revolution was reproduced in Brazil", and from the mid-nineteenth century, "with the buildings closed with exposed mud brick masonry walls, with the shape of the upper part following the design of the roof shed" (MAFFEI, 1982, p. 159).

Along these lines, Santos (2006) also notes that many of the factory projects were the responsibility of those responsible for the installation of machinery imported from Europe and North America, who represented the companies in Brazilian branches and, with the importation of machinery, the architectural project was often imported along with the equipment (SANTOS, 2006).

Among the main manufacturers of machinery for sugar production, the 'Société Anonyme des Anciens Établissements Cail' had in Rio de Janeiro, the Belgian civil engineer Francisco de Lumay as the company's representative and attorney. In addition to business representation, it maintained an office specializing in mechanical construction for industries; supply of material and complete facilities for central sugar and distillation mills; carrying out public works; metal bridges and iron buildings. At the Monte Alegre Central Mill in Piracicaba, Lumay, in addition to conducting the assembly of the machinery, was also the author of the construction project of the factory building, according to the contract signed with the owner²⁸.

In the same way, 'Brissonneau, Frères & C.' kept in the Brazilian subsidiary the industrial engineer André Paturau and the engineer Fernando Dumoulin, French, as representatives of the company and responsible for the assembly of central sugar mills, among them: the mills of Porto Feliz, Rafard and Piracicaba, being probably the authors of the projects of the buildings that housed the machinery.

However, not all contracts provided for the supply of exclusive or specific projects for the buildings. Moreira (2007) highlights the importance of the catalogs produced by British

²⁸ Information extracted from the Deed of purchase and sale made by Francisco Lumay to Doctor Pedro Augusto da Costa Silveira, of a central mill and assembly for the sum of one hundred and fifty-one thousand eight hundred and sixty francs, 30/12/1886II, inserted in the Inventory of Pedro Augusto da Costa Silveira, 1887. Piracicaba, 1st Office, box 21 A.

and American machinery industries, such as Platt Brothers & Co, Howard & Bullough Limited, Brooks & Doxey Limited and Dodson & Balow. In addition to detailed information about the machinery sold, these catalogs also contain proposals for industrial typologies and architectural and constructive solutions, which aimed to facilitate the assembly of factories.

Saia (1988) considers that the architectural solutions exhibited in these catalogs suggested a trend towards the standardization of façade treatment solutions and made it possible to understand some elements that distinguished textile manufacturing buildings, in addition to the dimensions, such as

the dust exhaust towers of the preparation areas, the stairwells, the engine room and areas corresponding to the situation of the sectors of the transmission systems that were externally evidenced, highlighted or deserving differentiated treatment on the homogeneous facades (SAIA, 1988).

During this period, just as it became frequent in Europe to consult treatises such as Blondel's 'Cours d'Architecture' (1750), it was also common to consult treatises and construction manuals by other European authors such as Louis Cloquet²⁹, João dos Santos Segurado³⁰ and Pasquale Carbonara³¹, as well as the Brazilian Alexandre Albuquerque³², which described and taught good ways to use the new techniques and common materials, for industrial constructions, as well as for institutional or residential buildings (BARDESE, 2011).

Cloquet's Treatise on Architecture (1922), divided into five volumes, brings in Volume IV, descriptions and examples illustrated with plans and facades, of buildings that are part of the repertoire of industrial architecture, such as markets and slaughterhouses, railway stations and collective housing for the working class.

The Insured (undated), 'Masonry and Stonework', 'Buildings' and 'Construction Materials' manuals provide information on the application of construction materials and systems, with several illustrations. The first volume was especially consulted by the builders, regarding the good use of rules for the execution of masonry, according to the devices most appropriate to the needs of the factories, mainly because they are, in the vast majority, buildings in exposed masonry in greater or lesser size.

²⁹ CLOQUET, Louis. *Traite d'architecture*. Paris: Librairie Polytechnique, 1898.

³⁰ SEGURADO, João Emílio dos Santos. *Masonry and Stonework* (4th edition). Lisbon: Bertrand, s.d..

³¹ CARBONARA, Pasquale. *Architettura Pratica*. Torino: Unione Tipografica - Editrice Torinese, 1980.

³² ALBUQUERQUE, Alexandre. *Civil Constructions*. São Paulo: Empresa gráfica da "Revista dos Tribunais" LTDA, 1952.

Carbonara's Treatise on Practical Architecture (1954) follows Clocquet's line, divided into eight parts distributed in five volumes, where he also presents descriptions and examples illustrated with plans and facades, by categories. The volumes of part 3 refer to 'buildings for the organization of work', bringing references applicable to factory buildings.

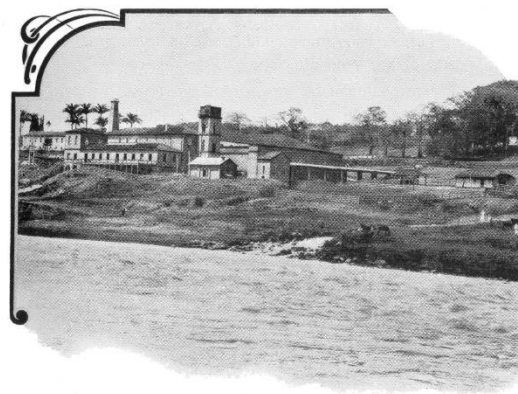
The manual of Civil Constructions of Albuquerque (1938; p. 52) brings in Chapter IX - referring to roofs - especially in the item 'Iron structures', examples of fabrication and assembly of trusses 'indicated in the roof of large spans', complemented with the item 'Roofing Materials', with several examples of metal shears for application in factory buildings.

Used by engineers and contractors, the manuals and treatises contributed to the consolidation of an architectural typology with common elements, currently considered as a determinant to be qualified as a typology of industrial architecture.

According to Moreira (2011), there was a greater occurrence of contractors with some experience in factory construction, in the last decades of the nineteenth century, among which the following stand out: Bernardo Mascarenhas, who provided services in the installation of the Companhia Industrial São Joannense, in São João del-Rei - MG; and the 'engineer' Carlos Hargreaves, in charge of the construction of the Santa Rita, Corcovado, América Fabril Factories and the expansion of the Cruzeiro Factory, in Rio de Janeiro. Still in the textile industry, in São Paulo, the English engineer Arthur Dryden Sterry built the pioneering São Luiz de Itu Factory and went to Piracicaba, where he installed and managed the Santa Francisca Fabric Factory (figure 285).

Figure 8

The Santa Francisca Fabric Factory at the beginning of the twentieth century



Fabrica de Tecidos « Arethusina ».

Source: FERRAZ, Mario de Sampaio. Piracicaba and its Agricultural School. Brussels: Imprimerie V. Verteneuil & L. Desmet, 1911, p. 27.

From this period on, it became quite common for foreign engineers from the railroad companies to work in the design and construction and assembly of factories, such as engineer William Ellison, from the D. Pedro II Railroad, responsible for the project of the Brasil Industrial Factory, in Rio de Janeiro (BALLEIRAS, 2003 in MOREIRA, 2007).

According to Bardi (1985):

At that time, São Paulo was adorned with the architecture of representation, but industrial parks were already being built and, if any engineer highlighted the façade, it was at the request of the principal, because the industrial establishments presented simplicity of construction, a harbinger of changes in architecture (Bardi, 1985, p.66 apud MIRANDA, 2003, p. 27).

Thus, in addition to the role of civil engineers in the development of projects for factory buildings, Rufinoni (2004, p. 54) shows that some of the most relevant architects of the period also designed industrial buildings in São Paulo, such as: Julio Michele, for the São Paulo Alpargatas Shed (1907); Giovanni Batista Bianchi, with the building of the Crespi Cotton Swirl (1897); Ramos Azevedo and Ricardo Severo, for the Ernesto de Castro Warehouses; and Victor Dubugras, in the Piratininga General Warehouses project.

Subsequently, Santos (2006) evaluates that in the Vargas government (1930-1945), industrial architecture began a new phase in Brazil, in qualitative and quantitative terms, because in addition to the growth in demand for this type of building (induced by the State), the pioneering relationship was also changed, characterized by imported projects ('packages'), in a typical situation of technological and political dependence.

Thus, from the 1930s onwards, the participation of Brazilian architects and engineers in large-scale manufacturing projects occurred gradually. According to Santos (2006), it was not by chance that, in the Vargas government, the greater participation of Brazilian professionals in manufacturing projects coincided with the modernization of industry, at a time when the concepts of the Modern Movement, which had been experimenting in Europe and the USA since the 1920s, were disseminated. Deemed

A diffuse ideology, but through the few schools, incipient patronage and especially public works, it guided Architecture and Engineering in the country in the following decades. Significant examples of Industrial Architecture were designed and built. Some are references to the creative capacity of Brazilian architects (SANTOS, 2006, p. 28).

However, in this period, Santos (2006) considers the participation of foreign architects and engineers who migrated to Brazil as a result of the world wars and in search of the new professional opportunities provided by Brazilian industrialization to be remarkable.

The author also highlights the training of these professionals through the ascending publication of industrial projects in articles in specialized journals of Engineering and Architecture, which were created in large numbers during this period, and the specialization of products, companies and professionals who began to dedicate themselves especially to manufacturing projects in these sources is noticeable (MAFFEI, 1982 and SEGAWA, 1997 apud SANTOS, 2006, p. 28).

The engineers who developed projects for the manufacturing buildings of the Engenho Central had academic training in the best educational institutions in France, such as Ecole Polytechnique, Ecole Centrale des Arts et Manufactures, Ecole Supérieure d'Electricité, Ecole des Arts et Métiers, Ecole Nationale des Industries Agricoles, Institut Industriel du Nord, among others (MIALHE, 2012), which justifies the quality of the projects, as well as its execution.

4 DISCUSSION

In this study, we sought to understand the formation and consolidation of industrial architecture in Brazil as a material expression of the economic, technical and cultural transformations that marked the process of national industrialization. Starting from a long historical path, from the factory restrictions imposed by the colonial system to the expansion of the large industries of the twentieth century, it was sought to demonstrate that, although late and dependent on foreign models, Brazilian industrialization developed its own architectural solutions, appropriate to local conditions and deeply linked to the territory.

The analysis showed that each stage of industrialization: prohibition, implementation, Brazilian industrial revolution, internationalization and expansion; corresponded to specific economic and political contexts, influenced by factors such as the coffee cycle, European immigration, the advance of railroads and state incentive policies, especially in the governments of Getúlio Vargas and Juscelino Kubitschek. These elements were decisive for industrial growth and for the consolidation of manufacturing centers, especially the State of São Paulo.

From the typological point of view, two main matrices were identified: the colonial, inherited from the sugar mills, and the Manchesterian, inspired by the British factories of the

nineteenth century. of lighting and large chimneys, which became symbols of progress and industrial modernity.

The forms of implantation of factories also revealed a significant evolution: from isolated mills to factory complexes and complexes articulated with railroads, new cultural landscapes emerged, in which workers' villages, schools, warehouses and churches express the intertwining between work, urbanization and daily life.

Finally, Brazilian industrial architecture cannot be understood as a simple imitation of European paradigms, but as a process of critical and creative appropriation, in which engineers and architects, such as Giovanni Batista Bianchi, Ramos de Azevedo, Ricardo Severo and Oscar Niemeyer, adapted concepts and techniques to the material, climatic and social realities of the country. Thus, industrial architecture constitutes an essential cultural heritage for the reading of Brazilian modernization, representing the living memory of the relationship between technology, territory and work.

5 CONCLUSION

The analysis of industrial architecture in Brazil allows us to understand that the development of this typology was profoundly conditioned by the economic, political and technological transformations that shaped the national industrialization process. From the colonial mills to the large factories of the twentieth century, it is observed that architectural evolution has always been associated with productive dynamics and forms of work organization, revealing the constant dialogue between tradition and modernity.

Although the country entered the industrial process late, under a strong dependence on foreign capital, techniques and models, Brazilian industrial architecture consolidated its own identity. This identity results from the creative adaptation of European models, especially the British and French, to the local conditions of climate, materials and labor, producing original architectural solutions that combined functionality, economy and aesthetics. The striking presence of exposed brick masonry, metal structures, shed roofs and chimneys became a symbol of industrial modernization and the emerging urban landscape.

The implementation of the factories, initially along watercourses and, later, railways and highways, profoundly transformed the territory, giving rise to industrial complexes and complexes accompanied by workers' villages and social equipment. These industrial centers not only boosted urban growth, but also configured new cultural landscapes and ways of life, expressing the interdependence between production, housing and social coexistence.

From a professional point of view, the study shows the passage from an initial phase, dominated by foreign engineers and imported projects, to a stage of technical and creative autonomy, marked by the work of Brazilian architects and engineers such as Giovanni Batista Bianchi, Ramos de Azevedo, Ricardo Severo and Oscar Niemeyer. This transition symbolizes the maturity of the national industrial architecture, capable of integrating technique, function and form in line with the demands of a country in modernization.

In summary, the historical path of industrial architecture in Brazil reveals more than the evolution of a constructive type: it mirrors the very trajectory of the formation of the modern nation. The factories, warehouses and workers' villages are material testimonies of a period of intense transformations, representing a cultural heritage of high historical, aesthetic and social relevance, whose preservation is essential for understanding the relations between technology, territory and collective memory in contemporary Brazil.

ACKNOWLEDGMENTS

Prof. Dr. Beatriz Mugayar Khül, Graduate Committee FAU USP.

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ASPECTS OF CRIMINALITY IN CITIES OF PAULISTA

ASPECTOS DA CRIMINALIDADE DAS CIDADES PAULISTAS

ASPECTOS DE LA CRIMINALIDAD EN LAS CIUDADES PAULISTA

 <https://doi.org/10.56238/sevened2025.036-037>

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ABSTRACT

The present work has that goal to verify empirically the economic and social determinants of crime in the cities of São Paulo State. Due to wide range of crime-related components, this work to estimate an econometric model able to show what impact economic and social variables have on the types of crimes (murders, thefts and robberies) that are present in the cities of São Paulo. Using cross-sectional data for all cities in São Paulo during the year of 2010, the study presents has as the crime rates react with the explication variable in the degree of urbanization, participation of young male population, Gini index, income per capita, illiteracy rate, spent on public safety and growth rate of crimes in the previous year to 2010. The results show an important inertial component in the crime rate. To the rate of thefts only spent on public safety is connected with the theft of the cities. For the murder rate model, variables such as per capita income and unemployment were those that had a negative relationship with their dependent.

Keywords: Crime Rate. Public Safety. Thefts. Robberies and Homicides. Economic Variables.

RESUMO

O presente trabalho tem como objetivo verificar empiricamente os determinantes econômicos e sociais da criminalidade nas cidades do estado de São Paulo. Devido a ampla gama de componentes ligados à criminalidade, este trabalho buscou em estimar um modelo econométrico capaz de apresentar qual o impacto que variáveis econômicas e sociais têm sobre os tipos de crimes (homicídios, furtos e roubos) que estão presentes nas cidades paulistas. Com a utilização de dados em corte transversal para todas as cidades paulistas durante o ano de 2010, o estudo apresenta como os índices de criminalidade reagem com a variação no grau de urbanização, participação da população jovem masculina, índice de Gini, renda per capita, taxa de analfabetismo, gasto com segurança pública e taxa de crescimento dos índices de crimes no ano anterior a 2010. Os resultados obtidos apontam para um importante componente inercial na taxa de criminalidade, que para a taxa de furtos apenas o gasto com segurança pública tem relação negativa com os furtos das cidades. Para o modelo de taxa de homicídio, variáveis como renda per capita e taxa de desemprego foram as que tiveram relação negativa com sua dependente.

Palavras-chave: Taxa de Criminalidade. Segurança Pública. Furtos. Roubos e Homicídios. Variáveis Econômicas.

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RESUMEN

El presente trabajo tiene como objetivo verificar empíricamente los determinantes económicos y sociales del crimen en ciudades del estado de São Paulo. Debido a la amplia gama de componentes vinculados al crimen, este trabajo buscó estimar un modelo econométrico capaz de presentar el impacto que las variables económicas y sociales tienen sobre los tipos de delitos (homicidios, hurtos y robos) presentes en las ciudades de São Paulo. Utilizando datos transversales de todas las ciudades de São Paulo durante el año 2010, el estudio presenta cómo las tasas de criminalidad reaccionan con la variación en el grado de urbanización, la participación de la población masculina joven, el índice de Gini, el ingreso per cápita, la tasa de analfabetismo, el gasto en seguridad pública y la tasa de crecimiento de las tasas de criminalidad en el año anterior a 2010. Los resultados obtenidos apuntan a un importante componente inercial en la tasa de criminalidad, que para la tasa de hurto sólo el gasto en seguridad pública tiene una relación negativa con el hurto en ciudades. Para el modelo de tasa de homicidios, variables como el ingreso per cápita y la tasa de desempleo fueron las que tuvieron una relación negativa con el dependiente.

Palabras clave: Tasa de Criminalidad. Seguridad Pública. Robos. Robos y Homicidios. Variables Económicas.

1 INTRODUCTION

The criminal economy has been gaining more and more prominence in the concern of Brazilian citizens and in the news of the mainstream media. However, Brazil has managed to achieve important economic results in the last decade in relation to extreme poverty, an increase in real wages simultaneously with an improvement in the labor market since 2003, which has resulted in a slight decrease in income inequalities, benefiting workers and families, as well as other social advances (DIEESE, 2014). Nevertheless, other economic and social factors still remain crucial problems that affect the lives of the population, such as crime rates (against life and property).

Although these improvements mentioned above are not yet in the standards of developed economies, there have been advances. However, these were not able to reverse the negative numbers that most Brazilian cities present on crime (thefts, robberies and homicides). An example of this negative situation are the IPEADATA figures, in which the evolution of the number of homicides in Brazil in five years from 2005 to 2009, showed an increase from 47578 in 2005, to 50318 for the year 2009.

This concern about crime has been gaining more and more space among researchers, whether in the social, economic or political areas, seeking to understand how economic and social variables can explain this phenomenon of crime. Balassiano et al. (2012), for example, applied an econometric model including economic variables such as unemployment, income distribution index and wage levels, with the objective of explaining crime in the state of Rio Grande do Sul. In this model, they also considered the different types of crime, with the intention of verifying whether each crime had different explanatory variables. This division of type of crime was classified as homicide, number of robberies and number of assaults on vehicles or other goods.

As with the work done for Rio Grande do Sul, the objective of this study is to try to understand the main variables that affect the crime rate of the municipalities of the state of São Paulo in the year 2010, applying an econometric model similar to the one done in Balassiano, et al. (2012).

We will use the crime rate considering two types of crimes: (i) homicides and (ii) thefts and robberies. The explanatory variables used will be: degree of urbanization, participation of the young male population aged between 15 and 24 years, Gini index, *per capita* income, illiteracy rate, public security expenditure and growth rate of crime rates in the year prior to 2010 (this variable seeks to capture the inertial component in the crime rate). With this, we

seek to understand how these chosen variables contribute to the increase or decrease of crime rates in the municipalities of São Paulo. And, in return, offer pertinent information to the authorities involved with public policies to combat crime, identifying its main economic and social aspects. It should be noted, however, that this work is a static and not a dynamic portrait for the year 2010.

1.1 PROBLEM AND ITS IMPORTANCE

In 2012, Brazil had around 50 thousand homicides according to Stuenkel (2014). Even with the drops in the homicide rate in some states, São Paulo still has alarming numbers. In 2005, the state had 8727 cases, decreasing this number to 6310 in 2009 (IPEADATA). Although there is a drop in the number of cases with intentional homicide, it is still considered relatively high when it comes to the number of lives that are lost every year, whether for economic or social reasons.

Analyzing the data from the work of Stuenkel (2014), it is noted that the number of homicides is not a problem exclusive to the state of São Paulo, which, by the way, has a rate much lower than the national average of 26.2 in 2010, according to the Map of Violence 2012. It is worth noting that São Paulo showed a significant drop in the numbers for the homicide rate from 42.2 in 2000 to 13.9 in 2010 for every 100 thousand inhabitants.

Being the richest state in the federation (ROTARY-SP), its economic importance is extremely relevant for Brazil, however, it must be taken into account, if really, better economic indices denote better indices in relation to the crime present in the cities of the richest Brazilian state. However, the other states of the country are always seeking to raise the levels of their economic activity in order to generate better living conditions for their population.

The objective of this study is to analyze the determinants of crime in the municipalities of the state of São Paulo in 2010, separating the variables (i) homicides and (ii) thefts and robberies. This division seeks to understand the specificities of each type of crime and how economic variables affect them differently.

In relation to economic aspects, crime generates insecurity, unhappiness and loss of manpower. In view of the data presented, most homicides occur among young people aged between 15 and 24 years, as revealed by the 2010 Map of Violence, as well as in Mello and Schneider (2004), who obtained in their results an elasticity of 4.5 for the variable participation of the male population between 15 and 24 years old, representing that the increase of 1% of the young population represents an increase of 4.5% in the homicide rate in the state in the

years 1990 to 2000, for women they also present significant parameters, representing a very large loss of young people in cases of intentional homicides.

From 2000 onwards, both federal and municipal authorities began to act with greater intensity in public security issues, managing to reduce the numbers related to crime, contributing to the increase in improvements in socioeconomic conditions. The relative decrease of young people in the population due to the drop in the birth rate in recent years has also contributed to the drop in crime rates in the State of São Paulo, since there is a greater propensity of young people to participate in criminal activities. Just as the more incisive presence in the areas of criminal justice has helped to reduce this rate:

During this period, there was also an increase in the growth rate of incarceration and sentences to alternative sentences. Finally, to complete the favorable scenario, it was possible to proceed with a relative control in the diffusion of firearms. The major problem observed in this last period refers to the growth of the illicit psychoactive drugs market. Still, after 11 consecutive years of increase in the homicide rate, it has begun to recede. (CERQUEIRA, 2010)

Considering other types of crimes, statistics such as robberies and thefts have a high level considering world standards. According to the São Paulo Public Security Secretariat, the capital city had a 41.8% increase in the number of robberies in the interregnum of 2013 and 2014. A survey by the security secretariat shows a comparison of robberies in the capital with robberies throughout the state. The result shows that in the capital alone, the number of robberies went from 8380 in 2011 to 13416 in 2014. The numbers found for the entire state were 18076 in 2011, increasing to 26987 in 2014, emphasizing that these numbers do not include vehicle thefts, but cargo theft, banks and homes.

In view of this fact, the feeling of insecurity that the population of large cities feels when they are circulating on the streets of their municipality is perceived. It is increasingly dangerous to travel at times with less flow of people on the streets, the fear of being robbed on the way home to work is increasing. With such a situation, even commerce feels the reflections of this fear that the population has due to the numbers of thefts and robberies in a certain region, whether in the smaller number of people who pass in front of the establishment, or in the risk of it being robbed.

In the work presented by Carvalho et al. (2014), they show the diffusion of crime that is occurring from the capital to the cities of the interior, breaking the taboo that the cities of the interior have total tranquility to live in. The study describes that criminals, when they

realize that small cities have possible victims to practice their robberies, take advantage of the more precarious security system of these municipalities, which end up making an environment conducive to robberies of securities institutions such as banks and jewelry stores, as well as people.

Some studies that relate the economy to aspects of crime associate economic performance and development with an increase or decrease in criminal activity (SANTOS et al., 2008; ANDRADE et al. 2007; ARAÚJO, 2002; BEATO FILHO, 2002). Even in a stable economy, economic factors such as income inequality, wage levels and unemployment are not able to mitigate the negative social effects generated by better numbers of these variables.

Thus, as described in macroeconomics textbooks, a low unemployment rate remains heated, and in parallel, with the result of better wages, the opportunity costs of perpetrators of crimes against property increase. It is worth noting that, in an environment with discrepant inequality, the offender is often faced with others who have assets and income relatively higher than his, which can induce acts of theft and robbery, promoting, even if inconsequentially, a distribution of income, in which the one who has less, takes possession of part of the assets, of the one who has more (BECKER, 1968).

However, it is hoped that this work will contribute to the understanding of the relevant causes of crime that the country has been facing for years, and which, unfortunately, consumes millions of lives, which has even reached the mark of more than one million people in three decades of recorded data, (CERQUEIRA, 2010). Another factor associated with crime is the loss of well-being that occurs with the increase in the number of crimes against property and against life, producing negative economic impacts.

1.2 GENERAL OBJECTIVES

This paper seeks to explain the most relevant causes of homicides, robberies and thefts in the municipalities of São Paulo in 2010, conditioning the components such as unemployment rate, *per capita* income, gini index, participation of the young male population, illiteracy rate, degree of urbanization, crime rate of the previous year and spending on public security. Using an econometric model of multiple regression, it is possible to estimate parameters that represent the impact of each variable on the components of crime, theft, robbery and homicide.

1.3 SPECIFIC OBJECTIVES

The specific objectives are to verify which are the most relevant economic variables to explain (i) homicides and (ii) thefts and robberies. With this, we will seek to understand the specificities of each type of crime, as well as the influence of each of the explanatory variables considered. Although it is a static and not dynamic work, we will seek to understand the aspects of each type of crime committed against life and property, in an attempt to contribute to the reduction of crime rates in the municipalities of São Paulo, being a possible orientation for policies that have this purpose.

2 THEORETICAL FRAMEWORK

Becker (1968) is the main reference when it comes to Economics of Crime. He proposed a model in which the behavior of criminality is conditioned by an individual process in the context of the rational choice model. In this way, the agent, when making his decision to commit or not commit a crime, compares possible costs and benefits of this activity. Thus, economic and social variables that describe the situation of a particular region or municipality could impact the choice of whether or not to enter into criminal activity.

In addition, as pointed out in Ehrlich (1973), income inequality can impact the choice of criminal activity. Thus, an increase in inequality would lead to an increase in criminal activity. A more recent model than the one presented in 1973, which relates crime to income inequality, was proposed by Mendonça (2003). In his work, he describes that the innovation of introducing the reference income variable into the classic structure of rational choice, mentioning the consumption expectations of individuals. With the impossibility of earning this income through the normal means of the labor market, such a situation drives the agents to resort to crimes in search of additional income and, thus, to obtain the reference income that had been imposed on them by their living environment. It is noted that a district with greater income inequality increases this difference, increasing the frustration of those who are on the verge of committing a criminal offense. In this context, new works add an explicit variable such as the Gini index to capture this theoretical dynamic.

Work such as the one offered by Sah (1991) is inferred in a model that shows that the citizen who has been convicted once for criminal activity has a certain tendency to be a repeat offender in the criminal act, since, when trying to re-enter the labor market, he finds it more difficult to reinsert, causing his opportunity cost against the patrimony to be reduced, inducing the field of violence again. Given this greater uncertainty in the labor market for people who

have already been incarcerated, crime can have an inertial character with these verified characteristics.

Regarding the empirical literature, we can cite the work of Hartwig (2010). It presents an estimate for crime in the State of Rio Grande do Sul using variables such as the participation of young people in the population, drug addiction, which refers to the number of occurrences or arrests of cases involving drug trafficking, income level, degree of urbanization and dummy for coastal cities in the South region. In this study, Hartwig used panel data for the years 2002 to 2006, the estimation method was the clustered MQO (Minimum of Ordinary Squares), finding a positive correlation for per capita income, degree of urbanization, dummy for coastal cities and drug addiction, however the correlation of crime in the population between 15 and 24 was negative, in contradiction to what was expected.

In this context, researchers from different areas of knowledge who work in research, dedicate more time of their time to be able to solve these problems and contribute more effectively, generating better results to this issue faced by Brazil and the world, which consume many lives every year. As the study of this work is referenced in the state of São Paulo, it is worth mentioning with greater emphasis some studies of Brazilian cases and in this specific area.

Andrade and Lisboa (2000) applied their models in an attempt to explain the evolution of homicide rates in the states of Minas Gerais, Rio de Janeiro and São Paulo, between 1981 and 1997. With this research, they identified that the homicide rate was related to the age group of men aged between 15 and 40, and that economic factors such as real wages, unemployment and inequality coefficient could explain the characteristics of homicides, showing that for other places with these same characteristics they could present similar results. From the collection of annual data in time series, the study observes that young people between 15 and 19 years of age, when there was an increase in their real salary, there was a drop in the homicide rate. However, the same process did not occur in older age groups. In this sense, it allows the acceptance that the effect of real wages in this age group of 15 to 19 years corroborates in a more forceful and lasting way in the fight against violence.

Another work that addresses this subject can be referenced by Hartung and Pessoa (2007), who apply similar models working with temporal factors to explain the inductions of homicide crimes. This time the approach becomes more specific, making the scope of application of the study the city of São Paulo, based on the demography of the region in the period between 1980 and 2000. Based on this analysis, he projected that the rates of theft

and robbery combined with a positive relationship with the level of income and inequality during these periods of economic instability, showing that it is not enough to make only one model for this type of explanation of crime, without taking into account the economic situation in which the agents are inserted.

3 METHODOLOGY AND RESULTS

3.1 EMPIRICAL MODEL AND ECONOMETRIC TESTS

For the estimation of the econometric model, it is intended to work with the following regression:

$$C_{s,i} = \beta_0 + \alpha C_{s,t-1} + \sum_{j=1}^k \beta_j X_{j,i} + u_i \quad (1)$$

Where:

$C_{s,i}$ = crime rate s at instant t (per 100 thousand inhabitants)

β_0 = Equation Intercept

α = parameter of the dependent variable lagged at $t-1$

$X_{j,i}$ = represents the k th explanatory variables

β_j = represents the parameters that will be estimated for the explanatory variables

u_i = is the term of the random error

Regarding the stage of verification of the adequacy of the model, the Jarque-Bera test was used to test whether the regression residuals follow a normal distribution. The data distribution curve should show kurtosis equal to three and asymmetry equal to zero. To confirm the normality of the residuals, a hypothesis test is applied, which the null hypothesis of the test implies a normal distribution of errors, following this characterization we have:

H_0 : $S=0$; $K=3$ (distribution is normal)

H_1 : $S \neq 0$; $K \neq 3$ (distribution is not normal)

Where:

S stands for Asymmetry and K stands for Kurtosis.

The decision rule used was p-value higher than the chosen level of significance indicates acceptance of the hypothesis, lower p-value is rejected in favor of where the distribution is not normal. $H_0 H_0 H_1$

The White Test was performed to verify whether there is heteroscedasticity, that is, to verify whether or not the residuals (U_i) have constant variance. This problem is verified when there are very discrepant databases (*outliers*), for example. As the model used works with several cities, which have different numbers of crime rates, especially in relation to large urban cities and small rural areas, the errors may present heteroscedasticity, due to the value of the variance of the samples. The hypotheses tested to verify the presence of heteroscedasticity of the model have the decision rule:

$$H_0: N^* > (\text{heteroscedasticity}) R^2 X_m^2$$

$$H_1: N^* < (\text{does not have heteroscedasticity}) R^2 X_m^2$$

3.2 DESCRIPTIVE ANALYSIS OF THE DATA

To carry out this work, it was decided to use secondary data, offered by the database of the STATE SYSTEM OF DATA ANALYSIS FOUNDATION (Seade), with estimation of the model in cross-sectional data with all cities in the state of São Paulo for the year 2010, totaling a sample of 646 cities. Based on the empirical literature, the following variables were included in the model:

- FUR = Theft rate of each city in the state of São Paulo, with the number of thefts occurring per hundred thousand inhabitants. The data were extracted from the database of the SEADE foundation.
- C_FUR = Growth rate of the number of thefts by city in the year 2009 to 2010, with the ratio between the two numbers. Data from the SEADE foundation.
- C_HOM = Growth rate of the number of homicides per city in the year 2009 to 2010, with the ratio between the two numbers.
- A_15_24 = Numbers of young people aged between 15 and 24 years of age for each city in the year 2010 in absolute numbers, SEADE foundation.
- DESEMP = Unemployment rate verified by city in the state, calculated by DATASUS.
- G_URB = Degree of urbanization obtained by the ratio of the urban population of the city to the total population of each city in 2010. SEADE.
- GINI = Gini index as a variable to measure the level of income concentration in the

cities of São Paulo, which the index that presents a number close to zero is consistent with the city with the lowest concentration of income and, values close to one with a higher concentration. DATASUS.

- ANALF = Illiteracy index of the cities, this data is calculated through the percentage of illiterates in relation to the total population of the city. SEADE.
- RENDA_PC = Per capita income, a variable found by dividing the city's GDP by its population in current reais. SEADE.
- G_PUB = Public expenditure on public security in each city in the year 2010 in current reais. SEADE.

In this part of the descriptive analysis, we seek to present the behavior of the explanatory variables and the dependent variable, relating them to each type of city, verifying the numbers in relation to metropolitan regions with a concentration of large industries, cities more focused on rural activity and others that have tourist attractions as attractions, present more clearly in coastal cities.

Starting with the description of the homicide rate that each city in São Paulo presents, it is noted that the city of Suzanápolis has the highest number of homicides for every hundred thousand inhabitants. To explain the behavior of this variable in a more forceful way, TABLE 1 shows which are the cities in São Paulo with the highest homicide rates in 2010.

Table 1

The 10 cities with the highest homicide rates in the state of São Paulo in 2010. (Homicides for every hundred thousand inhabitants)

Locality	Tx of homicide
Suzanápolis	1124,93
Santa Salete	968,19
Monteiro Lobato	267,25
Mira Estrela	248,40
Rinópolis	181,12
Fernando Prestes	144,59
Santana da Ponte Pensa	121,73
Flora Rica	113,96
Barra do Turvo	64,67

Embu

63,78

Source: Prepared by the authors with data from SEADE.

Suzanápolis is the city with the highest homicide rate, located in the mesoregion² of Araçatuba and microregion of Andradina. The city is 641 kilometers from the capital, in 2010 it had a population of 3378, according to data from the SEADE FOUNDATION. Its economic activity is more focused on beef cattle ranching in an extensive way with large land tenants. As TABLE 1 shows, Suzanápolis had 1124.93 cases of intentional homicide per hundred thousand inhabitants in 2010, a result well above the average of the same year for all cities in São Paulo, which was 13.02 per hundred thousand inhabitants.

Santa Salete, which is the second city with the highest homicide rate in the state, has characteristics similar to those of Suzanápolis, with a population of 1,447 inhabitants (IBGE/2010) and an area of 79.4 km². Santa Salete belongs to the Microregion of Jales. As well as the city with the highest homicide rate, Santa Salete's main economic activity is livestock and agriculture. Of the 1447 citizens living in the city, 819 are in the urban area and 628 are in the rural area, its demographics have 50% of people living in the rural area and a high homicide rate for every hundred thousand inhabitants with 968.19, very high in relation to the state average as well.

Another municipality with a high homicide rate, ranking third in the *ranking*, is Monteiro Lobato, located in the micro-region of Campos do Jordão, 132 kilometers from São Paulo, with an estimated population in 2010 of 4116 inhabitants (SEADE), 1516 in the urban area and 2100 in the rural area. The main economic activity is agriculture, with emphasis on the cultivation of beans, rice and corn, beef and dairy cattle raising, as well as pigs and horses. Embu, which from 2011 onwards was renamed Embu das Artes after a plebiscite held in the city, among the 10 cities is the one that is inserted in the Metropolitan Region of São Paulo, 30 kilometers from the capital, according to the SEADE FOUNDATION, had in 2010 about 63.78 homicides for every hundred thousand inhabitants.

In the entire State of São Paulo, in 2010, two hundred and sixty-two cities did not have homicides within their municipality, a very expressive number considering the total number of

² **Mesoregion** is a subdivision of Brazilian states that brings together several municipalities in a geographic area with economic and social similarities, which in turn are subdivided into microregions. It was created by the IBGE and is used for statistical purposes and therefore does not constitute a political or administrative entity.

the state, which has six hundred and forty-five cities, including Santana de Parnaíba, Monte Mor, São José do Rio Pardo, Dracena and Brotas.

Even with the positive changes in aspects such as the decrease in the Gini index that serves to analyze the level of income concentration, with an interval from 0 to 1, the lower the index, the better the income distribution in the country, region, state or city. According to the PNAD time series, the index had a significant reduction in the period from 2001 to 2011, presenting results from 0.594 to 0.527, respectively. In view of this information, it is sought to present how the crime rates behave in the face of these variations in the Gini, unemployment and average income of workers. An increase in the real wage of workers also seeks to explain this context of crime that occurs in São Paulo cities. Since 2003, the value of the minimum wage has had a real growth (already discounted for inflation) of 72.31%, according to data from the Inter-Union Department of Statistics and Socioeconomic Studies (Dieese), benefiting 48 million people and contributing to the increase in the average income of wages in recent years.

Another important component for the explanation of the dependent variable is unemployment, since crime can be conditioned by the number of people who cannot find work, but need income to survive, such a link between these two components can come from this need for consumption and the low opportunity cost of the individual who enters the criminal activity, in the search for social insertion, also highlighting that the existence of laws that allow the offender to easily avoid being punished may be another factor that induces an increase in crime. However, according to the data on unemployment, there is also a significant drop in the period 2000-2013, from a rate of around 20% to approximately 5% in 2013 (SUMMA, 2014).

As the 10 cities with the highest homicide rate, there is no city with industrial agglomerations and high demographic density, TABLE 2 brings the numbers of the 20 largest cities in the state and shows their crime rates, unemployment rate, gini index and population.

Table 2

Homicide Rate, Population, Unemployment and Gini Index of the 20 largest cities in the State of São Paulo

Locality	Population	Gini	Unemployment	Tx of homicide
São Paulo	11.245.983	0,6453	7,2	10,63
Guarulhos	1.220.653	0,5345	9,57	13,44
Campinas	1.079.140	0,5782	6,26	14,55

S. Bernardo do Campo	764.922	0,5525	7,94	8,89
Santo André	676.177	0,5428	7,94	11,54
Osasco	666.621	0,5459	7,93	9,15
São José dos Campos	629.106	0,5633	7,14	8,74
Ribeirão Preto	603.774	0,5458	4,91	7,12
Sorocaba	585.780	0,529	8,4	10,07
Saints	419.388	0,5624	7,59	8,58
Mauá	416.585	0,458	11,68	7,92
São José do Rio Preto	407.816	0,5081	4,1	6,87
Mogi das Cruzes	387.260	0,5487	9,38	8,52
Diadem	385.838	0,4592	9,44	20,99
Jundiaí	369.710	0,5435	5,28	5,14
Carapicuíba	369.368	0,4965	8,98	11,64
Piracicaba	364.261	0,5398	6,41	10,71
Bauru	343.695	0,5596	5,87	13,09
Saint Vincent	332.193	0,4892	9,43	13,25
Itaquaquecetuba	321.329	0,4556	12,05	20,23

Source: Prepared by the authors with data from SEADE and DATASUS (2010).

In TABLE 2, it is observed that the capital, which is the largest city in the state, has a homicide rate per hundred thousand inhabitants of 10.63, slightly below the state average. With 11,245,983 inhabitants, the city of São Paulo has the worst index of gini, in which the higher the index, the greater the concentration of income in the city. The average unemployment rate of the ten largest cities in the state is 7.87%, so the capital is below average with 7.2%, in this regard São José do Rio Preto is the city that has the lowest unemployment rate, 4.1%, Itaquaquecetuba has the highest, 12.05%, among the ten largest cities in the state. São Paulo occupies the eighth position, behind Ribeirão Preto, Jundiaí, Bauru, Campinas, Piracicaba and São José dos Campos. The lowest gini index found among these cities is found in Itaquaquecetuba with 0.4556, followed by Mauá and Diadema, which have 0.458 and 0.4592 respectively, both belonging to the Metropolitan Region of São Paulo.

Among this selection of cities, Jundiaí is the one with the lowest homicide rate, about 5.28 deaths for every hundred thousand. On the other hand, those with the highest homicide rates are those with the best indicators of income concentration, Diadema and Itaquaquecetuba, bringing with them 20.99 and 20.23 respectively.

As shown in TABLE 2, Guarulhos has a population of 1,220,653 inhabitants, 13.44 homicide rate, 9.57 unemployment rate and 0.5345 for the gini index. In the ranking of the homicide rate, Guarulhos occupies the fourth position, above the state average. Its

unemployment rate is also above the average of 6.72%. In relation to the concentration of income, its index is almost a tenth-higher than the average.

Campinas, the third largest city in the state, shows that it has the second highest index of gini, behind only São Paulo, which has the most concentrated income of this group, its index in 2010 was 0.5782. The city's unemployment rate was below the state average, standing at 6.26%, on the other hand, its homicide rate is in third position considering the group of the ten largest cities, standing at 14.55 deaths for every hundred thousand. Its estimated population for the same year was 1,079,140.

Now analyzing the characteristics of the last three cities among the twenty selected, starting with Bauru, it had an estimated population of 343,695 in 2010, a gini index of 0.5596, slightly above the average in relation to this group of cities. Its homicide rate was 13.09, very close to the state average of 13.02 for the same year. The unemployment rate is among the lowest in the group, with 5.87.

Following the analysis São Vicente, a coastal city with 332,193 inhabitants, presented a homicide rate of 13.25 for the year of selection, considering the ranking among the twenty cities, São Vicente would be in the fifth position in the aspect of value above the state average more than three percentage points that was observed at 6.27%. In relation to its gini index, it is in the fourth position of least concentrated income with 0.4892.

As the work also focuses on the theft rate of the cities of São Paulo and not only on the homicide rate, table three brings some of the data regarding the numbers of thefts in the municipalities in 2010, which were the highest and lowest rates for the year of study.

Table 3

The ten highest and lowest theft rates per hundred thousand inhabitants

THEFT RATE			
	10 More		10 Less
Ilha Comprida	7097,63	207,47	Santa Salete
Aparecida	3507,97	199,76	Colonel Macedo
Mongaguá	3096,18	197,91	Piquerobi
Itanhaém	2919,96	196,54	Santa Rita d'Oeste
Guaíra	2814,34	189,47	Guzolândia
Ilhabela	2552,89	159,07	Mesópolis
Praia Grande	2351,27	158,51	Gavião Peixoto
Barretos	2348,48	98,45	Monte Castelo
Peruíbe	2316,66	59,54	Stream
Ilha Solteira	2259,03	27,25	Balbinos

Source: Prepared by the authors with data from SEADE

Following the data in TABLE 3, which presents which are the cities with the highest and lowest theft rate per 100 thousand inhabitants, selecting the ten most and the ten least dangerous in relation to the number of thefts. As shown in the table, the city of Ilha Comprida is the municipality that has the highest theft rate in the state of São Paulo in 2010, with 7097.63 thefts for every hundred thousand inhabitants. Campina do Monte Alegre according to SEADE, (2010) had a population of 9003 inhabitants, the municipality is located 209 kilometers from the capital on the south coast of São Paulo.

In second place in the ranking is Aparecida with 3507.97 thefts per 100 thousand, population in 2010 of 35006 (SEADE), belonging to the region of Vale do Paraíba Paulista, is 168 kilometers from the capital. The city is very famous for its Basilica of Our Lady of Aparecida, it is considered one of the largest religious pilgrimage centers in Latin America, receiving millions of visitors annually, making the municipality one of the main tourist attractions in Brazil. Although the city has a large part of its economy linked to services and commerce that comes from municipal tourism, it brings with it a high number of thefts to the city, due to the large flow of people in the city at a certain time of the year.

Concluding the three cities with the highest theft rates in the state comes Mongaguá, another coastal city in São Paulo. In 2010 its population was estimated at 46186, it is located 93 kilometers from its capital, in the same year the city had a theft rate of 3096.18. Note that of the 10 cities selected, six of them are with beaches, Guaíra and Barretos, which are in the northeast of the state bordering Minas Gerais and Ilha Solteira, which is to the northwest of the state on the bank of the Paraná River, and Aparecida, which has already been mentioned, are the municipalities that do not border the sea. Although these cities are not coastal, they have similar characteristics, which is the attraction of tourists at a certain time of the year, Barretos and Guaíra have the pedestrian party, Ilha Solteira has its Carnival and university games and Aparecida its Basilica of Our Lady.

Looking at the opposite side of the table, in which we have the municipalities with the lowest numbers referring to theft rates in the cities of São Paulo, in the best position is the city of Balbinos with a little more than 3900 inhabitants in 2010 (IBGE), 405 kilometers from São Paulo in the mesoregion of Bauru and has a theft rate of 27.25 per hundred thousand inhabitants. Its economy has as its main activity agriculture in the cultivation of sugar cane, an interesting detail of the city is that in 2005 there was the construction of two prisons in the city, which according to the residents, enabled a better performance in commerce, because of the increase in the number of people who visit the imprisoned family members and even the increase in its population, or in the number of prisoners, who are counted as residents of the city, and even the relatives of the prisoners who end up moving to another city to be closer to the jail and be able to visit them every week.

The second city with the fewest thefts per hundred thousand inhabitants is Ribeira, located 354 kilometers from the capital, on the border with Paraná, population in 2010 of 3358, with a theft rate of 59.54 for the same year. Agriculture is the economic base of the municipality, with the production of bananas, exported to the capital, and also the cultivation of oranges, rice, sugarcane, beans, cassava, corn and cattle, pork and poultry farming. The raising and export of cattle are of great importance to the local economy.

Monte Castelo is the third best city in relation to the number of thefts per hundred thousand inhabitants in the state, with 98.45 in theft rate. With 4063 inhabitants in 2010, it is located in the micro-region of Dracena, 679 kilometers from São Paulo. Per capita income in 2010 was R\$17,039.15. Its economy is focused on agriculture with a strong participation of sugarcane and cattle raising.

Among all the municipalities of São Paulo, the average number of thefts per hundred thousand inhabitants in 2010 was 1005.82. São Paulo, which is the largest city, has 1904.85, almost double the state average, Campinas, another large city in the state, has 2036.52. It is noted that the lowest numbers of the theft rate are found in municipalities further away from the capital and with agricultural activity.

4 RESULTS AND DISCUSSIONS

After estimation of the regression considering several combinations of chosen variables. The best estimated model was the theft rate of the cities of São Paulo for the year 2010, using the following explanatory variables: number of young males aged 15 to 24 years, illiteracy rate in relation to the city's population, per capita income, public spending on public security, growth rate of thefts from 2009 to 2010 and Gini index, without the use of intercept. The unemployment rate was discarded because it did not present a significant parameter, perhaps this is due to the fact that the population with the highest participation in the number of thefts, especially people between 15 and 24 years old, were not looking for a job in the last 6 months before the data collection period, since a positive relationship with the crime rate was expected.

All variables were used in natural logarithm, except for public spending on public security, which for some cities assumes a value equal to zero and thus makes the application of logarithms unfeasible. Table 3 shows the result found for the estimation of the variable theft rate and homicide rate.

Table 4

Analysis of the estimated parameters

Variable	Theft	Homicide
C	-	3,400831 (0,0005)
A_15_24	0,149518 (0,0000)	-0,120648 (0,0125)
Gini	0,427797 (0,0549)	-
Renda_pc	0,240192 (0,0000)	-0,131927 (0,0532)
Urb	0,751130 (0,0000)	-

C_fur	0,940166 (0,0000)	-
Analf	0,222617 (0,0032)	0,273510 (0,0543)
Tx desperation	-	0,387309 (0,0003)
C_hom	-	0,474815 (0,0000)
G_pub	-2.92E-09 (0,0441)	4.19E-09 (0,0134)

Source: Prepared by the authors with E-views 6.0 software

With this estimation, the impact of each explanatory variable on the dependent variable is obtained, remembering that, as previously mentioned, the model has no intercept, which would be the result of the LOG of the theft rate in 2010 if no explanatory variable had undergone any change. Starting with the variable a_15_24, it is observed that the coefficient 0.1495, being a positive number, it says that an increase in the population of young males aged between 15 and 24 years, produces an increase in the theft rate as well. With the use of natural logarithms in the variables, their coefficients already give us the percentage generated in the variable that is being explained, that is, it presents the elasticities of each component of the regression. The interpretation shows that for the variation of one unit in the population aged 15 to 24 years, it corresponds to an increase of approximately 0.15% in the theft rate. In TABLE 4, the values in parentheses represent the respective p-values of each estimated coefficient, showing that all parameters are significant with α of 5%.

For the interpretation of the relationship of the gini index, it is observed that the addition of one unit of this index reflects 0.42% positively in the dependent variable, highlighting that this index varies from 0 to 1, so one unit represents one hundredth considering two places after the decimal point for the index. As has already been proposed in other works that deal with crime, the greater the concentration of income in a country, region or municipality, the greater the propensity of citizens with little or almost no income to commit crime against property, this can even occur as a measure of deconcentration of income in a forced and illegal way, within the laws that guarantee the right to property, evidenced in Mendonça (2003).

In relation to per capita income, the coefficient was also shown to have a positive participation, denoting that the increase of one real in the per capita income of a city increases

the theft rate by 0.24%, with a higher per capita income individuals are more likely to obtain it illicitly, since this higher income does not have a uniform distribution, it makes some have access to consumer goods that others do not have. All variables have a positive relationship with the dependent variable, except for public spending on public security. Following the interpretation, the degree of urbanization increases by 0.75% to dependent, thus, the increase of 1% in the urban population of the city generates an increase in the number of thefts, such a situation may be associated with the fact that in more urbanized cities people are more sensitive to social exclusion, and also, there is the issue of formation of favelas in neighborhoods further away from the central region of the city, In which public policies are less present, especially in education and health, in the absence of public power, criminals take control of these areas.

Trying to capture an inertial component (and also control for possible omitted variables) of the phenomenon explained by the insertion of the growth rate of thefts from one year to the next, it shows that the increase of 1% in the theft rate in one year produces an effect of 0.94% in the following year, showing that this phenomenon tends to keep increasing if this positive variation is not controlled. For the illiteracy rate, the variation of 1% in the rate reflects on thefts in 0.22%, in this case, there may be a scenario that the individual with low qualification, with little or no level of education, tends to participate in criminal activity to equate this educational difference, which submits him to the work of manual labor with lower remuneration.

Therefore, the only variable that showed an inverse relationship to what was expected was spending on public security. However, as this was used at a level (i.e., without the application of the natural logarithm). Although the estimated coefficient is statistically significant, its value is very small, being practically inexpressive to explain the crime rate. However, the exclusion of this variable causes a worsening in the performance of the model (measured by the information criteria), which is why it was decided to include it in the model.

The insertion of these variables mentioned in the model was able to explain the phenomenon studied in 88.78%, verified by the R^2 extracted from the *software* used to estimate the model. With this, it can be said that the components chosen for the model can describe a large part of the theft rate of cities in the state of São Paulo. All parameters were significant at the significance level of 10%.

Perhaps, variables such as corruption rates, measured by the number of complaints with the management of the public machine of a city, number of occurrences of drug seizures

in the city and the lack of daycare centers for children, which can increase the probability of this individual who without receiving dignified conditions at the beginning of his life, generates negative results in the social formation of this citizen. However, these data were not included in the model because some of these variables do not have them for the year 2010 or many cities do not have these values.

To create the estimated linear regression model for the homicide rate variable, a smaller number of observations was used than that used to estimate the theft rate, this difference occurs because the observations for the homicide rate there are many cities that have a number of homicides equal to zero, so this fact makes it impossible to use a logarithm in this variable. With this model, an R^2 of 0.4026 was obtained, i.e., it can describe a little more than 40% of the estimated variable and almost 60% is included in the random error variable.

In the application of the econometric tests mentioned in item 5 of this study, it was observed that for the homicide estimation model there is no autocorrelation in the errors, they have a normal distribution and there is no heteroscedasticity in the errors, all the hypothesis tests performed for each test presented a value greater than 0.10, accepting the null hypothesis of absence of heteroscedasticity, autocorrelation and normal distribution of waste. For the theft rate estimation model, heteroscedasticity was present, which was corrected through White's robust covariance variance matrix. The other of these showed results of normality and absence of autocorrelation.

Table 5

Model diagnosis

	Thefts	Homicides
Jarque Bera	13.85	1.73
White's Test (0.000)*	(0.8382)	
Godfrey-LM (0.5252)	(0.6445)	
R^2	0.8878	0.4026

Source: Prepared by the authors with software eviews 6.0.

* Values in parentheses are the p-values.

From the results of the tests, it is possible to find that the White test in the theft rate model rejected the H_0 hypothesis, however its correction was made with White's robust covariance variance matrix. For the other tests, the null hypothesis was not rejected.

The second model for the homicide rate was generated from a database with 292 observations, so it is understood that 352 observations were excluded, which are the number of cities that had zero deaths by intentional homicide in 2010.

Analyzing the results found, it is clear that the model that best fits to explain the homicide rate using the database of this work was with a regression with intercept whose estimated value was 3.400831, which represents how much the homicide rate of a given city would be if there was no variation of any explanatory variable for the period analyzed. The absolute number referring to the participation of the young population in the city had a negative impact on the homicide rate, inferring that given its estimated coefficient of -0.1206, the increase of 1% in the participation of the young population decreases the homicide rate by 0.1206%, a result different from what was expected, since young people in this age group are more likely to commit acts of crime, as well as in Andrade and Lisbon (2000) who applied an econometric model to the cities of the state of São Paulo, Rio de Janeiro and Minas Gerais between 1981 and 1997.

The illiteracy rate showed a positive correlation, indicating that for an increase of 1% in the participation of illiterate people in the population of a city, the dependent variable moves in the same direction in the proportion of 0.2735%. One hypothesis for this positive correlation may be the case that an illiterate individual is less inserted in society, whether in legal matters or issues of future perspective, which ends up reducing his opportunity cost when committing such a crime, as verified by Becker (1968). Smaller cities in the interior usually have higher illiteracy rates, it may be due to the old customs that these cities still preserve, which generates a relationship of homicide focused on the situation as a crime of passion, hurting the honor of an individual or even the tradition of a family and also the lack of investigation more consists of investigations in cases of homicides in these cities.

Regarding the growth rate of municipal homicides, the behavior of this variable is inferred as an inertial component of the crime rate, that is, if in the previous year the municipality had a high homicide rate, this result will also cause a high rate in the following year. In the estimated regression, its reflection on the dependent denotes that its growth from one year to the next in the variation of one unit generates a positive impact of 0.4748% on the estimated variable. A fact associated with this result must be that in regions high growth of crime makes the citizen who does not participate in criminal activity move from this area to one with fewer acts of crime, making the place that has increasing cases of homicides increasingly under the command of criminal people.

The unemployment rate, which was not significant and had its exclusion for the estimation of the theft rate, was significant for the homicide rate, its relationship with the dependent occurred positively, showing that the increase in the unemployment rate in one unit produces an effect in the same direction for homicides in 0.3873%, such a result was what was expected, Unemployed people are more likely to commit crimes against life, either because of the low opportunity cost "*I have nothing to lose*", or to acquire income in the search for social insertion, considering the cases of robberies that occur in the municipalities of São Paulo.

Per capita *income* was another variable that presented a negative relationship, an acceptable result since a *high per capita income* is assumed that such a region has a labor market with greater opportunities, better public services and even better levels associated with the education of the population. The impact of *per capita income* on the homicide rate infers that for the increase of one real in income generates a drop of 0.1319% in the homicide rate. In the study by Hartwig (2010), the result was also negative for its estimation in Rio Grande do Sul, with panel data from 2002 to 2006.

It is worth mentioning that the gini index was removed from the model because it was not significant at 10% significance, as well as the degree of urbanization of the municipalities. The last variable to be analyzed is public spending on public security, which, because it did not have values greater than zero for all observations, the logarithmic base was not applied to it. However, it showed a positive relationship, demonstrating that increased spending on public security produces an increase in homicide rates. This result, although statistically significant, is not economically relevant (given the low numerical value of the estimated coefficient). In addition, there may be a problem of simultaneity between these variables, a treatment that is beyond the scope of the present work.

5 CONCLUSION

The objective of this study was to empirically analyze the determinants of crime in the municipalities of São Paulo during the year 2010. To this end, a linear regression model was estimated using the following explanatory variables: participation of the male population between 15 and 24 years old, Gini index, per capita income, degree of urbanization, illiteracy rate, spending on public security and growth rate of thefts from 2009 to 2010, estimation for the variable theft and, for the variable homicide rate, the unemployment rate and growth rate of homicides were inserted, excluding degree of urbanism and Gini index.

The results obtained showed that for the homicide rate, spending on public security showed a somewhat controversial result, given that crime is expected to decrease with increased spending on public security, and not the other way around as the model shows. However, as explained, this result, although statistically significant, is not economically relevant (given the numerical value of the estimated coefficient). In addition, there may be a problem of simultaneity between these variables, a treatment that is beyond the scope of the present work.

The explanatory variable that had the most impact on the dependent was the growth in the theft rate in the previous year. This result indicates that the inertial component of criminality is quite important. We can conjecture, perhaps, that the non-punishment of the individual who commits the crime is the main factor in the behavior of this variable, since the offender, having no punishment, continues to commit his crimes, producing this inertial effect.

For the model estimated for the homicide rate, the variable with the greatest explanatory power was also the growth rate of the previous year, the second that most explains the homicide rate was the unemployment rate, with a positive correlation inferring that a 1% increase in the unemployment rate increases the homicide rate by 0.3873%. For *per capita income*, the correlation of the variables was negative, implying that the increase in *per capita income* decreases the homicide rate, as extracted from the model, an increase of one real in income decreases the homicide rate by 0.1319%. The illiteracy rate shows that a 1% increase in this rate increases homicides by 0.2735%.

With the results found for these variables, it is possible to reduce the number of homicides by making more persistent investments in job creation, which in itself produces an increase in *per capita income*, improvements in the education system, which also, in the long run, has an income-generating effect and a better degree of culture of the people who are part of society. producing a more harmonious social environment.

As possible extensions of this work, a dynamic analysis of crime with data for the cities of São Paulo is suggested. In addition, the inclusion of variables such as the corruption index, the index referring to drug trafficking, alcoholic beverages, the number of firearms in circulation in the cities, and even binary variables for black people, in an attempt to verify the social characteristics of the victims of homicides in the municipalities of São Paulo.

DEDICATION

I dedicate this work, first, to my family members, especially my mother and my brothers, who managed to pass on life values to me that enabled me to face any difficulty during my graduation.

My friends from the Federal University of Mato Grosso Rondonópolis campus, with whom I lived for a year at the beginning of my undergraduate studies, especially Talita Palacios who has always been my companion.

To conclude, I also dedicate it to my second family, the Republic of Sorocaba, which not only provided me with a home, but a place where I always had the security of being among good people, with an atmosphere of parties, discussions, respect, football, truco and beer.

ACKNOWLEDGMENTS

My special thanks go to my family, my mother who always encouraged me with her advice and teachings, allowing me to control my anxiety and contribute to the realization of this work. Special thanks also to my professor and advisor Prof. Dr. Andreza Ap. Palma, taught me, guided me, showed me how to do scientific research with econometric analysis, always patient and open to discuss issues pertinent to the research. I thank all the professors of the Department of Economics at UFSCar Sorocaba.

To the friends and brothers of the Republic, the board of directors, the course friends, the staff of the Toca da Onça Academic Center and all those who helped me directly and indirectly in the realization of this monograph.

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PENETRATING SCROTAL TRAUMA - CASE REPORT AND LITERATURE REVIEW

TRAUMA ESCROTAL PENETRANTE - RELATO DE CASO E REVISÃO DE LITERATURA

TRAUMATISMO ESCROTAL PENETRANTE: REPORTE DE CASO Y REVISIÓN DE LA LITERATURA

 <https://doi.org/10.56238/sevened2025.036-038>

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ABSTRACT

Introduction and Objective: Penetrating scrotal trauma is a rare but potentially serious condition, with a risk of compromising genital structures. The objective of this study is to review diagnostic and therapeutic approaches to penetrating scrotal injuries, proposing a clinical flowchart to guide medical care.

Method: A case report of scrotal trauma by a metal bar in a patient treated in an emergency room was conducted, followed by a systematic literature review in the PubMed and SciELO databases, without language or period restrictions. Case reports with penetrating or transfixing scrotal injuries were included. The extracted data included the mechanism of trauma, diagnostic tests used, and procedures adopted, allowing for descriptive analysis and the construction of a management flowchart.

Results: Twenty-one cases were analyzed (including the case presented). The most frequently used diagnostic methods were ultrasound (33.33%), computed tomography (33.33%), and radiography (28.57%). Regarding management, surgical exploration was performed in 71.42% of cases; debridement in 47.61%; drain use in 28.57%; and primary closure in 80.95%. Based on these data, a clinical flowchart was developed encompassing hemodynamic assessment, detailed physical examination, imaging studies, and indications for surgical intervention according to suspected injury to scrotal and adjacent structures.

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Conclusion: Penetrating scrotal trauma requires a systematic and individualized approach. The publication of reports such as this contributes to the improvement of medical conduct in the face of varied clinical presentations, expanding the diagnostic and therapeutic repertoire of professionals in the areas of emergency medicine and urology.

Keywords: Puncture Wounds of the Scrotum. Transfixing Wounds of the Scrotum.

RESUMO

Introdução e objetivo: O trauma escrotal penetrante é uma condição rara, mas potencialmente grave, com risco de comprometimento das estruturas genitais. O objetivo deste estudo é revisar condutas diagnósticas e terapêuticas diante de lesões penetrantes de escroto, propondo um fluxograma clínico para guiar o atendimento médico.

Método: Foi realizado um relato de caso de trauma escrotal por barra metálica em paciente atendido em pronto-socorro, seguido por revisão sistemática de literatura em bases de dados PubMed e SciELO, sem restrição de idioma ou período. Foram incluídos relatos de casos com lesões penetrantes ou transfixantes escrotais. Os dados extraídos incluíram mecanismo de trauma, exames diagnósticos utilizados e condutas adotadas, permitindo análise descritiva e construção de fluxograma de manejo.

Resultados: Foram analisados 21 casos (incluindo o relato apresentado). Os métodos diagnósticos mais utilizados foram ultrassonografia (33,33%), tomografia (33,33%) e radiografia (28,57%). Em relação ao manejo, a exploração cirúrgica foi realizada em 71,42% dos casos; debridamento em 47,61%; uso de dreno em 28,57%; e fechamento primário em 80,95%. Com base nesses dados, foi elaborado um fluxograma clínico contemplando avaliação hemodinâmica, exame físico detalhado, exames de imagem e indicações de intervenção cirúrgica conforme a suspeita de lesão de estruturas escrotais e adjacentes.

Conclusão: O trauma escrotal penetrante exige abordagem sistemática e individualizada. A publicação de relatos como este contribui para o aprimoramento da conduta médica frente a apresentações clínicas variadas, ampliando o repertório diagnóstico e terapêutico de profissionais das áreas de emergência e urologia.

Palavras-chave: Lesões Perfurantes de Escroto. Lesões Transfixantes de Escroto.

RESUMEN

Introducción y objetivo: El traumatismo escrotal penetrante es una afección poco frecuente pero potencialmente grave, con riesgo de comprometer las estructuras genitales. El objetivo de este estudio es revisar los abordajes diagnósticos y terapéuticos de las lesiones escrotales penetrantes, proponiendo un diagrama de flujo clínico para orientar la atención médica.

Método: Se realizó un reporte de caso de traumatismo escrotal por una barra metálica en un paciente atendido en urgencias, seguido de una revisión sistemática de la literatura en las bases de datos PubMed y SciELO, sin restricciones de idioma ni período. Se incluyeron reportes de casos con lesiones escrotales penetrantes o transfixiantes. Los datos extraídos incluyeron el mecanismo del traumatismo, las pruebas diagnósticas utilizadas y los procedimientos adoptados, lo que permitió el análisis descriptivo y la elaboración de un diagrama de flujo de manejo.

Resultados: Se analizaron veintidós casos (incluido el caso presentado). Los métodos diagnósticos más utilizados fueron la ecografía (33,33%), la tomografía computarizada (33,33%) y la radiografía (28,57%). En cuanto al manejo, se realizó exploración quirúrgica en el 71,42% de los casos; Se realizó desbridamiento en el 47,61 % de los casos; drenaje en el 28,57 %; y cierre primario en el 80,95 %. Con base en estos datos, se elaboró un diagrama de flujo clínico que abarca la evaluación hemodinámica, la exploración física detallada, los estudios de imagen y las indicaciones para la intervención quirúrgica según la sospecha de lesión en el escroto y las estructuras adyacentes.

Conclusión: El traumatismo escrotal penetrante requiere un abordaje sistemático e individualizado. La publicación de informes como este contribuye a la mejora de la práctica médica ante la variabilidad de las presentaciones clínicas, ampliando el repertorio diagnóstico y terapéutico de los profesionales de urgencias y urología.

Palabras clave: Heridas Punzantes del Escroto. Heridas Transfixiantes del Escroto.

1 INTRODUCTION

Penetrating scrotal trauma is an uncommon injury within medical practice, mainly because of the location of the scrotum and its mobility. Genitourinary lesions occur in about 10% of cases of abdominal trauma, and scrotal or testicular lesions are present in only 1% of these cases.¹

Penetrating trauma is an open injury with the possibility of injuring, in addition to the outermost layers of the skin, the subcutaneous, blood vessels, and even the various structures that make up the spermatic funiculus.² In this case, in the case of scrotal injury, there is the possibility of injury to structures such as testicles, epididymis, spermatic cords, nerve structures and blood vessels.

Anatomically, the scrotum is formed by two pouches divided by an internal septum and a cutaneous raphe, connected to the perineum. Each pouch has six layers, including the skin and cremaster muscle. The testicles, which are oval in shape and measure between 4.1 and 5.1 cm in length, contain seminiferous tubules and Leydig cells in the interstitial space, responsible for the production of testosterone.

The vas deferens, a muscular tube, connects the epididymis to the spermatic cord, which connects the testicle to the abdominal structures, involving arteries, veins, lymphatic vessels, and nerves, under a fibrous-connective layer called the spermatic fascia.² Arterial irrigation of the scrotum comes from branches of the internal pudendal artery, external pudendal artery, and cremasteric artery, while venous drainage occurs through the scrotal veins.

The innervation of the scrotum is anterior, by the genitofemoral nerve, and posterior, by the posterior scrotal nerves. In addition, the ilioinguinal and genitofemoral nerves innervate the cremaster muscle, which aids in thermoregulation.³

The diagnosis of scrotal injury is based on the physical examination of the affected area, which can often be difficult in post-trauma cases, due to various factors such as the patient's non-cooperation due to pain, excess blood hindering vision, hematoma or edema. Thus, the inability to perform a reliable physical examination leads to the use of imaging tests for a more assertive diagnosis, when possible. Ultrasound is the most used imaging method in practice for cases of penetrating trauma, being able to evaluate the involvement of deep structures. In addition, ultrasonography using the Doppler technique allows providing information about the blood supply to the testicles, which is critical to indicate or not surgical treatment.

Although ultrasonography is the main diagnostic means for penetrating scrotal trauma, there are still limitations regarding its use, since it is an operator-dependent method, reducing its diagnostic accuracy.

Computed tomography and magnetic resonance imaging also have a well-established role in the literature as an effective method for the diagnosis of penetrating trauma. However, they present important barriers to their use, such as high cost, low availability and inability to use them depending on the penetrating material (metal, for example).

The following case reports a transfixing trauma, isolated in the scrotum, in an 18-year-old man, by a metal bar. In addition, a flowchart for the management of penetrating scrotal trauma, and a table analyzing the conducts and diagnostic methods of a series of cases present in the literature are also presented below:

2 GOAL

The objective of this study is to review the management of traumatic cases and perforating scrotal injuries, in order to systematize the diagnosis and treatment, in order to help urologists and emergency physicians to deal with these situations, based on the elaboration of a flowchart.

3 METHOD

The following study addresses a case report of penetrating scrotal trauma by a metal bar in the emergency room of the Sorocaba Hospital Complex. This case encouraged the search for other reports based on a mechanism of trauma that is not very prevalent and the production of a systematic review based on other cases obtained in the current medical literature. The studies analyzed were obtained exclusively from the PubMed and Scielo databases. In order to select the appropriate studies, the advanced search tools 'perforating scrotal lesions' and 'transfixing scrotum lesions' were used, in addition to the 'case report' filter. There was no restriction on the date or nationality of the study.

Based on the bibliography obtained, a table was created, which will be shown below, structured in 6 columns, which are the numeral identification of the report within this article, its authors, the number of patients within the report, the mechanism of trauma, the diagnostic method and the conduct in the face of the accident. From the

table, the qualitative data, especially the conduct of the cases, could be more easily observed, which facilitated the performance of a descriptive analysis of the information. This analysis, in addition to the description of a case report of its own, provided us with the support for the construction of a flowchart about the treatment of perforating scrotum injuries, making it possible to achieve the objective of the study.

4 RESULT

From the analysis of 19 articles containing case reports with the trauma mechanism evaluated, added to the description of the case in our service, we obtained a sample of 21 cases involving perforating scrotal injuries. Based on the data obtained from these reports, the following percentages of imaging tests were requested: US in 33.33% of the cases; X-ray in 28.57%; Computed Tomography in 33.33%; Cystoscopy in 4.76% and Urethrography in 9.52%.

Regarding the approach to trauma: scrotal surgical exploration was performed in 71.42% of the cases; exploratory laparotomy in 19.04%; incisions on the route in 9.52%; debridement in 47.61%; Penrose drain was used in 28.57%; primary closure at 80.95%; Closing by second intention in 4.76% of the cases. In the remaining cases, the closure of the lesion was not explicit.

In view of the survey of the aforementioned data, it was possible to perform a flowchart of care for penetrating scrotal trauma. Taking into account primary care and evaluation of testicular, spermatic cord, penile, urethral and non-genitourinary structures.

5 DISCUSSION

Proper management of penetrating scrotal trauma is of paramount importance to save genital structures that may have been affected in the trauma. In parallel with our study, in the cases of Zhang⁷, Wen¹³ and Ofori²⁰, there was also scrotal involvement by a metal bar. In Zhang⁷, several structures of the body were affected by the bar, which required an abdominal computed tomography scan as an imaging method to evaluate tissue involvement. Regarding scrotal damage, the conduct was surgical exploration, in addition to debridement of non-viable tissues and primary closure. In Wen¹³, the lesion extended to the abdomen. Therefore, a simple abdominal X-ray and computed tomography were requested to assess the extent of

the lesion. The approach in this case was the delicate removal of the metal bar, with subsequent insertion of a Jackson-Pratt drain. There were no lesions in scrotal structures, and only saline irrigation of the wound was performed. Finally, Ofori²⁰ only needed evaluation through physical examination before performing surgical exploration with debridement and placement of a penrose drain.

Thus, after analyzing the cases listed above and their conducts, we assess that in the face of scrotal trauma, we should initially perform primary care following the protocol described by the ATLS, with the stabilization of the patient's vital signs, as well as any other trauma victim. Once stable, broad-spectrum antibiotic prophylaxis should be initiated, in addition to the tetanus vaccine.

During the complementary evaluation, a specific physical examination of the scrotum is performed in order to evaluate deep structures, which include the testicle, spermatic cord, penis, urethra, and non-genitourinary structures, such as vessels and nerves. If the physical examination is normal, scrotal repair is performed in the emergency room. However, if there is a suspicion of injury to any of the segments listed above, the patient must undergo different procedures. Signs of testicular or spermatic cord injury require the performance of a color Doppler USG; signs of penile injury point to the need for a cavernography; signs of urethral injury require retrograde urethrography for diagnostic complementation; and finally, in cases of lesions involving non-genitourinary structures, the physician should evaluate whether there is blood in the digital rectal examination, and if positive, indicate a rectosigmoidoscopy; in addition, the pulses in the lower limbs should be checked, and if altered, an arteries Doppler ultrasound or arteriography should be requested.

If the complementary examination is altered, the approach involves surgical exploration and subsequent debridement of any non-viable tissue. During exploration, the surgeon needs to pay attention so as not to injure structures of the spermatic cord and the vas deferens. The goal of the exploration is to save the gonads, control infectious, and maintain hemostasis. However, penetrating trauma often causes testicular injury, with values between 32 and 65%, and orchiectomy is often necessary.¹

In the case described, it was initially seen that the patient was hemodynamically stable, and antibiotic prophylaxis and tetanus vaccine were then performed, as recommended. Regarding the physical examination of the scrotum, it

was negative for lesions of other organs or active bleeding, which allowed the surgeons to take the patient to the operating room without the need to request other imaging tests, as described above. The excision of the metal bar was done, in addition to a surgical exploration to assess damage, which was not observed. In this way, only the repair of the affected skin was done.

6 CONCLUSION

Because this is a diverse case with variable clinical presentations and different forms of injury to the scrotal structures, it is important that reports such as this one be published in order to increase the arsenal of colleagues in specialties to have versatility in the surgical approach and techniques at the time of lesion interventions such as those presented in this review.

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APPENDIX

Figure 1

Scrotal transfixing trauma



Figure 2

Approximate transfixing scrotal trauma



Figure 3

Removal of the object under intraoperative vision



Figure 4

Intact testicle exteriorized for evaluation



Figure 5

Flowchart of the management of penetrating scrotal trauma

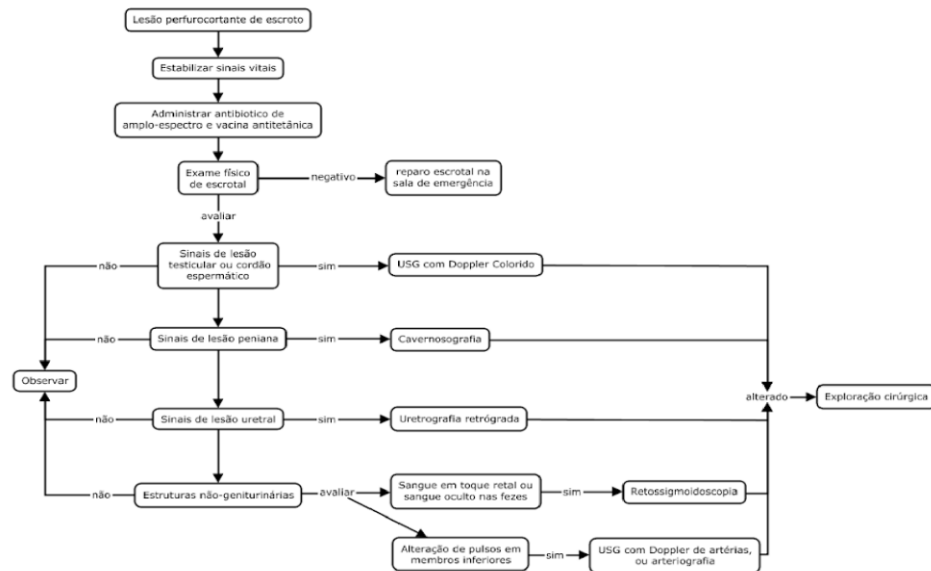


Table 1

Table referring to the cases analyzed, taking into account the trauma mechanism, diagnostic method and management

Relato	Autores	Número de pacientes	Mecanismo	Método diagnóstico	Conduta primária
1	Palinrungi	1	Tronco de árvore	EF, TC	ECE + debridamento + fechamento primário com dreno penrose
2	Pavia	1	Pistola de pregos	USG	ECE + fechamento primário
3	Theisen	1	Arma de Taser	USG	ECE + debridamento + fechamento primário
4	Dar	1	Vara de bambu	EF, TC	ECE + debridamento + fechamento primário com dreno penrose
5	Zhang	1	Barra metálica	EF, TC	ECE + debridamento + fechamento primário
6	Migliorini	1	Pistola de pregos	USG, Raio X	ECE
7	Bickel	1	Arma de fogo (projétil)	EF, Raio X	ECE + orquiectomia + fechamento primário com dreno penrose
8	McKitterick	1	Cabo de vassoura	EF, TC	Laparotomia exploratória + fechamento primário
9	Mbuyamba	1	Galho de árvore	EF, TC	Laparotomia exploratória por herniação traumática abdominal
10	Ferlise	1	Dardo	EF, USG com doppler	ECE + debridamento + drenagem pela sutura + retirada do objeto no intraoperatório
11	Wen	1	Barra metálica	EF, Raio X, TC	2 incisões sobre o trajeto do objeto + debridamento + dreno jackson pratt + fechamento primário
12	Datta	1	Cabo de vassoura	EF, Raio X, USG	Laparotomia exploratória + fechamento primário
13	Mante	1	Objeto metálico (explosão de navio)	EF, Raio X	ECE + fechamento primário com dreno penrose
14	Ficarra	1	Arma de fogo (projétil)	EF, Raio X, USG, TC	ECE + fechamento primário com drenagem de hematoma
15	Tan	1	arbusto espinhoso	EF, USG, Cistoscopia, Uretrografia	ECE + debridamento da lesão escrotal com fechamento por segunda intenção + colocação de cateter urinário via fio-guia
16	Reed	1	chifre de veado	EF, Uretrografia retrógrada	ECE + colocação de cateter urinário via fio-guia + fechamento primário + dreno penrose
17	Dorairajan	1	Ferimento de arma branca	EF	Laparotomia exploratória + ligadura de vasos deferentes bilaterais + fechamento primário escrotal após drenagem
18	Ofori	Paciente 1	Galho de árvore	EF	ECE + debridamento + fechamento primário
	Ofori	Paciente 2	Barra metálica	EF	ECE + debridamento + fechamento primário com dreno penrose
19	Telussa	1	Assento de bicicleta	EF	ECE + debridamento + fechamento primário

EF: Exame físico; USG: ultrassonografia; TC: tomografia computadorizada

**THE INFLUENCE OF SOCIAL SECURITY BENEFITS ON THE PRODUCTION
AND SOCIAL REPRODUCTION OF RURAL SETTLEMENTS IN SÃO PAULO:
CHALLENGES AND ACHIEVEMENTS**

**A INFLUÊNCIA DOS BENEFÍCIOS PREVIDENCIÁRIOS NA PRODUÇÃO E
REPRODUÇÃO SOCIAL DE ASSENTAMENTOS RURAIS EM SÃO PAULO:
DESAFIOS E CONQUISTAS**

**LA INFLUENCIA DE LAS PRESTACIONES DE SEGURIDAD SOCIAL EN LA
PRODUCCIÓN Y REPRODUCCIÓN SOCIAL DE LOS ASENTAMIENTOS
RURALES EN SÃO PAULO: RETOS Y LOGROS**

 <https://doi.org/10.56238/sevened2025.036-039>

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ABSTRACT

This study investigates the influence of social security benefits on the lives of settled families in two rural territories in São Paulo: Horto de Ibitiúva (Pitangueiras/SP) and Formiga (Colômbia/SP). We analyzed the application of social security resources, changes in quality of life, and challenges faced by these special insured individuals. The research covered 32 plots with permanent benefits in Horto de Ibitiúva (out of a total of 43) and 30 in Formiga (out of a total of 61), representing a significant sample of the titleholding families. It was observed that 62.5% of respondents in Horto de Ibitiúva and 36.7% in Formiga allocate part of their resources to purchase agricultural inputs, indicating the benefit's importance as production support. Additionally, these resources contribute to leisure, travel, and essential shopping, promoting an increase in food security, financial autonomy, and overall quality of life. The methodology included structured and semi-structured questionnaires, interviews with pioneers, and consultation of databases such as ITESP and INCRA, as well as specialized literature. The results highlight the fundamental role of social security in keeping families in the countryside, supporting the sustainability of family farming, and reducing inequalities. However, significant challenges persist in access and understanding of regulations by beneficiaries, often leading to judicialization. The research offers insights for developing more effective public policies focused on debureaucratization and valuing the special insured.

Keywords: Rural Settlements. Agrarian Reform. Social Security. Special Insured. Social Security Benefits.

RESUMO

Este estudo investiga a influência dos benefícios previdenciários na vida de famílias assentadas em dois territórios rurais de São Paulo: Horto de Ibitiúva (Pitangueiras/SP) e Formiga (Colômbia/SP). Analisamos a aplicação dos recursos previdenciários, as mudanças na qualidade de vida e os desafios enfrentados por esses segurados especiais. A pesquisa abrangeu 32 lotes com benefícios permanentes em Horto de Ibitiúva (de um total de 43) e 30 em Formiga (de um total de 61), representando uma amostra significativa das famílias

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titulares. Observou-se que 62,5% dos entrevistados em Horto de Ibitiúva e 36,7% em Formiga aplicam parte dos recursos na aquisição de insumos agropecuários, indicando a importância do benefício como suporte à produção. Além disso, os recursos contribuem para o lazer, viagens e compras essenciais, promovendo um aumento na segurança alimentar, autonomia financeira e qualidade de vida geral. A metodologia incluiu questionários estruturados e semiestruturados, entrevistas com pioneiros e a consulta a bancos de dados como ITESP e INCRA, além de literatura especializada. Os resultados destacam o papel fundamental da previdência social na fixação das famílias no campo, na sustentabilidade da agricultura familiar e na redução das desigualdades, embora persistam desafios significativos no acesso e na compreensão das normas pelos beneficiários, muitas vezes levando à judicialização. A pesquisa oferece insights para a formulação de políticas públicas mais eficazes, focadas na desburocratização e na valorização do segurado especial.

Palavras-chave: Assentamentos Rurais. Reforma Agrária. Previdência Social. Segurado Especial. Benefícios Previdenciários.

RESUMEN

Este estudio investiga la influencia de las prestaciones de seguridad social en la vida de familias asentadas en dos zonas rurales de São Paulo: Horto de Ibitiúva (Pitangueiras/SP) y Formiga (Colômbia/SP). Se analizó la aplicación de los recursos de seguridad social, los cambios en la calidad de vida y los retos que enfrentan estas personas aseguradas. La investigación abarcó 32 parcelas con prestaciones permanentes en Horto de Ibitiúva (de un total de 43) y 30 en Formiga (de un total de 61), lo que representa una muestra significativa de las familias beneficiarias. Se observó que el 62,5% de las personas entrevistadas en Horto de Ibitiúva y el 36,7% en Formiga destinan parte de los recursos a la adquisición de insumos agrícolas, lo que indica la importancia de la prestación como apoyo a la producción. Además, los recursos contribuyen al ocio, los viajes y las compras esenciales, lo que promueve una mayor seguridad alimentaria, autonomía financiera y una mejor calidad de vida en general. La metodología incluyó cuestionarios estructurados y semiestructurados, entrevistas con pioneros y la consulta de bases de datos como ITESP e INCRA, además de literatura especializada. Los resultados resaltan el papel fundamental de la seguridad social para mantener a las familias en las zonas rurales, garantizar la sostenibilidad de la agricultura familiar y reducir las desigualdades, si bien persisten importantes desafíos en el acceso a la normativa y su comprensión por parte de los beneficiarios, lo que a menudo deriva en litigios. La investigación ofrece perspectivas para la formulación de políticas públicas más eficaces, centradas en la reducción de la burocracia y la valoración de los asegurados especiales.

Palabras clave: Asentamientos Rurales. Reforma Agraria. Seguridad Social. Asegurados Especiales. Prestaciones de Seguridad Social.

1 INTRODUCTION

Social security, in its various facets, has been an intrinsic concern of human existence, evolving from rudimentary protection mechanisms to formalized systems. In the Brazilian context, this trajectory is marked by significant advances, especially with the enactment of the Federal Constitution of 1988 (CF/88), which established social security as a fundamental tripod – health, assistance and social security – and expanded rights to several categories, including rural workers. This normative framework was consolidated with Law No. 8,213/1991, which defined the "special insured", a crucial category for understanding the socioeconomic dynamics in the countryside (BRASIL, 1991b).

The "special insured" encompasses producers, partners, sharecroppers, fishermen and beneficiaries of agrarian reform settlements who carry out their activities in a family economy regime. This classification, while essential for social protection, is often obscured by bureaucratic requirements and the need for proof of rural activity, which proves to be a persistent challenge. The National Institute of Social Security (INSS), by requiring documentation of material evidence that many workers do not have. This constitutional right is denied. Leading to the search for judicial protection to guarantee their rights.

Despite the barriers, the realization of access to social security benefits has a transformative power in the lives of the settlers. The resources obtained not only meet basic needs, but also enable investments in agricultural production, improve housing conditions, health and promote leisure, elements that contribute to the dignity and permanence of families in the countryside. Social Security, therefore, transcends the mere welfare function, acting as a pillar of social and economic development in historically marginalized regions.

The present research is part of this panorama, seeking to analyze the influence of social security benefits in two rural settlements in the state of São Paulo: Horto de Ibitiúva, in Pitangueiras, and Formiga, in Colombia. The study aims to unravel how these financial resources impact the socioeconomic dynamics and quality of life of settled families. The specific objectives that guide this research are:

Analyze the patterns of use of financial resources from social security benefits by settled families;

Identify changes in the quality of life and family structure of beneficiaries after obtaining retirement or pension, with special attention to the impact when the benefit is received by women;

- Evaluate the participation of settled families in public policy programs (such as PAA, PNAE, PPAIS and Pronaf) and the possible relationship with the receipt of social security benefits;
- Investigate the challenges faced by family farming in the settlements and the way in which social security resources contribute to the permanence of families on the land and the improvement of their social conditions;
- Examine whether the benefits are used for the purchase of agricultural inputs, and how this affects agricultural production and family income;
- To analyze the perception of the settlers about the titling and practices of partnerships/leases in relation to social security benefits.

By addressing these points, it is expected to offer an in-depth understanding of the reality of the settlements studied, as well as to contribute to the academic debate and provide subsidies for the formulation of fairer and more effective public policies that promote territorial development and social inclusion in rural areas.

1.1 LITERATURE REVIEW AND THEORETICAL FOUNDATION

Rural social security in Brazil is a vast and complex field, permeated by historical, legislative and socioeconomic nuances. The discussion on the influence of social security benefits on the lives of rural settlers requires an in-depth analysis of the existing literature, which ranges from the evolution of social protection in the country to the particularities of the special insured regime and its impacts on the social and economic reproduction of families.

Social protection, in a broad sense, goes back to ancestral forms of solidarity. However, its formalization and institutionalization are more recent phenomena. The article highlights that the Brazilian Social Security had its first formal registrations in 1821, with the granting of retirement to teachers, and the Mexican Constitution of 1917 is pointed out as a precursor milestone in the inclusion of social rights, influencing Brazilian constitutionalism, especially the CF/88 (BRASIL, 1988).

A crucial moment in the formalization of social security in Brazil was the enactment of the Eloy Chaves Law (Decree No. 4,682/1923), which regulated the Retirement and Pension Funds (CAPs) for specific professional categories, such as railroad and seafarers. This initial phase, however, was markedly urban and corporatist, with social protection linked to contributions and formal employment. Rural workers, in turn, remained on the margins of

these systems for a long period, reflecting the economic duality of twentieth-century Brazil, with the predominance of large estates and incipient industrialization in the cities (ABREU *et al.*, 2016).

The CF/88 represented a watershed, consolidating the concept of the Welfare State and the tripartite social security system. For the countryside, the great innovation was the universalization of rural social security and the creation of the figure of the "special insured", establishing the equalization of social security rights between rural and urban workers. This advance was regulated by Laws No. 8,212/91 and No. 8,213/91, which defined the criteria for classification and benefits.

1.2 THE SPECIAL INSURED REGIME: RIGHTS AND CHALLENGES

The concept of "special insured" covers a wide range of rural workers, including producers, partners, sharecroppers, fishermen and settlers, who work in a family economy regime. This regime is characterized by the indispensability of the work of family members for the subsistence and socioeconomic development of the family nucleus, without the use of permanent employees (BRASIL, 1991a). The legislation allows occasional assistance from third parties, but imposes clear limits on the area explored (up to 4 tax modules)¹ and on income from other sources.

Despite the clarity of the law, the practical application of the concept of special insured is full of ambiguities and challenges. Proof of rural activity, essential for access to benefits, often becomes a bureaucratic obstacle. The lack of formal documentation, the informality of rural activities, and the lack of knowledge of rights are recurrent obstacles, as pointed out by Lima, Silva and Braga (2024), Thethê and Pestana (2024) and Moreira and Santana Junior (2024).

A central point in the discussion about the special insured is their form of contribution. Many critics argue that these workers receive benefits "without contributing," generating a perception of injustice toward urban workers. However, CF/88 (art. 195, § 8) establishes an indirect contribution, calculated on the gross revenue from the commercialization of production, showing that there is, indeed, a participation in the cost of the system, even if differentiated (ELIZIÁRIO, 2017). The normative complexity, with sometimes subjective rules, leads to a high incidence of judicialization, where the administrative decisions of the INSS are often judicially reversed (SANTINI, 2024; OLIVEIRA, 2012; MARANHÃO; VIEIRA FILHO, 2018).

1.3 SOCIOECONOMIC IMPACTS OF SOCIAL SECURITY BENEFITS IN RURAL AREAS

The literature is abundant in demonstrating the multifaceted impact of social security benefits on the lives of rural workers and their families:

Studies such as those by Delgado and Cardoso Junior (1999), Beltrão, Oliveira and Pinheiro (2000), Brumer (2002) and Castro (2017) consolidate the idea that rural social security is one of the main mechanisms for reducing poverty and social inequality in the countryside. The benefits guarantee a minimum income that, in many families, is essential for food security, investments in health, education and improvements in housing conditions. In regions such as the South and Northeast, social security income can represent a substantial portion of household income, keeping many families above the poverty line.

Social security income not only guarantees subsistence, but also works as "agricultural insurance", allowing families to invest in their productive activities. Velleda (2008) and Delgado and Cardoso Júnior (1999) point out that the social security benefit can be used to finance the purchase of inputs, equipment and even to cover losses in bad harvests. This directly contributes to the continuity of family farming and to the establishment of families in the countryside, avoiding rural exodus, especially in small municipalities, as demonstrated by Chies and Rocha (2015) and Schiefelbein (2010). Retirement often allows the elderly to remain on their properties, maintaining their way of life and identity (SIMONATO and BERGAMASCO, 2021).

1.3.1 Women's Autonomy and Local Economic Dynamization

The inclusion of rural women as direct beneficiaries of social security is an aspect of great relevance. Santos (2022), Marin (2023) and Souza (2023, 2024) show that social security is crucial for the income autonomy of peasant women, reducing sexist violence and expanding their participation in family funding. This financial autonomy transforms the social role of women, going from dependent to provider. In addition to the direct impact on families, the social security resources injected into rural areas boost local economies, boosting trade and services in small municipalities, configuring an important redistributive character (ELIZIÁRIO, 2017; BARBOSA; RÔMULO, 2007; BRUMER, 2002).

1.4 CONTEMPORARY CHALLENGES AND FUTURE PERSPECTIVES

Despite the advances, the rural social security system faces challenges. Rodrigues (2018) projects a continuous increase in the number of beneficiaries, warning of the need for

structural reforms to ensure the sustainability of the system in the face of population aging and the growing deficit. Recent reforms, such as Constitutional Amendment No. 103/2019, although not directly changing the age and contribution time requirements for the special insured, impose new requirements and indirect barriers, such as the digitalization of services, which affect the most vulnerable populations (SOUZA, 2024).

The persistence of "biases" in the granting of pensions, identified by Kreter and Bacha (2006) – favoring men, whites and more educated people – and the need for specific policies for indigenous populations (SOUZA; STADUTO; KRETER, 2018) point to the importance of transversal and intersectional approaches in public policies.

The systematic review presented in Eliziário's thesis (2025), which covers national studies published between 1999 and 2024, reinforces these analyses by highlighting the scarcity of research aimed at retirees living in rural settlements in the State of São Paulo, revealing a knowledge gap that the present study seeks to fill. In addition, the author revisits specific works on the São Paulo context (ELIZIÁRIO; FERRANTE; HERRMANN, 2018; SIMONATO; BERGAMASCO, 2021), which already indicated both the relevance of social security benefits for the maintenance of settled families, and the insufficiency of agricultural income as the main source of livelihood.

2 MATERIAL AND METHODS

The investigation on the influence of social security benefits on the lives of rural settlers was designed with a predominantly qualitative and exploratory methodological approach, using the multiple case study as a central strategy. The choice for this approach is justified by the complexity of the phenomenon studied, which involves social, economic, cultural and legal dimensions, and by the need to understand the contextual particularities of the settlements.

The study adopts a multiple case study design, focusing on two rural settlements located in the state of São Paulo: Horto de Ibitiúva, in the municipality of Pitangueiras, and Formiga, in the municipality of Colombia. The selection of these settlements allowed a comparative analysis of different realities, but with common characteristics that qualify them as territories of special insured, enriching the discussion on the impacts of social security. The exploratory nature of the research made it possible to identify relevant variables and to delve into emerging aspects of the interaction between beneficiaries, their communities and the social security system.

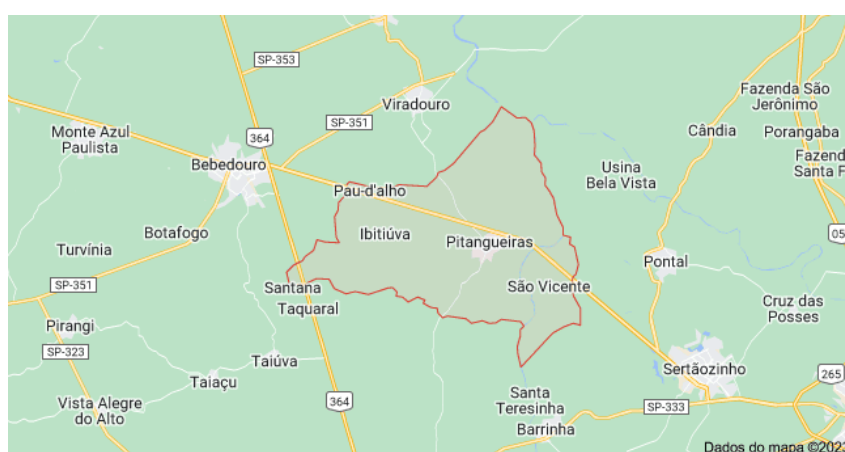
2.1 CHARACTERIZATION OF THE STUDY SITES

2.1.1 Horto de Ibitiúva Settlement (Pitangueiras/SP)

The Horto de Ibitiúva Settlement is a rural territory located in Pitangueiras/SP. It was formed from a process of agrarian reform, consolidating itself over the years. Currently, it consists of 43 agricultural lots, housing 60 titular families and a total of 178 people. Its average area per lot (11.50 ha) fits it into the category of special insured, according to the criteria of the fiscal module. The community has a rich history, marked by the struggle for land and the construction of new forms of life and production. Agricultural production, although diversified, faces challenges inherent to family farming (Figures 1 and 2).

Figure 1

Location of Ibitiúva – Pitangueiras/SP



Source: Google Maps (2023).

Figure 2

View of the area of the Horto de Ibitiúva Settlement – Pitangueiras/SP



Source: Google Earth (2023).

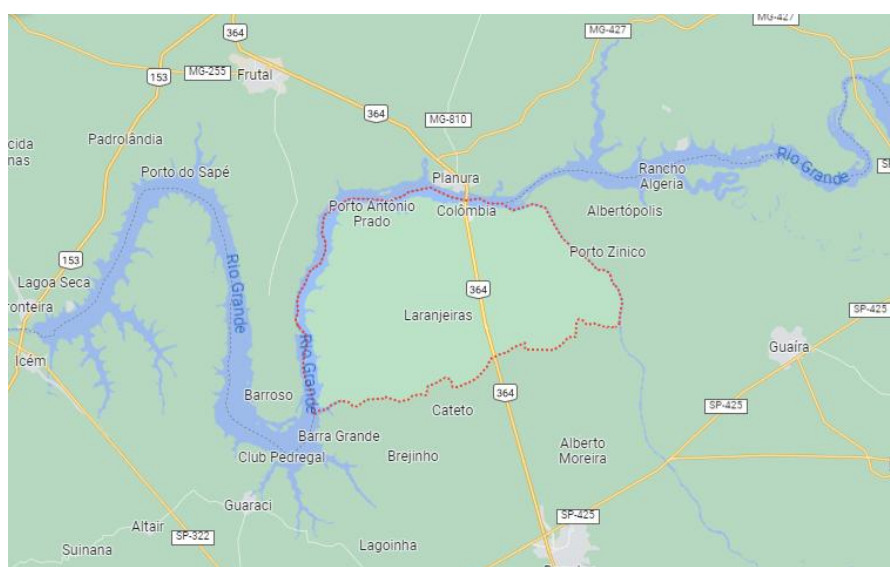
2.1.2 Formiga Settlement (Colombia/SP)

Located in Colombia/SP, the Formiga Settlement consists of 61 lots and 91 titular families, totaling 193 people. Like Ibitiúva, its average area per lot (14.50 ha) categorizes it as a settlement of special insured. Formiga's history, from its initial occupation to the consolidation phase, reflects the vicissitudes and resilience of social movements on land in Brazil. The community is dedicated to various agricultural activities, seeking subsistence and local development.

The historical reconstruction of both territories, as pointed out in the article, covers the formation process, the demographic and socioeconomic situation of the families, the current situation of titling and the existing partnerships/leases. This contextualization is fundamental to understand the internal dynamics and the way in which social security benefits are inserted in the life of these settlements (Figures 3 and 4).

Figure 3

Location of Colombia/SP



Source: Google Maps (2023).

Figure 4

Area view of the Formiga Settlement – Colombia/SP



Source: Google Maps (2023).

2.2 POPULATION AND SAMPLE

The target population of the survey included all families receiving permanent social security benefits (retirements or pensions) in both settlements. In Horto de Ibitiúva, the owners and spouses of 32 lots with permanent benefits were investigated. In the Formiga settlement, the sample consisted of the holders and spouses of 30 lots that receive these benefits. This selection allowed us to focus directly on the experiences of those impacted by social security benefits. In addition, interviews were conducted with three pioneers from each territory. The choice of the pioneers is justified by their ability to provide a historical and in-depth perspective on the formation and transformations of the settlements, enriching the analysis of the social reproduction of families over time.

For data collection, multiple instruments were used, seeking triangulation and coverage:

- **Structured and Semi-Structured Questionnaires:** Applied to all heads of household or spouses who receive permanent social security benefits. The questionnaires sought to collect socioeconomic data, information on the benefit received, its use, perceptions about quality of life, participation in public policies and other relevant issues;

- **Semi-Directive Interviews:** Conducted with the three pioneers of each settlement. This technique allowed us to explore narratives, memories, and opinions about the history of the settlement, the struggles for rights, the evolution of living conditions, and the role of social security benefits from a more in-depth perspective;
- **Field Diary:** The researcher kept a field diary, recording observations, impressions, interactions, and informal contexts. This instrument is valuable for capturing nuances and contextual data that complement the formal information collected.

The survey complemented the primary data with the survey and analysis of secondary sources, including:

- **Institutional Databases:** Information from the Land Institute Foundation of the State of São Paulo (ITESP) and the National Institute of Colonization and Agrarian Reform (INCRA) were consulted to contextualize the land, demographic and productive situation of the settlements;
- **Specialized Literature:** Theses, dissertations, scientific articles and books related to rural social security, agrarian reform, special insurance and territorial development were reviewed to support the theoretical discussion and compare the findings of the research with the consolidated knowledge in the area.

The data analysis followed a predominantly qualitative approach, with the use of content analysis for the interviews and open questions of the questionnaires. The quantitative data, obtained by the closed questions of the questionnaires, were tabulated and presented by means of descriptive statistics (frequencies and percentages), illustrated with figures and charts, to characterize the population and the patterns of use of the benefits. The triangulation of data from different sources and instruments allowed a more robust interpretation of the results.

The study was conducted in strict accordance with the ethical precepts of research involving human beings. All participants were duly informed about the objectives of the research, guaranteeing them the right to confidentiality, anonymity and the possibility of withdrawing at any time. The Informed Consent Form (ICF) was signed by the participants, and the procedures were approved by the Research Ethics Committee, aiming at responsible research and is duly approved under CAAE No. 84862624.3.0000.5383.

3 RESULTS AND DISCUSSION

The analysis of the data collected in the Horto de Ibitiúva and Formiga settlements revealed a series of impacts and complex dynamics related to the influence of social security benefits on the lives of rural settlers. The results will be presented and discussed in order to dialogue with the literature and the proposed objectives.

The settlements studied, Horto de Ibitiúva and Formiga, represent microcosms of the reality of agrarian reform in São Paulo. Horto de Ibitiúva, with its 43 lots and 60 families (178 people), and Formiga, with 61 lots and 91 families (193 people), demonstrate the persistence of family farming in a context of great transformations. The average area per lot in Ibitiúva (11.50 ha) and Formiga (14.50 ha) fits them into the category of special insured, although the area of the fiscal module in the region is higher (64 ha and 88 ha, respectively).

The demographic analysis of the interviewees who receive social security benefits in the Formiga Settlement reveals a mostly female profile, indicating a significant presence of women among the beneficiaries. This predominance may be associated with higher life expectancy and the growing participation of women in formal and community activities, which guarantees them access to social security rights.

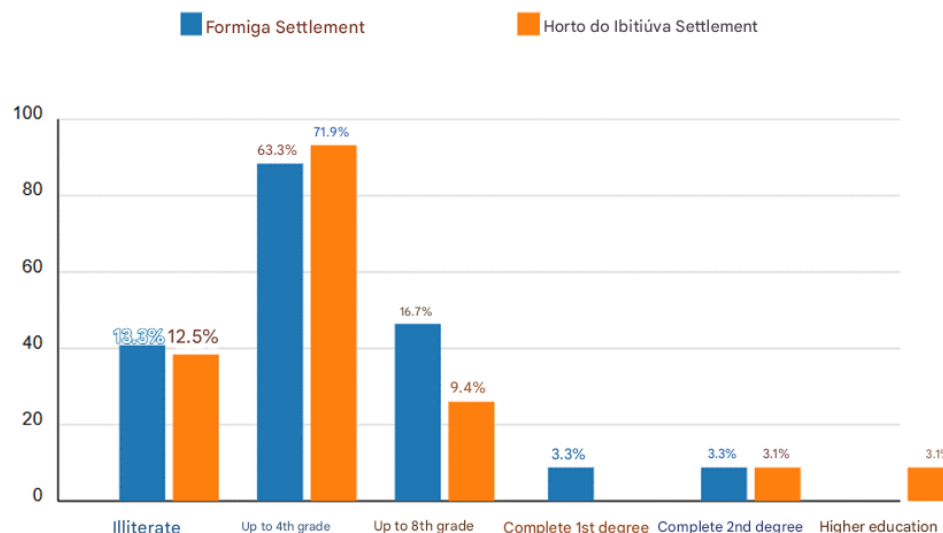
It is observed, however, that men still represent a significant portion of retirees and pensioners, which may reflect longer work trajectories or early start of productive life.

These data reinforce research and literature on the growing inclusion and protagonism of women in the rural social security system (SANTOS, 2022; MARIN, 2023; SOUZA, 2023). The average age of the beneficiaries suggests that rural age retirement, with its different age requirements for men and women (60 and 55 years, respectively), is the most common benefit.

The level of education showed that most of the beneficiaries have a low educational level, which can aggravate the difficulties in understanding norms and digital access to social security services, a contemporary challenge pointed out by Souza (2024) (Figure 5).

Figure 5

Level of education of the interviewees

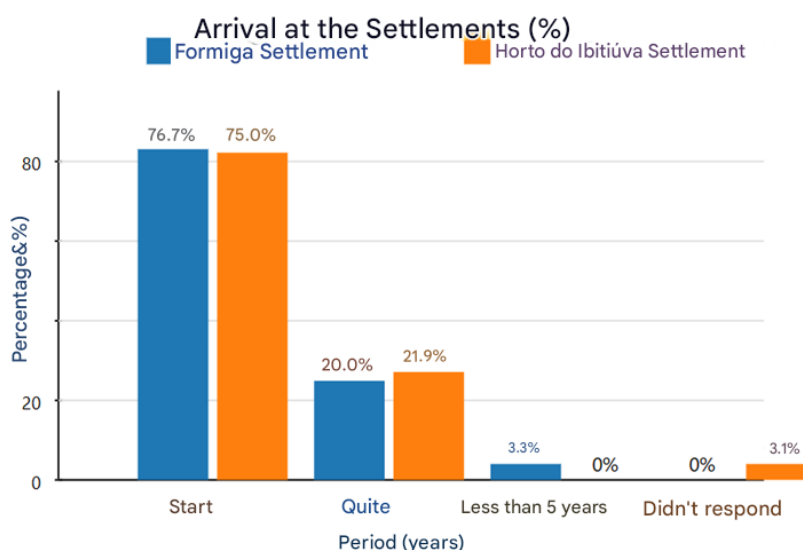


Source: Research data, 2024.

During the period of arrival, it is observed that most arrived at the beginning of the formation of the settlement (Figure 6). It shows that many beneficiaries have been consolidated on the land for a long time, which is in line with the idea that social security acts as a fixation factor in the countryside (SCHIEFELBEIN, 2010). The permanence of families in the settlements is a relevant fact.

Figure 6

Period of arrival at the settlement



Source: Research data, 2024.

The analysis of the residence of the spouses in the settlements shows different realities between the Formiga Settlement and the Horto de Ibitiúva Settlement.

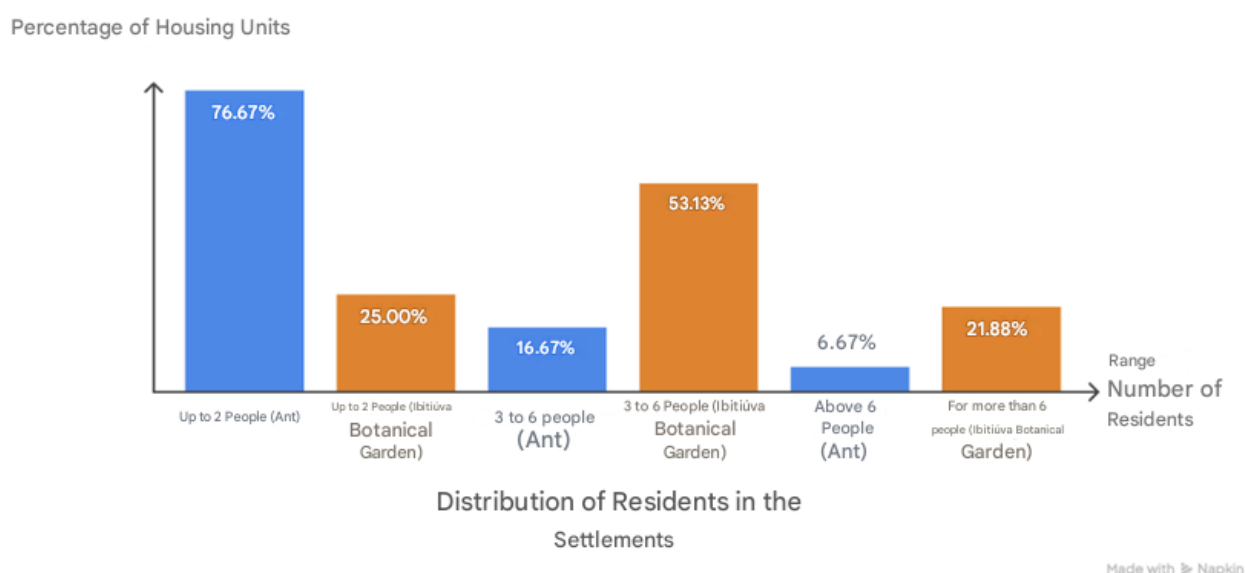
In the first, there is a strong marital cohabitation, with 87% of the interviewees declaring that the spouse lives in the settlement. This data suggests greater family stability and territorial settlement, reflecting solid community ties and a consolidated domestic structure around the lot.

On the other hand, in the Horto de Ibitiúva Settlement, only 53% stated that the spouse resides in the place, while 47% indicated the opposite. This significant difference may be related to external work dynamics, temporary separations for economic reasons, or different family configurations, such as unions in which only one of the partners remains on the lot.

Most respondents share the lot with others, with some families being larger than others. Another indication of a strong family nucleus in the settlements (Figure 7). It is common in the lots of the 2 territories to have more than one house in the agricultural lots, where the children or a relative lives.

Figure 7

Number of people living on the lot



Source: Research data, 2024.

The analysis regarding the children's residence in the lots reveals relevant differences between the two settlements surveyed.

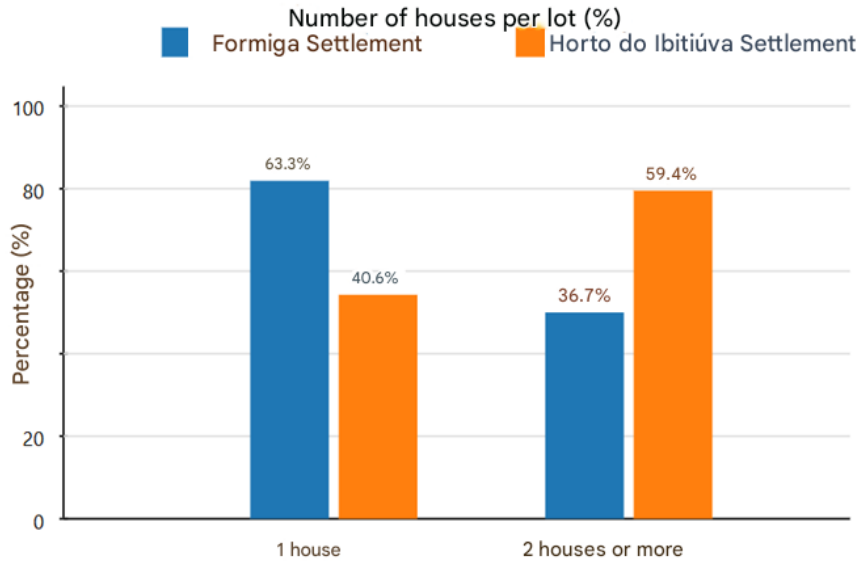
In the Formiga Settlement, 77% of the interviewees stated that their children still reside on the lot, while 23% stated the opposite. This result demonstrates a strong family permanence, indicating that the lot continues to be the main space for coexistence and sustenance of families, possibly due to the continuity of agricultural activities and community cohesion.

In the Horto de Ibitiúva Settlement, 69% of the children live on the lots, while 31% no longer live there. Although the percentage of permanence is still high, there is a greater tendency for young people to leave, which may be related to searches for work, study or new opportunities outside the settlement.

Regarding the number of houses per lot, these data show the importance of social security income for the maintenance of the family group, often in more than one residence per lot (Figure 8).

Figure 8

Number of houses per lot

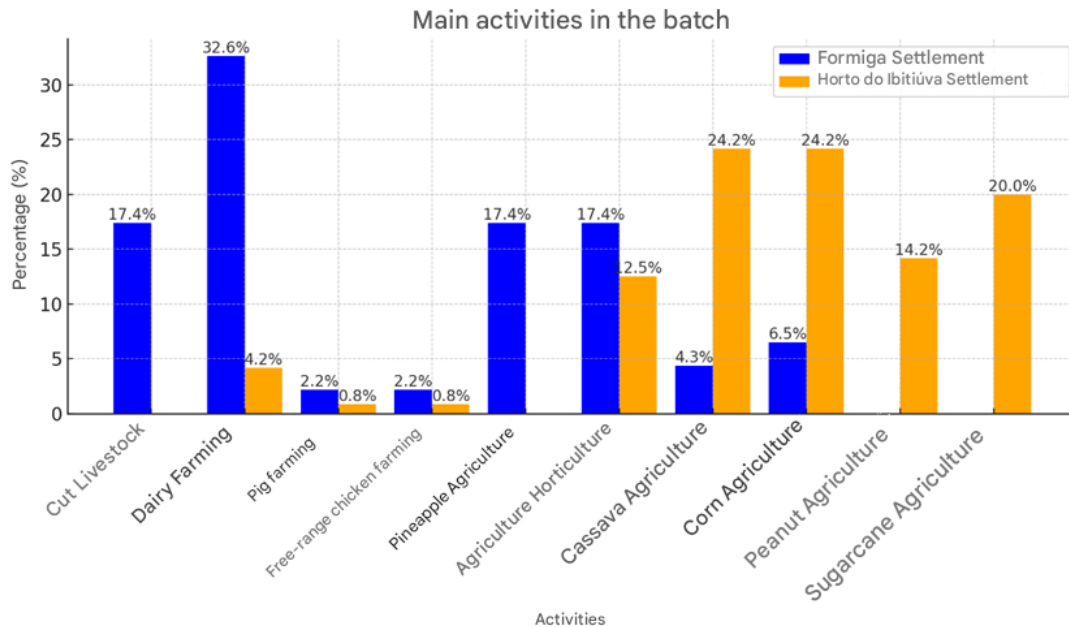


Source: Research data, 2024.

In terms of production, the main activities performed in the batches (Figure 9). In the Formiga Settlement, the creation of dairy and beef cattle stands out, and in the Ibitiúva Settlement, the planting of cassava and sugar cane.

Figure 9

Main activities performed in the lot



Source: Research data, 2024.

3.1 THE APPLICATION OF SOCIAL SECURITY BENEFITS AND THE IMPROVEMENT OF QUALITY OF LIFE

The results of this study corroborate the literature that highlights the central role of social security benefits in the social and economic reproduction of settled families. The survey revealed that a significant portion of respondents use retirement or pension resources beyond basic subsistence:

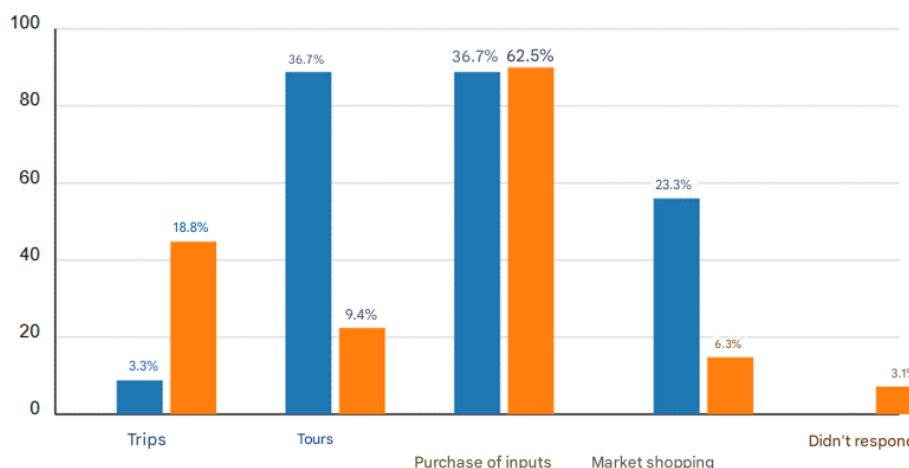
Investment in Production: in Horto de Ibitiúva, 62.5% of the interviewees, and in Formiga, 36.7%, apply social security resources in the acquisition of agricultural inputs, such as seeds, fertilizers and feed. This data is crucial, as it demonstrates the role of social security as an "agricultural insurance" (DELGADO; CARDOSO JÚNIOR, 1999) and as capital for production, allowing family farmers to maintain their productive activities, even in the face of insufficient income generated exclusively by farming, as already observed by Eliziário, Ferrante and Herrmann (2018).

Improved Quality of Life: Resources are also directed to leisure, travel, and grocery shopping (Figure 10). This indicates an improvement in quality of life that goes beyond the basics, providing moments of rest and consumption that would previously be inaccessible. This dynamic aligns with Simonato and Bergamasco's (2021) observation that retirement

contributes to a sense of tranquility and security, allowing for well-being and permanence in the countryside.

Figure 10

What has changed with the benefit



Source: Research data, 2024.

Food Security and Financial Autonomy: The general perception of beneficiaries is of an increase in food security and financial autonomy. The constant and predictable income of social security mitigates the vulnerability inherent to agricultural activities, subject to bad weather and market fluctuations. For women, especially, the income provided by retirement has redefined social roles, guaranteeing them greater autonomy and decision-making power within the family and community, as argued by Santos (2022) and Souza (2023).

Income Sharing and Financing: Social security income is often shared with other family members (Figure 14), which demonstrates its role in sustaining the family nucleus.

The analysis of the way family income is managed in the settlements shows a majority trend of sharing financial resources among family members, although with differences between the territories.

In the Formiga Settlement, 63% of respondents stated that income is shared among family members, while 37% indicated that income is managed individually. This division shows a predominance of collective management, which may be associated with family organization aimed at economic cooperation, especially in contexts where production and consumption are strongly interconnected with work on the lot.

In the Horto de Ibitiúva Settlement, the proportion of shared income is even more expressive, reaching 72%, against 28% of individual management. This result reinforces the presence of a culture of solidarity and economic co-responsibility, possibly driven by joint productive activities and more cooperative family structures.

The analysis of access to financing by the settlers reveals a moderate level of use of rural credit, with noticeable differences between the two settlements surveyed.

In the Formiga Settlement, 57% of respondents said they had already taken out some type of financing, while 43% had never accessed credit. This result indicates a reasonable integration with agricultural development policies, suggesting that a significant part of the families was able to mobilize financial resources for productive investment, whether in the purchase of inputs, equipment or in the improvement of the infrastructure of the lots.

In the Horto de Ibitiúva Settlement, the proportion is slightly reversed: 47% of the settlers have already resorted to financing, and 53% have never done so. This difference may be associated with difficulties in accessing rural credit, such as bureaucratic requirements, lack of guarantees, or lack of adequate technical guidance.

3.2 CHALLENGES IN ACCESSING BENEFITS AND JUDICIALIZATION

Despite the positive impacts, access to social security benefits for special insured persons is still a process marked by bureaucratic difficulties and the persistence of judicialization. The survey revealed that:

Need for Legal Action: A considerable portion of the benefits were granted judicially (Figure 16), rather than administratively by the INSS. This corroborates the conclusions of Santini (2024), Oliveira (2012) and Maranhão and Vieira Filho (2018) about subjectivity in the analysis of rural activity and the divergent interpretations between the INSS and the Judiciary. The need to resort to lawyers to guarantee the right increases the costs and complexity for beneficiaries.

In the Formiga Settlement, 67% of the participants said they had needed a lawyer, while 33% had never needed this type of support. This data suggests a significant demand for legal guidance, possibly related to land, social security, contractual or family issues, which require legal mediation.

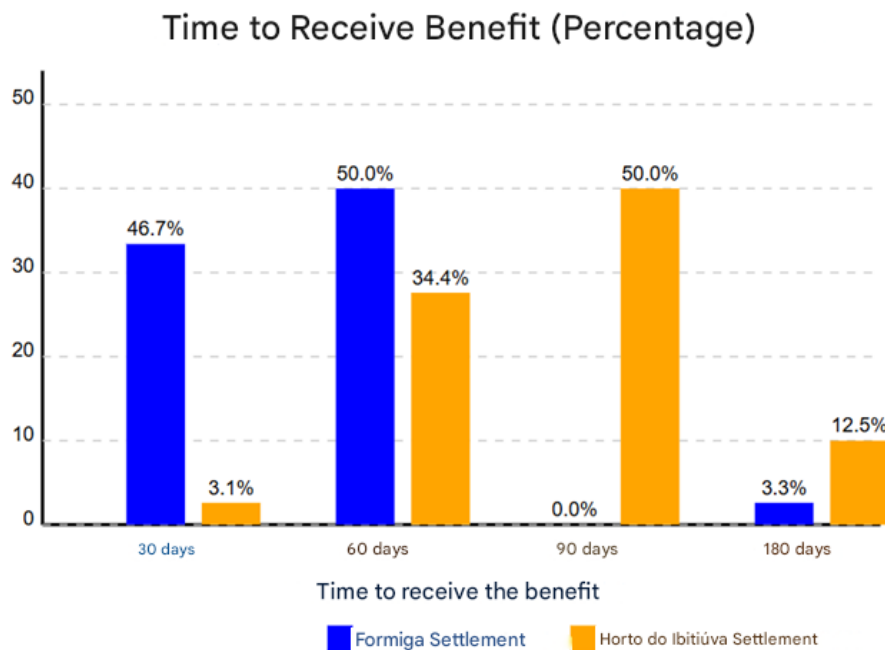
In the Horto de Ibitiúva Settlement, the proportion is similar, although slightly lower: 59% declared that they had already resorted to a lawyer, against 41% who did not need to. This proximity between the percentages indicates that the presence of conflicts or legal

demands is a common reality in rural settlements, which reinforces the importance of accessible and continuous legal aid services in these communities.

Slowness in the Process: The expected period for receiving the benefit (Figure 11) is often long, generating anxiety and financial difficulties during the wait.

Figure 11

Expected period for receiving the benefit



Source: Research data, 2024.

These challenges are accentuated by the lack of formal documentation, informality of rural work and lack of knowledge of rights, elements frequently mentioned in the literature (LIMA; SILVA; BRAGA, 2024; THETHÊ; PESTANA, 2024; MOREIRA; SANTANA JUNIOR, 2024).

3.3 PARTICIPATION IN PUBLIC POLICIES AND COMMUNITY ARTICULATION

Participation in public policies is an indicator of the integration of settlers in the support networks and promotion of family farming. The research investigated adherence to programs such as PAA (Food Acquisition Program), PNAE (National School Feeding Program), PPAIS (São Paulo Program for the Acquisition of Social Interest) and Pronaf (National Program for the Strengthening of Family Agriculture).

The analysis shows a low adherence of the settlers to government programs, both in the Formiga Settlement and in the Horto de Ibitiúva.

In the Formiga Settlement, only 33% of respondents said they participated in some public policy, while 67% declared that they were not included in any program. This proportion suggests a fragility in the articulation between the government and the community, which may result from lack of information, excessive bureaucracy or discontinuity of government actions aimed at rural areas.

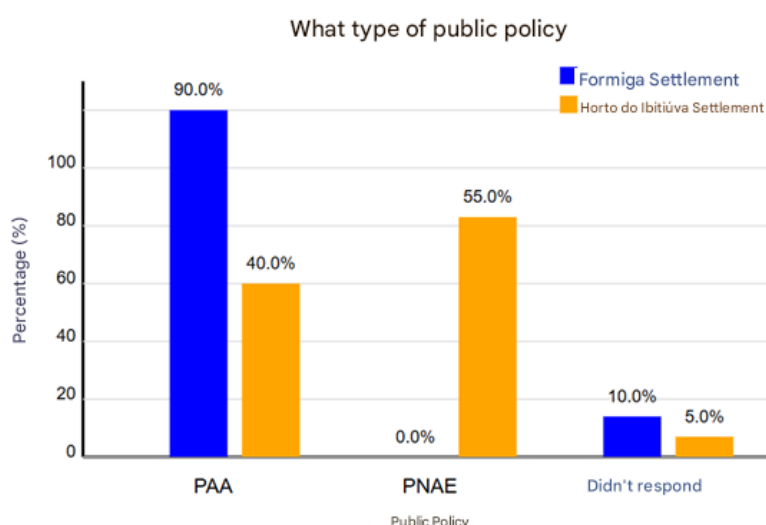
A similar situation is observed in the Horto de Ibitiúva Settlement, where 34% participate in public policies and 66% are not linked to any initiative. The percentage coincidence between the two territories points to a pattern of exclusion or underutilization of social policies, possibly related to the lack of technical assistance, institutional support and local integration mechanisms.

The data reveal the need to strengthen public policies aimed at rural settlements, with an emphasis on information, training and expansion of the settlers' access to promotion, social assistance and sustainable development programs.

In general, the results highlight that public procurement policies, especially the PAA and PNAE, are the main instruments for strengthening family farming, although with different degrees of consolidation and scope among the settlements analyzed (Figure 12).

Figure 12

What type of public policy



Source: Research data, 2024.

3.4 INFRASTRUCTURE, CONNECTIVITY AND WORK DYNAMICS

Basic infrastructure and connectivity are essential elements for the development of settlements. The survey addressed the type of water supply and its use, access to telephone and solar energy. This data provides a snapshot of living conditions and technological barriers that can affect access to information and services.

Regarding internet access, in the Formiga Settlement, 93.3% of people have access via radio, while in Horto do Ibitiúva, 75% use internet through a provider. In Horto, 15.6% people access the internet by rural cell phone, while only 3.3% people in Formiga use this technology. In total, 3.3% of people in Formiga and 9.4% in Horto reported not having internet at home.

As for the quality of the internet, 93.1% of people in the Formiga Settlement classified the connection as good, against 62.5% in Horto do Ibitiúva. However, 6.9% of people in Formiga and 34.4% in Horto consider the internet regular. In Horto, 3.1% of people did not answer this question.

Finally, in terms of telephone, both in the Formiga Settlement and in Horto do Ibitiúva, the majority of families, 90.6% and 93.3% people, respectively, use conventional cell phones. Only 3.3% of people in the Formiga Settlement and 9.4% in the Horto de Ibitiúva Settlement use rural cell phones, and 3.3% of people in Formiga reported not having a telephone.

The data report that both settlements have a significant dependence on artesian wells for water supply, use mostly water for domestic use and animal husbandry, have good internet and cell phone coverage, with variations in the types of internet and telephone access.

Regarding the number of people who work on the lot, in the Horto do Ibitiúva Settlement, 65.6% of the interviewees stated that members of the family nucleus work as salaried workers, which represents a considerable difference in relation to the Formiga Settlement. This data suggests that there is a greater integration of the family components of the Formiga Settlement into the formal labor market, or a need to supplement the income generated by the activities on the lot.

According to the data, in both settlements, most people still depend on working on the lot as their main source of livelihood, with a higher prevalence in the Formiga Settlement. However, the percentage of people in the family who seek salaried work is higher in Horto do Ibitiúva, 61.1% more than 2 people. Suggesting that the settlers of this place have a greater diversification of income. This difference can be a result of factors such as access to local

labor markets, educational opportunities, or different levels of mechanization and agricultural infrastructure between settlements.

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The results of the survey in the Horto de Ibitiúva and Formiga settlements provide a rich tapestry of evidence that confirms and deepens the understanding of the multifaceted influence of social security benefits. They not only ensure livelihoods, but also act as engines of local development, ensuring the permanence of families in the countryside and promoting improvements in the quality of life, despite persistent bureaucratic challenges and the complexity of regulations.

4 FINAL CONSIDERATIONS

This study demonstrated the fundamental influence of social security benefits on the production and social reproduction of families in the rural settlements of Horto de Ibitiúva (Pitangueiras/SP) and Formiga (Colombia/SP). By analyzing the use of resources received from social security benefits, the transformations in the quality of life and the challenges faced by special insured persons, the research contributed significantly to the understanding of the reality of these territories.

The data confirm that retirement and pensions, far from being mere aids, function as a pillar of economic support, allowing the complementation of agricultural income, investments in inputs for production and the improvement of family infrastructure. This injection of resources translates into greater food security, financial autonomy and leisure possibilities, raising the quality of life of the settlers and contributing to the settlement of

families in rural areas. The central role of women as beneficiaries and managers of these resources emerges as a factor of autonomy and social transformation within the settlements.

However, the survey also exposed the persistent barriers to access to these rights. The high rate of judicialization to obtain social security benefits, the slowness of the processes and the vulnerability to scams and fraud show the urgent need to reduce bureaucracy and simplify the rules for proving rural activity. The complexity of qualifying as a special insured, the difficulties in obtaining formal documentation and the lack of knowledge about one's own rights contribute to this reality.

Participation in public policies to support family farming and access to technical assistance are crucial, but heterogeneous. Basic infrastructure and connectivity, although present to some extent, still pose challenges for the full inclusion and development of settlements.

The contributions of this study are multiple. Academically, it fills a gap in the literature on retirees in rural settlements in the State of São Paulo, deepening the debate on the intersection between agrarian reform, social security, and territorial development. Socially, it sheds light on the reality and demands of a group that is often made invisible, but which plays a fundamental role in food production and environmental conservation. Professionally, it offers data and analysis that can support the performance of rural extension workers, social workers, lawyers and public managers.

For public policy makers, the recommendations are clear:

- **Debureaucratization:** Implement more simplified and transparent mechanisms for proving rural activity, reducing dependence on judicialization;
- **Education and Guidance:** Promote information campaigns and social security education programs in the settlements, training farmers on their rights and duties;
- **Policy Integration:** Strengthen the articulation between social security policies and programs to promote family farming (PAA, PNAE, Pronaf), ensuring that benefits act as catalysts for productive development;
- **Technical Assistance and Access to Technology:** Expand and qualify the offer of technical assistance and promote digital inclusion, facilitating access to INSS services and relevant information.

This study, although limited to the two settlements analyzed, paves the way for future research. It is suggested that the scope be expanded to other settlements and regions,

longitudinal studies to monitor the impacts of social security reforms, and deepen the analysis of gender and race in access to benefits. Only with a careful look and coordinated policies will it be possible to ensure that social security continues to be an instrument of justice and transformation for Brazilian rural workers.

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**CRITICAL POINT INDICATOR OF FATAL ACCIDENTS: A CONTRIBUTION TO
THE REDUCTION OF TRAFFIC DEATHS**

**INDICADOR DE PONTO CRÍTICO DE SINISTRO COM MORTE: UMA
CONTRIBUIÇÃO PARA A REDUÇÃO DE ÓBITOS NO TRÂNSITO**

**INDICADOR DE PUNTOS CRÍTICOS DE ACCIDENTES MORTALES: UNA
CONTRIBUCIÓN A LA REDUCCIÓN DE LAS MUERTES POR ACCIDENTES DE
TRÁFICO**

 <https://doi.org/10.56238/sevened2025.036-040>

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ABSTRACT

Despite significant advances in road safety research, gaps remain in measuring and monitoring the factors that determine severe traffic crashes. This study proposes the Critical Point Indicator for Fatal Traffic Crashes (CPIF), a tool designed to identify and prioritize highway segments with the highest concentration of fatalities. More than 2.1 million crash records were analyzed from 2007 to 2024, involving 4.7 million people and resulting in 121,661 deaths on Brazilian federal highways. The research also compared trends across three groups of countries — the nine largest by area, nine South American nations, and 22 European countries — revealing an increase in fatalities since 2019 and conceptual divergences regarding the definition of “critical point” among national and international institutions. The results highlight distinct spatial and causal patterns that demand targeted engineering and policy responses. The CPIF is presented as a decision-support instrument to optimize public investments, guide localized interventions, and contribute to achieving the UN and Brazil’s PNATRANS goal of reducing road deaths by 50% by 2030.

Keywords: Road Safety. Crash Hotspots. Performance Indicators. Public Policies. Safe System Approach.

RESUMO

Apesar dos avanços em pesquisas sobre segurança viária, persistem lacunas na mensuração e no monitoramento dos fatores que determinam os sinistros graves. Este estudo propõe o Indicador de Ponto Crítico de Sinistro de Trânsito com Óbito (IPCO), instrumento destinado a identificar e priorizar segmentos rodoviários com maior concentração de mortes. Foram analisados 2,1 milhões de registros de sinistros ocorridos entre 2007 e 2024 em rodovias federais brasileiras, envolvendo 4,7 milhões de pessoas e resultando em 121.661 óbitos. O estudo também comparou tendências em três grupos de países — nove de maior extensão territorial, nove sul-americanos e 22 europeus — identificando aumento das fatalidades a partir de 2019 e divergências conceituais sobre “ponto crítico” entre instituições nacionais e internacionais. Os resultados evidenciam padrões espaciais e causais distintos que demandam abordagens específicas de engenharia e gestão pública. O IPCO é apresentado como ferramenta de apoio à decisão para otimizar

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investimentos, direcionar intervenções localizadas e contribuir para o alcance da meta da ONU e do PNATRANS de reduzir em 50% as mortes no trânsito até 2030.

Palavras-chave: Segurança Viária. Pontos Críticos. Indicadores de Desempenho. Políticas Públicas. Sistemas Seguros.

RESUMEN

A pesar de los avances en las investigaciones sobre seguridad vial, aún existen vacíos en la medición y el monitoreo de los factores que determinan los siniestros graves. Este estudio propone el Indicador de Punto Crítico de Siniestro de Trafico con Muerto (IPCO), una herramienta destinada a identificar y priorizar los tramos viales con mayor concentración de muertes. Se analizaron más de 2,1 millones de registros de siniestros ocurridos entre 2007 y 2024 en carreteras federales brasileñas, que involucraron a 4,7 millones de personas y resultaron en 121.661 fallecidos. El estudio también comparó las tendencias en tres grupos de países — nueve de mayor extensión territorial, nueve sudamericanos y 22 europeos — identificando un aumento de las fatalidades a partir de 2019 y divergencias conceptuales sobre el término “punto crítico” entre instituciones nacionales e internacionales. Los resultados evidencian patrones espaciales y causales diferenciados que exigen enfoques específicos de ingeniería y gestión pública. El IPCO se presenta como una herramienta de apoyo a la decisión para optimizar inversiones, orientar intervenciones localizadas y contribuir al cumplimiento del objetivo de la ONU y del PNATRANS de reducir en un 50% las muertes en el tránsito hasta 2030.

Palabras clave: Seguridad Vial. Puntos Críticos. Indicadores de Desempeño. Políticas Públicas. Sistemas Seguros.

1 INTRODUCTION

Since the 1960s, the **World Health Organization (WHO)** has recognized traffic accidents as a global public health problem, as discussed in 1962 and later reaffirmed in **Resolution WHA27.58 (1974)**. In 2004, the *World Report on Road Traffic Injury Prevention* (WRI) consolidated evidence on the magnitude of the problem, leading the UN to institute **World Health Day dedicated to Road Safety**. Despite successive international initiatives, such as **Resolution No. 64/255 (2010)**, which inaugurated the *Decade of Action for Road Safety 2011–2020*, and **Resolution No. 74/299 (2020)**, which established a new target by 2030, the results are still insufficient. Road traffic accidents remain at unacceptable levels, with **1.19 million deaths and about 50 million injuries annually**, especially in developing countries.

In addition to the human impact, the **economic costs** are significant, ranging from **0.4% to 4.1% of GDP** in 31 countries analyzed (Wijnen & Stipdonk, 2017), which highlights the need for more targeted and sustainable interventions. Both in the resolutions and in subsequent global plans, the *Global Plan for the Decade of Action for Road Safety 2011–2020 and the Global Plan 2021–2030*, **safe road infrastructure** is recognized as an essential pillar, in line with the **Safe Systems approach**, which is based on the principle that human error is inevitable, but roads must be designed to absorb it without causing fatalities (UN, 2010; Wegman, 2017).

In view of this scenario, the present study proposes the creation of a **Traffic Accident Critical Point Indicator with Death (IPCO)** as a strategic tool to **prioritize road stretches with the highest concentration of deaths** and guide short and medium-term public policies. In the Brazilian context, this proposal supports the achievement of the goals of the **National Plan for the Reduction of Traffic Deaths and Injuries (PNATRANS)**, instituted by Law No. 13,614/2018, and contributes to the UN agenda of reducing traffic deaths by 50% by 2030.

The investigation was based on **open data on fatal accidents** from OECD countries, **South America, China, Russia and India**, and, in the Brazilian case, on records from the **Federal Highway Police (PRF)**, covering the period from **2007 to 2024**, totaling **2.1 million occurrences, 4.7 million people involved, 1.17 million minor injuries, 404 thousand serious injuries and 121,661 deaths**.

The article is structured in six parts: introduction; methodology; theoretical framework; empirical analysis of accidents on federal highways; proposal and rationale of the **IPCO**; and considerations, with implications and recommendations for public policies

2 METHODOLOGY

The research developed has a quantitative, descriptive and comparative character, aimed at identifying patterns of concentration of accidents with deaths on Brazilian federal highways and the proposition of a Critical Point Indicator of Traffic Accidents with Death (IPCO). The study adopts a reactive approach, based on empirical data already recorded, according to the classification of *Fletcher et al.* (2020), privileging the analysis of claims that actually occurred as a reference for the planning of corrective interventions.

2.1 DATA SOURCES

Public and official databases were used. At the international level, the bases of the Organization for Economic Cooperation and Development (OECD) were used, as well as national organizations of South American countries, China, Russia and India, allowing comparisons between three groups:

- a) the nine countries with the largest territorial extension;
- b) the nine countries of South America;
- c) twenty-two European countries.

For the purposes of this comparison of Brazil with the three groups of countries, national data published by the Mortality Information System (SIM), linked to the Ministry of Health, which consolidates deaths in all routes: federal, state, and municipal routes, were used.

For the purposes of the study on the IPCO, which was limited to records of accidents on federal highways in Brazil, open data from the National Department of Transport Infrastructure (DNIT) and the Federal Highway Police (PRF) were used. The PRF database of records of traffic accidents that occurred on federal highways between 2007 and 2024, totaled 2,122,326 occurrences, with 4.7 million people involved, 1.17 million minor injuries, 404 thousand serious injuries and 121,661 deaths at the event site.

2.2 SAMPLING AND SELECTION CRITERIA

For analysis purposes, the federal highways were segmented into 1-kilometer stretches, totaling 74,344 km evaluated. A critical point of accident with death was considered to be any segment of 1 km with the occurrence of at least one accident with death in the period studied. Of the 74,344 km, 36,494 km (49%) had at least one death. The final sample

was composed of the 100 segments with the highest concentration of deaths, defined based on the following criteria:

- d) registration of deaths in at least five years, of the last ten in the time series;
- e) exclusion of stretches that, in the last three years (2022–2024), did not record deaths, to avoid segments that have undergone recent interventions.

The selection guaranteed a confidence level of 95% and a margin of error of less than 2%, giving representativeness to the sample.

2.3 ANALYSIS PROCEDURES

The data were organized and tabulated in electronic spreadsheets, and analyses of **frequency, spatial distribution and temporal recurrence were performed**. For each critical segment, the following were identified:

- a) the number of claims;
- b) the total number of deaths;
- c) the type of claim;
- d) the predominant cause;
- e) the characteristics of the road (single, double or multiple lane).

Based on these variables, a matrix of fatality concentration was elaborated, which supported the identification of critical segments, in descending order, that is, from the one with the highest number of deaths to the one with the lowest per 1km segment.

2.4 LIMITATIONS AND ETHICAL CONSIDERATIONS

The study is based exclusively on **public secondary data**, without personal identification, in compliance with the ethical principles of confidentiality and anonymization. The main limitations stem from possible inconsistencies in registration between years and the absence of complementary variables, such as traffic volume and local socioeconomic characteristics. Even so, the method adopted is **replicable and scalable**, and can be applied by public managers at different administrative levels.

2.5 INTERNATIONAL COMPARATIVE PROCEDURES

For the purposes of global contextualization, a comparative analysis of traffic mortality trends was conducted in three groups of countries:

- a) the nine countries with the largest territorial extension (including Brazil, China, India, the United States, Russia, Australia, Canada, Argentina and Kazakhstan);
- b) nine South American countries with consolidated data with the OECD and national authorities; and
- c) twenty-two European countries, selected for the availability of consistent data, between 2012 and 2022.

The information was obtained from OECD databases, the World Bank and official national sources, standardized to allow the comparison of annual variations and identification of trends.

3 THEORETICAL FRAMEWORK

There are several terms or expressions in the literature to identify the concentration of traffic accidents, such as hotspot, darkspot, critical point, critical segment, critical stretch or red area. All these definitions have in common a high concentration of claims occurring in the same location. Locations with a high concentration of claims can be described as high risk, hazardous, hot spots, or black spots. It is in these places that better performance is required from drivers, and that, therefore, engineering interventions can reduce performance requirements, increasing the safety margin between driver performance and the demand for road performance, specifically in that location, resulting in a lower probability of an accident (Verkeersonveiligheid, 2003).

Normally, the definition of critical point has a single objective, which is to explain the reason for this concentration of events in the same point, region, highway segment, etc. According to Anderson (2009), the identification of critical points of traffic accidents is important for the appropriate policies of allocation of public resources in the search for improved safety. The analysis of critical points focuses on road segments or intersections and suggests dependence on the place where they occur, and may have one or several causes in common.

Erdogan et al. (2008), when studying 7,634 occurrences of accidents between 1996 and 2006, using the *GeoFigureic Information System* (GIS) platform, identified the concentration of accidents at crossroads of access to small cities, sharp curves and areas that became slippery during the rainy season. Among the causes are disobedience to signals, traffic light advances, improper overtaking, etcetera. For Shariff et al. (2018), they define *hotspot* as the place with the highest probability of an accident in relation to the surrounding

areas; in a study on the **Petani–Bukit Lanjan Expressway (Malaysia, 2011–2024)**, a hotspot *was considered* to be the stretch with **200 or more incidents up to 1,000 meters** in length.

In the Brazilian context, the concept of critical point has been addressed by several agencies since the 1970s and 1980s. The National Traffic Department (DENATRAN, 1982), currently the National Traffic Secretariat (SENATRAN) used the term black spots, classifying them according to different indices for accidents without victim, with victim and with death. The National Department of Highways (DNER), precursor of the DNIT, implemented safety programs financed by the World Bank between 1976 and 1994, including methodologies for identifying critical segments (IPR, 2004).

One of the most used methodologies to identify a critical segment is the Standard Severity Unit (UPS), used by DNIT and several Roads and Roads Departments (DERs). The methodology applies a severity index, where the accident without a victim has an index of 1 (one), with a victim of 5 (five) and with a death of 13 (thirteen).

The Federal Highway Police (PRF), on the other hand, has developed its own methodologies over the last decades. In 2010, the institution considered a critical stretch a 10 km segment with a high concentration of occurrences, applying weights of 1, 5 and 25 for accidents without victims, with victims and with deaths, respectively, according to studies by the Institute of Applied Economic Research (IPEA). In 2022, the PRF updated the model, aligning it with Resolution No. 798/2020 of the National Traffic Council (CONTRAN). This resolution, of a normative nature, is the only one of national scope on the subject, as it requires technical studies for the installation of speed meters based on the identification of critical sections of accidents. Article 6 of the rule defines a critical stretch as one that has a high number of accidents with deaths and injuries, covering a radius of up to 2,500 meters in rural areas and 500 meters in urban areas (CONTRAN, 2020). However, by leaving the quantification to the discretion of the local authority, the normative text results in heterogeneous standards among the bodies of the National Traffic System (SNT).

In addition to the regulatory framework, the National Plan for the Reduction of Traffic Deaths and Injuries (PNATRANS), instituted by Law No. 13,614/2018, which adopts six structuring pillars, stands out. Pillar 2 – Safe Roads provides for Action A2018, aimed at establishing procedures for identifying and treating critical points of claims, with three main products:

- a) Preparation of a technical manual for the identification and treatment of

these points;

- b) Training of technicians, designers and managers; and
- c) National program for the treatment of critical points (DENATRAN, 2018).

These initiatives reinforce the importance of territorial analysis and standardization of indicators to guide preventive interventions. However, there is a lack of a unified synthetic model that integrates the severity, temporal recurrence and spatial density of accidents, a gap that the present study seeks to fill through the proposal of the Critical Point Indicator for Traffic Accidents with Death (IPCO).

4 EMPIRICAL ANALYSIS OF ACCIDENTS ON FEDERAL HIGHWAYS

To identify the importance of identifying and treating critical points in reducing deaths in traffic accidents, the present investigation used an open database, especially that of accidents that occurred on federal highways, between 2007 and 2024, supplied by the PRF and the database of the National Road System (SNV). The objective is to identify the spatial distribution of deaths, understand the behavior of the types and causes of accidents and highlight the importance of identifying and treating critical points as an instrument to reduce traffic deaths.

4.1 DATABASE AND SCOPE OF ANALYSIS

2,122,326 accidents registered on federal highways were analyzed between 2007 and 2024, involving approximately 4.7 million people and resulting in 121,661 deaths on the spot. The base comprises a universe of 74,344 km of highways under federal jurisdiction, of which 7,530 km (10.1%) are double or multiple lanes and 66,814 km (89.9%) are single lanes. During the period of analysis, there were deaths recorded in 36,494 km, corresponding to 49% of the total length of the federal network. In all, there are about 1.7 million highways in Brazil, according to the National Transport Confederation (Cristaldo, 2017), with federal highways being the most strategic because they connect large cities, economic centers, states, geofunctional regions and border countries. It is on federal highways, which are responsible for registering accidents and the PRF, that just under 20% of deaths recorded in traffic accidents in Brazil are concentrated

In the set analyzed, 33,330 deaths (27%) occurred on roads with two or more lanes per direction and 88,331 (73%) on single-lane roads. This difference reflects infrastructure limitations and the role of duplication in mitigating the severity of claims.

4.2 IDENTIFICATION OF CRITICAL SEGMENTS

For the purposes of this investigation, a critical point is defined as the 1 km long segment with a record of at least one fatal accident in the analyzed period. The 74,344 segments were ranked by the sum of deaths, and the 100 most critical were selected, according to the following criteria:

- statistical reliability with a confidence level of 95% and a margin of error of less than 2%;
- exclusion of stretches that did not record deaths between 2022 and 2024, to avoid distortions due to recent interventions;
- prioritization of segments with temporal persistence, occurrence of deaths in at least five of the last ten years.

These segments correspond to the areas with the highest concentration of fatalities and, therefore, the greatest potential for corrective intervention.

4.3 SPATIAL DISTRIBUTION OF FATALITIES

Table 1 shows the concentration of deaths by extension of federal highways, considering the 10,000 km most critical. It is observed that, by concentrating efforts on only 2,000 km (2.6%) of the federal network, it would be possible to impact approximately 23% of deaths on federal highways, which represents approximately 4.4% of national traffic deaths (base 2023).

Table 1

Deaths in accidents on federal highways in the 10,000 most critical km (2007–2024)

Extensão (km)	Mortes entre 2007 e 2024 (acumulada)	Percentual (%) do total de Óbitos entre 2007 e 2024 (acumulada)	Percentual da extensão de rodovias federais* (%) (acumulada)	Média anual de mortos (acumulada)
100km	2928	2,41%	0,13%	163
500km	10287	8,46%	0,67%	572
1000km	17014	13,98%	1,35%	945
2000km	27571	22,66%	2,69%	1532
5000km	49712	40,86%	6,73%	2762
10000km	73661	60,55%	13,45%	4092

Source: author's organization (2025), based on data open to PRF and DNIT.

4.4 TYPES AND CAUSES OF CLAIMS

Table 2 summarizes the average types and causes of accidents in the 100 km most critical, revealing significant diversity. On average, each kilometer had nine types and ten different causes of accidents. This demonstrates that the determining factor is not the nature

of the event, but the place where it occurs, which reinforces the relevance of the proposed territorial approach.

Table 2

Average types and causes of accidents in the 100 km most critical on federal highways (2007–2024)

UF	AL	BA	CE	DF	ES	GO	MG	MT	PE	PI	PR	RJ	RS	SC	SP	Total
Segmentos de 1km analisados por UF (2)	1	1	7	1	4	5	11	1	7	3	5	21	2	4	27	100
Quantidade de sinistros registrados (3)	13	15	179	21	87	131	264	33	174	67	111	490	45	92	749	2471
Média de sinistros por segmento de 1km (4)	13	15	25	21	22	26	24	33	24	22	22	23	22	23	27	24
Média de tipos de sinistros por km (5)	8	7	9	10	10	9	9	9	9	11	9	9	8	11	9	9
Média de causas de sinistros por km (6)	8	7	10	9	10	11	9	14	11	9	10	10	10	11	12	10
Total Geral de mortes (7)	20	22	189	21	11	141	339	37	194	68	116	529	46	98	807	2727

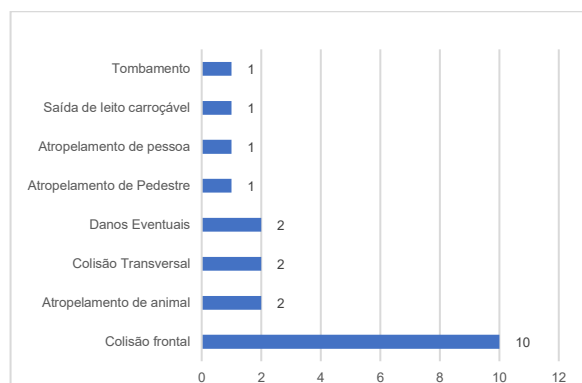
Source: author's organization (2025), based on open PRF data.

Figures 1 and 2 exemplify this diversity in the BR-316 segment, Km 255 (Alagoas-AL), with a predominance of frontal collisions, typical of single lanes. In Figures 3 and 4, referring to BR-381, Km 525 (Minas Gerais-MG), the deadliest point in the country, with 72 deaths in 18 years, there is a predominance of speeding (39 deaths), associated with accidents such as overturning, overturning and lane departure, which add up to 60 deaths.

In Figures 5 and 6, relating to BR-381 (São Paulo/SP, Km-83, 84, 85, 86 and 88), 153 deaths are identified, of which 98 were due to being run over, evidencing the high risk in densely populated urban areas. In this case, the incompatible speed stood out among the 16 causes identified.

Figure 1

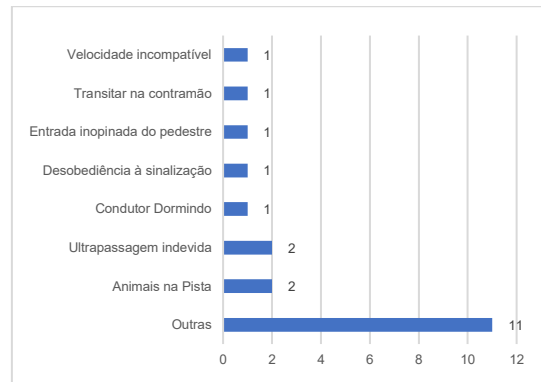
Deaths by type of accident on BR-316, Km-255, Alagoas/AL



Source: author's organization (2025), based on Abertis data from PRF.

Figure 2

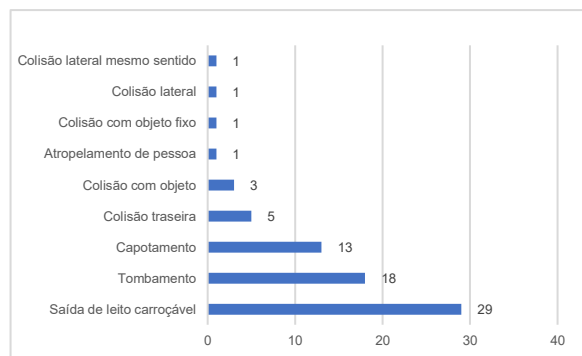
Deaths due to an accident on BR-316, Km-255, Alagoas/AL



Source: author's organization (2025), based on Abertis data from PRF.

Figure 3

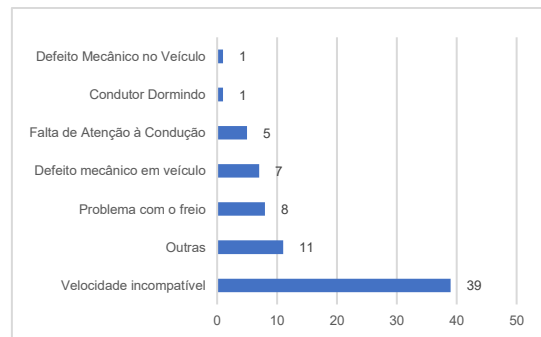
Deaths by type of accident on BR-381, Km-525, Minas Gerais/MG



Source: author's organization (2025), based on Abertis data from PRF.

Figure 4

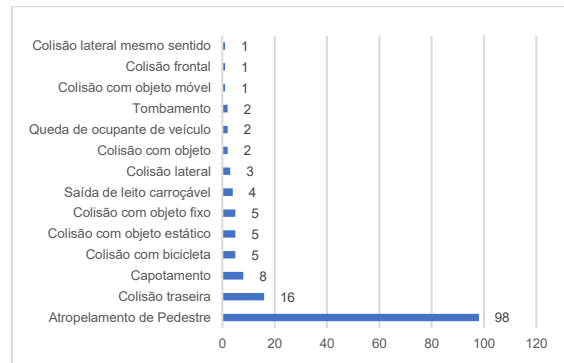
Deaths due to an accident on BR-381, Km-525, Minas Gerais/MG



Source: author's organization (2025), based on Abertis data from PRF.

Figure 5

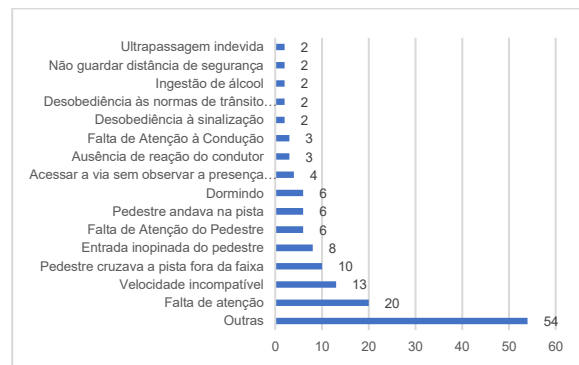
Deaths by type of accident on BR-381, Kms (83, 84, 85, 86 and 88), São Paulo/SP



Source: author's organization (2025), based on Abertis data from PRF.

Figure 6

Deaths due to accidents on BR-381, Kms (83, 84, 85, 86 and 88), São Paulo/SP



Source: author's organization (2025), based on Abertis data from PRF.

The importance of this analysis lies precisely in the identification of the predominant types and causes at each critical point, making it possible to guide specific measures of engineering, inspection or traffic education according to local characteristics.

In the segment of BR-316, Km 255 (Alagoas), for example, the records of frontal collisions indicate the need for stricter actions to combat improper overtaking, with intensification of face-to-face inspection and use of electronic control technologies. In addition, it is recommended to adapt the infrastructure, with the implementation of third lanes to reduce exposure to risk during overtaking maneuvers.

In urban segments of BR-381 (São Paulo, Kms 83, 84, 85, 86 and 88), where pedestrians are run over, priority measures include the construction of footbridges, the installation or expansion of speed bumps and the realization of educational campaigns with the local community.

These examples demonstrate how the IPCO can work as an alert and prioritization instrument, allowing public managers to quickly identify the most critical locations and adopt targeted and cost-effective interventions, aligned with the Safe Systems approach.

4.5 RELATIONSHIP BETWEEN CRITICAL POINTS OF CLAIMS AND FATALITIES

The comparative analysis between the 100 critical points of claims with deaths and the 100 critical points of general claims (Table 3) shows that the two sets do not overlap entirely. While in the 100 points of general claims there is, on average, one death for every 76 claims, in the 100 critical points of claims with death there is more than one death per claim.

Illustrative example: the BR-101/RJ point, Km 322 recorded 2,852 accidents and 14 deaths, occupying only the 678th position among the points of highest lethality, that is, it is the 678th most lethal kilometer, of the more than 73 thousand federal highways, while the BR-381/MG point, Km 525, with 72 deaths, occupies the 552nd position when the criterion is the total number of accidents.

Table 3

Comparison between the 100 most critical points of general claims and death claims (2007–2024)

Pontos críticos	Quantidade de pontos críticos	Quantidade de sinistros	Quantidade de sinistros com mortes	Quantidade de mortes	Comparativos
Pontos críticos de sinistros com mortes	100 (os 100 pontos críticos com mais mortes entre 2007 e 2024)	2.471	2.471	2.726	- A cada 1(um) sinistro, ocorre 1,1 óbitos. - Em 76 sinistros ocorre em média, mais de 83 óbitos.
Pontos críticos de sinistros (incluindo os sinistros com mortes)	100 (os 100 pontos críticos com mais sinistros entre 2007 e 2024)	140.704	1.753	1.839	- A cada 76 sinistros ocorre um óbito.

Source: author, 2025.

These results converge with the conclusions of Pianezzer et al. (2020), who identified five groups of claims, three of which were high-risk (with a higher concentration of deaths) and two low-risk (predominance of victimless claims). Thus, the places with the highest lethality are, in fact, the most critical for road safety policies.

4.6 DISCUSSION OF THE RESULTS

The findings demonstrate that the distribution of fatalities in the Brazilian highway system is highly concentrated, and that prioritizing interventions in a few critical kilometers

can have a disproportionately positive impact on the reduction of deaths. In addition, it was observed that the diversity of causes and types of claims at the same point reinforces the need for interdisciplinary analyses, which combine engineering, inspection and education, precisely the tripod of road safety, established in §10 of article 144 of the Federal Constitution of Brazil.

These results also corroborate the international literature on *hotspots* (VERKEERSONVEILIGHEID, 2003; ERDOGAN et al., 2008; SHARIFF et al., 2018), which emphasizes the role of physical space as a central variable for risk mitigation.

5 PROPOSAL AND RATIONALE FOR THE CRITICAL POINT INDICATOR FOR TRAFFIC ACCIDENTS WITH DEATH (IPCO)

5.1 THE SECURE SYSTEMS APPROACH

The Safe Systems approach, initiated in Sweden in the late 1990s, according to the *World Resources Institute* (WRI, 2020) and Ferrier et al. (2017), gave rise to the Vision Zero program, later adopted in several countries. The central principle is that human errors are inevitable, and therefore roads must be able to absorb them, reducing the severity of claims.

According to Fletcher et al. (2020), insurance systems prioritize the prevention of serious claims through proactive and reactive actions. The reactive approach, based on the identification and treatment of hotspots based on historical data, remains the most widely used worldwide. The proactive approach, on the other hand, seeks to anticipate risks before the occurrence of claims, through safety audits and urban planning.

In the present study, we opted for the reactive approach, as it is understood that Brazil still faces gaps in the identification and treatment of critical points, and that this approach offers greater economic and operational viability, in addition to allowing rapid responses based on empirical evidence.

5.2 INSTITUTIONAL DIAGNOSIS AND GOVERNANCE CHALLENGES

International experience shows that the treatment of critical points is an essential component of road safety programs. The Court of Auditors of the European Union (ECA-EU, 2024) audited 13 infrastructure projects financed between 2018 and 2023, totaling €242 million in investments in Spain, Slovakia, Romania and Lithuania, and identified conceptual divergences on "tipping point" between member states. This methodological heterogeneity reinforces the need for standardization of criticality indicators, as shown in Table 4.

Table 4

Concepts of critical point in countries audited by the ECA-EUFor: author's organization (2025), based on data from the European Court of Auditors (ECA-EU, 2024)

Estado Membro	Estratégia/Definição
Lituânia	Pontos críticos são segmentos com quatro ou mais sinistros registrados no ano anterior; Os pontos críticos devem ser identificados para o público que circula no local, com recomendações aos condutores.
Espanha	Ponto crítico (definição 01) – é o grau de periculosidade, considerando a quantidade de sinistros ocorridos anteriormente, extensão do segmento e volume de tráfego por faixa de horário. Ponto crítico (definição 02) – Número absoluto de sinistros.
Romênia	Ponto crítico é um segmento que tem uma taxa de sinistro superior à média registrada. Embora esteja revogada, até que se apresenta uma nova metodologia.
Eslováquia	Ponto crítico é um segmento de 1km com cinco ou mais sinistros registrados no ano anterior.

A similar situation occurs in Brazil. The Federal Court of Accounts (TCU), through Ruling No. 275/2016, pointed out that only 7 of the 337 audited construction contracts dealt with the correction of critical segments, revealing low institutional prioritization. The Office of the Comptroller General of the Union (CGU, 2022) reinforced this finding by identifying weaknesses in the indicators of the National Highway Improvement Plan (PNMR), especially in the management of critical segments, which received only 1.5% of the R\$ 14.6 billion invested between 2020 and 2021.

All three audit programs have in common the analysis of the importance of investments in critical points, although they have highlighted some difficulties, including low investment, the lack of a unified concept in the case of the EU, and non-standardized indicators in the Brazilian context.

5.3 EMPIRICAL EVIDENCE OF SUCCESS

Latin American experiences reinforce the effectiveness of the Secure Systems approach. In Buenos Aires, a 33% reduction in deaths was observed between 2015 and 2019, after the adoption of integrated engineering and inspection measures (Santos et al., 2020). In Brazil, Avenida M'Boi Mirim, in São Paulo, recorded reductions of 80% in deaths and 72.7% in injuries between 2016 and 2017, after integrated engineering, inspection, and education interventions (São Paulo Road Plan, 2019). These results show that the identification of priority stretches is an effective strategy and rapid implementation.

5.4 INTERNATIONAL COMPARATIVE ANALYSIS OF DEATHS DUE TO TRAFFIC ACCIDENTS (2012–2022)

5.4.1 Nine countries with the largest land area

Table 5

Deaths in traffic accidents in the 9 (nine) largest countries in area

Countries	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2012-2022
Argentina	5074	5209	5279	0	5550	5611	5493	4898	3513	4481	4567	2,7%	1,3%	100%	-	1,1%	2,1%	10,8%	28,3%	27,6%	1,9%	-10%
Australia	1299	1185	1151	1205	1295	1223	1135	1187	1097	1116	1188	8,8%	2,9%	4,7%	7,5%	5,6%	7,2%	4,6%	7,6%	1,7%	6,5%	8,5%
Brazil	44812	42266	43780	38651	37345	35375	32655	31945	32716	33813	33894	5,7%	3,6%	11,7%	3,4%	5,3%	7,7%	2,2%	2,4%	3,4%	0,2%	-24%
Kazakhstan	2279	2323	2401	2549	2390	2086	2096	2094	1997	0	0	1,9%	3,4%	6,2%	6,2%	12,7%	0,5%	0,1%	4,6%	-	-	-
Canada	2075	1951	1841	1887	1900	1861	1939	1756	1746	1768	1934	6,0%	5,6%	2,5%	0,7%	2,1%	4,2%	9,4%	0,6%	1,3%	9,4%	6,8%
China	59997	58539	58523	58022	63093	63772	63194	62763	61703	62218	60676	2,4%	0,0%	0,9%	8,7%	1,1%	0,9%	0,7%	1,7%	0,8%	2,5%	1,1%
USA	33782	32893	32744	35484	37806	37473	36835	36355	39007	42939	42795	2,6%	0,5%	8,4%	6,5%	0,9%	1,7%	1,3%	7,3%	10,1%	0,3%	26,7%
India	138258	137572	139671	146133	150785	147913	157593	158984	138383	153972	168491	0,5%	1,5%	4,6%	3,2%	1,9%	6,5%	0,9%	13,0%	11,3%	9,4%	21,9%
Russia	27991	27025	26958	23114	20308	19088	18214	16981	16152	14874	14172	3,5%	0,2%	14,3%	12%	6,0%	4,6%	6,8%	4,9%	7,9%	4,7%	50% OFF
Total	315567	308963	312348	307045	320472	314402	319154	316963	296314	315181	327717	2,1%	1,1%	1,7%	4,4%	1,9%	1,5%	0,7%	6,5%	6,4%	4,0%	20% OFF

Source: author's organization (2025), based on OECD and country data.

- Two periods are distinguished: (i) 2012–2019, with a slowdown in the fall and, in some cases, an increase (China, USA, and India with more deaths in 2019 vs. 2012); (ii) 2020–2022, with a resumption of deaths in 2021 compared to 2020 in eight countries (exception: Russia).
- Between 2022 and 2021, only three countries reduced deaths: Russia, China, and the USA; six increased — Brazil had the smallest increase (+0.2%), while Canada recorded the highest increase (+9.4%).
- In the full 2012–2022 cycle, Russia showed a continuous reduction in all ten periods; Brazil, China and the USA reduced in six periods; Australia and Canada in five; Argentina in four; India and Kazakhstan in three.
- Comparing 2012 vs. 2022, five countries reduced (especially Russia, Brazil, Argentina, Australia, and Canada) and three increased (USA, India, and China).

5.4.2 Nine South American countries

Table 6 shows higher volatility and worse relative performance:

Table 6

Deaths in traffic accidents in 9 (nine) South American countries

Countries	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022
Argentina	5074	5209	5279	0	5550	5611	5493	4898	3513	4481	4567	3%	1%	-100%	-	1%	-2%	-11%	-28%	28%	2%
Brazil	44812	42266	43780	38651	37345	35375	32655	31945	32716	33813	33894	-6%	4%	-12%	-3%	-5%	-8%	-2%	2%	3%	0.2%
Bolivia						1226	1140	1201	1022	1325	1467	-	-	-	-	-	-7%	5%	-15%	30%	11%
Chile	1979	2103	2116	2136	2178	1925	1955	1973	1794	2052	2137	6%	1%	1%	2%	-12%	2%	1%	-9%	14%	4%
Colombia	5320	5757	6118	6406	6936	6505	6629	6577	5447	7238	8030	8%	6%	5%	8%	-6%	2%	-1%	-17%	33%	11%
Ecuador	2242	2277	2322	2138	1967	2153	2151	2180	1591	2131	2202	2%	2%	-8%	-8%	9%	0%	1%	-27%	34%	3%
Paraguay	1165	1191	1118	1157	1202	1198	1162	1292	1146	1396	1026	2%	-6%	3%	4%	0%	-3%	11%	-11%	22%	-27%
Peru	3209	3110	2798	2965	2696	2826	3244	3110	2159	3032	3328	-3%	-10%	6%	-9%	5%	15%	-4%	-31%	40%	10%
Uruguay	510	567	538	506	446	470	528	422	391	434	431	11%	-5%	-6%	-12%	5%	12%	-20%	-7%	11%	-1%
Total	64311	62480	64069	53959	58320	57289	54957	53598	49779	55902	57082	-3%	3%	-16%	8%	-2%	-4%	-2%	-7%	12%	2%

Source: author's organization (2025), based on OECD and country data.

- In 2021 vs. 2020, all nine countries increased deaths (first year after the pandemic was declared).
- In 2022 vs. 2021, seven countries increased; Uruguay and Paraguay differed with a reduction. Brazil recorded the lowest increase in the group (+0.2%); Bolivia and Colombia (+11%) and Peru (+10%) had the highest.
- In the cut of the ten periods, Brazil and Uruguay reduced in six; Peru in five; Argentina and Paraguay in four; Ecuador and Colombia in three; Bolivia and Chile in two (Bolivia with analysis hampered by data gaps).

5.4.3 Twenty-two European countries (and Brazil as a reference)

Table 7 indicates relatively better performance, but with the same post-2019 inflection:

Table 7

Deaths in traffic accidents in 22 (twenty-two) countries in Europe and Brazil

Countries	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022
Austria	531	455	430	479	432	414	409	416	344	362	370	-14,31 %	-5,49%	11,40%	-9,81%	-4,17%	-1,21%	1,71%	17,31 %	5,2%	2,21%
Belgium	827	764	745	762	670	609	604	644	499	516	540	-7,62%	-2,49%	2,28%	12,07 %	-9,10%	-0,82%	6,62%	22,52 %	3,4%	4,65%
Brazil	44812	42266	43780	38651	37345	35375	32655	31945	32716	33813	33894	-5,68%	3,58%	-11,72%	-3,38%	-5,28%	-7,69%	-2,17%	2,41%	3,3%	0,24%
Czech Republic	742	654	688	734	611	577	658	617	517	531	527	11,86 %	5,20%	6,69%	16,76 %	-5,56%	14,04 %	-6,23%	16,21 %	2,7%	-0,75%
Denmark	167	191	182	178	211	175	171	199	163	130	154	14,37 %	-4,71%	-2,20%	18,54 %	17,06 %	-2,29%	16,37 %	18,09 %	20,2 %	18,46 %
Finland	255	258	229	270	258	238	239	211	223	225	189	1,18%	11,24 %	17,90%	-4,44%	-7,75%	0,42%	-11,7%	5,69%	0,9%	-16,0%
France	3653	3268	3384	3461	3477	3448	3248	3244	2541	2944	3267	10,54 %	3,55%	2,28%	0,46%	-0,83%	-5,80%	-0,12%	21,67 %	15,9 %	10,97 %

Germany	3600	3339	3377	3459	3206	3180	3275	3046	2719	2562	2788	-7,25%	1,14%	2,43%	-7,31%	-0,81%	2,99%	-6,99%	-	10,74%	-5,8%	8,82%
Greece	988	879	795	793	824	731	700	688	584	624	641	11,03%	-9,56%	-0,25%	3,91%	11,29%	-4,24%	-1,71%	-	15,12%	6,8%	2,72%
Hungary	605	591	626	644	607	625	633	602	460	544	535	-2,31%	5,92%	2,88%	-5,75%	2,97%	1,28%	-4,90%	-	23,59%	18,3%	-1,65%
Iceland	9	15	4	16	18	16	18	6	8	9	9	66,67%	73,33%	300,00%	12,50%	11,11%	12,50%	-66,7%	-	33,33%	12,5%	0,00%
Ireland	163	188	192	162	182	154	134	140	146	136	155	15,34%	2,13%	-	12,35%	-	-	4,48%	-	4,29%	-6,8%	13,97%
Italy	3753	3401	3381	3428	3283	3378	3334	3173	2395	2875	3159	-9,38%	-0,59%	1,39%	-4,23%	2,89%	-1,30%	-4,83%	-	24,52%	20,1%	9,88%
Lithuania	301	258	267	239	188	191	173	186	175	148	120	14,29%	3,49%	-	21,34%	1,60%	-9,42%	7,51%	-	15,4%	-	-18,9%
Luxembourg	34	45	35	36	32	25	36	22	26	24	36	32,35%	22,22%	2,86%	11,11%	21,88%	44,00%	-38,9%	-	18,18%	-7,7%	50,00%
Holland	650	570	570	621	629	613	678	661	610	582	745	12,31%	0,00%	8,95%	1,29%	-2,54%	10,60%	-2,51%	-	-7,72%	-4,6%	28,01%
Norway	145	187	147	117	135	106	108	108	93	80	116	28,97%	21,39%	20,41%	15,38%	21,48%	1,89%	0,00%	-	13,89%	14,0%	45,00%
Poland	3571	3357	3202	2938	3026	2831	2862	2909	2491	2245	1896	-5,99%	-4,62%	-8,24%	3,00%	-6,44%	1,10%	1,64%	-	14,37%	-9,9%	-15,5%
Portugal	718	637	638	593	563	602	700	688	536	561	618	11,28%	0,16%	-7,05%	-5,06%	6,93%	16,28%	-1,71%	-	22,09%	4,7%	10,16%
Spain	1903	1680	1688	1689	1810	1830	1806	1755	1370	1533	1759	11,72%	0,48%	0,06%	7,16%	1,10%	-1,31%	-2,82%	-	21,94%	11,9%	14,74%
Sweden	285	260	270	259	270	252	324	221	204	210	227	-8,77%	3,85%	-4,07%	4,25%	-6,67%	28,57%	-31,8%	-	-7,69%	2,9%	8,1%
Switzerland	339	269	243	253	216	230	233	187	227	200	241	20,65%	-9,67%	4,12%	14,62%	6,48%	1,30%	-19,7%	-	21,4%	11,9%	20,5%
Total	6805 1	6353 2	6487 3	5978 2	5799 3	5560 0	5299 8	5166 8	4904 7	5085 4	5198 6	-6,64%	2,11%	-7,85%	-2,99%	-4,13%	-4,68%	-2,51%	-	-5,07%	3,7%	2,23%

Source: author's organization (2025), based on OECD and country data.

- 2021 vs. 2020: 12 of the 22 countries increased deaths.
- 2022 vs. 2021: 16 of the 22 countries increased deaths; 9 were discharged in both intervals.
- Brazil was included only for comparative reference, reinforcing the trajectory analogous to the European one, but with a slightly more intense recovery trend in 2021–2022.

5.4.4 Comparative synthesis and implications

- Common pattern: deceleration of reductions at the end of the decade and resumption from 2019 (post-pandemic, economic recovery, change in mobility patterns).

- Order of performance: Europe (best performer) > largest countries (average performer) > South America (performance below the other two groups of countries).
- Brazil: evolution similar to the global pattern, with the lowest increase between 2021–2022 (+0.2%) among the countries that grew in Table 5; Still, trend reversal since 2019.

The convergence of these results — resumption of deaths in different geographies and income levels — reinforces the need for standardized criticality metrics, capable of locating stretches where lethality is concentrated and prioritizing engineering, inspection, and education interventions. It is in this context that the Critical Point of Death Claim (IPCO) Indicator is inserted, presented below (Section 5.5), which measures the lethal density per kilometer adjusted for temporal recidivism, allowing operational ranking and alignment with the UN/PNATRANS goals.

5.5 THEORETICAL FOUNDATION OF THE IPCO

The formulation of the Critical Point Indicator for Traffic Accidents with Death (IPCO) is based on three theoretical axes:

a) the need for standardized measurement to enable results-based management. According to Holló and Eksler (2010): *"you cannot manage what you cannot measure"*. Kevin, quoted by Holló and Eksler, previously stated that *"if you can't measure it, you can't improve it"*;

b) Wegman's (2017) emphasis on *the go fishing where the fish are strategy*, that is, concentrating efforts where there is greater density of data and occurrences;

c) the recognition by Mononen and Leviäkangas (2016) that performance indicators are essential instruments to reduce knowledge gaps and measure institutional advances.

The literature on Road Safety Performance Indicators (RSPI), according to Hakkert, Gitelman and Vis (2007) and Yannis et al. (2013), distinguishes behavioral indicators (speed, use of belts, alcohol) from structural indicators (infrastructure and management). The IPCO falls into this second category, seeking to quantify the spatial and temporal risk of fatalities.

5.6 CONSTRUCTION AND APPLICABILITY OF THE IPCO

The conception of the IPCO considered essential variables:

- Segment length (L), expressed in kilometers;
- Number of fatalities (ΣS_m);

- Temporal frequency (R_t) — number of years with death records;

The proposed formula is:

$$IPCO = \frac{(\sum S_m \times R_t)}{L} \quad (1)$$

The indicator is dimensionless and always shows values greater than zero.

Considering the empirical distribution of fatalities, the following criticality classification is suggested:

- $IPCO \geq X$ severe critical $\rightarrow$ (those that concentrate 50% of deaths);
- $Z \leq IPCO < X$ moderate critical $\rightarrow$ (those that concentrate between 20% and 49% of deaths);
- $IPCO < Z \rightarrow$ mild critical (those that concentrate below 20% of deaths).
- It is suggested that the R_t remain between 5 and 10 years, as very long periods may not portray the current situation.

The X and Z values will depend on the period of analysis (R_t) and the extension (L). For rural areas, the length of the segment (L) is usually larger than urban areas. In urban areas, critical intersections can be identified, where the extension (L) does not exceed 200 meters (0.2 km).

Regarding the temporal frequency (R_t), it is important to note that historical series should be 5 (five) years, accepting up to three years, to avoid the use of very short periods, and not to generate errors from a statistical phenomenon known as regression to the mean (DER/SP, 2023).

For the purpose of defining priority points for intervention, the segments that have $IPCO \geq X$ should receive immediate attention (engineering works, inspection and educational measures), as they can positively impact the goal proposed by the UN and PNATTRANS.

The simplicity of the calculation favors its replication by state and municipal agencies, as it depends only on open data from RENAEST and its own databases, supplied with claims records. This characteristic responds to the warning of Tesic et al. (2018) that excessively complex indicators are not very applicable in countries with incomplete or divergent databases.

5.7 CONCEPTUAL SYNTHESIS AND INTEGRATION WITH PUBLIC POLICIES

The absence of a standardized indicator for critical points was confirmed in the analysis of 12 road safety and urban mobility plans of Brazilian capitals and state agencies (Table 5). In practically all of them, the reactive approach prevails, and the UPS methodology is the one with the greatest coverage among the documents analyzed.

Table 5

Mobility or road safety plans that address critical points (capitals and public agencies)

Órgão	Metodologia e Estratégias realizadas em relação a pontos críticos
Departamento de Infraestrutura Nacional de Transportes – DNIT	1) O DNIT emprega a metodologia Unidade Padrão de Severidade – UPS, com pesos diferentes para sinistros sem vítima, com vítima e com óbito, segundo Pena, C. Mori, F. Otto, G. e Tani, V. (2009) ; 2) A metodologia UPS é a mais comumente utilizada pelos diversos órgãos, que tem no DNIT a referência em estudos de infraestrutura viária; 3) A Resolução No 10 de 2023 do DNIT, estabeleceu procedimentos para identificação e procedimentos para eliminação de pontos críticos.
Polícia Rodoviária Federal – PRF	1) A PRF instituiu o indicador de ponto crítico em 2022, com seguinte descrição: o indicador “Ponto Crítico” no âmbito da PRF, se refere a uma extensão de rodovia federal que não ultrapasse 500m em vias de zonas urbanas e 2.500m em vias de zona rural, e que possua alta concentração ¹ de sinistros graves ² , e que possua fator de infraestrutura viária contribuinte para a ocorrência dos sinistros; 2) A série histórica de análise deve contemplar três anos, e considerar apenas os sinistros graves, aqueles com feridos graves ou mortos.
Departamento de Estradas e Rodagem – DER/SP	1) O Manual de Segurança Viária do DER/SP, adota a UPS para identificar a severidade dos segmentos. De uma forma geral utiliza a metodologia adotada pelo DNIT, onde os sinistros sem vítima valem 1 ponto, com vítima 5 pontos e com morto, 13 pontos.
Município de São Paulo/SP	1) O município adota um Plano de Segurança Viária do município de São Paulo de 2019; 2) Intervenções em pontos críticos de travessia de pedestre é uma das sete estratégias para reduzir mortes no trânsito; 3) A metodologia utilizada para identificar segmentos críticos de mortes de pedestres leva em consideração a Unidade Padrão de Severidade-UPS; 4) A UPS = DM + 4VF + 6PF + 13FAT, onde DM se refere a sinistros com danos materiais, VF a sinistros com vítimas feridas, PF a sinistros com pedestre feridos e FAT se refere a sinistro com vítima fatal; 5) O ranking de severidade é adotado dividindo-se a UPS/extensão da via; 6) Já a UPS de uma forma geral utiliza a metodologia adotada pelo DNIT, onde os sinistros sem vítima vale 1 ponto, com vítima 5 pontos e com morto, 13 pontos.
CET-RIO/RJ	1) O município do Rio de Janeiro adota um agrupamento de sinistros em um raio de 25m, como ponto crítico; 2) É levado em consideração além da quantidade de sinistros, a quantidade de pessoas feridas, mortas, envolvimento de pedestres e ciclistas; 3) A Unidade Padrão de Severidade - UPS é a metodologia utilizada pela CET-RIO para ranquear pontos críticos.
Empresa de Transportes e Trânsito de Belo Horizonte/MG	1) A Política de Segurança no Trânsito de Belo Horizonte (2016), apresenta uma análise das vias com maior frequência de sinistros, tanto considerando dados absolutos como sinistros por quilômetro
Município de Fortaleza/CE	1) Informações extraídas do relatório de segurança viária de Fortaleza em 2019; O município de fortaleza também utiliza a Unidade Padrão de Severidade para ranquear os pontos críticos; A Autarquia Municipal de Trânsito – AMT realiza levantamentos periódicos sobre pontos críticos.
Secretaria de Mobilidade de Recife/PE	1) Informações coletadas na Minuta do Programa de Segurança Viária para Recife, 2024-2030. Observar-se-á que a única metodologia identificada no plano foi a GDCl; Ação 132 - Desenvolver o monitoramento sistemático com caracterização do segurança viária a partir da metodologia para definição de pontos e trechos críticos, considerando a severidade dos sinistros e, quando possível, o nível de exposição; Ação 413 - Criar procedimento para Inspeção e tratamento sistemático de segurança viária em trechos e pontos críticos baseado em dados; A416 - Definir e implementar procedimentos para avaliar os projetos de mobilidade a partir de métricas (antes e depois), usando como referência a metodologia da Global <i>Designing Cities Initiative</i> , (GDCl).
Secretaria Municipal de Mobilidade Urbana – STTU, Natal/RN	1) As informações foram extraídas no Plano Diretor de Mobilidade de Natal de 2022; 2) O plano realiza um diagnóstico com várias análises quantitativas e qualitativas, apresenta diretrizes de educação para o no trânsito e elenca a necessidade de elaborar um Plano de Segurança Viária (Implantação de um Plano de Segurança Viária, que esteja alinhado à abordagem de Sistemas Seguros e à Agenda 2030 da ONU, sobretudo com a ODS 11 (Cidades e Comunidades Sustentáveis); 3) Apresenta diversos indicadores, bem elaborados, entre os quais o Indicador 2: Percentual de interseções semaforizadas ou satisfatoriamente tratadas com <i>traffic calming</i> para garantir a travessia segura de pedestres (em relação ao total de interseções das vias arteriais). Objetivo: Melhorar constantemente o grau de segurança para pedestres nas interseções das vias arteriais e pontos críticos na ocorrência de sinistros.
Secretaria Municipal de Mobilidade Urbana – SMMU Empresa Pública de Transporte e Circulação – EPTC (Porto Alegre/RS)	1) O plano para década prevê no pilar engenharia a identificação e tratamento de pontos críticos de sinistros, ou seja, aqueles locais concentradores dessas ocorrências; 2) Os pontos críticos são definidos em um ano, com previsão de adoção das medidas corretivas no ano seguinte; 3) Os pontos críticos foram segmentados, levando-se em consideração o tipo de veículo envolvido e de sinistro.
Prefeitura municipal de Florianópolis/SC.	1) O Plano de Mobilidade Urbana de Florianópolis (2016) menciona em poucas partes do documento a redução de sinistros, mas não trata na identificação e tratamento de pontos críticos; 2) EM 2021, o plano passou por uma revisão, muito embora não foi possível acessar por problemas de download da página. Na revisão foi adotado o termo Plano de Mobilidade Urbana Sustentável – PLAMUS.
Secretaria de Mobilidade – SEMOB (Distrito Federal)	1) Foi consultado o Plano de Mobilidade Ativa - PMA do Distrito Federal de 2020, onde se verifica um esforço para identificação de pontos críticos de sinistros envolvendo pedestres e direcionamento de fiscalização
Prefeitura Municipal de Campo Grande/MS.	1) Campo Grande, capital do Mato Grosso, no Plano Diretor de Mobilidade Urbana (2024), caderno 14, estabelece a necessidade de desenvolvimento de um programa específico para identificação e tratamentos de pontos críticos, com ações de engenharia, reforço ou adequação da fiscalização eletrônica e com agentes de trânsito; 2) Apesar do plano dispor de uma tabela com indicadores propostos, não figura qualquer um que se assemelhe ao que se propõe no presente artigo.
Prefeitura Municipal de Manaus/AM.	1) O Plano de Mobilidade Urbana de Manaus de 2015, menciona discretamente a necessidade de realizar verificações constantes nos locais de maior periculosidade, sem contanto mencionar como identificar esses locais (metodologia utilizada).
Secretaria Municipal de Segurança e Mobilidade Urbana de Palmas/TO	1) O Plano de Mobilidade de Palmas/TO, “Mobilize-se”, lançado em 2024, possui alguns cadernos (produtos) entre os quais um de indicadores, não constando, porém, um indicador de ponto crítico ou algo nesse sentido; 2) O produto 6 do plano (Diagnóstico da infraestrutura e da segurança viária), aponta análise reativa com base no histórico de sinistros e feridos, destacando a necessidade de tratar essas localidades.

Source: author (2025).

The IPCO proposes to fill this gap by offering a uniform criticality metric that can be integrated into PNATRANS and Road Safety and Mobility Plans of states and municipalities. In this way, the indicator is consolidated as a strategic tool for public management, allowing the planning of prioritized interventions.

6 CONSIDERATIONS

Even fifteen years after the first United Nations (UN) resolution establishing the Decade of Action for Road Safety 2011–2020, the goal of reducing traffic deaths by 50% has not yet been achieved. The analysis of three groups of countries, those with the largest territorial extension, the South American and the European, revealed a similar behavior: a slowdown in the reduction of deaths at the end of the last decade and a resumption of growth from 2019 onwards. This sample covers approximately 60% of the world's population, giving global representativeness to the results. Brazil has a similar trajectory, with a continuous increase since 2019. Despite this, among the countries analyzed, it had the second lowest growth percentage (+0.2%) between 2021 and 2022, behind only Iceland, a country with the smallest demographic and vehicular scale.

The main plans analyzed, Global Plans 2011–2020 and 2021–2030 (UN), PNATRANS (SENATRAN, 2024) and the European Road Safety Plan, converge on the improvement of infrastructure and the adoption of the Safe Systems approach. According to Fletcher et al. (2020) and the *World Resources Institute* (WRI, 2020), this approach seeks to eliminate serious claims, recognizing that human errors are inevitable and that roads must be designed to absorb them without causing fatalities.

In Brazil, the analysis of 15 mobility and road safety plans revealed that almost all of them mention the need to identify and treat critical points. However, there is still a lack of uniformity regarding the definition criteria, the historical series used and the radius of coverage of the stretches (which varied between 25 m and 2,500 m). Although PNATRANS mentions the term *critical point* in its strategic actions, and Contran Resolution No. 798/2020 establishes distance parameters, there is still no standardized criticality methodology or indicator, resulting in significant methodological differences between the federal, state, and municipal spheres, resulting in losses in the evaluation of the critical point treatment policy. For example, it is not possible to know the measures adopted with the respective costs, and the results obtained later after implementation.

This gap is reinforced by the control agencies, which warn of the need to prioritize investments in places with a higher concentration of claims. The Federal Court of Accounts (TCU) and the Office of the Comptroller General of the Union (CGU) highlighted, in recent reports, that only 1.5% of the resources allocated to the maintenance of federal highways (2020–2021) were applied to the treatment of critical segments. Similarly, the Court of Auditors of the European Union (TCE-EU, 2024) pointed out divergent concepts of critical points between countries, recommended methodological standardization and expansion of resources for the correction of high-risk stretches.

Based on the analysis of 2,122,326 accidents that occurred on Brazilian federal highways between 2007 and 2024, involving 4.7 million people, 1.17 million minor injuries, 404 thousand serious injuries, and 121,661 deaths, a sample was separated with 100 points with the most death records in the last 18 years, each 1 km long, totaling 2,471 accidents and 2,726 deaths. On average, each point presented nine types and ten different causes of accidents, showing that the common factor is not the type of event, but the location, which confirms the conclusions of Anderson (2009) and Erdogan et al. (2008) about the territorial relevance in the concentration of fatalities. In summary, the research showed:

- a) absence of a standardized national indicator for critical point;
- b) significant spatial concentration of fatal claims within a few kilometers;
- c) institutional fragility in budget prioritization and in the integration of road safety plans.

In view of this diagnosis, the article proposed the Critical Point Indicator for Traffic Accidents with Death (IPCO) as an instrument of public management and decision support, integrating severity, temporal recurrence and spatial density. The IPCO represents a contribution to road safety and seeks to fill the gaps identified in current policies and programs, contributing to the fulfillment of the UN and PNATTRANS goal of reducing traffic deaths by 50% by 2030.

The investigation did not address, however, correlations between critical points and socioeconomic, demographic or vehicle typology factors, which constitutes a limitation and, at the same time, an opportunity for future research. Complementary studies may associate the IPCO with indicators of exposure, logistics cost and territorial vulnerability, expanding its application in integrated transport planning and road safety.

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**THE IMPORTANCE OF CONTROLLERSHIP IN THE MANAGEMENT OF RIVER
TRANSPORTATION COMPANIES IN THE AMAZON**

**A IMPORTÂNCIA DA CONTROLADORIA NA GESTÃO DE EMPRESAS DE
TRANSPORTE FLUVIAL NO AMAZONAS**

**LA IMPORTANCIA DE LA CONTRALORÍA EN LA GESTIÓN DE LAS
EMPRESAS DE TRANSPORTE FLUVIAL EN AMAZONAS**

 <https://doi.org/10.56238/sevened2025.036-041>

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ABSTRACT

This article aims to analyze the application of controllership as an essential tool for process optimization, cost control, and strategic decision-making support in river transport companies in the Northern Region of Brazil, focusing on the state of Amazonas. In this region, river transport is the main means of moving people and goods, playing a vital role in territorial integration and socioeconomic development. Considering controllership as a management support area responsible for ensuring the transparency and reliability of accounting and managerial information, this study seeks to verify how controllership is applied in river transport companies in Amazonas and to identify how its implementation contributes to the efficiency and sustainability of business operations. To this end, a qualitative, descriptive, and exploratory approach was adopted, based on bibliographic and documentary research, as well as a case study applied to a company in the sector. The research, qualitative in nature and descriptive-exploratory in character, was developed based on bibliographic and documentary review and a case study conducted in a company from the sector. The results show that the absence of structured controllership practices leads to administrative and financial deficiencies, while the implementation of an integrated management system, combined with employee training and process digitalization, resulted in significant improvements in efficiency, control, and reliability of information. It is concluded that controllership is a strategic and indispensable instrument for the sustainability and competitiveness of river transport companies in the Amazon region.

Keywords: Controllership. Business Management. River Transport.

RESUMO

O presente artigo tem como objetivo analisar a aplicação da controladoria como ferramenta essencial para a otimização de processos, o controle de custos e o suporte à tomada de decisões estratégicas nas empresas de transporte fluvial da Região Norte, com foco no estado do Amazonas. Nessa localidade, o transporte fluvial constitui o principal meio de deslocamento de pessoas e cargas, sendo vital para a integração territorial e o desenvolvimento socioeconômico. Considerando a controladoria como área de apoio à

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gestão, responsável por assegurar a transparência e a confiabilidade das informações contábeis e gerenciais, este estudo busca verificar como a controladoria é aplicada nas empresas de transporte fluvial no Amazonas e identificar de que forma sua implantação contribui para a eficiência e sustentabilidade das operações empresariais. Para tanto, adotou-se uma abordagem qualitativa, de caráter descritivo e exploratório, baseada em pesquisa bibliográfica, documental e em um estudo de caso aplicado a uma empresa do setor. A pesquisa, de natureza qualitativa e caráter descritivo-exploratório, foi desenvolvida com base em revisão bibliográfica, documental e em um estudo de caso aplicado a uma empresa do setor. Os resultados evidenciam que a ausência de práticas estruturadas de controladoria gera deficiências administrativas e financeiras, enquanto a implementação de um sistema de gestão integrado, aliada à capacitação dos colaboradores e à informatização dos processos, proporcionou melhorias significativas na eficiência, no controle e na confiabilidade das informações. Conclui-se que a controladoria é um instrumento estratégico indispensável à sustentabilidade e à competitividade das empresas de transporte fluvial na Amazônia.

Palavras-chave: Controladoria. Gestão Empresarial. Transporte Fluvial.

RESUMEN

Este artículo tiene como objetivo analizar la aplicación de la contraloría como herramienta esencial para la optimización de procesos, el control de costos y el apoyo a la toma de decisiones estratégicas en las empresas de transporte fluvial de la Región Norte, con enfoque en el estado de Amazonas. En esta localidad, el transporte fluvial es el principal medio de desplazamiento de personas y carga, siendo vital para la integración territorial y el desarrollo socioeconómico. Considerando la contraloría como un área de apoyo a la gestión, responsable de garantizar la transparencia y confiabilidad de la información contable y de gestión, este estudio busca verificar cómo se aplica la contraloría en las empresas de transporte fluvial en Amazonas e identificar cómo su implementación contribuye a la eficiencia y sostenibilidad de las operaciones comerciales. Para ello, se adoptó un enfoque cualitativo, de carácter descriptivo y exploratorio, basado en una investigación bibliográfica y documental y en un estudio de caso aplicado a una empresa del sector. La investigación, de carácter cualitativo y de carácter descriptivo-exploratorio, se desarrolló a partir de una revisión bibliográfica y documental y un estudio de caso aplicado a una empresa del sector. Los resultados muestran que la ausencia de prácticas estructuradas de contraloría genera deficiencias administrativas y financieras, mientras que la implementación de un sistema integrado de gestión, combinado con la capacitación de los empleados y la informatización de los procesos, proporcionó mejoras significativas en la eficiencia, control y confiabilidad de la información. Se concluye que la contraloría es un instrumento estratégico indispensable para la sostenibilidad y competitividad de las empresas de transporte fluvial en la Amazonía.

Palabras clave: Contraloría. Gestión Empresarial. Transporte Fluvial.

1 INTRODUCTION

River transport is one of the main means of transport in the Amazon region, playing an essential role in territorial integration, in the supply of riverside communities and in the flow of products. However, this system faces significant challenges, such as the precariousness of the port infrastructure, low accessibility, lack of investments, limited mobility, lack of adequate routes for the flow of production, and the incompatibility of the logistics system with the characteristics of regional production. Studies by Rodrigues et al. (2014) and Cardoso (2013) point out that these structural and operational limitations compromise the efficiency of the modal and restrict its potential to contribute to the economic development of the Amazon.

In view of this, added to the geographical and operational particularities of the Amazon, such as dependence on rivers, seasonality of waters, and limited infrastructure, it is essential to adopt management practices that ensure efficiency, sustainability, and control. In this scenario, controllership stands out as a fundamental strategic tool for the management of river transport companies.

Thus, this article seeks to verify the importance of the application of controllership in river transport companies in the state of Amazonas and to evaluate how its implementation contributes to strategic decision-making, governance, sustainability and operational efficiency.

For this, the application, through a case study, of a controllership in a company in the sector will be presented in order to highlight the improvements obtained with the implementation of such instrument in the organization.

2 THEORETICAL FRAMEWORK

2.1 WATERWAY TRANSPORT IN BRAZIL

Waterway transport comprises the movement of cargo and passengers through rivers, lakes and seas, using various vessels, such as ships, ferries and boats. It is one of the oldest and most efficient modes of transport in history, fundamental for trade and territorial integration. Its main advantages are the ability to move large volumes at a lower cost and with less environmental impact, especially over long distances and for low value-added products (Ballou, 2006).

From an environmental perspective, the modal has reduced emissions of pollutants and lower rates of loss and damage when compared to other means of transport (CNT, 2019). However, compared to road and rail modes, infrastructure limitations and lack of intermodal

integration restrict their full use in the country (ANTAQ, 2025).

According to official data from the National Waterway Transport Agency (ANTAQ, 2025), Brazil has approximately 20 thousand kilometers of economically navigable waterways, distributed between large and small ports. Even so, only 30.9% of the waterway network is effectively used (CNT, 2019), with emphasis on the Madeira, Paraná-Tietê, Paraguay, Solimões-Amazonas, and Tocantins-Araguaia waterways, responsible for significant movement of agricultural, mineral, and fuel cargo, according to ANTAQ's TKU 2021 report (2022). The Amazon and Tocantins-Araguaia basins accounted for approximately 76% of the total volume of cargo handled in 2022 (ANTAQ, 2023), which highlights the relevance of the Amazon in the national waterway context.

2.2 RIVER TRANSPORT IN THE AMAZON REGION

In the Amazon Region, river transport plays a vital role in the integration and supply of communities. Of the 62 municipalities in Amazonas (IBGE, 2022), only six have a land connection, which makes waterway transport the main means of mobility and regional logistics (ARSEPAM, 2024). Air transport acts in a complementary way, but limited by high costs and restricted infrastructure.

The Amazon waterway network adds up to more than 16 thousand kilometers of navigable rivers, representing about 80% of the Brazilian network (ANTAQ, 2022). The system interconnects cities and riverside communities in isolated areas, moving millions of passengers and tons of cargo annually, which reinforces its essential economic and social character (ANTAQ, 2018).

In the state of Amazonas, intercity waterway transport registered a flow of 808,462 passengers in 2023, representing an increase of 8.63% compared to the previous year, when 744,209 passengers were recorded. Even in the face of severe droughts, this increase demonstrates the resilience of the modal and its social and economic importance for the State (ARSEPAM, 2024).

Even with its relevance, the modal faces structural deficiencies. DNIT (2018) points out that most Amazon routes do not meet the technical standards of a waterway, as they lack adequate signaling, dredging and maintenance. In addition, there is a mismatch between the obsolete fleet used by communities and the modern vessels employed by large companies, which reflects operational inequalities. Studies by ANTAQ and UFPA (2018) classified the quality of passenger terminals as "poor", with a General Quality Index of 0.17, and this

number varies from zero to one.

In summary, although Amazonian river transport is a vital component for the mobility, economy, and territorial integration of the region, its full potential is still limited by structural deficiencies, the seasonality of rivers, and the lack of continuous investments in infrastructure and management.

2.3 THE EVOLUTION AND IMPORTANCE OF CONTROLLERSHIP IN THE BUSINESS MANAGEMENT PROCESS

Controllership emerged in the United States at the beginning of the twentieth century as an instrument of control and administrative coordination in large corporations (Schmidt, 2002). In Brazil, its development was driven by North American multinationals, which introduced management accounting methods and information systems aimed at organizational efficiency (Beuren; Borgoni; Fernandes, 2008).

For Mosimann (1999), controllership is an interdisciplinary science that combines principles of administration, economics and accounting, with the objective of guiding economic management and supporting decision-making. Oliveira (1998) points out that its effectiveness depends on the ability to transform accounting data into strategic information, promoting greater security and agility in decisions.

According to Alves, Fisch and Mosimann (1993), controllership acts as an integrating link between organizational sectors, providing information that favors the alignment between planning and execution. Bruni and Gomes (2010) and Padoveze (2014) expand this conception by highlighting its strategic functions: planning, control, coordination, evaluation and monitoring, all of which are indispensable to business performance.

Recent studies reinforce the evolutionary character of the area, Lunkes (2010) identified that Brazilian controllership practices focus on planning and cost control, while Guedes and Costa (2019) highlight the need for theoretical and methodological deepening in the field. Tavares (2022) observes that the controllership professional has been assuming strategic functions, aimed at generating value and organizational sustainability. Thus, controllership is consolidated as an essential tool for business competitiveness, integrating information, control and performance.

2.4 THE IMPORTANCE OF CONTROLLERSHIP IN THE MANAGEMENT OF RIVER TRANSPORT COMPANIES IN AMAZONAS

Studies by Tavares (2024) show that for companies in the river transport sector in Amazonas, the definition and control of vessel operating costs represent constant challenges, considering factors such as the oscillation of river levels, the absence of consistent financial records, market competition, and the quality of the services offered. These companies deal with complex and variable expenses, with fuel and fixed costs accounting for more than half of these expenses.

According to Datamarnews (2024) and Pereira, Roberto and Almeida (2025). The annual variation in the water level in the Amazon, marked by severe droughts, compromises navigability, affecting mobility, supply and increasing operating costs. In addition to natural adversities, the absence of consolidated information systems and consistent accounting records still limits the internal control of organizations (Lobato; Araújo Júnior, 2025). Research by Queiroz (2019) and Lacerda and Situba (2020) also highlights structural and institutional failures in the sector, which impact the efficiency and reliability of operations.

In this way, the application of controllership in the Amazon context goes beyond the accounting dimension and assumes a strategic and adaptive role, allowing river companies to minimize risks, optimize resources and strengthen their competitiveness in the face of a challenging logistics environment.

3 METHODOLOGY

The research is characterized as qualitative, descriptive and exploratory, since it seeks to understand how controllership is applied in river transport companies in the state of Amazonas, analyzing its impacts on operational efficiency and decision making. According to Gil (2017), this type of approach is appropriate when it is intended to deepen the understanding of complex phenomena in specific contexts, allowing for more detailed and contextualized interpretations. According to Gerhardt and Silveira (2009), qualitative studies privilege direct observation and interpretative analysis, and are appropriate for understanding practices and perceptions in the organizational environment.

The method used was the case study, chosen because it allows an in-depth analysis of a specific organization in the river transport sector. According to Yin (2015), the case study is a method of empirical investigation that allows one to examine contemporary phenomena in their real context, especially when the boundaries between the phenomenon and the

context are not clearly defined.

Data collection was carried out through direct observations and semi-structured interviews with managers and employees of Company R, which chose anonymity for confidentiality reasons. The interviews sought to understand the control practices adopted, the use of accounting and management information in the decision-making process and the difficulties faced in management. In addition, internal documents and administrative records were analyzed. The use of different data collection techniques, such as interviews, observations, and document analysis, contribute to strengthening the validity and consistency of the findings (Yin, 2015).

4 RESULTS AND DISCUSSIONS

During the data collection, problems of an administrative, technological and operational nature were observed. The sales of tickets and orders were carried out predominantly manually or at the counters located in the ports of Manaus and Parintins, with fees ranging from 5% to 10% on the value of the tickets. The absence of this control generated risks of selling fake tickets, undue charges and loss of revenue, in addition to potential legal liabilities for embarrassment to passengers and moral damages

It was also found that the management system used by the company did not present centralization or integration of information, being restricted to the issuance of Electronic Bill of Lading (CT-e), a digital tax document used to register cargo transport services. However, this system does not allow efficient control of sales, shipments or monitoring of income and expenses per trip.

In the parcel sector, there was a lack of standardization in the identification of senders and recipients, which caused loss of volumes and difficulty in tracking goods. In addition to the absence of correct identification of the goods, it was also observed that they were improperly handled during loading and unloading, which contributes to physical damage and possible loss of packages.

In the restaurant and in the boat's cafeteria, sales control was carried out through receipts and manual carbon paper sheets, without integration with the financial sector, resulting in divergences between the number of meals produced and the total amount calculated in the cashier.

Another critical point refers to the lack of internet connection during trips, which made it impossible to use real-time management systems during trips, making it difficult to control income and expenses per trip.

The aforementioned diagnosis revealed challenges common to the sector, such as the lack of technological integration and limited control of costs and revenues. Recent studies by Moura (2024) on the river transport of passengers between Manaus and Barcelos point out that about 58% of the operating costs of these companies are variable, with emphasis on fuel, maintenance and passenger food. This data reinforces the need for control tools capable of monitoring spending in real time and supporting decision-making.

Based on this, the creation of a controllership in the company was proposed and implemented, structured in four main stages:

First step: implementation of an integrated management software, with digital control of receipts through automatic PIX, applicable to the sales of tickets, parcels and food products on board.

Figure 1 shows the new flow of ticket purchase after the implementation of the integrated management software. The system automated steps previously carried out manually, allowing the real-time registration of ticket sales, orders and restaurant orders. In addition, it has expanded the payment options available to customers, making transactions more agile, secure, and efficient.

Figure 1

Purchase of tickets

21/10/2025, 20:31

Aquaviário - Passagens Fluviais

Alexandre de Moraes Lima - SUPERUSER

Aquaviário Cadastros Sair

Passagens Barco Viagem Procurar passagem por:

aa Barco de Teste do Sis 19/09/2025 - De Manaus a Tabatinga

>>> Nova Passagem Lista Geral

Nova Passagem

Valor: R\$ 0,00

Viagem: 60 Inicio: 19/09/2025

CPF/RG/Passaporte: >>> Passageiro: (Id.) Telefone:

Nascimento: dd/mm/aaaa Sexo: Masculino

Origem: MANAUS Destino: TABATINGA Lugar: Rede Idoso- R\$ 0.5 - 4 Vagas

Valor (R\$): 0,00 Pagmto.: Em Aberto Modalidade: Dinheiro Passageiro.: Não viajou

Responsável: Telefone Resp.: CPF Resp.:

Cancelar Nova Passagem Lista Geral

https://aquaviario.net.br/app/index.php

1/1

Source: Prepared by the authors themselves.

Second stage: training of employees and business partners, including self-employed salespeople, with the objective of promoting adaptation to new work routines and overcoming resistance to organizational changes

Third stage: implementation of satellite internet to enable the use of the system in real time, also expanding the sources of revenue with the commercialization of network access for passengers.

Fourth stage: modernization of the process of selling tickets, parcels and cargo through applications connected to the internet, ensuring greater security, agility and reliability in financial and legal operations, in addition to generating accurate management reports.

Figure 2 demonstrates the process of integrating the system after sales have been made. With each purchase of tickets, food or packages, the software automatically generates the receipt on the company's machine, ensuring greater effectiveness, control and traceability of transactions.

Figure 2

Software Integration



Source: Prepared by the authors themselves.

Table 1 represents the sales report of September 25, 2025 generated by the software and allows you to visualize the restaurant's integration with the financial sector, presenting information such as quantity sold, period, type of meal, unit value, and total value at the end

of the day. Thus ensuring an accurate and real-time report, allowing for more efficient and effective control by managers.

Table 1

Sales Report of 09/25/2025 (Integration of sectors)

DATE	MEAL	MODE	QUANT.	VALUE (R\$)	TRAVEL
25/09/2025	FULL COFFEE	Covenant	28	560,00	62
25/09/2025	COFFEE	Covenant	2	10,00	62
25/09/2025	CAKE	Covenant	9	180,00	62
25/09/2025	MIXED SANDWICH	Covenant	10	200,00	62
TOTAL AGREEMENT			49	950,00	
DATE	MEAL	MODE	QUANT.	VALUE (R\$)	TRAVEL
25/09/2025	COFFEE	Credit	2	10,00	62
25/09/2025	FULL COFFEE	Credit	12	120,00	62
TOTAL CREDIT			14	130,00	
DATE	MEAL	MODE	QUANT.	VALUE (R\$)	TRAVEL
25/09/2025	CAKE	Debit	1	5,00	62
25/09/2025	COFFEE	Debit	4	20,00	62
25/09/2025	FULL COFFEE	Debit	15	150,00	62
TOTAL DEBIT			20	175,00	
DATE	MEAL	MODE	QUANT.	VALUE (R\$)	TRAVEL
25/09/2025	FULL COFFEE	Money	22	440,00	62
25/09/2025	CAKE	Money	7	49,00	62
25/09/2025	COFFEE	Money	167	3.340,00	62
TOTAL MONEY			196	3.829,00	
DATE	MEAL	MODE	QUANT.	VALUE (R\$)	TRAVEL
25/09/2025	MIXED SANDWICH	Pix	1	7,00	62
25/09/2025	COFFEE	Pix	1	5,00	62
25/09/2025	FULL COFFEE	Pix	24	240,00	62
TOTAL PIX			26	252,00	
TOTAL MORNING			305	5.336,00	
DATE	MEAL	MODE	QUANT.	VALUE (R\$)	TRAVEL
25/09/2025	STEAK	Credit	14	280,00	62
25/09/2025	OVEN CHICKEN	Credit	1	20,00	62
25/09/2025	GRILLED CHICKEN	Credit	10	200,00	62
TOTAL CREDIT			25	500,00	
DATE	MEAL	MODE	QUANT.	VALUE (R\$)	TRAVEL

25/09/2025	GRILLED CHICKEN	Debit	31	620,00	62
25/09/2025	OVEN CHICKEN	Debit	4	80,00	62
25/09/2025	STEAK	Debit	54	1.080,00	62
TOTAL DEBIT			89	1.780,00	
DATE	MEAL	MODE	QUANT.	VALUE (R\$)	TRAVEL
25/09/2025	COFFEE	Money	28	140,00	62
25/09/2025	GRILLED CHICKEN	Money	128	2.560,00	62
25/09/2025	FULL COFFEE	Money	68	680,00	62
25/09/2025	STEAK	Money	155	3.100,00	62
TOTAL MONEY			379	6.480,00	
DATE	MEAL	MODE	QUANT.	VALUE (R\$)	TRAVEL
25/09/2025	STEAK	Pix	57	1.140,00	62
25/09/2025	GRILLED CHICKEN	Pix	34	680,00	62
25/09/2025	OVEN CHICKEN	Pix	9	180,00	62
TOTAL PIX			100	2.000,00	
TOTAL AFTERNOON			682	10.760,00	
DATE	MEAL	MODE	QUANT.	VALUE (R\$)	TRAVEL
25/09/2025	SOUP	Credit	8	160,00	62
25/09/2025	POT MEAT	Credit	12	240,00	62
TOTAL CREDIT			20	400,00	
DATE	MEAL	MODE	QUANT.	VALUE (R\$)	TRAVEL
25/09/2025	POT MEAT	Debit	98	1.960,00	62
25/09/2025	SOUP	Debit	10	200,00	62
TOTAL DEBIT			108	2.160,00	
DATE	MEAL	MODE	QUANT.	VALUE (R\$)	TRAVEL
25/09/2025	SOUP	Covenant	49	980,00	62
TOTAL AGREEMENT			49	980,00	
DATE	MEAL	MODE	QUANT.	VALUE (R\$)	TRAVEL
25/09/2025	SOUP	Pix	9	180,00	62
25/09/2025	POT MEAT	Pix	56	1.120,00	62
TOTAL PIX			65	1.300,00	
TOTAL NIGHT			242	4.840,00	
TOTAL ON THE TRIP			1.229	20.93 6,00	

The implementation of controllership in Company R provided a series of significant improvements in administrative, operational and financial processes. The adoption of more

structured management practices, combined with the implementation of appropriate technologies, contributed to the modernization of internal control and increased efficiency of operations.

Among the main changes, the implementation of an integrated management software, with digital control of receipts by automatic PIX, stands out. The system now covers all areas of operation — ticket sales, parcels, restaurant and snack bar — offering greater security in transactions and transparency in financial transactions.

To consolidate this stage, training was promoted with employees and business partners, including self-employed salespeople. The training involved both the use of the system and the adaptation to new work routines, seeking to reduce resistance to change and increase operational efficiency. In addition, the company paid for basic computer courses, considering that part of the team had a low level of familiarity with digital tools.

Another relevant improvement was the implementation of satellite internet, which started to meet both the administrative needs of the company and passengers during trips. This action also generated a new source of revenue, with the sale of internet access on board.

The way services are marketed has also undergone significant transformations. The sales of tickets, parcels, cargo and food were integrated with online management applications, providing greater agility, security and legal reliability in operations. As a result, there was an improvement in the traceability of transactions and the integrity of financial information.

The results of the first trips after the implementation of the controllership have already shown gains in efficiency, agility and reliability in waterway transport activities. Among the benefits observed, the following stand out:

- a) Qualification of revenues, costs and expenses, allowing better management analysis and decision making;
- b) Possibility of scheduling cargo, parcels and tickets in advance, avoiding overbooking and ensuring logistical organization;
- c) Creation of new sales channels over the internet, expanding the company's commercial reach;
- d) Convenience to the customer, who started to make purchases remotely, with greater practicality;
- e) Reduction of operating costs, due to the elimination of commissions to intermediaries and the use of automated payments via PIX;

- f) Reliability in financial reports, which are now generated automatically, replacing manual controls susceptible to failures;
- g) Automated sending of messages through the WhatsApp application, confirming tickets and orders and increasing efficiency in service;
- h) Increased cash flow, with the possibility of reselling advance tickets, reducing dependence on third-party capital and strengthening the financial sustainability of the business.

In general, the adoption of controllership proved to be fundamental for the improvement of the management of Company R, promoting integration between sectors, the standardization of processes and the strategic use of accounting and management information.

5 CONCLUSION

River transport represents one of the pillars of mobility and socioeconomic development in the Amazon region, especially in the state of Amazonas, where land routes are scarce and rivers are the main axes of regional integration (Cardoso, 2013). Despite this natural vocation, the sector still faces significant limitations due to the seasonality of the rivers, the precariousness of the port infrastructure and the low technological integration, factors that compromise logistics efficiency and business competitiveness.

Based on the case study carried out, it was possible to identify how the control and management processes are conducted in river transport companies, finding that the absence of structured controllership practices results in administrative, financial and operational deficiencies. The controls observed were largely manual and decentralized, which made it difficult to systematically monitor revenues, expenses, and performance indicators.

From the theoretical and empirical analysis, controllership practices capable of improving management and decision-making in the sector were identified, especially those related to the integration of accounting and management information, the automation of processes and the standardization of operational routines. The implementation of an integrated management system proved to be decisive in ensuring greater security in transactions, data reliability and agility in the planning of operations.

During the course of the survey, the main difficulties faced by companies in the river sector were also raised, among which the shortage of qualified labor, the absence of

adequate connectivity in navigable stretches and cultural resistance to the adoption of new technologies stand out. These factors constitute significant barriers to the implementation of modern management practices and highlight the need for continuous investments in training and technological infrastructure.

Finally, the practical demonstration of the application of a controllership plan in the analyzed company confirmed the hypothesis that this instrument is essential for strengthening management and organizational sustainability. The adoption of an integrated management system, combined with team training and the computerization of processes, resulted in significant improvements in the reliability of financial information, operational efficiency, and strategic planning capacity. Controllership has therefore proved to be a decisive element for the balance between control, performance and decision-making.

It is concluded, therefore, that controllership should be permanently incorporated into the organizational structure of companies in the river sector, not only as a control instrument, but as a strategic management element. Its integrated performance with the administrative, financial and operational areas strengthens corporate governance, increases the transparency of processes and contributes to the economic sustainability of the sector.

As a limitation of the study, the fact that the research was conducted in a single company stands out, which restricts the generalization of the results. It is recommended, for future research, to expand the investigation to other organizations in the sector and regions of the Amazon, in order to compare different controllership models and identify the best practices applicable to the management of river transport in different contexts.

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APPENDIX

SEMI-STRUCTURED INTERVIEW

Block 1 – Characterization of the Interviewee

Table 2

1. Current position or function	2. Industry or department	3. Length of time working in the company
Operations Manager	3 years	Administration

Block 2 – Management and control practices

4. What are the main administrative and financial controls used in the company?

A: The control of orders is carried out through protocol books, in which the sender writes down the name of the recipient who will receive the package, without any additional documentation or traceability system. Financial controls are based on bank statements and order protocol records when payments are made in cash.

5. How is income and expenses monitored?

A: The monitoring of income and expenses practically does not exist. It is done through passenger relationships, number of food tokens sold, order protocols and cargo invoices. Expenses are controlled by receipts and invoices for purchases, and employee payments are made in cash.

6. Are there routines for checking or internal auditing of financial information?

A: There is no type of internal audit. Practically all controls are done manually.

Block 3 – Operational and technological processes

7. What system (software) is used to control operations?

A: The company uses Sebrae software only to issue the Electronic Bill of Lading (CT-e), in order to meet the tax requirements of mandatory cargoes, such as crude oil and its derivatives, natural gas, alcoholic beverages, soft drinks, cement, minerals, wood and transportation of valuables, according to Article 110, paragraph 7 of Decree No. 20,686, of December 28, 1999, of the ICMS Regulation of the State of Amazonas.

8. Is this system integrated between sectors (e.g., sales, finance, inventory)?

A: The company does not have an integrated management system. All processes are carried out manually.

9. What difficulties or limitations do you observe in using this system?

A: The main difficulty for the implementation of a management system is the lack of qualified labor. Most employees have a low level of familiarity with technological tools, being considered digitally illiterate, which makes it difficult to use computers and software.

Block 4 – Use of accounting and management information

10. Is accounting information used by managers in strategic decisions?

A: No. The company's accountant only closes the payroll and calculates the Simples Nacional based on an estimated revenue.

11. How do accounting reports help in day-to-day decisions?

A: There are no accounting reports available. The absence of reliable data makes it impossible to use this information in decision-making.

12. What types of information would be most useful to improve management?

A: It would be essential to implement a complete accounting and an integrated management system, including the sales, financial and input inventory modules. The system should allow the centralization of cost centers by activity — such as tickets, packages, food and cargo — and enable apportionment according to operational needs.

Block 5 – Perceptions about controllership

13. Do you have knowledge about the role of controllership in a company?

A: I had no knowledge about the controllership's role until I contacted the company Aquaviários Net, responsible for the proposal to implement a management system.

14. In your opinion, what would be the main benefits of implementing a controllership in Company R?

A: The main benefit would be to know the real profitability of the company, enabling the planning of solid and sustainable growth, in addition to making the business more competitive.

15. What barriers or challenges could hinder this implementation?

A: The main barriers are the deficiency of internet connection, which makes it difficult to use a 100% online system in real time, and the lack of skilled labor, requiring training from the basic level.

Final remark

This script was applied in person to the operations manager of Company R, during the second stage of the field research. The answers were recorded manually and faithfully transcribed, preserving the original content, with minimal language adjustments for academic adequacy.

**COMPUTATIONAL SIMULATIONS AS REPRESENTATIONS OF REALITY:
PHILOSOPHICAL ANALYSIS AND IMPLICATIONS FOR ARTIFICIAL
INTELLIGENCE**

**SIMULAÇÕES COMPUTACIONAIS COMO REPRESENTAÇÕES DA
REALIDADE: ANÁLISE FILOSÓFICA E IMPLICAÇÕES PARA A INTELIGÊNCIA
ARTIFICIAL**

**SIMULACIONES COMPUTACIONALES COMO REPRESENTACIONES DE LA
REALIDAD: ANÁLISIS FILOSÓFICO E IMPLICACIONES PARA LA
INTELIGENCIA ARTIFICIAL**

 <https://doi.org/10.56238/sevened2025.036-042>

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ABSTRACT

The use of computational simulations has become central in various scientific and technological fields. In addition to enabling the modeling of complex systems and the prediction of behaviors, simulations feed reinforcement learning algorithms, digital twins, and interactive prototypes. However, when these simulations are employed to represent or recreate reality, philosophical problems arise concerning the nature of representation, the difference between appearance and reality, and the limits of knowledge. This theoretically exploratory article critically examines computational simulations as representations of reality, articulating classical and contemporary philosophical traditions. In light of authors such as Plato, Aristotle, Kant, Descartes, Baudrillard, Heidegger, Putnam, Bostrom, Winsberg, Turing, Searle, and others, it analyzes the relationship between imitation and original, the distinction between phenomenon and thing-in-itself, the role of signs in the construction of reality, skeptical hypotheses, and the crisis of representation in the age of technology. The text then discusses implications for artificial intelligence (AI), especially in the context of learning algorithms and digital twins. It reflects that simulations are not mere copies, but constructions mediated by theories, signs, and technology, requiring epistemological and ethical reflection on their use in AI.

Keywords: Computational Simulations. Representation of Reality. Philosophy of Technology. Artificial Intelligence. Digital Twins.

RESUMO

O uso de simulações computacionais tornou-se central em diversos campos científicos e tecnológicos. Além de viabilizarem a modelagem de sistemas complexos e a previsão de comportamentos, as simulações alimentam algoritmos de aprendizagem por reforço, gêmeos digitais e protótipos interativos. Contudo, quando essas simulações são empregadas para representar ou recriar a realidade, emergem problemas filosóficos relativos à natureza da representação, à diferença entre aparência e realidade e aos limites

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do conhecimento. Este artigo, de natureza teórico exploratória, examina criticamente as simulações computacionais como representações da realidade, articulando tradições filosóficas clássicas e contemporâneas. À luz de autores como Platão, Aristóteles, Kant, Descartes, Baudrillard, Heidegger, Putnam, Bostrom, Winsberg, Turing, Searle e outros, analisa se a relação entre imitação e original, a distinção entre fenômeno e coisa em si, o papel dos signos na construção da realidade, as hipóteses céticas e a crise da representação na era da técnica. Em seguida, o texto discute implicações para a inteligência artificial (IA), especialmente no contexto de algoritmos de aprendizagem e gêmeos digitais. Reflete-se que simulações não são meras cópias, mas construções mediadas por teorias, signos e tecnologia, exigindo reflexão epistemológica e ética sobre seu uso em IA.

Palavras-chave: Simulações Computacionais. Representação da Realidade. Filosofia da Tecnologia. Inteligência Artificial. Gêmeos Digitais.

RESUMEN

El uso de simulaciones computacionales se ha vuelto central en diversos campos científicos y tecnológicos. Además de posibilitar la modelización de sistemas complejos y la predicción de comportamientos, las simulaciones alimentan algoritmos de aprendizaje por refuerzo, gemelos digitales y prototipos interactivos. Sin embargo, cuando estas simulaciones se emplean para representar o recrear la realidad, surgen problemas filosóficos relacionados con la naturaleza de la representación, la diferencia entre apariencia y realidad y los límites del conocimiento. Este artículo, de carácter teórico-exploratorio, examina críticamente las simulaciones computacionales como representaciones de la realidad, articulando tradiciones filosóficas clásicas y contemporáneas. A la luz de autores como Platón, Aristóteles, Kant, Descartes, Baudrillard, Heidegger, Putnam, Bostrom, Winsberg, Turing, Searle y otros, se analiza la relación entre imitación y original, la distinción entre fenómeno y cosa en sí, el papel de los signos en la construcción de la realidad, las hipótesis escépticas y la crisis de la representación en la era de la técnica. A continuación, el texto discute las implicaciones para la inteligencia artificial (IA), especialmente en el contexto de los algoritmos de aprendizaje y los gemelos digitales. Se reflexiona que las simulaciones no son meras copias, sino construcciones mediadas por teorías, signos y tecnología, lo que exige una reflexión epistemológica y ética sobre su uso en la IA.

Palabras clave: Simulaciones Computacionales. Representación de la Realidad. Filosofía de la Tecnología. Inteligencia Artificial. Gemelos Digitales.

1 INTRODUCTION

The advancement of computational technologies has allowed the creation of mathematical models capable of simulating natural phenomena, social processes, and complex technical systems. In the fields of data science, physics, and biology, simulations replace or complement experiments, allowing to "test" theories and project future scenarios (Winsberg, 2009, 2010). In the area of artificial intelligence, simulations are used to train reinforcement learning algorithms, as they allow agents to perform millions of interactions in virtual environments, saving resources and avoiding risks in real contexts (Simwell, 2021). Companies and governments implement digital twins, virtual replicas of machines, cities, or processes, in order to monitor and optimize systems in real time (Simio, 2023). The popularity of the "metaverse" and the success of virtual reality platforms highlight a cultural trend of interaction in simulated worlds. Despite this centrality, the philosophical literature warns of risks and ambiguities. For centuries, philosophers have reflected on the difference between image and reality, as well as on the limits of knowledge obtained through representations. Plato (2006) described art as "imitation of imitation" and, in the famous allegory of the cave, prisoners rely on shadows projected on the wall, ignoring that they are only copies of real objects (Plato, 2006). Aristotle (1973), although accepting mimesis, maintains that poetry does not imitate particular events, but what can occur according to the laws of verisimilitude and necessity (Aristotle, 1973). The philosopher Kant (2001, 2011) distinguished the world as a phenomenon, that which appears according to the filters of space and time of sensibility, of the noumene, the "thing in itself", inaccessible to experience (Kant, 2001, 2011). For Heidegger (2001, 2014), modernity has reduced the world to an image: reality is established as a calculated image, so that the world "exists in an image" and becomes manipulable by technique (Heidegger, 2001). In addition to these classic analyses, contemporary thinkers draw attention to the implications of the new techniques. Jean Baudrillard diagnoses an era of simulacra in which copies have no originals and the real is replaced by hyperreality (Baudrillard, 1981). Hilary Putnam (1981) uses the "brain in a vat" thought experiment to argue that we cannot prove that we are not immersed in a computer-controlled simulation, although he considers such a hypothesis to be incoherent under certain semantic assumptions (Putnam, 1981, 1988, 1990). Nick Bostrom formulates the *simulation argument* by suggesting that, given the computational capacity of advanced societies, we are likely to live in an ancestral simulation (Bostrom, 2003). In the philosophy of science, Eric Winsberg shows that simulations are not mere experimental tools, as they require epistemological

justifications and validation criteria that are different from physical experiments (Winsberg, 2009, 2010). John Searle, in turn, argues that computers can manipulate symbols without understanding their meaning, as illustrated by the *Chinese fourth* (Searle, 1980, 2006). These discussions indicate that the use of computer simulations evokes ontological, epistemological and ethical issues that go beyond technique. This research aims to examine, in the light of these traditions, to what extent computer simulations can be considered representations of reality. The work is exploratory and theoretical, based on a bibliographic review of classic and contemporary works. It seeks to articulate concepts of imitation, representation, sign, appearance, reality and technology, to then discuss the implications for artificial intelligence and in the end, considerations are presented that highlight the need for critical reflection on the development and use of simulations in AI and science.

2 THEORETICAL FRAMEWORK

2.1 IMITATION AND REPRESENTATION IN THE CLASSICAL TRADITION

The analysis of computer simulations as representations of reality requires recovering the long philosophical tradition that discussed the relationship between imitation and original. Plato (2006) argues that works of art imitate sensible objects, which, in turn, are imperfect imitations of ideal forms, so that art is *three times far from the truth* because it imitates particular things and not the idea of the thing (Plato, 2006). This vision appears metaphorically in the allegory of the cave: prisoners see only shadows projected on the wall and take them for reality (Plato, 2006). In the same perspective, computer simulations can be seen as shadows of mathematical models that seek to get closer to real phenomena. Thus, Platonic criticism warns of the risk of confusing representation with reality, a recurring phenomenon in credulity in virtual worlds. Aristotle (1973) proposes a revision of this critique. Although he agrees that art is *mimesis* (imitation), he states that the poet's craft does not consist in narrating facts that have occurred, but in representing what can happen according to verisimilitude and necessity (Aristotle, 1973, 1988). Poetry tends to represent the universal, not the particular (Aristotle, 1973, 1988), when watching a tragedy, we learn something about the human being in general. Such a view opens space to recognize the cognitive value of simulations, which allow exploring possibilities and variations of systems, extrapolating the particular. However, Aristotle (1973, 1988) insists that *mimesis* must remain credible, which implies criteria for evaluating the fidelity of the simulation to the behavior of the world.

2.2 APPEARANCE, KNOWLEDGE AND REALITY

During modernity, reflection on the relationship between appearance and reality intensified. Descartes (1999), when starting the *Metaphysical Meditations*, decides to put everything in doubt. He considers that his senses can deceive him and hypothesizes an *evil genius* who could manipulate him in all things. To reinforce the doubt, imagine that perhaps you are dreaming and that all perceptions are illusions. The Cartesian goal is to find indubitable truths, but the thought experiment suggests an uneasiness about the reliability of representations. If the mind can be deceived, how can we believe that a simulation adequately portrays reality? Immanuel Kant (2001, 2011) reacts to the polarizations between empiricism and rationalism, proposing a synthesis. For the philosopher, we know the world only as a phenomenon, that is, as it is organized by *the a priori forms* of sensibility, space and time, and by the categories of understanding. Space and time are not properties of objects, but filters added by the mind, without them, we would not perceive anything. Therefore, there is a reality in itself (*noumeno*) that we cannot know directly. Consequently, validation criteria must recognize this limitation: simulations approximate observed phenomena, but do not capture the essence of things.

2.3 SEMIOLOGY AND CONSTRUCTION OF MEANING

Another fundamental contribution to understanding representations comes from semiology. Chandler (2017, p. 22) states that *we think only of signs*, anything can become a sign if it is interpreted as such. Ferdinand de Saussure, as cited by Chandler (2017), in turn, describes the linguistic sign as composed of a signifier (the sound or visual form) and a signified (the concept). The association between signifier and signified is arbitrary and depends on social conventions. Simulations, as sets of images, codes and *outputs*, function as signs whose interpretation gives meaning to the data. This means that the status of *reality* attributed to a simulation depends on the intersubjective agreement about its correspondence with the modeled phenomenon. If users interpret the *outputs* as reliable representations, the simulation acquires epistemological power; if not, it loses credibility. Jean Baudrillard radicalizes this view by arguing that the era of postmodernity is dominated by simulacra: representations that have no original. He describes four stages of the image: first, it reflects a reality, then it masks and denaturalizes reality, then it masks the absence of reality, and finally it becomes pure *simulacra* unrelated to the real. In the *hyperreal*, representation replaces the real in such a way that distinction becomes useless. The popularity of virtual

worlds, social networks, and digital twins can be seen as a manifestation of this phenomenon: individuals interact with images that do not refer to an original, building identities and strategies based on simulated data. If simulations take the place of reality, the question about their fidelity becomes less relevant than the analysis of their social and psychological effects. Baudrillard (1991) relates these phases of the image to the concept of *hyperreal*, emphasizing that representations dispense with the original and establish a logic of simulacra.

2.4 PHILOSOPHY OF TECHNIQUE: FROM THE WORLD AS IMAGE TO FRAME

Heidegger (2001, 2014) emphasizes that modernity conceives the world as a calculated and manipulable image, and Anders (1956) observes that reality comes into existence as an incessant chain of images. Martin Heidegger (2014), in his essay *The Age of the Worldimage*, examines the relationship between technique and representation. For him, modernity is characterized by the conception of the world as an image: it is not only a matter of creating images of the world, but of converting the world itself into an image. Reality comes to be defined by calculated and manipulated images, and "knowing the world as an image" becomes the rule. The philosopher observes that the essence of technique is not instrumental; Modern technology reveals the world as a "reserve of resources" and imposes a calculating way of thinking. Anders comments that the world exists as an image, a chain of images that covers the real incessantly. From this point of view, computer simulations are not simple tools, but expressions of a way of being in which the real is produced and controlled by representation. Heidegger (2014) identifies consequences of this phenomenon: thought becomes calculating, technical acceleration imprints speed to processes, masses and gigantism subordinate singularity, and subjectivism and objectivism are intertwined in technical domination. The "frame" (*Gestell*) organizes all entities as available for use. Modern technology, by reducing the world to a manipulable image, reinforces the separation between subject and object, making man the master of a calculated reality and, at the same time, the object of control systems. To understand the status of simulations in AI, one must consider this horizon: they are part of the mode of production of the world as an image and of the technical organization of reality.

2.5 SIMULATION, KNOWLEDGE AND PHILOSOPHY OF SCIENCE

In the contemporary field, the philosophy of science discusses the epistemological status of simulations. Eric Winsberg (2009, 2010) notes that they have emerged as tools to

investigate complex systems, such as climate or cosmological models, that cannot be studied directly. However, simulations differ from physical experiments. While experiments are based on direct manipulation of natural systems, simulations operate on mathematical representations and depend on processes of discretization, parameterization, and computational implementation. Winsberg (2009, 2010) distinguishes verification, the process of ensuring that the computational code correctly implements the model, validation, evaluation of how well the model represents the physical system. This distinction shows that the epistemic value of simulation results not only from its predictive capacity, but from the theoretical and empirical justification of the models employed. Frigg and Reiss maintain that simulations do not have a single epistemology; they are part of a broader scientific practice and lack specific criteria of justification. Winsberg (2009, 2010) also discusses the debate over whether simulations are analogous to experiments. Some defend the "identity thesis", according to which simulations are experiments run on models, and that, therefore, experimental epistemology applies to them. Others, such as Parker, propose a pragmatic approach, suggesting that validation methods can combine elements of empirical testing and statistical analysis. For the purposes of this article, it is important to highlight that simulation does not replace empirical research, but complements it, and that its results should be interpreted in the light of underlying models and hypotheses. When employed for AI, simulations constitute artificial environments that may or may not reflect the real world.

2.6 SKEPTICAL HYPOTHESES: BRAINS IN VATS AND SIMULATED UNIVERSES

Questions of reality and simulation take on metaphysical contours in the thought experiments of Putnam (1981, 1988, 1990) and Bostrom (2003, 2018). Hilary Putnam (1981) proposes to imagine that all human beings are brains in a vat connected to a computer that produces sensory experiences. The "brains" believe they live in a real world, but all they perceive is manipulation. Putnam (1981) argues that this hypothesis is self-contradictory because, if the linguistic terms refer to the *inputs* produced by the simulation, the phrase "we are brains in a vat" could not be true in the reference system. Despite this semantic critique, the experiment reveals the concern that our perceptions can be controlled by advanced computer systems, an idea that resurfaces in science fiction narratives and debates about virtual reality. Nick Bostrom (2003, 2018) develops the simulation argument, formulating a trichotomy: (1) the probability that advanced civilizations will become extinct before reaching a "posthuman" stage is high; (2) the probability that posthumans are not interested in running

many "ancestral simulations" is high; or (3) we are almost certainly living in a simulation. The philosopher maintains that if future computational capabilities allow the creation of simulated universes containing conscious beings, and if there is interest in doing so, the number of simulated beings will outnumber the original beings. The conclusion is that "there is a significant possibility that we are in a simulation," and that the hypothesis cannot be easily ruled out. This line of thought, although speculative, reinforces the need to question the relationship between simulations and reality, including in the daily use of computer models.

2.7 TURING TEST, COMPUTATIONALISM, AND ARTIFICIAL CONSCIOUSNESS

In the early 1950s, Alan Turing proposed a pragmatic criterion for evaluating machine intelligence. The "Turing test", formerly called the "imitation game", consists of a human evaluator talking to a machine and a human without knowing which is which. If the evaluator is unable to distinguish, within a given time, who the machine is, it is considered to demonstrate intelligent behavior. Turing replaces the question "Do machines think?" with "Can machines imitate human language indistinguishably?" The test influences the development of AI and gives rise to debates about whether the ability to generate believable responses is enough to attribute intelligence. Hilary Putnam (1981, 1988, 1990), initially an advocate of "computationalism", later criticized the view that the mind is a computer program. In an argument known as "multiple realization," he asserts that any physical system can be interpreted as implementing a finite state machine, which would trivialize the notion of computation, requiring additional criteria to distinguish truly computational systems. In a similar vein, John Searle (1980, 2006) argues, in the "Chinese room" thought experiment, that a computer can manipulate symbols and provide correct answers without understanding their meaning. In the example, a person who does not know Chinese follows a set of rules to correlate questions in Chinese to answers in English; To observers, it seems that she understands the language, but internally nothing is understood. For Searle (1980, 2006), syntactic manipulation is not enough to generate semantics, therefore, simulations of cognitive processes are not equivalent to conscious experience. These arguments suggest conceptual limits to mind and consciousness simulations.

2.8 SIMULATION AND ARTIFICIAL INTELLIGENCE: REINFORCEMENT AND DIGITAL TWINS

With the rise of *reinforcement learning* (RL), simulations have become essential components of algorithm training. Unlike supervised methods, in which models learn from labeled data, RL requires an agent to explore an environment and receive rewards or punishments according to their actions. To conduct thousands or millions of experiments without physical risk, simulations that emulate the environment are used. A case study from the company Simwell notes that simulation provides a controlled and risk-free environment for testing strategies, and is indispensable for RL because it allows for repeatable testing and collecting performance metrics. In these simulations, the agent evaluates different policies and adjusts their behavior, later, the policies can be implemented in the real world, reducing costs and risks. Another technological trend is the use of digital twins. A digital twin is a virtual replica of a physical object, built from sensor data, mathematical models, and AI algorithms. The *Simio* report highlights that digital twins originated in the aerospace sector, when NASA used simulators to replicate flight conditions, and that the concept was formalized by Michael Grieves in the early 2000s. Today, digital twins incorporate AI to perform predictive analytics, optimization, and predictive maintenance, allowing systems to be monitored and adjusted in real-time. The integration between AI and digital twins results in "smart twins" that learn from data and evolve over time. However, such technology reinforces Baudrillard's concern: the virtual replica can become more real than the object, influencing decisions based on calculated projections. Researchers are also investigating the use of real images to generate photorealistic simulations. A 2024 paper from the University of Washington reports on the development of the RialTo and URDFFormer systems, which build digital twins of buildings or environments from smartphone scans or internet images. These simulations allow you to train robots quickly and cost-effectively, allowing them to adapt to real-world conditions. The goal is to democratize the use of detailed simulations, reducing the *gap* between virtual models and the physical world. Despite the benefits, the ability to create reliable simulations from available data also raises ethical questions about privacy and surveillance.

3 METHODOLOGY

This study is characterized by a qualitative approach of a theoretical-exploratory nature, based on systematic bibliographic research and documentary analysis (Gil, 2019). The investigation adopts the hermeneutic-dialectical method to understand the complex

relationships between computer simulations and representations of reality, articulating classical and contemporary philosophical traditions with current technological implications (Minayo, 2014). The methodological design followed the assumptions of exploratory research, which aims to provide greater familiarity with the problem, making it more explicit and allowing the construction of hypotheses (Gil, 2019). According to Marconi and Lakatos (2017), exploratory research increases the researcher's knowledge of the facts, allowing for a more accurate formulation of problems and the creation of new hypotheses. This approach proved to be adequate given the multidisciplinary nature of the theme, which requires the articulation of philosophical, epistemological and technological knowledge. The collection of primary data was based on a systematic review of the literature, conducted by consulting the main academic databases. The bibliographic survey followed criteria of thematic relevance and academic quality, prioritizing reference works in the field of philosophy, epistemology, and philosophy of science (Severino, 2017). The search strategies included the descriptors: "computer simulations", "representation of reality", "philosophy of technology", "artificial intelligence", "epistemology of simulations", combined with Boolean operators. The time frame ranged from fundamental classic works to more recent contemporary publications, ensuring the historical breadth necessary for the proposed analysis (Severino, 2017). The theoretical *corpus* was made up of primary and secondary sources, including: (i) classical philosophical texts by Plato, Aristotle, Descartes, Kant and Heidegger; (ii) contemporary works of philosophy of science and epistemology, especially by Winsberg, Putnam, Searle and Bostrom; (iii) specialized literature on artificial intelligence and computer simulations; and (iv) technical papers and case studies on practical applications of AI simulations.

4 ANALYSIS AND DISCUSSIONS

The theoretical foundation presented outlines multiple perspectives on the relationship between simulation and reality. The tradition of Plato (2006) and Aristotle (1973, 1988) shows that imitation can both distance from the truth and allow the learning of universals. In computer simulations, the Platonic concern is manifested in the risk of taking models for reality, especially when technical verisimilitude masks simplifications. An example of this are climatic or epidemiological models that, although indispensable, do not capture all the variables of the real system. The Aristotelian reading, on the other hand, inspires a constructive use: simulations are spaces to explore possibilities and general laws, as long as the difference between possibility and fact is recognized. In AI, reinforcement learning

algorithms learn from a model of the world, but transfer to the physical world requires care to avoid illusions of control. Kant (2001, 2011) and phenomenologists remind us that our experience is always mediated by cognitive structures and a *priori* forms. Simulations, as products of our sensitivity and understanding, carry these structures, including prejudices and biases. Spatiotemporal "shapes" and logical categories are programmed into the models and algorithms. Thus, the validation of simulations needs to go beyond numerical fitting, it must consider whether the models incorporate questionable assumptions. For example, facial recognition systems trained on unbalanced data sets can perpetuate discrimination, demonstrating that the statistical representation of the world becomes a form of co-production of reality. When mapping urban environments to create digital twins, it is crucial to reflect on which perspectives are privileged and which are invisible. The semiotic apparatus focuses on interpretation. As Peirce observes, nothing is a sign unless it is interpreted as such. The validity of a simulation depends, therefore, on the interpretive community that recognizes it as faithful or useful. Acceptance of the results of a climate model, for example, requires consensus among scientists on the methods and parameters. In everyday interactions, people accept the veracity of simulations when they trust the institution or technology that produces them, hence the importance of transparency and communicability of models. The dissociation between signifier and signified observed by Saussure warns that representations can slide and produce divergent interpretations. In AI, interfaces that show simplified visualizations can suggest accuracy where there is uncertainty. Baudrillard's hyperreal warns that the avalanche of simulations can displace the real: graphs and indicators of a digital twin can determine urban decisions, even if people's experience in physical space is different. Heidegger's (2001, 2014) philosophy of technique expands the analysis by situating simulations in the context of a technically armed world. Simulations participate in the logic of "frame": they transform entities into calculable and manipulable objects, favoring a dominant posture in relation to the world. The expansion of networks of sensors, algorithms and digital twins induces a vision in which all dimensions of life, health, education, mobility, are quantified and translated into data. The "world as image" implies that the real only exists when represented and calculated. However, this technical perspective needs to be balanced by a reflection on what escapes calculation. In education, for example, simulators can help learn mathematics or physics, but they do not replace the living experience of dealing with students' mistakes, doubts, and singularities. The risk is that the class becomes a mechanical reproduction of models, erasing the dialogical and creative dimension of teaching. Winsberg

(2009, 2010) shows that simulations require verification and validation processes that are different from experiments. This applies directly to AI. In reinforcement learning, the simulator code must be checked for correct model implementation, and the results must be validated by comparing simulated behaviors with empirical data. The validity of a digital twin depends on the continuous updating of the data and the fidelity of the equations used. When it comes to replicating complex social phenomena, such as human interactions in virtual environments, validation becomes even more challenging. The absence of clear criteria can lead to overconfidence in simulation or, on the contrary, to its rejection by skeptics. The skeptical thought experiments of Putnam (1981, 1988, 1990) and Bostrom (2003, 2018) invite us to reflect on levels of simulation. If reality itself could be a simulation, the distinction between "real" and "virtual" would lose meaning. Regardless of the plausibility of this hypothesis, it points to the power of technology to alter the experience. In AI, virtual environments created to train robots, such as *RialTo* and *URDFormer*, show that we can produce worlds so believable that agents generalize well to the physical world. However, if the data used to build these simulations reflect only part of social reality, we can perpetuate inequalities. The brain in a vat reminds us that by blindly trusting the *outputs* of automated systems, we can lose the ability to distinguish between representation and direct experience. The Turing test and the critiques of computationalism highlight the conceptual limits of simulations. Although machines are capable of passing modern variants of the test, this does not imply that they understand or have consciousness. Searle (1980, 2006) argues that syntactic manipulation of symbols does not generate semantics. This debate has implications for AI: conversational simulators based on large language models (LLMs) can generate coherent texts, but this does not guarantee understanding. In the educational context, it is important not to confuse a *chatbot's ability* to answer questions with a real understanding of the content or the needs of the students. Finally, the use of simulations in AI brings both benefits and challenges. Reinforcement learning in simulated environments accelerates the development of autonomous agents. Digital twins allow you to optimize industrial and urban processes, and the creation of photorealistic simulations based on images democratizes access to complex virtual environments. However, these technologies are consumed in a context of *hyperconnectivity* and data economy that involves issues of privacy, security, digital exclusion and sustainability. The power to represent and predict brings with it ethical responsibilities: who sets the parameters of the models? Who benefits from the simulations and who is excluded? How to prevent simulations from becoming mechanisms of social control? These

questions should guide the development and application of simulations in the field of AI and beyond.

5 FINAL CONSIDERATIONS

The objective of this article was to investigate computer simulations as representations of reality, articulating a philosophical analysis with implications for artificial intelligence. The review of classical authors, from Plato to Heidegger, showed that the relationship between image and reality is problematic and full of nuances. Plato (2006) warns that images can take us away from the truth, while Aristotle (1973) recognizes their heuristic value. Kant (2001, 2011) and phenomenologists remind us that all representation is conditioned by our cognitive structures, Heidegger (2001, 2014) denounces that technology transforms the world into a calculable image, and Baudrillard announces the era of simulacra, in which the distinction between original and copy dissolves. The contemporary philosophy of science, represented by Winsberg (2009, 2010), reinforces that simulations require their own criteria for verification and validation, and that they do not replace experimentation, although they complement it. Thought experiments by Putnam (1981, 1988, 1990) and Bostrom (2003, 2018) expand the reflection on the ontological status of simulated reality, while Searle (1980, 2006) and Putnam (1981, 1988, 1990) criticize the reduction of the mind to computation. In the field of artificial intelligence, simulations play fundamental roles: they enable reinforcement learning, support digital twins, and provide environments for robot testing. These uses demonstrate that simulations are powerful modeling and forecasting tools. However, the evidence and arguments discussed suggest caution. It is necessary to recognize that every simulation is built from models and assumptions, therefore, it is not the world, but a representation that can hide or distort aspects of reality. Confidence in the results of algorithms trained in simulations should be proportional to the transparency of the models and the empirical validity of the data. From a pedagogical point of view, simulations can enrich teaching, but never replace the living experience of learning. And, in the ethical sphere, the use of data and images to build simulations must respect individual and collective rights. Computer simulations are representations that, at the same time, reflect and construct realities. Its growing adoption in science and AI invites a permanent dialogue between technique and philosophy. Only an analysis that considers the ontological, epistemological and ethical foundations will be able to guide a responsible and emancipatory use of these technologies. The contributions of this study to society and academia are multiple. For academia, the work

offers a philosophical foundation for understanding the epistemological status of computer simulations, bridging a gap between classical philosophy and contemporary debates on technology and artificial intelligence. The articulation between distinct philosophical traditions provides a conceptual basis that can guide future research in the philosophy of technology, the epistemology of simulations, and the ethics of AI. For society, the study warns about the risks of confusing computational representations with reality, an issue that is increasingly relevant in a context of proliferation of digital twins, metaverses, and automated decision-making systems. The proposed critical reflection can support public policies and corporate practices that seek the responsible use of simulations, especially in sensitive areas such as health, education, public safety, and urban planning. In addition, by showing that simulations carry theoretical assumptions and biases, the work contributes to the debate on algorithmic transparency and social justice, central themes in the contemporary agenda of technological governance. As for the limitations of the research, it is recognized that the study has an eminently theoretical and exploratory character, not contemplating empirical analyses of specific cases of application of computer simulations in AI contexts. Although the literature review has covered relevant classical and contemporary authors, the literature on the philosophy of simulation is vast and constantly expanding, so that other philosophical perspectives could enrich the analysis. In addition, the article did not develop a specific methodological protocol for epistemological and ethical evaluation of simulations, limiting itself to identifying general conceptual issues. Finally, the discussion on digital twins and reinforcement learning drew on secondary sources and available technical literature, without direct access to proprietary implementations or primary data from companies developing these technologies. It is recommended, for future studies, to carry out empirical research that analyzes concrete cases of use of simulations in AI projects, examining how philosophical assumptions manifest themselves in the practice of modeling and validation. It would be productive to develop operational criteria, inspired by the philosophy of science, to assess the epistemological adequacy of simulations employed in critical contexts, such as public health or social policies. It is also suggested to investigate, from an interdisciplinary perspective, the psychosocial impacts of immersion in simulated environments, articulating philosophy, psychology and sociology. Studies on the relationship between simulations and algorithmic biases, analyzing how simplifications and *design* choices perpetuate inequalities, constitute an urgent research agenda. It is recommended to develop *specific ethical frameworks* for the use of digital twins and AI training environments considering privacy,

consent, and transparency concerns, in dialogue with emerging regulations on artificial intelligence.

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**REFLECTION FROM THE AMERICAS ON WALTER BENJAMIN'S CRITICAL
THEORY: WORKING AND MEANING IN THE ANTI-FASCIST RESISTANCE
1933–1945**

**REFLEXÃO DESDE AS AMÉRICAS SOBRE A TEORIA CRÍTICA DE WALTER
BENJAMIN: TRABALHAR E SIGNIFICAR NA RESISTÊNCIA ANTIFASCISTA
1933–1945**

**REFLEXIÓN DESDE LAS AMÉRICAS SOBRE LA TEORÍA CRÍTICA DE
WALTER BENJAMIN TRABAJAR Y SIGNIFICAR EN LA RESISTENCIA
ANTIFASCISTA 1933-1945**

 <https://doi.org/10.56238/sevened2025.036-043>

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ABSTRACT

Eighty years after the arrival of the Red Army troops — whose doctors treated the very few prisoners who had not yet been murdered — at the Auschwitz extermination camp, it is necessary to reflect on the role of a mistaken historical theory of the German, European, and ultimately global left, which made it impossible to resist with the necessary strength against National Socialism and the extermination of European Jews.

Keywords: Walter Benjamin. Critical Theory. Concept of Progress. Fetishism. Karl Marx. Anti-Fascist Resistance.

RESUMO

Oitenta anos após a chegada das tropas do Exército Vermelho — cujos médicos atenderam os poucos prisioneiros que ainda não haviam sido assassinados — ao campo de extermínio de Auschwitz, é necessário refletir sobre o papel de uma teoria histórica equivocada da esquerda alemã, europeia e, em última instância, mundial, que tornou impossível resistir com a força necessária ao nacional-socialismo e ao extermínio dos judeus europeus.

Palavras-chave: Walter Benjamin. Teoria Crítica. Conceito de Progresso. Fetichismo. Karl Marx. Resistência Antifascista.

RESUMEN

A los ochenta años de la llegada de la tropas del ejército rojo —cuyos médicos atendieron los muy pocos presos que todavía no habían sido asesinados— al campo de exterminio de Auschwitz, hay que reflexionar sobre el papel de una teoría histórica equivocada de la izquierda alemana, europea y, al fin de cuentas, mundial que hizo imposible que se resistiera con la fuerza necesaria al nacionalsocialismo y al exterminio de los judíos europeos.

Palabras clave: Walter Benjamin. Teoría Crítica. Concepto de Progreso. Fetichismo. Karl Marx. Resistencia Antifascista.

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1 INTRODUCTION

In 1945, Allied troops liberated German and Austrian cities that were still under the yoke of Nazi forces. During the last two weeks of the war, between April and May, the Nazis still murdered 250,000 people, in the famous death marches. At a time when Germany's defeat was imminent, the Nazis killed a quarter of a million people in their almost countless "secondary" camps that existed in addition to the large camps and centers of immediate extermination such as Auschwitz, Treblinka or Sobibor, among others.

In addition to the best-known extermination centers, there was a vast system of minor camps, at least forty thousand in Germany and in the occupied countries. Of the latter, the prisoners were sent to death marches; in part so that the genocide would not be so obvious. They were killed little by little, those who walked the slowest were killed by the SS guards and stayed there, spread over miles and miles across Europe.

The aim of this text is to question how Critical Theory in general and Walter Benjamin in particular reacted intellectually to the genocide, which Claude Lanzmann calls *the Shoah*, and Raul Hilberg calls *The Destruction of the European Jews*, in his famous book that bears this title, undoubtedly the most important study on the subject.²

The question posed by Critical Theory is not: why was this possible? Well, this is a very difficult question; Lanzmann, for example, recommends not formulating it, since he considers that it diverts us from *seeing* the fact itself.³ Therefore, we do not pose this question, but emphasize what Benjamin and the whole of Critical Theory investigate: why did the German and European left not know how to react to the fact of fascism in general and Nazism in particular? This question is more concrete than inquiring directly about the genocide because, following Lanzmann, this diverts attention from the fact that few or none have been able to see, in the face of the terror and complexity of the historical and social event itself.

2 THE THEORETICAL ERROR OF THE LEFT AND ITS RESISTANCE

What Benjamin formulated was: why did the left not know how to react? Here it is worth commenting on something important: there is a myth that there was resistance; but at least in the case of Germany and Austria, this is not true. In France there was some resistance, but much more limited than what was usually said later.

² Hilberg, Raul. (2005): *The Destruction of European Jews*, trans. Cristina Pina Aldao. Madrid, Akal.

³ Lanzmann, Claude. (1990): "Hier ist kein Warum" in Bernard Cuau and Michel Deguy et al., *Au sujet de Shoah*. Paris, Belin. p. 279.

In Poland there was strong resistance, but it was mostly not left-wing, but nationalist, made up of mostly conservative Poles and/or Catholics. The most famous of the left-wing resistance in Poland has been the significant resistance in the Warsaw ghetto, which was organized mainly by Jewish young socialists, whose armed wing was not much more than a dozen *ghetto fighters*.⁴ There was also a very important anti-fascist resistance and resistance against the German occupation of the Soviet Union. In this regard, it is known that Stalin, when he tried to call for resistance, did so with the argument of defending the motherland, rather than with the argument of defending communism, socialism or revolution. The Stalinists agreed that this was the best way to organize resistance. Although I do not share this idea, it is true that under the given conditions it was the strategy that was used with some success.

Thus, left-wing resistance, specifically against Nazism and fascism in general, existed in Spain during the Civil War, this is undeniable; there was also a more left-wing definition of resistance in Yugoslavia; even, isolated cases in other countries; but, in general and mass terms, it was not something that existed, much less in Austria and Germany. For this reason, we return to the question of Critical Theory and Benjamin, why was it not possible to organize a massive resistance of anti-fascist leftists? The contradiction lies in the fact that the European left was stronger than ever in the 1920s; neither before nor since has it been as intense as then. This left was well organized, and also armed; The German communists, for example, had hundreds of thousands of rifles hidden to prepare the resistance, which they did not use: not a single one was directed against the genocide.

Why? What Benjamin answers is that the lack of resistance was not so much a mistake, although obviously it is a political error, but it was not due to cowardice, or the inability to organize, nor to Nazi repression, which of course was strong; rather, this philosopher would say, reason was a *theoretical* error.

There were one or more very serious errors in the theory of the German-Austrian and European left that, in some way, led them to commit very wrong acts and this provoked non-resistance or almost non-existent resistance against the Nazis from the left. This question is still important today, eighty years after the end of military Nazism, because this error has not ceased to exist. Benjamin died in 1940: he was arrested during his flight from France to Spain, and he committed suicide because he concluded that he would not reach the United States,

⁴ This resistance was reduced both in terms of the number of participants and because of the little support received from the non-Jewish Polish resistance or other groups.

but a Nazi death camp. I think with almost absolute certainty that he would agree with me: this theoretical problem is still valid.

Today we live the same theoretical error on the left, and I speak in the plural on purpose, because I consider myself part of it. In reality, there are several errors; the central thing, Benjamin emphasizes, are two elements: one, how history is conceived and, the other, how the popular support that can be given to a struggle is conceived. I would like to begin by analyzing the second.

During Benjamin's time and until the fall of the Soviet Union and its allied countries in the 1980s, a cult of the proletariat predominated. There was the idea that the proletariat, by definition, was left-wing; It was also thought that *it would de facto* fight against capitalist social relations and that it would be anti-fascist. Practically the entire left was convinced of this.

I believe that this error persists, although almost no one uses the term proletariat as such anymore. The cult of the proletariat has been transformed into a cult of democracy; Deep down it is practically the same: it is believed that the majorities are right, that they are anti-fascists; unless they are deceived or someone sees their faces, such as the mass media or governments; that there is electoral fraud, and so on. If something like that doesn't happen, then the populations —whether they are the proletariat or the population in general— are right, in terms of an anti-fascist reason. Despite the disappearance of the dogmatic left of the Soviet Union, these political-theoretical errors still exist. There has never been a real discussion about it.

The exception was precisely Benjamin and other authors of Critical Theory, but their contributions have been largely ignored or turned into something else. Nowadays Benjamin is mentioned a lot, but the core part of his thought is not addressed.

There is, then, a naïve belief of the party leaders deposited in the popular mass that follows them, and vice versa; also a naïve belief in leaders. Benjamin argued that deep down it is the same; It looks different, but it is a single construction: the mass leader and the masses, together, supposedly guarantee that a resistance against the fascists will work.

3 THE DEMOCRATIC IMPOSSIBILITY OF AN ANTI-NATIONAL SOCIALIST RESISTANCE

The German left insistently defends *democracy*, and it must be clarified that with this argument, anti-National Socialist resistance would have been impossible, because the Nazis came to power democratically in 1933. That vote was not falsified, there was no electoral

fraud, so that, by way of democracy, anti-Nazi resistance would have been a falsehood, even before the time of repression. Indeed, in the following years they falsified the elections to always obtain 99.5% of the votes. In any case, many people thought that the Nazi policy was correct, including extermination, in it there was something close to a social agreement.

Today, it is said that in Germany and other countries the populations did not know that the genocide was happening, which is false. Hitler tirelessly repeated the phrase of the *final solution of the Jewish question* [*Endlösung der Judenfrage*], he mentioned it on any occasion and everyone understood what he meant. Everyone saw their neighbors disappear and knew that they would never return, they were aware that they were going "to the East" and that there was no food there; they saw trains full of people leaving empty. To claim that no one knew what was happening is a "white" lie to sleep peacefully.

People, for the most part, agreed with these actions. Herein lies the big problem. The left did not resist, in part, because if they did, they were against democracy, the proletariat and, at least in part, against the convictions of the population.

The Vatican protested once: when the Nazis began exterminating the so-called disabled. After the claim by the highest Catholic institution, the reaction of the Nazis was to change the regulations that provided that all people with certain disabilities, defined in a long list, had to be exterminated. After this criticism, it was modified to the fact that only if the family agreed, it would be carried out – but the families, in a large percentage of cases, were. There were few cases in which the family said "we don't want to"; There were even those who took their children, parents or siblings directly to euthanasia centers to suffer a violent death. At first these centers were hospitals, then they became *more sophisticated*. Thus, in many cases the relatives not only did not wait for permission to be asked, but they themselves took the initiative to provoke the euthanasia of their "disabled" relatives; In the same way, they did not hesitate to denounce their Jewish neighbors.

A large part of the Jews imprisoned in Germany were found by the Nazis, not thanks to their methods of finding them, which at that historical moment were not yet as sophisticated as they are today in terms of digitized databases. The German state was not yet so organized, it needed the denunciation of the population and this worked "very well". Many building dwellers, for example, systematically flagged suspicious people. If the neighbors rested on Saturdays, but not on Sundays, they called the police to warn of such a terrible action. In many cases, they concluded that this neighbor had a grandfather, up to two or more, Jews; then that person was exterminated. There was a "democratic" agreement in this sense, which

made it difficult for the left to resist; They didn't know how to deal with it, how to commit the "undemocratic" act of going against the popular will, they couldn't say, "We, even though we are a minority, oppose genocide."

Today we blindly and unconditionally believe in "democracy". Moreover, the concept has been reduced to a simple system of elections held every four or six years. There is not even a complete definition of democracy and, even if the concept were more complete, the first step would be to question it. Herbert Marcuse, also a member of Critical Theory, presented a very good formulation on this subject in *Reason and Revolution*,⁵ his book on Hegel and the Theory of Bourgeois Society. He points out that democracy would only really work if each member of society had the will to take care of the good of all; if each one, at the time of voting, proposing, leading, etc., had this in mind. But, Marcuse points out, living immersed in capitalist social relations, this is impossible. The social formation that reigns today educates us, from birth, from the moment we have the first consciousness, to take care only of our individual and selfish interests; If we are very open, perhaps we could worry about two or three more people; or if we are very radical, perhaps by a group of up to a hundred people, but almost no one gets more.

In the form of capitalist reproduction it is impossible, by definition, for anyone to think of the good of all; this problem necessarily exists. The democracy we have today, for example, does not have a systematic structure to protect minorities. If decisions are made on the basis of democracy, it is very easy to see what is happening now in Europe, where it was democratically decided not to send ships to the Mediterranean, where thousands of expatriates drown every year. One of the ideas of European governments is to send ships and planes to destroy the boats where refugees could later be transferred. For this reason, it has become the most dangerous sea in the world despite being calmer and with less strong storms than the Atlantic or the Pacific; because nowhere else do so many people die.

There are no majorities that raise their voices, no one says: "we are no longer going to vote for our government if it acts in this way against Africans and Asians". This is how the left failed in the face of Nazism. We must say it: there was a resounding failure of the European left, perhaps with the exceptions mentioned; the Spanish and the Yugoslav, the only ones that more or less stood out. Another would be Holland, where on the day the

⁵ Marcuse, Herbert. (1971): *Reason and Revolution: Hegel and the Emergence of Social Critical Theory*, trans. Julieta Fombona de Sucre. Madrid, Alianza. (The paperback book. Humanidades, 292) (1st ed. in Col. Area of knowledge: Humanities, 2003. 462 pp.)

deportations of Jews began in Amsterdam, a general strike was organized. There are other small cases that are significant in historical terms, but unfortunately, in numerical terms they are almost irrelevant. We then return to the initial question: Why is there this naïve faith in the majority? And why does the left submit to it knowing that it is false? He submits to the wrong argument of the majorities and then justifies it theoretically.

There were long debates after Nazism focused on how that could happen, how the majority of the populations could agree. The communist justification, and also that of some socialists, is that they were all deceived: the populations themselves are not so revanchist and pro-war, so racist, so anti-Semitic; but they were deceived by the Nazis. This explanation persists in many countries today, especially on the left; However, it is a dangerous explanation and is based on a very simple theory of manipulation.

For Georg Lukács, deception and manipulation exist, but the central problem lies in objectification. This occurs in capitalist relations and is reflected in consciousness. Reification means that things dominate the world, we are their annexes; what decides, Marx would say, is the automatic subject, the value that valorizes itself, we are only its helpers. Even we become things. Adorno formulates a similar idea: reality itself, materiality itself, is already ideology. From the material there is an ideological presence. The current ideological instances are not the television stations or the newspapers managed or the manipulated or manipulative teachers, all that exists, but it is not the central point. The central point is the materiality socially reproduced on a daily basis; that is why it must be changed.

Horkheimer, Adorno and Benjamin argue that this is the reason why the left acts this way. The problem is this: although the left is aware of a certain tendency of many people to manifest a wrong consciousness due to capitalist relations of coexistence, it nevertheless submits to the decisions of the majority. It is at first glance strange, since it implies that people with anti-capitalist political positions accept the pro-capitalist consciousness with the argument that it is about "modernity".

It is difficult to understand why this comes to this. Benjamin would argue that it is due to a naïve faith in the masses of people and that they are automatically heading towards a revolution, or at least a better society. This simplifying view is the result of limited and mistaken interpretations of Karl Marx.

Marx may suddenly, in certain places in his extensive work, have statements of this kind, yet they appear in his writings on few occasions. Marx's main work never mentions it like this, in the main construction that is expressed in the famous chapter "The Commodity"

in section four of *Capital* says the following: "The fetishism of the commodity and its secret", Marx expresses how the very consciousness in our society is systematically wrong. However, hardly any Marxists at the time took these critical statements of Marx seriously. For this reason, Benjamin would affirm that they have a progressive and naïve interpretation of this author. *Progressive* in the sense of assuming a naïve faith in progress; part of this progress would be that the population, which will be increasingly intelligent, more lucid, will have a greater desire for democracy. In today's Mexico, this ideology that dates back to the 1980s persists. Why is it thought that Mexico is more democratic now than ever?

It is strange that the left, to this day, legitimizes this discourse and believes that it works. For Benjamin, it has to do with the illusory faith we have in progress – this is the theoretically most profound point – a faith that history advances automatically. This had already been formulated by social democratic thinkers and the entire German reformist left; Benjamin critically quotes Josef Dietzgen, who stated that every day the population is wiser and the workers are more intelligent because they go to work punctually.⁶ That is why the greatest contribution we can make to the socialist revolution is to go to the factory every day, without delay, to carry out as few strikes as possible, not to miss work even if we are sick: this is how we achieve a more productive system. This is the real "anti-capitalist" attitude, according to Dietzgen.

These ideas were preached not only by the communists, but also by German social democracy. The Communists on this point were slightly less dogmatic, which is strange, since the Stalinists were dogmatic, but sometimes the Social Democrats, the reformist left, beat them to the punch in dogmatism. On this point the most dogmatic were the reformists. Dietzgen was one of the *great* social democratic intellectuals, one of the pioneers of the first line of thought; he insisted on efficiency, discipline and submission. I insist: dogmatism is not specifically Stalinist, but of the entire reformist left.

Benjamin's critique of faith in *progress*, as something that necessarily improves people's lives, is based on the observation that this blind belief is wrong *in its entirety and in all perspectives*. Today, the critics of progress reduce it to certain aspects or certain perspectives, they criticize that only the technical, quantitative, productivity aspect is considered; while human progress, that of democracy, of human rights, is stagnant.

Today, this argument is shared by several thinkers: the critique of progress has gained strength since the 1980s, but practically no one develops it with Benjamin's radicalism. He

⁶ Cf. Dietzgen, Josef. (1906): *Sozialdemokratische Philosophie*. Berlin, Vorwärts.

did not think that there was a need to redefine progress or to broaden the concept beyond the technical and organizational; he believed that progress is a misconception for the left. He postulated that the idea is merely bourgeois: in making the French Revolution and others like it, the bourgeoisie needed this concept; He turned out to be the strongest against classes, political and economic relations, as well as medieval ideologies.

In this context, the idea of progress was brilliant and managed to crush a large part of the medieval heritage. From the bourgeois point of view, progress is undoubtedly the best thing there is. Many theories were based on this: the German idealists and many bourgeois theoreticians, the positivists themselves, who at first glance were very different from the idealists, but on this subject they have common ground; so are the empiricists and pragmatists. All the more or less bourgeois theories are almost identical in interpreting progress, they have, of course, their variants, but between them the difference on this subject is not really that important.

Benjamin would point out to the left the error of thinking, as the bourgeoisie often do, in terms of progress. As is known, in our time there is a worldwide deindustrialization, present for several years, clear examples are Detroit in the United States and Ciudad Juárez in Mexico, where many factories remain empty. The only thing that politicians mention in this regard is that there has been *negative growth*.

However, the criticism cannot be reduced to the fact that progress is not carried out in a broader way, that transcends the technological and economic to reach a social progress of inclusion. Benjamin would argue that the very idea of progress does not serve the left; it only works for the bourgeoisie, originally more revolutionary and determined. When Benjamin refers to the bourgeoisie, he does not do so derogatorily, but rather in terms of a social class that at one time was revolutionary, which organized the revolution against the feudal class. The bourgeois developed and used the concept with remarkable sophistication.

But on the left, specifically on the anti-capitalist left, this concept does not work at all. It is a serious mistake to think that we must radicalize the concept of progress. The left generally assures: "You make progress halfway; we, on the other hand, do it for real" and it is proposed that progress will now go well, which before had only been a promise or a half-fact, but now it will be complete.

For Benjamin, it is necessary, during revolutions or radical political, economic or ideological changes, to attack the ideological center of the era that one wants to overcome. However, this has not been done by those who were and are on the European and world left;

They have failed to detect that the ideological and economic center of the capitalist form of reproduction, of the bourgeoisie and its philosophers, is precisely the idea —and even a certain reality— of progress; that is the center from which everything starts. If it is not attacked, the bourgeois tendencies will always be victorious, both ideologically and politically and militarily.

The bourgeois class would never have won over the feudal class if it had not attacked religious concepts. If someone fights for an anti-feudal stance, but accepts that God himself created the king and queen, he will certainly lose. First it will be necessary to demonstrate that one is not a king by divine decree and that there is no God, that this king imposed himself violently and militarily. This is what the bourgeois politicians and thinkers of the *siècle des Lumières* did.

The left has never reached this level of argumentation, Benjamin would affirm, it has not achieved a radicalism comparable to the bourgeoisie in its break with the dominant thinking of its time. It has never gone as far in ideological struggles as the bourgeoisie, which did succeed in a certain way in destroying the existing theology, which supposedly put the old upper class in its place. With this rupture, the bourgeoisie was able to justify, analyze and promote its struggle, and also convince the people to participate in it. The left is nowhere near anything like it.

Marx tried, of course, but the problem is that Marx has been systematically misunderstood. His most boring and repetitive phrases of the dominant ideology of his time have always been taken up, the most "progressive", where he demonstrates a naïve belief in progress. These ideas exist in Marx, undeniably, they are the quasi-bourgeois moments in which he copied with a certain naivety the dominant model of the moment. The problem is that these concepts have been repeated ad nauseam while the most critical and profound part of his thought, precisely his criticism of progress, has been denied, or at least ignored and minimized. For example, he speaks of the need for him to give up "the human progress of resembling that horrible pagan idol that only wanted to drink the nectar in the skull of the sacrificed."⁷ This is the way Marx, in his best moments, refers to progress; the one by which more and more people died every day from diseases that could be cured, and even more so if they were working-class children or war refugees.

⁷ Cf. Marx and Engels (1973), "Future Results of British Domination in India", in: *On Colonialism*, Buenos Aires: Pasado y Presente, pp. 83-84.

In the subchapter "The Fetishism of the Commodity and Its Secret" Marx also refers to the development of consciousness. He distances himself from the bourgeois (revolutionaries), who claim that every day, every generation, we are more aware and, above all, that we owe to the great break with feudalism an explosion of consciousness – at least according to bourgeois epistemological theory in its many variants. All bourgeois thinkers agree on this point, Marx, on the other hand, compared in this passage of his magnum opus four or five historically existing economic forms and their degree of economic consciousness, and concluded that the degree of this consciousness has been decreasing.

According to him, the so-called *primitive men* knew perfectly well how their economy worked; the slaves were also very clear about their slavery and exploitation. In the Middle Ages, the forms of exploitation and the servant-master relationship became more sophisticated and complicated, but people were still clear about their exploited, subordinated, violated condition.

In the form of capitalist reproduction, on the contrary, Marx affirms, economic consciousness tends to disappear, it almost no longer exists, because practically no one understands—sometimes not even specialists—what is really going on. Marx asserts that there is a fall in the level of economic consciousness, but hardly any dogmatic Marxist has cited this Marxian observation.

Benjamin notes that Marx began to develop a critique of progress and naïve progressivism, but most of his readers did not perceive it, much less other leftists: such as the German social democratic reformist left. As this party distanced itself over the years from Marx's theory, it further increased its naïve faith in progress because they do not understand the historical, social, and economic contradictions that Marx analyzes. We must return to Benjamin's argument to understand what is happening in the process of contemporary history, and the first thing we must do is leave behind the naïve idea of *progress*, as something that necessarily improves the life and coexistence of humans.

Now, returning to the subject of Nazism: the German left, and the European left in a certain way thought, mistakenly, that the Nazis were fighting against progress and that since this was considered something automatic, like a river that advances and only by its own weight it would drag the Nazis because according to this mistaken imagination, the fascists swam against the current and would not persist for long. That was the conviction of almost the entire German left: the Social Democrats and the Communists, although they had great differences between them, were in complete agreement on this point. They were convinced

that Nazism would not last long and, in large part, for this reason they did not fight in an armed way against National Socialism and against genocide. Why fight, why risk your life, why get involved in armed military fights, if Nazism would soon fall under its own weight anyway? And, by the way, at first glance they were right, the *Behemoth* (Neumann, 1943) of National Socialism only remained in power for twelve years.

In terms of time, twelve years is not that long and in that sense they were apparently right; the point is that in those years they killed, in the concentration and extermination camps, six million people – not to mention the dead of the Second World War – they destroyed the European Jews and with them, to a whole way of life. They changed the continent, I'm afraid forever, although I hope I'm wrong. At least until there is an interruption of this social form, until there is a radical rupture, we have to observe that they changed – in an apparently permanent way – Europe.

If we think that it was a continent with a very strong Jewish presence, important in every way, and that the Nazis managed to almost disappear this Jewish imprint in Europe, the change was almost total. There is still some Jewish manifestation, in France perhaps a little more than in other countries; in Germany, for example, it is minimal, almost non-existent, there are almost no synagogues, compared above all to the previous situation.

The Nazis succeeded: they managed to change the planet; not only did they murder many people, but they changed the European social structure. The German government is so cynical about this that a few years ago, when the European Union was founded, they suggested that it be written in its constitution, at the beginning of the founding text: "Europe is by definition a Christian continent." Not only did they kill people, but they pretend to deny their existence before they were killed. As if to say: "European Jews have never existed deep down."

Implicitly, these negationist statements convey the idea that the National Socialists fulfilled the *de facto* advance of progress and in this readjustment it was necessary to homogenize. One of the great goals of capitalist modernity and progress as we know it is to homogenize, and part of this process is precisely to make people equal. Within models of progress that are less openly violent and aggressive than the National Socialist, it is thought that members of minorities should be convinced of the need for this homogenization. But if they are not allowed, what is done with them? Today, since the Nazis no longer exist, European governments deport new minorities to arrive, or leave them to fend for themselves in the Mediterranean. The Nazis had a more efficient plan: it was not enough for them to wait

for them to die by de *facto* banning rescue on the high seas; they took more drastic measures and developed the death camps.

The logic implicit in this type of politics was *progressive*, in the eagerness to create a homogenized society it would be necessary to eliminate everything that made it complicated, contradictory, tangled, too complex. Since each one believes in different things, totally homogenized coexistence becomes a highly difficult matter; The Nazi option was extermination in order to achieve, not a society with happy members, but what they imagined as a "*healthy*" organism-people.

As is known, Hitler and his people often referred to what they called *the body of the German people and the German people* had to be "healthy"; so those persecuted groups: Jews, Gypsies, homosexuals – of which the largest group was the Jews – were perceived as a "disease"; the *healthy body* had to be cured of this supposed *disease*. The idea was to "work better", in that sense this position had something democratic about it, if we understand democracy as it is erroneously done today: that the majority imposes itself and does what it pleases.

The problem is that in this sense the National Socialists were "progressive", they made progress not only in their policy of extermination, but also in their cultural policy. For example, German is a highly diversified language to this day. If you are in northern Germany, it is very difficult to understand the dialect, sometimes, as absurd as it may seem, it is easier to speak English. It is also the other way around, going from Frankfurt to the region of Innsbruck, to a small mountain village in Austria, there are Germans who think: "What are these people talking about?" This was something that the Nazis also tried to homogenize, and to a large extent succeeded.

Many Austrian conservatives did not like the Nazis just because of their progressive tendencies. The conservatives in Austria were the ones who detested them the most; One of them was my grandfather. Conservative, middle-class, he had a more or less good position in the Austrian Post Office and did not like the Nazis because of their line of *progress*, advance, homogenization, their intention to leave behind the specific way of speaking in Austria or in Innsbruck.

The Nazis imposed the so-called "Hochdeutsch" [High German] in schools and on the radio, a dialect from a specific area in the north of the country. In the schools of Austria, a German quite different from that of the Germans was spoken, and in certain Austrian areas, the National Socialists also managed to homogenize it. In this line and following Walter

Benjamin, the Nazis were a modernizing movement, a modern movement that imposed progress and radicalized, in some way, bourgeois ideology. This is not to say that the bourgeoisie would have done the same as the Nazis; although many did ally with them and changed, they renounced and betrayed their own ideology, which was originally humanist.

In the history of philosophy there are two famous cases, one more than the other: Martin Heidegger, who joined the National Socialists; he worked for them as rector of the University of Freiburg [Freiburg] and developed his philosophy as an increasingly racist and anti-Semitic one. On the other hand, there is the similar, and at the same time different, case of Hans-Georg Gadamer; His story is less well known and although he did not speak of it later, there are twelve of his texts on what he called at that time Platonic *violence*, where he justifies National Socialist violence. In fact, in May 1941, he presented the lecture "The *Volks* and History in Herder's Thought" at the German Institute in occupied France. Over the years he tried to forget those texts – and especially their openly pro-Nazi passages.

Martin Heidegger and Hans-Georg Gadamer are two representatives of that part of the German (and European) bourgeoisie that betrayed its own ideals. Why? Because they were convinced that the bourgeoisie was not proactive, but too lukewarm. I refer to them because they both represent two minds that formulated their ideas with sophisticated intelligence and clarity, many people thought – and continue to do so – the same as them, although they cannot raise it with the same skill.

The basic idea is that the bourgeoisie does not develop progress with the necessary intensity due to its "kitsch" on issues such as human rights and respect for minorities. It should not be forgotten that the bourgeoisie of the old school tried to give certain guarantees to minorities in their first constitutions. However, this represented a contradiction with his progressive model and would cause his project not to be carried out with the desired speed. This was where the criticism of philosophers such as Heidegger or Gadamer came in, since they affirmed that the bourgeoisie should leave behind the *corniness* of humanism. This generated conflicts for several bourgeoisie, because it implied leaving behind their old theory; and in this context Gadamer acquires greater importance, who "explained" to the bourgeoisie who doubted, in his texts of the nation-to-socialist period, that the violent acts of the National Socialists were basically something "platonic".⁸

⁸ See: Orozco, Teresa (1995). *Platonische Gewalt. Gadamer's politische Hermeneutik der NS-Zeit*. Hamburg/Berlin, Argument.

4 FINAL THOUGHTS

Benjamin would argue that in order to criticize the concept of *progress*, it would be necessary to go a step further and analyze the now dominant concept of *time*, as something linear, uninterrupted, directed, and homogeneous, clearly directed towards a definite direction called *the future*. This idea of *time* is necessary for the idea of progress to work in turn. Benjamin's critique is radical towards the concept of time as it is established today, in which each second is equal to the previous one. These three aspects of the current concept of time: homogeneity, uninterruptedness, and clear direction, Benjamin would say, would have to be forgotten in order to leave behind the naïve imagination of *progress*.⁹

This is a very close point between Marx and Benjamin – I insist on this closeness, because there are several Marxists who reject Benjamin, falsely thinking that he distances himself from Marx because of his criticism of progress, and in reality Benjamin is the one who understands it best. Karl Marx argues on several occasions in *Capital* that the center of capitalist economic construction is the *time measured in hours*, obviously, of labor. This defines value: that of each commodity is determined by the labour-power time expended in them; and this quantity of labour-power is measured in hours. Thus, for Marx, the form of capitalist reproduction needs a central concept: time, precisely the homogeneous, uninterrupted and clearly directed one; without it, this social form does not function, its economic form would cease to exist.

Benjamin is a little more explicit than Marx, but the two agree: without *time* —as we perceive it today— the currently reigning social form would not function. Marx refers by this above all to the economic; Benjamin to the political and philosophical. Without these concepts of *time* and *progress*, the society we have would not exist. As the left, what we must do is to radically break with it. Only if we do could we really resist. Obviously it is too late to oppose National Socialism, but we can fight against other similar movements, but for this it is imperative to separate ourselves from bourgeois ideology and to conceive our own way, now, of understanding the world, history and *time*.

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⁹ See: Gandler, Stefan (2009). *Fragments of Frankfurt. Essays on Critical Theory*. Mexico, Siglo XXI Editores/UAQ, especially the chapter: "Interruption of the *historical continuum* in Walter Benjamin." pp. 37-84.

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**WATER CONTAMINATION ASSOCIATED WITH THE USE OF RUDIMENTARY
SEPTIC PITS: STATISTICAL ANALYSIS OF WATER QUALITY DATA IN
ITIQUEIRA-MT (2019–2023)**

**CONTAMINAÇÃO HÍDRICA ASSOCIADA AO USO DE FOSSAS
RUDIMENTARES: ANÁLISE ESTATÍSTICA DE DADOS DE QUALIDADE DA
ÁGUA EM ITIQUEIRA-MT (2019–2023)**

**CONTAMINACIÓN HÍDRICA ASOCIADA AL USO DE FOSAS RUDIMENTARIAS:
ANÁLISIS ESTADÍSTICO DE DATOS DE CALIDAD DEL AGUA EN ITIQUEIRA-
MT (2019–2023)**

 <https://doi.org/10.56238/sevened2025.036-044>

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ABSTRACT

This study analyzes the impacts of rudimentary cesspit use on the quality of water intended for human consumption in the municipality of Itiquira–MT, based on data collected by environmental surveillance between 2019 and 2023. A total of 547 water sample results were evaluated, considering the parameters free residual chlorine, turbidity, pH, total coliforms, and *Escherichia coli*. Data were statistically processed using Jamovi software, allowing identification of temporal and spatial contamination patterns. Results indicated a recurrent presence of *E. coli*, peaking in 2021 (24.6% of samples). It is concluded that rudimentary cesspits significantly contribute to water contamination, reinforcing the need for public sanitation policies and preventive actions.

Keywords: Basic Sanitation. Water Contamination. *Escherichia Coli*. Statistical Analysis. Public Health.

RESUMO

Este estudo analisa os impactos do uso de fossas rudimentares na qualidade da água destinada ao consumo humano no município de Itiquira–MT, com base em dados coletados pela vigilância ambiental entre 2019 e 2023. Foram avaliados 547 resultados de amostras de água, considerando os parâmetros cloro residual livre, turbidez, pH, coliformes totais e *Escherichia coli*. Os dados foram tratados estatisticamente no software Jamovi, permitindo identificar padrões temporais e espaciais de contaminação. Os resultados indicaram presença recorrente de *E. coli*, com pico em 2021 (24,6% das amostras). Conclui-se que as fossas rudimentares contribuem significativamente para a contaminação hídrica, reforçando a necessidade de políticas públicas de saneamento e ações preventivas.

Palavras-chave: Saneamento Básico. Contaminação da Água. *Escherichia Coli*. Análise Estatística. Saúde Pública.

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RESUMEN

Este estudio analiza los impactos del uso de fosas rudimentarias en la calidad del agua destinada al consumo humano en el municipio de Itiquira–MT, con base en datos recolectados por la vigilancia ambiental entre 2019 y 2023. Se evaluaron 547 resultados de muestras de agua, considerando los parámetros de cloro residual libre, turbidez, pH, coliformes totales y *Escherichia coli*. Los datos fueron tratados estadísticamente en el software Jamovi, lo que permitió identificar patrones temporales y espaciales de contaminación. Los resultados indicaron la presencia recurrente de *E. coli*, con un pico en 2021 (24,6% de las muestras). Se concluye que las fosas rudimentarias contribuyen significativamente a la contaminación hídrica, lo que refuerza la necesidad de políticas públicas de saneamiento y acciones preventivas.

Palabras clave: Saneamiento Básico. Contaminación del Agua. *Escherichia Coli*. Análisis Estadístico. Salud Pública.

1 INTRODUCTION

Basic sanitation is essential for public health, especially in small municipalities with deficient infrastructure. In Itiquira-MT, the absence of a sewage system with treatment results in the predominant use of rudimentary cesspools. This scenario favors the infiltration of contaminants into the soil, aquifers and the drinking water distribution system to the population, representing a risk of waterborne diseases. The objective of this article is to analyze water quality monitoring data in the municipality between 2019 and 2023 and relate the results to the presence of rudimentary cesspools.

2 METHODOLOGY

The study is characterized as quantitative and descriptive, using secondary data from the environmental surveillance of the municipality of Itiquira-MT. Between 2019 and 2023, 547 water samples collected in 12 neighborhoods and in the district of Ouro Branco do Sul were analyzed. The parameters evaluated were:

- Free Residual Chlorine (CRL);
- Turbidity (TU);
- pH;
- Total Coliforms (TC);
- Escherichia coli (EC).

The data were processed in the Jamovi software to calculate descriptive statistics and frequencies, with presentation of results in tables and graphs that allowed the evaluation of the conformity of the results achieved with the goals proposed by the Municipal Plan for Basic Sanitation and Sustainable Development Goal 6 - SDG 6.

3 RESULTS

The Municipal Basic Sanitation Plan (PMSB) of Itiquira-MT is a fundamental instrument for the planning and management of sanitation services in the municipality, covering water supply, sanitary sewage, solid waste management and urban drainage. Established by Municipal Law No. 994, of November 13, 2017, the PMSB aims to ensure the protection of public health and the healthiness of the urban and rural environment.

Water Supply (SAA): The Water Supply System in Itiquira faces challenges related to infrastructure and municipal management. The research by Vasconcelos (2018) highlights

the need for investments to ensure the quality and regularity of the supply of drinking water to the population.

However, the absence of an efficient basic sanitation system in Itiquira – MT causes some problems such as: wastewater running on the streets, in the rainwater galleries, in addition to the fact that rudimentary cesspools are often installed on the sidewalks and close to the water supply networks, representing a direct risk to public health and the environment. The contamination of the water table, associated with the inadequate construction of these cesspools, compromises urban springs and rivers, putting at risk not only the supply of drinking water, but also the biodiversity and environmental balance of the region.

3.1 DISTRIBUTION OF SAMPLES

The number of samples varied annually, with a peak in 2019 and 2023 (119) and a lower volume in 2022 (89). The spatial distribution covered all neighborhoods and catchment points, as shown in table 01 below.

Table 1

Number of samples analysed for CE and TC (2019–2023)

Neighborhoods	Real estate	Samples 2019	Samples 2020	Samples 2021	Samples 2022	Samples 2023	Samples Total
Itiquira (Centro) – B1	1493	56	32	24	19	20	151
Ouro Branco do Sul – B2	1323	00	16	29	20	34	99
Jd. Planalto – B3	509	12	11	07	09	08	47
Stº Antônio – B4	235	14	07	15	10	15	61
Poxoréo – B5	205	09	10	13	11	15	58
Goiás – B6	138	07	09	13	08	14	51
Arco Ires I – B7	82	05	02	02	04	07	20
Jd Natal – B8	75	00	04	01	02	03	10
Arc Ires II – B9	52	05	02	04	02	01	14
Coohab Apoená – B10	49	06	08	03	02	02	24
Villa I – B11	164	00	00	00	02	00	02

João de Barros – B12	57	05	07	01	0	00	13
TOTAL	4.325	119	108	112	89	119	547

Source: Prepared by the author (2024).

The neighborhood with the highest representativeness (chart 01) was the Center (Itiquira – B1), with a total of 151 samples, corresponding to approximately 27.6% of the total. Next are the neighborhoods of Ouro Branco do Sul (B2) with 59 samples, and Santo Antônio (B4) with 61 samples. Other neighborhoods such as Poxoréo (B5) and Goiás (B6) also presented significant amounts of samples, totaling 58 and 51 analyses, respectively.

The samples analyzed (Environmental Surveillance 2019 – 2023) comply with the national guideline of the sampling plan – basic parameters that include the information system for monitoring the quality of water for human consumption, which is responsible for carrying out a minimum quantity of ten monthly samples of each parameter (total coliforms, *Escherichia coli*, free residual chlorine, turbidity and pH), in addition to five monthly fluoride samples, which will not be analyzed in this work because the municipal agency does not perform analysis for this parameter.

3.2 PHYSICOCHEMICAL AND MICROBIOLOGICAL PARAMETERS

The analysis of the results of biological tests is essential to ensure the quality of water intended for human consumption, as it allows the presence of microorganisms and substances potentially harmful to health to be assessed. This evaluation plays a crucial role in several aspects, such as the detection of microbiological contamination, as biological assays identify bacteria, viruses, protozoa, and other pathogenic microorganisms that can cause diseases such as gastroenteritis, hepatitis A, and cholera. The presence of fecal coliforms, for example, indicates contamination by sewage and the need for corrective measures.

The analysis revealed that, despite pH and turbidity values often within the standards, the detection of coliforms and *E. coli* was recurrent.

- ✓ Free residual chlorine: fluctuations associated with operational failures in chlorination.
- ✓ Turbidity: occasional increases in rainy periods.
- ✓ pH: variation within the recommended range, with few exceptions.
- ✓ Total Coliforms: significant presence at several points.
- ✓ *E. coli*: highest incidence in 2021.
- ✓ Tables 01 to 15: Descriptive statistics and frequencies (2019 to 2023)

Frequent analyses allow you to quickly identify the source of contaminants, enabling effective corrective actions to protect water resources. Table 1 below presents the descriptive statistics for three variables: CRL, TU and PH. In addition, the Shapiro-Wilk normality test was performed, whose results (W statistic and p-value) are also indicated, with the exception of the variable TU, for which it was not possible to calculate the test, resulting in "NaN" values.

Analyzing table 2 based on the description of the data for the N (number of cases), the TU was the one with the highest number of cases with 93 values not omitted, while the pH had 91 followed by the CRL with 81, however, all the values presented by the variable (TU) were 0 (zero) which may mean that in this period the water was completely transparent, that is, it did not contain suspended particles detectable by the measuring instrument. Another relevant data in this table, regarding the minimum and maximum values, is noteworthy that the pH variable obtained results lower than 6 (six).

Table 2
Descriptive Statistics, 2019

	N	Silent	Average	Median	Standard deviation	Minimum	Maximum	Shapiro-Wilk	
								W	p
CRL	81	75	0.671	0.610	0.371	0.160	1.99	0.884	<.001
YOU	93	63	0.000	0.000	0.000	0.000	0.00	Nan	Nan
ph	91	65	6.435	6.550	0.752	2.120	7.78	0.832	<.001

Source: Data organized by the author and analyzed in the Jamovi software (2024).

The frequency table in Jamovi is an important tool in data analysis, as it organizes and summarizes categorical or discrete variables, showing the distribution of data in terms of frequency. Overall, this table is essential to better understand the data and is an initial step in many exploratory statistical analyses. Thus, tables 3 and 3 of frequency will be presented below, referring to the variables of total coliforms (TC) and Escherichia coli (EC).

Table 3

CT A and P frequencies, 2019

CT	Counts	% of Total	Cumulative %
The	109	91.6 %	91.6 %
P	10	8.4 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

Table 4 of total coliform frequencies indicates the frequency distribution for two identified groups: "A" for absence and "P" for the presence of pathogenic bacteria in the water samples collected in 2019 in the municipality studied. Group "A" has 109 counts, representing 91.6% of the total. Group "P" has 10 counts, representing 8.4% of the total.

Table 4

EC A and P frequencies, 2019

EC	Counts	% of Total	Cumulative %
The	116	97.5 %	97.5 %
P	3	2.5 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

In the analysis of table 4 of frequency presented for *Escherichia coli* cases, there is a predominance of absence (A): the overwhelming majority of the cases analyzed correspond to the absence of *E. coli*, with 116 occurrences, representing 97.5% of the total. This demonstrates that the presence of this bacterium is rare in the dataset. Only 3 cases (or 2.5%) have the presence of *E. coli*, indicating that this condition is uncommon. The accumulated frequency reaches 100% after adding the two values (A and P), which confirms the completeness of the data.

Considering that the biological analysis of water is an indispensable tool for the management of water quality, ensuring that the water consumed is safe, promoting public health and contributing to the sustainability of natural resources. Table 5 will be presented below with the descriptive statistics of the results of the biological trials for the year 2020.

Table 5

Descriptive Statistics, 2020

	N	Silent	Average	Median	Standard deviation	Minimum	Maximum	Shapiro-Wilk	
								W	p
CRL	49	61	0.734	0.2000	1.070	0.0500	2.80	0.596	<.001
YOU	90	20	0.228	0.0400	0.381	0.0000	1.50	0.652	<.001
ph	80	30	6.470	6.3950	0.739	2.9000	7.80	0.886	<.001

Source: Data organized by the author and analyzed in the Jamovi software (2024).

The analysis of Table 5, which presents descriptive statistics for the variables free residual chlorine (CRL), turbidity (TU) and pH, provides important information on the quality of water for human consumption. Main points can be highlighted such as: free residual chlorine (CRL): average: 0.734 mg/L, with a median of 0.2 mg/L; standard deviation: 1.070, indicating high variation in chlorine levels; minimum and maximum values: 0.05 mg/L to 2.80 mg/L; Shapiro-Wilk $p < 0.001$ indicates that the distribution is not normal. The high standard deviation suggests instability in the levels of residual chlorine, which can compromise the safety of the water consumed, as chlorine is important to ensure proper disinfection.

As for turbidity (TU), the average is 0.228, with a median of 0.04; standard deviation: 0.381, reflecting moderate variations; minimum and maximum values: the NTU at 1.50; and Shapiro-Wilk $p < 0.001$ shows that the distribution is also not normal. High turbidity values may indicate the presence of suspended particles that protect pathogenic microorganisms, compromising water quality.

The average pH was 6.470, with a median of 6.395; standard deviation: 0.739, indicating smaller variations in comparison with the other variables; minimum and maximum values: 2.90 to 7.80; and Shapiro-Wilk $p < 0.001$ points to a non-normal distribution. The average pH is within the recommended by Brazilian legislation (between 6 and 9.5), but the minimum value (2.90) is extremely acidic and may indicate a serious problem in some samples.

Table 6 shows the frequencies of total coliforms (TC) in samples of water intended for human consumption, highlighting two categories: A (Absent) and P (Present). The detection of total coliforms is an essential parameter for the evaluation of water quality, since their presence can indicate failures in the treatment processes or contamination during distribution.

Table 6

CT A and P frequencies, 2020

CT	Counts	% of Total	Cumulative %
The	74	69.8 %	69.8 %
P	32	30.2 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

When analyzing table 6, the absence of Total Coliforms (A) represents 74 counts (69.8% of the total). Indicates that most of the monitored samples are within the desired standards for drinking water. As for the presence of Total Coliforms (P), it corresponds to 32 counts (30.2% of the total). This percentage suggests a significant concern, since approximately one third of the samples have microbiological contamination, indicating potential risks to human health. Table 06 of the frequency of absence and presence of the *E. coli* variable for the year 2020 will be presented below.

Based on table 7, it can be highlighted that, in the absence of *E. coli* (A), there were 101 counts (93.5% of the total). This high percentage indicates that most water samples conform to microbiological quality standards, without the presence of *E. coli*. The presence of *E. coli* (P) had only 7 counts (6.5% of the total). Although this percentage is small, the presence of *E. coli* is a critical indicator of fecal contamination and poses a significant risk to public health, even in small amounts.

Table 7

EC A and P frequencies, 2020

EC	Counts	% of Total	Cumulative %
The	101	93.5 %	93.5 %
P	7	6.5 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

Based on the idea that the analysis of the results of biological tests is crucial for monitoring the quality of water intended for human consumption, as they allow the identification of the presence of pathogenic microorganisms, such as bacteria (*Escherichia coli*), which can cause diseases. Table 8 will be shown below with the descriptive statistics of the free residual chlorine, turbidity and pH variables referring to the results of the samples collected in 2021.

Table 8

Descriptive Statistics, 2021

	N	Silent	Average	Median	Standard deviation	Minimum	Maximum	Shapiro-Wilk	
								W	p
CRL	151	8	0.7113	0.2900	0.8984	0.0000	3.000	0.708	<.001
YOU	157	2	0.0843	0.0400	0.0908	0.0400	0.780	0.533	<.001
ph	149	10	7.4854	7.4000	0.9673	0.4300	8.800	0.822	<.001

Source: Data organized by the author and analyzed in the Jamovi software (2024).

Analyzing the main relevance of Table 8 on the quality of water used for human consumption, observe the following points: the mean free residual chlorine (CRL) was 0.7113 mg/L, with a standard deviation of 0.8984, the amplitude ranged from 0 mg/L (minimum) to 3 mg/L (maximum), and the Shapiro-Wilk normality test indicates that the CRL data do not follow a normal distribution. High variability may suggest inconsistencies in water monitoring or treatment. The value 0 may indicate the absence of disinfection in some points; the turbidity (TU) had a mean of 0.0843, with a standard deviation of 0.0908, the amplitude ranged from 0.04 to 0.78 and the Shapiro-Wilk test, indicating the absence of normal distribution. Turbidity was at low levels (within the recommended limits), but variability may be relevant to identify episodes of temporary increase in suspended solids; as for pH, the mean was 7.4854, standard deviation of 0.9673, the amplitude ranged from 4.3 to 8.8 and the Shapiro-Wilk test, indicating absence of normality.

Although the average value is close to the ideal (between 6.5 and 8.5 according to quality standards), the minimum value (4.3) suggests episodes of extreme acidity, which can compromise the quality of the water and the safety of consumption. The non-normality of the distributions indicates the need to use nonparametric statistical methods for subsequent analyses. Values outside the acceptable standards for free residual chlorine and pH can indicate problems in the water treatment system or failures in monitoring. The high variability in some measurements suggests the need for more rigorous investigation and control to ensure the consistency and safety of the water supply.

Table 08 shows the frequencies of total coliforms, with (A) indicating the absence and (P) the presence of bacterial indicators.

Table 9

CT A and P frequencies, 2021

CT	Counts	% of Total	Cumulative %
The	66	57.9 %	57.9 %
P	48	42.1 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

The analysis of Table 9 reveals important data on the presence of total coliforms (TC) in samples of water intended for human consumption, where: the absence contains 66 cases, representing 57.9% of the total, did not present total coliforms; and the presence appears with 48, corresponding to 42.1%, detected the presence of total coliforms.

Regarding the relevance of the data regarding water quality, the striking fact that 42.1% of the samples presented total coliforms is worrisome, indicating a potential risk to public health, since the presence of these microorganisms may indicate evidence of fecal contamination.

In the distribution, most samples are within acceptable standards (57.9% with absence of TC), but the percentage of contamination is still significant. In monitoring, the data reinforce the need to intensify corrective and preventive measures, such as water disinfection and maintenance of supply systems, to ensure the safety of the water consumed.

Table 10 represents the frequencies of *E. coli* resulting from the analysis of the results of biological tests carried out in 2021, which aimed to monitor the quality of water used for human consumption.

Table 10

EC Frequencies, 2021

EC	Counts	% of Total	Cumulative %
The	86	75.4 %	75.4 %
P	28	24.6 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

Analyzing table 10, the following relevant points are shown for the monitoring of the quality of water for human consumption: as for the absence (A) of *E. coli*, it is recorded in 86 samples, which represents 75.4% of the total. This indicates that most of the water samples analyzed are free of the presence of this bacterium, which suggests generally safe conditions for human consumption; in the presence (P) of *E. coli* was detected in 28 samples, corresponding to 24.6% of the total. This percentage is worrisome, as it indicates a significant amount of contaminated samples, representing a risk to public health.

Table 11 presents the descriptive statistics of the free residual chlorine, turbidity, and pH variables for the year 2022.

Table 11
Descriptive Statistics, 2022

	N	Silent	Average	Median	Standard deviation	Minimum	Maximum	Shapiro-Wilk	
								W	p
CRL	87	2	1.4291	1.3800	0.57789	0.3500	2.8000	0.965	0.018
YOU	89	0	0.0506	0.0500	0.00921	0.0400	0.0800	0.848	<.001
PH	89	0	7.5034	7.5000	0.50485	6.3000	8.8000	0.991	0.821

Source: Data organized by the author and analyzed in the Jamovi software (2024).

Based on table 11, which presents the essential descriptive statistics for monitoring the quality of water used for human consumption, analyzing the variables free residual chlorine (CR), turbidity (TU) and pH. Being able to highlight the main relevant points such as:

1 - The free residual chlorine (CR) had a mean of 1.429 mg/L, a median of 1.38 mg/L, a standard deviation of 0.5778 mg/L, a minimum and maximum of 0.35 mg/L to 2.80 mg/L, and the Shapiro-Wilk normality test: $W = 0.96$, $p = 0.01$. Based on the data, the average concentration of residual chlorine is within the recommended standards for water disinfection (usually between 0.2 and 2.0 mg/L). High variability (standard deviation of 0.5778) may indicate fluctuations in disinfection levels over time. The p -value < 0.05 in the Shapiro-Wilk test suggests that the data do not follow a normal distribution.

2 - In turbidity (TU) the mean was 0.056 mg/L, the median 0.050 mg/L, the standard deviation: 0.0092 mg/L, the minimum and maximum: 0.04 mg/L to 0.08 mg/L, Shapiro-Wilk normality test: $W = 0.84$, " p " < 0.001 . It can be interpreted that the average turbidity is well

below the maximum limit allowed for human consumption (usually ≤ 5 , according to WHO and Brazilian standards). The low standard deviation indicates little variation in the data, suggesting a good stability in the water quality in terms of turbidity. The Shapiro-Wilk test indicates that the data do not follow a normal distribution ($p < 0.001$).

3 - In pH, the mean was 7.503, the median 7.50, the standard deviation 0.5048, the minimum and maximum 6.30 to 8.80, and the Shapiro-Wilk normality test $W = 0.99$, $p = 0.82$. This indicates that the average pH value is within the recommended range for drinking water (usually between 6.5 and 8.5). The moderate standard deviation suggests a variation within acceptable limits. The Shapiro-Wilk test shows that the data follow a normal distribution ($p > 0.05$).

Thus, residual chlorine and turbidity showed a non-normal distribution, while pH followed a normal distribution. The average values of chlorine, turbidity and pH are within the recommended standards for human consumption. The greater variation in chlorine levels may indicate the need for more rigorous monitoring to ensure efficiency in disinfection. The turbidity remains low and stable, suggesting a good efficiency in water treatment and the pH is well balanced, with no worrying variations. These results indicate that water quality is within acceptable standards, but continuous monitoring of residual chlorine may be necessary to avoid excessive variations in disinfection.

Table 12 below shows the frequency of total coliforms with results (A) for absence and (P) for the presence of bacteria, with the quantities and percentages referring to the results of biological tests for the year 2022.

Table 12

CT A and P frequencies, 2022

CT	Counts	% of Total	Cumulative %
The	74	83.1 %	83.1 %
P	15	16.9 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

By analyzing table 12 of total coliform (TC) frequencies in water samples collected in the municipality of Itiquira-MT in 2022. The data indicate that, of the 89 samples analyzed, 74 (83.1%) showed absence of total coliforms (A), while 15 (16.9%) showed presence (P).

Table 13 shows the frequencies of *Escherichia coli* with results (A) for absence and (P) for the presence of bacteria, with the quantities and percentages referring to the results of the biological tests for the year 2022.

Table 13

EC A and P frequencies, 2022

EC	Counts	% of Total	Cumulative %
The	88	98.9 %	98.9 %
P	1	1.1 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

Table 13 presents the frequencies of *Escherichia coli* (EC) in water samples collected in the municipality of Itiquira-MT in 2022. The data indicate that, of the 89 samples analyzed, 88 (98.9%) showed absence of *E. coli* (A), while only 1 sample (1.1%) showed presence (P).

Table 14 presents the descriptive statistics of the variables free residual chlorine, turbidity and pH referring to the results of the biological tests for the year 2023, fundamental parameters for the evaluation of the quality of water for human consumption.

Table 14 shows the descriptive statistics of the variables free residual chlorine (CRL), turbidity (TU) and pH in the monitoring of the quality of water for human consumption in the municipality of Itiquira-MT, based on 119 samples collected in 2023.

Table 14

Descriptive Statistics, 2023

								Shapiro-Wilk	
	N	Silent	Average	Median	Standard deviation	Minimum	Maximum	W	p
CRL	119	0	1.7570	1.8900	0.6368	0.2100	2.800	0.952	<.001
YOU	119	0	0.0629	0.0500	0.0550	0.0400	0.580	0.307	<.001
ph	119	0	7.7311	7.7000	0.6665	6.7000	8.900	0.910	<.001

Source: Data organized by the author and analyzed in the Jamovi software (2024).

Analyzing the free residual chlorine (CRL) variables: the mean was 1.757 mg/L, median 1.890 mg/L, standard deviation 0.6368 mg/L, minimum 0.210 mg/L, maximum 2.800 mg/L and the normality test (Shapiro-Wilk): $W = 0.952$, " p " < 0.001. In this case, the CRL is within the recommended standards for drinking water disinfection (0.2 to 2.0 mg/L, according to Ordinance GM/MS No. 888/2021). However, there is significant variation in the values and the distribution is not normal ($p < 0.001$); turbidity (TU) had a mean of 0.0629, a median of 0.0500, a standard deviation of 0.0550, a maximum of 0.580, and a normal test (Shapiro-Wilk): $W = 0.307$, $p < 0.001$. Therefore, the average turbidity is well below the upper limit of 5.0 for human consumption. Low variability indicates that the water is being well treated in relation to the removal of suspended particles. However, the data does not follow a normal distribution; and finally, the pH had a mean of 7.7311, the median 7.7000, the standard deviation 0.6665, the minimum 6.7000, the maximum 8.9000 and the normality test (Shapiro-Wilk): $W = 0.910$, " p " < 0.001. Showing that the average pH is within the recommended range (6.0 to 9.5). The distribution shows slight variation, but with values within acceptable limits for consumption.

The parameters analyzed indicate that the water quality in Itiquira-MT in 2023 is within the standards required for human consumption. Free residual chlorine varies, but remains within limits. Turbidity is low, suggesting good efficiency in water treatment. The pH is within the recommended levels. None of the variables follows a normal distribution, according to the Shapiro-Wilk test.

Table 15 presents the total coliform frequencies referring to the results of biological tests for the year 2023.

The analysis of Table 15 of Total Coliform Frequencies reveals important information about the microbiological quality of water in the municipality of Itiquira-MT in 2023. The main points to be highlighted are:

Table 15

CT A and P frequencies, 2023

CT	Counts	% of Total	Cumulative %
The	90	75.6 %	75.6 %
P	29	24.4 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

1. Predominance of Absence of Contamination: category "A" (Absence of total coliforms) was identified in 90 samples, representing 75.6% of the total. This indicates that most of the samples analyzed met the quality standards required for drinking water.

2. Presence of Contamination in Part of the Samples: category "P" (Presence of total coliforms) was found in 29 reports, corresponding to 24.4% of the total. This percentage may be worrisome, as it indicates that almost a quarter of the samples showed microbiological contamination.

3. Accumulated Percentage: the accumulated percentage of 100% confirms that all samples were classified between the two categories mentioned, with no intermediate values.

4. Relevance to Public Health and Sanitation: the fact that 24.4% of the samples had total coliforms may indicate treatment failures or contamination in certain areas of the municipality. This outcome may require corrective measures, such as inspecting supply sources, improving chlorination, or maintaining distribution networks.

Table 15

EC A and P frequencies, 2023

EC	Counts	% of Total	Cumulative %
The	118	99.2 %	99.2 %
P	1	0.8 %	100.0 %

Source: Data organized by the author and analyzed in the Jamovi software (2024).

Table 16 presents the distribution of the frequencies of absence (A) and presence (P) of the bacterium *Escherichia coli* (*E. coli*) in the year 2023, indicating the number of occurrences, the percentage in relation to the total, and the accumulated percentage obtained from the data analysis.

The analysis of Table 16 of *Escherichia coli* (EC) Frequencies provides essential information on the microbiological quality of water in the municipality of Itiquira-MT in 2023. The main points to be highlighted are:

1. Low Presence of *E. coli* Contamination: category "A" (Absence of *E. coli*) was identified in 118 samples, corresponding to 99.2% of the total. This data indicates that the vast majority of the samples analyzed meet the standards of potability, suggesting good sanitary conditions of the water.

2. Only 1 sample showed contamination: category "P" (Presence of *E. coli*) was found in only 1 sample, representing 0.8% of the total. This result is positive, as the presence of *E. coli* is directly associated with fecal contamination, which can pose risks to public health.

3. Cumulative Percentage: the cumulative percentage of 100% confirms that all samples were classified as absent or present of *E. coli*, with no intermediate variations.

4. Relevance to Public Health and Water Quality: the fact that almost all samples are free of *E. coli* suggests that the water treatment and distribution system in Itiquira-MT is working properly. However, the detection of a contaminated sample indicates that there may be isolated sources of contamination, which requires attention to avoid risks of outbreaks.

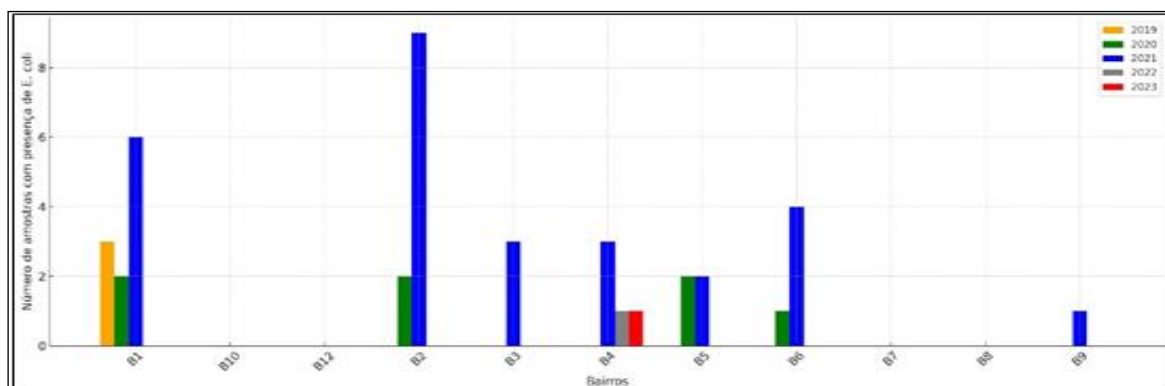
3.3 TEMPORAL TRENDS

In order to understand the temporal and spatial distribution of microbiological contamination of water intended for human consumption, Graph 01 was prepared, which presents the consolidated data regarding the presence of the *Escherichia coli* bacterium in the neighborhoods of the municipality of Itiquira-MT, in the period from 2019 to 2023. The choice of this variable is due to the fact that *E. coli* is widely recognized as an indicator of recent fecal contamination, whose presence in water samples represents a potential risk to public health.

Figure 1 allows the comparative visualization between the different years and neighborhoods, facilitating the identification of critical areas and the recurrence of cases, thus constituting a fundamental tool for environmental diagnosis and the formulation of health control and prevention strategies.

Figure 1

Temporal and spatial distribution of E. coli contamination from 2019 to 2023



Prepared by the author (2025).

Based on Graph 01, the analysis of the presence of *Escherichia coli* in the water samples collected in the neighborhoods of the municipality of Itiquira-MT, in the period from 2019 to 2023, shows significant variations in its spatial and temporal occurrence. In 2019, only neighborhood B1 had positive cases, while in 2020, the expansion of contamination was observed to neighborhoods B2, B5 and B6. The year 2021 concentrated the highest number of records, with emphasis on neighborhoods B2 ($n = 9$) and B1 ($n = 6$), demonstrating a worsening in the quality of the water distributed. In the years 2022 and 2023, although there was a reduction in occurrences, the identification of consecutive cases in the B4 neighborhood indicates the possibility of a persistent focus of contamination.

In view of this scenario, it is recommended to intensify microbiological monitoring, inspect the supply infrastructure and adopt corrective measures in places with recurrence, in order to ensure the potability of water and the protection of public health, according to the parameters established by current legislation.

The recurrence of *E. coli* and total coliforms, even with acceptable levels of chlorine in some cases, indicates post-treatment contamination, probably associated with infiltration from black pits located near pipes and wells. Studies by Fagundes & Andrade (2005) and FUNASA (2013) corroborate the relationship between rudimentary systems and the degradation of water quality.

4 CONCLUSION

Analysis of the results of biological assays demonstrates a significant variation in the detection of *Escherichia coli* (*E. coli*) over the years. In 2019 and 2020, the incidence was relatively low, with rates of 2.52% (3/119) and 6.48% (7/108), respectively. However, in

2021, a significant increase was observed, with 28 cases in 114 samples, representing a rate of 24.56%, which may indicate an outbreak or an environmental factor favorable to contamination and data (Annex) from the Epidemiological Surveillance of the municipality studied, points out that there were 195 cases of acute diarrheal disease notified during this year that may be directly related to the increase in *E. coli* in the samples of water used for human consumption. In subsequent years, there was a sharp drop, with only 1 case in 89 samples analyzed in 2022 (1.12%) and 1 case in 119 results in 2023 (0.84%).

This trend suggests that after the 2021 peak, corrective measures may have been successfully implemented, resulting in reduced contamination in the following years. According to the water and sewage department, the possible causes of the 2021 increase are associated with network ruptures and irregularities between the sewage system (rudimentary cesspool) and the water system, as many residents do not obey the necessary distance, however, it was evident in the result of the analysis that there was an inefficiency in water treatment, Specifically chlorination, in which some samples showed zero results, which may contribute to the increase of the aforementioned bacterium, but improvements in the water supply network and in the treatment system ensured the reduction of cases of presence of the aforementioned bacterium in subsequent years.

The results show that the use of rudimentary cesspools in Itiquira-MT is directly related to the microbiological contamination of the water. It is recommended:

- Gradual replacement by septic tanks or sewage system.
- Continuous and georeferenced monitoring of supply sources.
- Strict supervision regarding the minimum distance between cesspools and wells.
- Educational actions with the community.

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LEGAL CONSIDERATIONS ON ARTIFICIAL INTELLIGENCE

CONSIDERAÇÕES JURÍDICAS SOBRE A INTELIGÊNCIA ARTIFICIAL

CONSIDERACIONES JURÍDICAS SOBRE LA INTELIGENCIA ARTIFICIAL

 <https://doi.org/10.56238/sevened2025.036-045>

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ABSTRACT

Artificial intelligence is a technology that has the capacity to greatly influence almost every aspect of human activity and therefore has the potential to transform social life in many ways. Law, as the discipline responsible for regulating social dynamics, faces the great challenge of establishing legal frameworks that promote the use of artificial intelligence to support human activity, as well as preventing uncontrolled and dangerous uses that could be harmful. This paper aims to provide a descriptive introduction to what is currently understood by this technology and to the progress made in its regulation at the international, supranational, and national levels in Mexico, as of the time of its publication.

Keywords: Artificial Intelligence. Law. Regulation. Risk.

RESUMO

A inteligência artificial é uma tecnologia que tem a capacidade de influenciar fortemente quase todos os aspectos da atividade humana e, por isso, tem o potencial de transformar a vida social de muitas maneiras. O Direito, como disciplina encarregada de regular as dinâmicas sociais, enfrenta o grande desafio de estabelecer marcos jurídicos que promovam o uso da inteligência artificial como apoio à atividade humana, bem como de impedir usos descontrolados e perigosos que possam ser prejudiciais. Este texto busca fazer uma introdução descritiva sobre o que se entende atualmente por essa tecnologia e sobre os avanços na sua regulamentação nos âmbitos internacional, supranacional e nacional, no caso do México, até o momento de sua publicação.

Palavras-chave: Inteligência Artificial. Direito. Regulação. Risco.

RESUMEN

La inteligencia artificial es una tecnología que tiene la capacidad de influir grandemente en casi todos los aspectos de la actividad humana y por ello tiene el potencial de transformar la vida social en muchos sentidos. El Derecho como disciplina que se encarga de regular las dinámicas sociales, tiene ante sí el gran reto de establecer los marcos jurídicos que fomenten el uso de la Inteligencia artificial para apoyo de la actividad humana, así como para impedir los usos descontrolados y peligrosos que puedan ser perjudiciales. En este escrito se trata de hacer una introducción descriptiva de lo que se entiende por esta tecnología en la actualidad y el avance en la regulación que, en el plano internacional, supranacional y nacional en México, se tiene al momento de emitirlo.

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Palabras clave: Inteligencia Artificial. Derecho. Regulación. Riesgo.

1 INTRODUCTION

The content of this paper is derived from a research project by the author, which has just been concluded. The issue of artificial intelligence is technical, specialized in areas of exact sciences, but its impact on a diversity of activities is so great that it necessarily has to be studied also from the legal perspective, where very important debates are generated to be addressed. The aim is to make a general overview of some of the main advances in artificial intelligence and relate it to some phenomena with legal relevance that could be generated by its application in social aspects.

2 PROBLEMS AND JUSTIFICATION:

The advancement of science and technology has given rise, among many other things, to what is now called artificial intelligence, an aspect in constant development that has to do with different aspects of the life of the human being individually and in societies. Different phenomena and problems are generated, which the law has to observe in order to regulate and better still it must investigate to try to foresee the harmful that can occur and issue proposals for solutions. It is the task that corresponds to Law very broad, diverse, which is why, in the research project, it has been intended to make general, introductory analyses of the relationship between artificial intelligence and law, proposing some contributions in this world of growing possibilities.

3 BACKGROUND

The exact sciences and technology have made great advances in recent decades, which have transformed human life in many ways, sometimes to facilitate it, make it more comfortable or sometimes causing unprecedented problems that have been difficult to solve or, even worse, have left a permanent mark. As these scientific contributions have a direct impact on human life, it is necessary that they have legal systems that regulate them in order to achieve the purpose of the law as a whole: to allow coexistence in a more or less peaceful way, guaranteeing the recognition of people's rights.

The issue of artificial intelligence is one of those that poses a revolution in social life, in various aspects due to its special characteristics, so the law must be attentive to regulate these phenomena in the most appropriate way and also allow scientific growth and development in harmony with human activity

It is necessary to emphasize that Artificial Intelligence is not a new topic, it has already been under construction for decades, but it is a few years to date that it has reached a level that is related, like much of technology, in many areas of life and therefore has been highlighted in the media, achieving great dissemination.

Due to its degree of development and the great progress achieved, it has been considered that apart from the great benefits that it can attract to humanity, it implies serious risks to the labor aspects of different activities, trades or professions.

4 DEFINITION OF ARTIFICIAL INTELLIGENCE

In UNESCO's 2022 publication Recommendations on the Ethics of Artificial Intelligence, it defines:

"AI systems are information processing technologies that integrate models and algorithms that produce an ability to learn and perform cognitive tasks, leading to outcomes such as prediction and decision-making in physical and virtual environments. AI systems are designed to operate with varying degrees of autonomy, through the modelling and representation of knowledge and the exploitation of data and the calculation of correlations" (UNESCO, 2022)

One of the main factors considered when analyzing AI is the problem that its indiscriminate use could cause to life in its various manifestations. There are those who consider that these fears are unjustified since for decades there has been software that humanity uses for very varied purposes, if the biggest problem in general. In relation to software, a machine does not "think"; He does exactly what he is ordered to do and therefore, everything is under control. So, we can say that the main difference (and revolutionary novelty) with Artificial Intelligence is that although it receives a feed of information or programming, through the collection of data, AI is capable of obtaining solutions by itself, doing operations that approximate the functioning of the human brain, this being the main characteristic that triggers fears about its existence and future development. In addition, the so-called generative AI enhances all these capabilities of the technology

It is precisely in this capacity, in this possibility of relating information, of integrating solutions, of emulating the mental processes of the human brain where the fears generated by Artificial Intelligence lie. So much so, that there have been expressions, requests from different organizations of society at the international level where governments are asked to regulate it effectively. All or at least the vast majority recognize its importance, the degree of

irreversible intervention it has in many aspects of life, the convenience of the support it can provide to human beings, but also the expectation is great that uncontrolled development can cause more harm than good.

It is said, sometimes with support and seriousness, sometimes with a bit of levity, that the use of AI will change the work schemes, the exercises of carrying out the different trades or professions. It is undeniable that it will impact some activities more than others, but in general it is considered that human beings must learn, adapt to using these technologies and do their job better, since they will have a tool that will provide great support to relieve them of repetitive tasks that would take a lot of time.

Some time ago I watched on the channel of the Federal Judiciary, a program hosted by the prominent jurist Miguel Carbonell, called: The legal profession and artificial intelligence, has the future caught up with us? (Justicia TV 2023) where the point of whether AI would displace lawyers, law graduates and the panel of experts agreed that it would not, since although the capabilities of artificial intelligence are so broad that they allow it to collect information, process it, provide solutions, even learn, the use of this tool implies great possibilities for the jurist to make his time more efficient since he will dedicate himself to the reasoning tasks with greater emphasis, since other tasks of support, of search, which represented a lot of time invested, will now be of very short duration

In general, some advantages and disadvantages of the use of AI are identified, among the first: Constant and unrestricted availability, fewer risks due to the automation of dangerous jobs, automation of repetitive jobs, constant learning through the development of AI. In terms of disadvantages, high implementation costs are mentioned, when it comes to large equipment or updated machinery, biased decision-making, since AI works based on algorithms with which it is fed and whoever does so can imprint their intentionality or ideology, very specialized skills that are concentrated in a few, possible substitution or displacement of human beings in some areas.

We dealt with the regulation that must be made on this technology, it is essential to create an advanced legal framework

5 REGULATORY FRAMEWORK

5.1 INTERNATIONALLY

In this regard, efforts have been made for years to achieve this regulation, but it was not until August 2024 that the regulation known as the European Union's Artificial Intelligence

Law came into force. Which is identified as a European-wide regulation that regulates this technology, "the first comprehensive regulation on AI from a major regulator anywhere in the world" (artificial EUA, 2023).

In the second half of 2024, the Council of Europe opened for signature the first Global Treaty on AI, called the Council of Europe Framework Convention on Artificial Intelligence and Human Rights, Democracy and the Rule of Law, which is the first legally binding international treaty whose objective is to establish that the use of AI is consistent with human rights. the rule of law and democracy.

"The treaty, which is also open to non-European countries, establishes a legal framework that covers the entire life cycle of AI systems and addresses the risks they may pose, while promoting responsible innovation. The agreement takes a risk-based approach to designing, developing, using and decommissioning AI systems, which requires careful consideration of any potential negative consequences of the use of AI systems." (European Council, 2025)

The agreement was signed by Iceland, Norway, the United Kingdom, the European Union and other non-European countries, such as the United States and Mexico.

For Mexico, which does not yet have a specific legal regime, it represents a challenge since companies and suppliers of AI systems will have to adapt to those prescribed by the treaty to operate in Europe and the other signatory countries.

The treaty provides a legal framework that covers everything related to the development of AI systems, promotes progress and innovation, and addresses the risks that their exercise may pose to human rights, the rule of law and democracy.

Returning to the European regulation, we said in previous paragraphs that this regulation on AI came into force as of August 2024 for some purposes and in a gradual process over two years, it will come into force in all its aspects.

For this regulation, what is identified as risk is fundamental. In general, when approaching the study of this technology, the risk, that is, the aspects of danger that the use of various manifestations of AI may represent for the population, is fundamental, since due to its particular characteristics it is necessary to address in order to prohibit or regulate the use of technology in certain areas of society's activity.

The regulation in question identifies four levels of risk:

- a) Unacceptable, that is, when the use of Artificial Intelligence technology involves a manipulative activity of human consciousness or involves systems of segregation or social discrimination. For example: exploiting vulnerabilities in which people find themselves, such as a disability or certain socioeconomic conditions; using people's biometric data to create systems to organize or classify people based on those natural identifiers; Classify people by social behaviors or other similar factors, among others
- b) High risk, which is extensively addressed in this Law, identifies as areas in which, if artificial intelligence is not properly regulated, it could represent serious dangers, areas such as education, access to health services, and even immigration procedures.
- c) Limited risk, although this regulation deals with it to a lesser extent than with high risk, if it considers above all in relation to the need for AI developers to make sure, take the necessary measures to inform and create awareness in users that communication and the relationship are being carried out with technology, not with human beings.
- d) Minimal risk. It is not regulated by this law (at least at the time of its issuance). It would include topics such as video games with AI, although the recent development of generative AI somewhat modifies the panorama

The organization called the Organization for Economic Cooperation and Development (OECD), has very relevant studies and documents on the subject and in 2019 issued the Principles of Artificial Intelligence, which were revised in 2024.

"The OECD AI Principles promote the use of innovative and trustworthy AI that respects human rights and democratic values. Adopted in May 2019, they set standards for AI that are practical and flexible enough to last over time." (OECD, 2025)

Among them are: Inclusive growth, sustainable development and well-being, Human rights and democratic values, transparency and explainability as well as accountability

5.2 LEGAL FRAMEWORK AT NATIONAL LEVEL

In our country, Mexico, several attempts have been made to reform the Constitution to incorporate the power to legislate on AI matters, so most attempts have been to reform Article 73 and expressly include that the Congress of the Union may legislate in this area. Currently section XVII." To enact laws on general communication routes, information and communication technologies, broadcasting, telecommunications, including broadband and the Internet, posts and postal services, and on the use and exploitation of waters under federal jurisdiction." (Political Constitution of the United Mexican States 2025) And what has

been intended is that it expressly says Artificial Intelligence, as another of the areas considered federal matter for its legislation.

Legislative attempts have also been made to regulate this technology, especially from 2020 to 2024 (CECO, 2025); We can identify four most prominent ones:

AI and Robotics Ethical Regulation Act 2023

Law regulating the use of AI 2023

Law that creates the Mexican Agency for the development of AI 2023

Federal Law Regulating AI 2024 (Meza, 2024)

The latter establishes in its first article, the object of regulation.

I.- To regulate the development, commercialization and use of artificial intelligence systems.

II.-Guarantee respect for the human rights of consumers and users and avoid any form of discrimination when using AI systems

III.-Protect Intellectual Property Rights

IV.-To facilitate the national development of artificial intelligence systems. (Chamber of Senators, 2024)

Already in the current year, 2025, on April 22, the initiative of the Federal Law for the Ethical, Sovereign and Inclusive Development of Artificial Intelligence was presented, which defines as its object:

Article 1. The purpose of this Law is to establish the general regulatory framework for the development, implementation, use, supervision and promotion of artificial intelligence in the United Mexican States, in accordance with the principles of universality, interdependence, indivisibility, and progressivity of human rights, ensuring an ethical approach and promoting technological sovereignty. In order to guarantee that everyone enjoys the benefits derived from development and innovation, in the field of Artificial Intelligence, in full observance and respect for Human Rights. (Chamber of Deputies, 2025)

In both initiatives, the most recent and complete presented in Mexico, the aim is to regulate the development of AI with a perspective of respect for human rights in its exercise, which must be carried out with the values that guide the Mexican legal system and a general scope of access to the use of this technology and its benefits.

The issue of harmonization between AI and respect for intellectual property rights is of particular interest at the international level since it is one of the areas in which the greatest impact is produced and that practices and even criteria have been generated, which are of

great concern to intellectual creators. because of the impact that may be caused or even generalized to their rights.

Likewise, we have administrative documents that deal with some aspects of the use of AI, for example, we will cite Recommendations for the Treatment of Personal Data derived from the use of AI, from the National Institute of Transparency and Access to Information and Protection of Personal Data INAI of June 2024, a document that being of high quality, defines some issues of great importance in AI, always within the orbit of its objective, which is the protection of people's data and information and which is certainly one of the areas that presents the greatest challenges.

In Mexico, work is being done on this issue, it has been on the table for some years. At least since 2019 we have already had texts, serious and sustained studies on Artificial Intelligence. There are areas such as the judiciary where it has been the object of particular attention and extremely valuable studies. The judicial sphere is one of the governmental spheres in which the greatest attention has been paid to the use of this technology to reduce its negative impact and take advantage of its enormous possibilities of benefit. In 2023, the House of Legal Culture of the Supreme Court of Justice of the Nation, held an academic event called "The vision of Artificial Intelligence on Justice" where the panorama of how AI was being incorporated into the exercise of judicial power was presented. The event was of enormous quality because of the speakers who discussed advanced points, describing the important actions that are already being carried out and identifying that even in relatively new areas, in Mexico there are scientific studies of great quality in this regard and above all put into practice, incorporated into the exercise of the work.

6 CONCLUSION

Artificial AI is a technology that surpasses what was known until its appearance and is under development. The challenge for human beings is to adapt, adapt, be able to get the most out of it without compromising the rights and stability of human beings, combining the support of AI with their own activity so that the world offers better opportunities, problem solving and better living standards to more people.

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**INSECTICIDAL ACTIVITY OF 1,4-DIHYDROPYRIDINES AGAINST BEMISIA
TABACI MEAM1 (GENN.) (HEMIPTERA: ALEYRODIDAE)**

**ATIVIDADE INSETICIDA DE 1,4-DIIDROPIRIDINAS CONTRA BEMISIA TABACI
MEAM1 (GENN.) (HEMIPTERA: ALEYRODIDAE)**

**ACTIVIDAD INSECTICIDA DE LAS 1,4-DIHIDROPIRIDINAS CONTRA BEMISIA
TABACI MEAM1 (GENN.) (HEMIPTERA: ALEYRODIDAE)**

 <https://doi.org/10.56238/sevened2025.036-046>

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ABSTRACT

The silverleaf whitefly (*Bemisia tabaci*) is a pest that feeds on a wide range of herbaceous plants' phloem. This insect can cause direct damage to the hosts and transmits over 350 different species of viruses to the plants, reducing the crop productivity up to 100% in some cases. The main current strategy for pest control is the application of chemical pesticides, but the emergence of resistance to the pesticides due to prolonged and extensive use has been reported. In this study, a series of 1,4-dihydropyridine (1,4-DHPs) was synthesized through a one-pot multicomponent reaction and evaluated for their in vivo insecticidal potential against *B. tabaci* MEAM1 nymphs. Among the 24 compounds tested, at a concentration of 5 mg/L, compounds 10 (ethyl 2,7,7-trimethyl-4-(3-nitrophenyl)-5-oxo-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate), 15 ethyl 4-(furan-2-yl)-2,7,7-trimethyl-5-oxo-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate), 16 (ethyl 2,7,7-trimethyl-5-oxo-4-(thiophen-2-yl)-1,4,5,6,7,8-hexahydroquinoline-3-carboxylate), and 18 (diethyl 4-(4-methoxyphenyl)-2,6-dimethyl-1,4-dihydropyridine-3,5-dicarboxylate) displayed control efficiencies twice as high as that of the pyriproxyfen at 100 g/L, which was used as the positive control.

Keywords: *Dihydropyridines*. Hantzsch Reaction. Multicomponent Reaction. Silverleaf Whitefly.

RESUMO

A mosca-branca (*Bemisia tabaci*) é uma praga que se alimenta do floema de uma ampla variedade de plantas herbáceas. Este inseto pode causar danos diretos às plantas

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hospedeiras e transmitir mais de 350 espécies diferentes de vírus, reduzindo a produtividade agrícola em até 100% em alguns casos. A principal estratégia atual de controle é a aplicação de pesticidas químicos, mas o surgimento de resistência devido ao uso prolongado e intensivo tem sido relatado. Neste estudo, uma série de 1,4-diidropiridinas (1,4-DHPs) foi sintetizada por meio de uma reação multicomponente em um único passo (one-pot) e avaliada quanto ao seu potencial inseticida in vivo contra ninfas de *B. tabaci* MEAM1. Entre os 24 compostos testados, na concentração de 5 mg/L, os compostos 10, 15, 16 e 18 apresentaram eficiências de controle duas vezes maiores do que o piriproxifeno a 100 g/L, usado como controle positivo.

Palavras-chave: *Diidropiridinas*. Reação de Hantzsch. Reação Multicomponente. Mosca-Branca.

RESUMEN

La mosca blanca de los invernaderos (*Bemisia tabaci*) es una plaga que se alimenta del floema de una amplia variedad de plantas herbáceas. Este insecto puede causar daños directos a los hospedadores y transmitir más de 350 especies diferentes de virus a las plantas, reduciendo la productividad de los cultivos hasta en un 100% en algunos casos. La principal estrategia actual para el control de esta plaga es la aplicación de pesticidas químicos; sin embargo, se ha informado de la aparición de resistencia debido al uso prolongado y extensivo de estos compuestos. En este estudio, se sintetizó una serie de 1,4-dihidropiridinas (1,4-DHPs) mediante una reacción multicomponente en un solo paso (one-pot) y se evaluó su potencial insecticida in vivo contra ninfas de *B. tabaci* MEAM1. Entre los 24 compuestos ensayados, a una concentración de 5 mg/L, los compuestos 10 (etil 2,7,7-trimetil-4-(3-nitrofenil)-5-oxo-1,4,5,6,7,8-hexahidroquinolina-3-carboxilato), 15 (etil 4-(furano-2-il)-2,7,7-trimetil-5-oxo-1,4,5,6,7,8-hexahidroquinolina-3-carboxilato), 16 (etil 2,7,7-trimetil-5-oxo-4-(tiofen-2-il)-1,4,5,6,7,8-hexahidroquinolina-3-carboxilato) y 18 (dietil 4-(4-metoxifenil)-2,6-dimetil-1,4-dihidropiridina-3,5-dicarboxilato) mostraron eficiencias de control dos veces superiores a las del piriproxifeno a 100 g/L, que se utilizó como control positivo.

Palabras clave: *Dihidropiridinas*. Reacción de Hantzsch. Reacción Multicomponente. Mosca Blanca de los Invernaderos.

1 INTRODUCTION

Bemisia tabaci Middle East-Asia Minor 1 (MEAM1) Genn. (Hemiptera: Aleyrodidae), also known as silverleaf whitefly, is an insect that lives usually in herbaceous plants, feeding from their phloem (DE BARRO et al., 2011). *Bemisia tabaci* diet causes direct damage to various types of crops such as cotton (SHUKLA et al., 2016), cabbage (SANTIAGO-ÁLVAREZ et al., 2006), potatoes (SANTIAGO-ÁLVAREZ et al., 2006), lettuce (NG & CHEN, 2011), eggplant (LEITE et al., 2003), tomato (CALVO et al., 2012), and soybeans (PADILHA et al., 2021), besides many others (ABUBAKAR et al., 2022). Besides causing direct damage to its hosts, the silverleaf whitefly's feeding is responsible for the transmission of more than 350 species of viruses, some capable of reducing the crop productivity by 20 to 100% (SANI et al., 2020). *Bemisia tabaci* is considered a pest capable of causing substantial damage and economic losses.

Numerous techniques for managing the population growth of silverleaf, referred to as whitefly management (WFM) strategies, have been documented. These strategies include a variety of methods, such as the application of diverse mixtures: botanical extracts (ATEYYAT et al., 2009; ZHANG et al., 2004), animal waste (SINGH et al., 2021), and ash (SHAILAJA, 2012) to crops, as well as mechanical and biological methods. Nevertheless, many cultural strategies are either suitable only for small-scale farmers or lack robust scientific validation (ABUBAKAR et al., 2022). Additionally, the biological approach may yield inconsistent results due to the numerous factors and parameters that influence the efficacy of biological control agents (ABUBAKAR et al., 2022; KIDANE et al., 2015). Chemical pesticides are the most reliable method for the control of *B. tabaci*, and most commonly include pyriproxyfen, buprofezen, spiromesifen, spirotetramat, anthranilic diamides, cyantraniliprole, and chlorantraniliprole (HOROWITZ et al., 2020). However, the application of these chemicals is associated with adverse effects on both human health and ecological safety (KIM et al., 2017). Furthermore, the persistent use of these substances in increasing amounts has resulted in the emergence of resistance in *B. tabaci* (HOROWITZ et al., 2020; SHAH et al., 2020). Consequently, the development of insecticide resistance makes the silverleaf management a substantial challenge.

The 1,4-dihydropyridine nucleus (1,4-DHP) is present in the structure of several compounds that present pharmacological activities, such as bronchodilator (WEI et al., 2015), anticonvulsant (WEI et al., 2015), hypotensive (MAGER et al., 1992; ROVNYAK et al., 1992), and calcium channel blockage (MIRI et al., 2006). 1,4-DHP compounds are also known for

their ability to reverse multidrug resistance (CAROSATI et al., 2012). In addition, several compounds of this class exhibit diverse biological activities (NUNEZ-VERGARA et al., 1997). For example, recent studies demonstrated that 1,4-DHPs display *in vitro* antileishmanial and antitoxoplasmal activities (OLIVEIRA et al., 2025; OLIVEIRA et al., 2024). However, despite the wide variety of biological activities, the insecticidal activity of 1,4-DHPs is still little exploited in the literature.

In this scenario, this study aimed to investigate the toxicity of a series of synthetic 1,4-DHPs obtained via Hantzsch reaction in 2nd instar nymphs of *B. tabaci* MEAM1.

2 METHODOLOGY

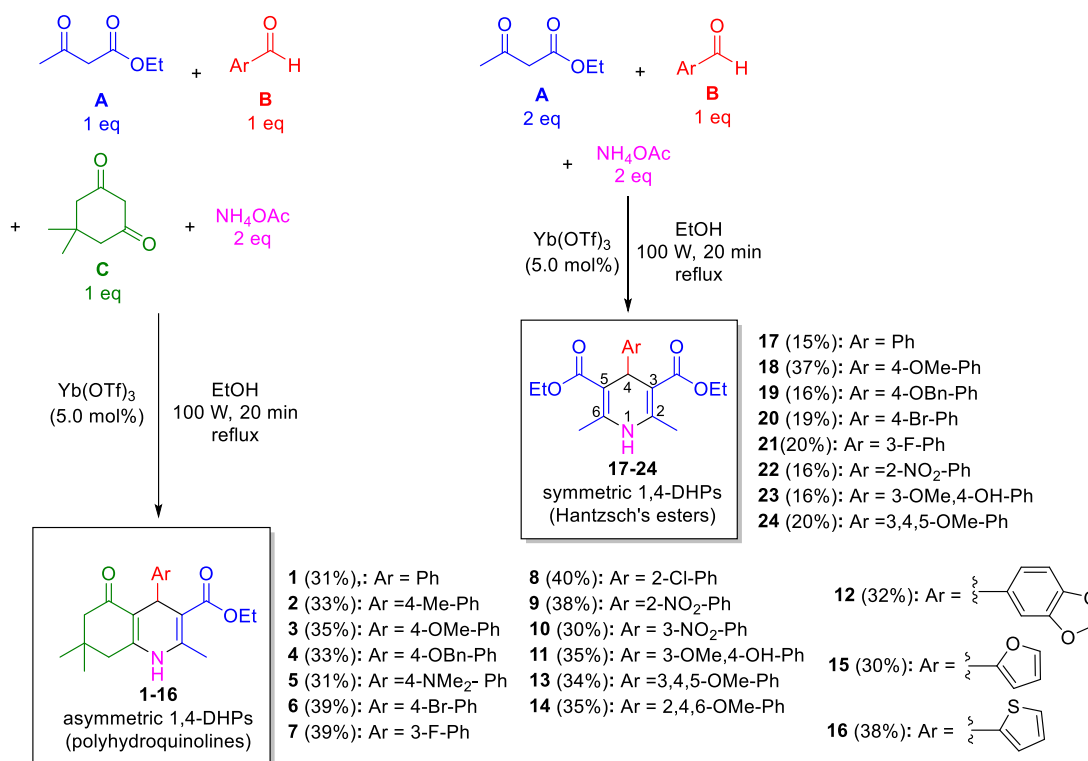
2.1 SYNTHESIS OF 1,4-DIHYDROPIRIDINES 1-24

The 1,4-dihydropyridines **1-24** were synthesized according to the multicomponent one-pot methodology previously described in the literature, with some modifications (Figure 1) (WANG et al., 2005). For the synthesis of asymmetric 1,4-DHP's (**1-16**), 2.0 mmol of dimedone (Aldrich), 2.0 mmol of ethyl acetoacetate (Aldrich), and 0.06 g (5.0 mol%) of ytterbium triflate (Aldrich) were added to a 15-mL round-bottom flask containing 5.0 mL of ethanol. Subsequently, 2.0 mmol of an aromatic aldehyde (Aldrich) and 2.0 mmol of ammonium acetate (Scientific Exodus) as a source of nitrogen were added to the flask, which was coupled to a reflux condenser and set to a CEM Discover microwave reactor (CEM Corp, Matthews, NC). All reagents were added at room temperature. The reaction mixture was taken to the microwave reactor, where it was maintained for 20 min at a fixed power of 100 W in an open vessel system configuration. The symmetric 1,4-DHPs (**17-24**) were obtained following a similar procedure, in which 2 eq. (4.0 mmol) of ethyl acetoacetate was used in place of 1 eq of ethyl acetoacetate and 1 eq of dimedone (Figure 1).

The starting material consumption and the product formation were monitored by thin-layer chromatography using a mixture of hexane: ethyl acetate 3:1 (v/v) as a mobile phase. After the reaction ended, compounds **1-24** were separated from the reaction mixture by vacuum filtration and further purified by recrystallization in ethanol. Compounds **1-24** were obtained in yields ranging from 15% to 40% (Figure 1) and identified based on their ¹H and ¹³C NMR and mass spectrometry data, as previously reported (OLIVEIRA et al., 2025). Compounds **1-16** were evaluated as mixtures of enantiomers.

Figure 1

Synthesis of 1,4-DHPs 1-14



2.2 INSECTICIDAL ASSAY

The tests were carried out at the Laboratory of Plant Resistance to Insects and Insecticide Plants (LARESPI), located in the Department of Plant Protection (22° 50' 40" S 48° 26' 05" W) at the FCA/UNESP in the city of Botucatu, SP, during September 2022.

The tests with *B. tabaci* MEAM1 were carried out in the laboratory and a greenhouse, in a completely randomized design, with 25 treatments and five replicates, each replicate consisting of a leaflet with 20 nymphs (2nd instar) of *B. tabaci* MEAM1, totaling 100 nymphs per treatment. The rearing of *B. tabaci* MEAM1 was maintained in a greenhouse (3.0 × 3.0 × 2.5 m), covered with shade (30%), and closed laterally with an anti-aphid screen (200 mesh). For the maintenance of insects, cabbage (*Brassica oleracea* var. *acephala* L.), soybean (*Glycine max* L. Merrill), cotton (*Gossypium hirsutum* L.), and tomato (*Solanum lycopersicum* L.) plants were grown in 2.5 L plastic pots.

Soybean cultivar 'NA 5909' seeds were sown in plastic pots (0.70 L) containing Tropstrato® substrate (Vida Verde Indústria e Comércio de Insumos Orgânica Ltda, Mogi Mirim, São Paulo, Brazil). The pots were placed in a greenhouse, free from insect infestation, and received the other cultural practices normally recommended for the crop. Soybean plants

with the first fully developed trifoliate leaf (0.7 L pots) were conditioned in the *B. tabaci* MEAM1 rearing, for oviposition by whitefly adults. After three days, the pots were removed and taken to a greenhouse until the eggs hatched and the nymphs reached the second instar, which were demarcated with the aid of a magnifying glass and glitter glue, and then sprayed with the different treatments. Five plants were used per treatment, and each plot consisted of a plant (leaflet) marked with 20 nymphs. In sequence, a single spraying was carried out using a professional airbrush (Model BD134K), coupled to an air compressor adjusted to provide a pressure of 0.5 bar. At the time of spraying, the plants were at stage 12, according to the BBCH scale (VARIANI, 2001). Compounds **1-24** were solubilized in Tween 20 and tested at a concentration of 5 mg/L. Tiger 100 EC® (pyriproxyfen 100 g/L) was used as a standard insecticide (positive control).

After spraying, the pots were kept in a greenhouse. The evaluation of nymphs was performed daily during seven consecutive days after application by counting live nymphs. During the evaluation period, the possible phytotoxicity of the products on the leaflets was also verified.

The effectiveness of the products was determined using the Abbott formula (NAKANO et al., 1981), as described below:

$$\%E = \left(1 - \frac{I}{C}\right) \times 100 \quad (1)$$

Where: %

E = Control effectiveness;

C = number of live *B. tabaci* nymphs in the control;

I = number of live *B. tabaci* nymphs in the evaluated treatment.

2.3 STATISTICAL ANALYSIS

The data obtained were subjected to analysis of variance by the F test. Normality was verified using the Shapiro-Wilk test and homogeneity using the Levene test. When significance was verified in the treatment effects, the Fisher LS-Means Test was used, adjusted for Tukey ($P \leq 0.05$) to compare means. For the analysis, the PROC MIXED-SAS 9.2 statistical package was used (INSTITUTE, 2011).

3 RESULTS AND DISCUSSION

Table 1 illustrates the results and the control efficiency obtained during the 7-day treatment with the 1,4-DHPs **1-24** at a concentration of 5 mg/L against *Bemisia tabaci* MEAM1 nymphs.

Compounds **1-9** and **11** displayed lower efficacy compared to the positive control (pyriproxyfen, 16.37%), whereas compounds **17**, **22**, and **23** had efficacies similar to the positive control. On the other hand, all the other 1,4-DHPs tested were more effective against *B. tabaci* nymphs than the positive control. The most effective compounds were **10** (34.38%), **15** (30.38%), **16** (34.83%), and **18** (34.83%).

The 1,4-DHP scaffold is present in many compounds whose biological activities have been explored. Recently, the potential of 1,4-DHPs derivatives obtained by the Hantzsch synthesis as agrochemicals has been addressed (PARTHIBAN & MAKAM, 2022). These nitrogen-containing molecules, although not directly derived from nicotine, possess structural resemblance to the neonicotinoid class, whose insecticidal properties are well-established in the literature (GUPTA et al., 2019). Studies report the insecticidal activity of DHPs against *Aphis medicaginis*, *Aphis craccivora*, *Nilaparvata lugens*, *Brevicoryne brassicae*, and many others, which can be considered pests capable of damaging different types of crops (PARTHIBAN & MAKAM, 2022). However, to date, data on the insecticidal activity of 1,4-DHPs are unreported in the literature.

Noteworthy, the insecticide pyriproxyfen, at a concentration of 100 g/L, had an efficiency of only 16.37% (e.g., the efficiency of pyriproxyfen to reduce the number of live *B. tabaci* nymphs compared to the positive control group was low). In other studies performed by our group, pyriproxyfen at 100 g/L caused 100% mortality of *Bemisia tabaci* biotype B adults (BALDIN et al., 2018; HE et al., 2013). This may indicate that the *B. tabaci* biotype used in this study is resistant to pyriproxyfen.

Among the 24 1,4-DHPs tested, 14 showed higher control efficacy than the positive control. All the symmetrical compounds (the Hantzsch esters) **17-24** were more effective against *B. tabaci* MEAM1 as compared to pyriproxyfen, whereas most (but not all) of the asymmetrical 1,4-DHPs (polyhydroquinoline) were less effective than the positive control. On the other hand, the polyhydroquinolines **10**, **15**, and **16**, alongside the Hantzsch ester **18**, were two times more effective than the positive control.

Compounds **15** and **16** display a heteroaromatic substituent at C4. On the other hand, compound **10** displayed a 3-nitro group at the aromatic ring, whereas compound **18** displayed

a 4-methoxy group. These results could indicate that the presence of the 4-methoxyphenyl, 2-furanyl, 2-tiophenyl, and 3-nitrophenyl groups may play a key role in the activity of 1,4-DHPs against *Bemisia tabaci* MEAM1. However, further studies are needed to better understand the structure-insecticidal activity relationships of 1,4-DHPs against *B. tabaci* MEAM1.

Table 1

Number of live Bemisia tabaci MEAM1 nymphs (mean $\pm$ SD) and control efficiency (%) after 7-day exposure to treatments with compounds 1-24 at 5 μ L/mL

Treatment	<i>Bemisia tabaci</i>	
	Number of live individuals ^a	% efficiency ^b
Witness	19.03 $\pm$ 0.48 a	---
1	17.14 $\pm$ 0.80 ab	9.91
2	17.31 $\pm$ 0.73 ab	9.01
3	17.26 $\pm$ 0.38 ab	9.31
4	17.66 $\pm$ 0.51 ab	7.21
5	16.91 $\pm$ 0.72 ab	11.11
6	17.91 $\pm$ 0.86 ab	5.86
7	16.37 $\pm$ 0.52 ab	13.96
8	17.26 $\pm$ 0.48 ab	9.31
9	17.31 $\pm$ 1.21 ab	9.01
10	12.49 $\pm$ 1.20 b	34.38
11	18.43 $\pm$ 0.48 ab	3.15
12	14.34 $\pm$ 0.83 ab	24.62
13	14.34 $\pm$ 0.70 ab	24.62
14	13.94 $\pm$ 1.14 ab	26.73
15	12.49 $\pm$ 2.28 b	34.38
16	12.40 $\pm$ 1.39 b	34.83
17	15.63 $\pm$ 1.14 ab	17.87
18	12.40 $\pm$ 1.11 b	34.83
19	14.66 $\pm$ 0.77 ab	22.97
20	14.60 $\pm$ 1.44 ab	23.27
21	14.46 $\pm$ 1.67 ab	24.02
22	15.63 $\pm$ 1.07 ab	17.87
23	15.66 $\pm$ 1.15 ab	17.72
24	15.11 $\pm$ 1.30 ab	20.57
Pyriproxyfen	15.91 $\pm$ 0.73 ab	16.37

P <0.0001

^aMeans followed by the same letter in the column do not differ by Tukey's adjusted LS-means test ($P \geq 0.05$); ^bTo calculate the efficiency, the Abbott formula was used (NAKANO et al., 1981).

4 CONCLUSION

The polyhydroquinolines **10**, **15**, and **16**, and the Hantzsch ester **18**, displayed higher efficacy than pyriproxyfen (10 g/L) against *B. tabaci* MEAM1 nymphs at a concentration of 5 mg/L. These preliminary results indicated that 1,4-DHPs are a promising class of alternative insecticides against *B. tabaci* MEAM1 that can be obtained through an attractive methodology that requires only a synthetic step, employs mild and green conditions, and has short time reactions, which deserve to be deeper investigated.

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**CELL CHARACTERIZATION: PRINCIPLES AND TECHNIQUES OF
MICROSCOPY, FLOW CYTOMETRY AND IMMUNOFLUORESCENCE**

**CARACTERIZAÇÃO CELULAR: PRINCÍPIOS E TÉCNICAS DE MICROSCOPIA,
CITOMETRIA DE FLUXO E IMUNOFLUORESCÊNCIA**

**CARACTERIZACIÓN CELULAR: PRINCIPIOS Y TÉCNICAS DE
MICROSCOPIA, CITOMETRÍA DE FLUJO E INMUNOFLUORESCENCIA**

 <https://doi.org/10.56238/sevened2025.036-047>

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ABSTRACT

This chapter aimed to present the two main techniques for cellular study: optical, immunofluorescence, and confocal microscopy, and flow cytometry. Both have specific techniques for sample preparation, but all are based on immunological or immunocytochemical methods. The chapter explains the operating principles of these two instruments and their variations, as well as the principles of immunological techniques and fluorescence. It also presents concepts and methods for preparing immunocytochemistry samples, along with all the preceding procedures on how different types of antibodies are produced and which should be selected for each purpose—whether for cell surface, intracellular, or organelle and nuclear labeling. At the end of each technique, the reagents to be used and their preparation methods are presented.

Keywords: Optical Microscopy. Immunofluorescence Microscopy. Confocal Microscopy. Flow Cytometry. Immunocytochemistry. Antibodies.

RESUMO

O presente capítulo teve como objetivo apresentar as duas principais técnicas para o estudo celular, a microscopia óptica, de imunofluorescência e confocal e a citometria de fluxo. Ambas têm técnicas específicas para preparação de amostras, mas todas se baseiam em técnicas imunológicas ou imunocitoquímicas. O capítulo traz os princípios de funcionamento desses dois equipamentos e suas variações, bem como o princípio das técnicas imunológicas e o princípio da fluorescência. O capítulo também traz conceitos e técnicas de preparo de amostras de imunocitoquímica, como também todos os procedimentos anteriores, sobre como são produzidos os diversos tipos de anticorpos e quais devem ser escolhidos para cada objetivo, se marcação da superfície celular, intracelular ou dentro de organelas e núcleo. Ao final de cada técnica é apresentado quais reagentes usar e como prepará-los.

Palavras-chave: Microscopia Óptica. Microscopia de Imunofluorescência. Microscopia Confocal. Citometria de Fluxo. Imunocitoquímica. Anticorpos.

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RESUMEN

El presente capítulo tuvo como objetivo presentar las dos principales técnicas para el estudio celular: la microscopía óptica, de inmunofluorescencia y confocal, y la citometría de flujo. Ambas poseen técnicas específicas para la preparación de muestras, pero todas se basan en métodos inmunológicos o inmunocitoquímicos. El capítulo aborda los principios de funcionamiento de estos dos equipos y sus variaciones, así como el principio de las técnicas inmunológicas y el principio de la fluorescencia. También se presentan conceptos y técnicas de preparación de muestras de inmunocitoquímica, además de todos los procedimientos previos sobre cómo se producen los diferentes tipos de anticuerpos y cuáles deben elegirse para cada objetivo, ya sea para marcación de la superficie celular, intracelular o dentro de orgánulos y núcleo. Al final de cada técnica se indica qué reactivos deben utilizarse y cómo prepararlos.

Palabras clave: Microscopía Óptica. Microscopía de Inmunofluorescencia. Microscopía Confocal. Citometría de Flujo. Inmunocitoquímica. Anticuerpos.

1 INTRODUCTION

Cells are microscopic living beings that cannot be observed with the naked eye. All the knowledge that is known about cells was obtained by indirect means of amplification (such as the increase in the sample size by optical lenses) or transduction of cellular information (detection and transformation of analog information into electronic and digital information) in a way that the observer can have contact with such a tiny dimension. There is a whole technological development for equipment that detects cell structures and takes them to the observer, as well as a whole technology for sample preparation. Electronic, chemical and biological processes have to be combined to obtain the most accurate information about the cell and its contents. These techniques have become more sophisticated to the point that it is not only possible to study cell structure, but also the population, the identification of cell types and even metabolism. Two main pieces of equipment are mandatory for the study of cells: microscopy, which can be brightfield or fluorescence, and flow cytometry. Both approaches necessarily rely on sample preparation techniques; The essential ones are immunocytochemistry, immunohistochemistry and fluorescence technology. This chapter aims to show the principles of operation of these two pieces of equipment as well as the techniques for preparing samples. The language is technical and accessible, with the aim of serving the reader, especially students, who are starting their laboratory functions in undergraduate and graduate courses on the ways of cell characterization.

2 IMMUNOFLUORESCENCE: TECHNIQUES FOR FLUORESCENCE MICROSCOPY AND FLOW CYTOMETRY

2.1 DETECTION OF SPECIFIC PROTEINS

When we talk about protein detection, we immediately refer to immunochemistry, a technique that allows the localized study of specific cellular proteins using the antigen-antibody reaction.

Suppose we need to study a certain protein, however, we do not know in which cell or cell location this protein is found. Through appropriate techniques, this protein is isolated and purified. By injecting this protein (antigen) into a rabbit, for example, it will form a gamma globulin (antibody) with the ability to combine exclusively with the protein of interest, to the exclusion of any other protein. The antibody (Ab) or immunoglobulin (Ig) is produced due to the immune reaction induced in the rabbit by the "foreign" protein that is of mouse origin, for example. Thus, it is possible to obtain from the rabbit's blood a specific Ab for that protein.

As will be seen in this book, there are several techniques for the characterization of stem cells. When we talk about immunochemistry, other derived terms come to mind such as immunocytochemistry (labeling for cultured cells), immunohistochemistry (isolated tissue), immunoblotting (detection of proteins in gel race), immunoprecipitation (recovery of proteins), among others. However, the most widely used in the study of stem cells is immunofluorescence, where cells and tissues are marked for analysis in fluorescence microscopy and flow cytometry. These two techniques are used because they indirectly identify very specific proteins that indicate the differentiation potential of stem cells. Therefore, it is necessary to have prior knowledge of immunochemistry, which identifies through the specific antibody-antigen binding the protein linked to the characteristic, function or state of a cell.

The term widely used for when we want to find a cellular protein using immunochemistry is labeling. For example, when we want to know if stem cells express Oct-4, a protein found in embryonic cells, it is said that it will be labeled for Oct-4 in a particular cell line. The immunochemistry technique is divided into immunocytochemistry, for cell marking, and immunohistochemistry, for tissue marking, both of which are widely used for observing markings in brightfield microscopy. The technique was developed after the discovery of fluorochromes, which are substances that emit fluorescent light at a certain wavelength when excited by a light source with a shorter wavelength. Fluorochromes make the technique more sensitive, due to the contrast of the light emitted by fluorochromes with the dark background. This innovation could be called immunofluorescence, used for the observation of cells in fluorescence microscopy and in quantification in flow cytometry.

Fluorochromes can be conjugated directly to primary Ab, when the labeling is direct, or conjugated to secondary Ab, as the indirect immunochemistry technique. Later, the protocols described will allow us to visualize the steps of cell protein labeling. Direct marking has the advantage of avoiding some washing steps essential for the application of secondary Ab; another advantage is the low cost, because it does not require secondary Ab (**Figure 1**). Indirect labeling is more versatile, as it allows the use of the primary with a set of available secondaries, of different fluorochrome colors, which can be applied to labels of several simultaneous proteins identified with different colors. Another difference is that indirect labeling produces more fluorescence and is more sensitive than direct labeling, since secondary Ab can bind in quantity to a single primary Ab, and primary Ab, in turn, binds to a single epitope of the antigen, especially when it is monoclonal (**Figure 2**).

In the specific chance of immunofluorescence, Ab is conjugated with a fluorescent compound (fluorochrome).

Figure 1

Direct immunocytochemistry, where a primary Ab (which has a covalently bonded fluorochrome that emits a specific color) binds specifically to an antigen. The fluorescent labeling will show the location of the protein of interest in the cell under study

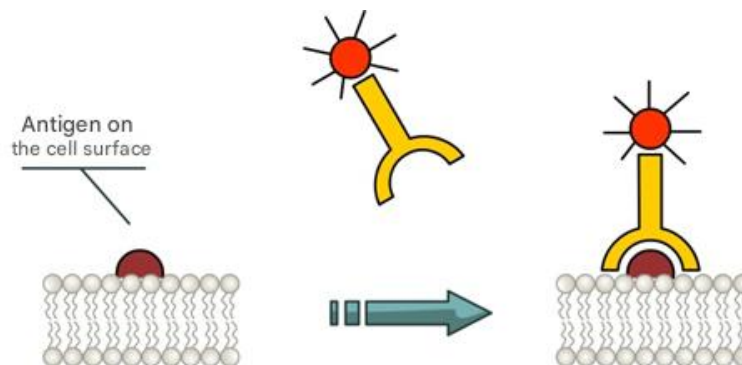
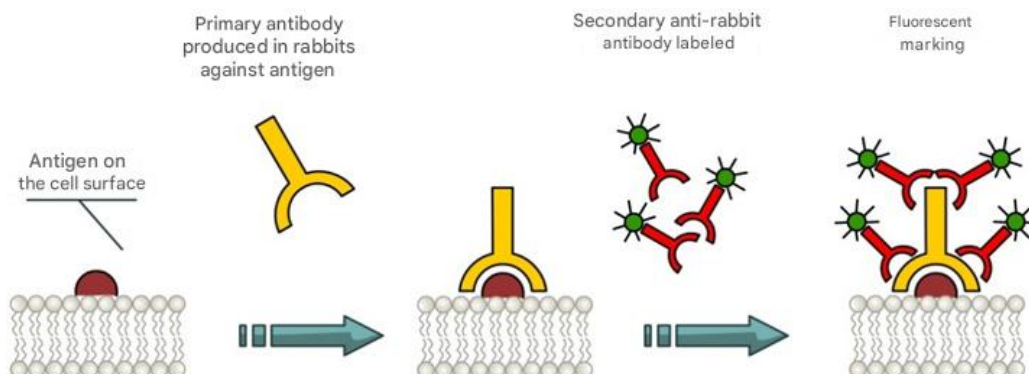


Figure 2

Indirect immunocytochemistry where a specific primary Ab binds to an antigen and, in a second moment, the secondary Ab (covalently bound to a fluorochrome), specific to the primary Ab, binds in quantity to the primary Ab molecule, increasing the final fluorescence



2.1.1 Principle of Immunocytochemistry

The principle of Immunocytochemistry is very simple, however care must be taken in selecting primary and secondary Abs, and pay close attention to the labeling procedures so as not to lose cells, obtain weak markings, or on the contrary, non-specific (**see protocol below**).

2.1.1.1 Primary antibody

The entire immunological technique for labeling cellular proteins begins with the objective of the molecule of interest. Usually this molecule is a protein and, in immunological aspects, it is our antigen. The labeling of cell structures or molecules is based on the specific affinity between antigen and Ab. These molecules of interest are associated with a cell structure, region, function, or cellular state. Taking the Oct-4 molecule as an example once again, it is a transcription factor that promotes the transcription of genes linked to cell renewal and the embryonic state of cell undifferentiation. Its marking indicates that the cell is undifferentiated at an embryonic stage.

Once the antigen of interest has been identified, the next step is the choice of the primary Ab. The choice of primary Ab will depend on how the immunocytochemistry process will be performed, whether a single labeling, double or multiple labeling, direct or indirect labeling, the specificity of the secondary (or the secondary is chosen by the characteristic of the primary), intracellular or extracellular labeling. These criteria are commented below and in the protocols at the end of the microscopy and flow cytometry chapters, since each immunocytochemistry technique is specific to each type of analysis to be performed.

Ab cells are produced by the B cells of animals immunized by the antigen of interest. There are monoclonal and polyclonal Abs. Monoclonals are generated by a single clone of B cells from a single animal (host) that results in a homogeneous set of Ab specific to a single epitope (region of the antigen recognized by an Ab; an antigen can have multiple epitopes). Monoclonal Abs have the advantage of low probability of cross-reaction, contributing less to nonspecific markings (in the general sense, when markings of molecules other than those of interest occur), and low background marking. Polyclonal Abs, on the other hand, are generated from different clones of B cells of an animal and recognize various epitopes of the antigen of interest; have the advantage of being more tolerant to the influences of fixation and labeling methods and processes that can hinder the interaction between Ab and antigen.

In addition to the types of Ab we have the animals where they are produced and the isotypes or classes generated. Among the animals used for the production of Ab we have mice, rats, hamsters, rabbits, goats, horses, monkeys, among others. Ab have two types of chains, two light and two heavy and both chains have constant and variable regions (antigen recognition). The isotypes or classes are associated with the structure of the constant regions of the heavy chain and are classified into IgA (*alpha*), IgB (*beta*), IgD (*delta*), IgE (*epsilon*), IgG (*gamma*) and IgM (*mu*). The Ab classes can be subdivided into subclasses, as occurs in

humans, where the IgA and IgG classes are subdivided into IgA1 and IgA2, and IgG1, IgG2, IgG3 and IgG4. Other animals have other subclasses. As many Ab are produced in mice, it has subclasses that we should know: IgG1, IgG2a, IgGb and IgG3. We still have the isotypes related to the light chain: *kappa* (κ) and *lambda* (λ) are present in all the isotypes of the heavy chains, but always alone, never together – for example, the heavy chain isotype IgM can have the light chain κ isotype, or the λ , but never both together. There are differences in the amino acid sequence between the κ and γ chains, but all κ chains of the different heavy chain isotypes (IgA, IgB, IgD, IgE, IgG and IgM) are the same, as are the λ chain.

2.1.1.2 Secondary antibody

Before we start choosing the most appropriate secondary Ab for a given marking, let's try to understand which formats of secondary Ab are marketed, their structure and use.

In contrast to primary Ab, most commercialized secondary Abs are polyclonal, purified directly from animal serum that has been immunized according to the type of a region of the primary Ab that we wish to bind, i.e., the fragment or class or subclass of a specific Ab of a specific species. In addition to the type of Ab, the purification method used will also influence the final characteristic of the secondary Ab.

As stated above, Abs have light and heavy chains and their constant and variable regions, so that, depending on the type of immunization done and the enzymatic treatment, we can isolate different formats of secondary Abs. Thus, when we talk about secondary Abs, some will be prepared to bind in all parts of a complete IgG (including both the light and heavy region, L+H), or only in the Fab or Fc region, or only in the γ region of the IgG. There are other Ab specific to the μ region of IgM, or to the light chain type such as κ or λ .

3 WHAT ARE THE ADVANTAGES AND DISADVANTAGES OF USING A SPECIFIC SECONDARY AB FOR A COMPLETE ANTIBODY FRAGMENT OR MOLECULE?

A complete IgG molecule (Anti-IgG (H+L)), having a Y shape, has two heavy chains (larger, approximately 50kDa each) and two light chains (smaller, approximately 25kDa each) and are joined together by disulfide bonds and hydrophobic interactions. This type of secondary Ab is produced by injecting an animal (goat, for example) with a complete primary Ab IgG from another species (mouse, for example). The secondary Ab produced is a polyclonal Ab that recognizes the heavy and light chain of the primary Ab. The downside is that light chain is common for all classes of Ab or immunoglobulin (Ig), which can lead to

cross-reactions. In labeling for cells in culture this problem is not as critical, but for tissue labeling, as there are many cell types, this problem becomes more common. When there is no concern with the type of Ig class (independent of the subclass) or to give a strong signal or when the type of Ig of the primary is not known, this secondary Ab format is very advantageous. Let's look at other types of Ab.

Heavy chain specific anti-Ig (α , γ , μ): taking an anti-IgG Ab as an example, its production is carried out by injecting a complete IgG into a host. Then, the Ab produced in this host go through an absorption process, where they are incubated with Ab IgG from other species attached to a column (i.e., there is no Ab in the column of the species of interest). The anti-IgG Abs that are not of interest have bound to the Abs of the column and the anti-IgG of the species of interest is recovered. This approach avoids cross-linking with other species and reduces the background due to its better specificity. This secondary Ab recognizes all fragments of an IgG: complete IgG and the fragments Fab, F(ab')₂ and Fc. As light chains are present in all Ab classes, there is absorption of anti-IgG that are specific to the K and L chains, which prevents cross-reactions by this type of bonding. So, in the same way as the anti-IgG Ab, other types of Ab specific to other classes can be obtained, such as IgA, IgG, IgM. Its use is interesting when it is intended to perform double labeling where one primary Ab IgG and another IgM can be used, using the secondary anti-IgG conjugated with a fluorochrome and the anti-IgM conjugated with another fluorochrome.

Fc-specific anti-IgG: This type of Ab is specific only to an IgG class like the heavy-chain-specific anti-Igs described earlier. The difference is its specificity only by the Fc portion of the IgG molecule. Its production is done by injecting only the Fc portion of IgG, without the light chains and without the upper portion of the heavy chains, removed by enzymatic digestion by pepsin. This type of Ab further diminishes background and unspecific undesirable bonds.

Fragment F(ab')₂: consists of a complete IgG without the Fc region, by digestion with pepsin. Fragment F(ab')₂ is the two arms of Ab's Y-structure. With a molecular weight of approximately 110 kDa (less than the full 150 kDa IgG molecule) it is very useful for having better penetration and facilitating antigen recognition. These fragments, because they do not have the Fc portion, have the advantage of not binding to the Fc receptors of the immune system's defense cells. The fragment F(ab')₂ is used to produce anti-F(ab')₂ that recognizes only the light chains and the upper portion of the heavy chain of a primary Ab, not recognizing the Fc portion.

Fab fragment: this fragment is produced by digestion with papain removing the Fc portion and the bond between the bivalent molecule $F(ab')_2$ generating two Fab fragments. With a molecular weight of approximately 50kDa, this fragment has greater penetrating power. This fragment is not recognized by Fc receptors. Its main use is to block nonspecific bonds with internal immunoglobulins in the sample, especially in double-labeling procedures.

3.1 CHOOSING THE MOST APPROPRIATE ANTIBODY

As previously stated, the choice of primary Ab depends on the molecule of interest to be labeled. Necessarily the primary Ab has to be reactive to the molecule of a given species. For example, a human cell that will be labeled for CD34, a surface molecule found in hematopoietic precursors, the primary Ab will have to be anti-human CD34 produced in an animal of a different species than the one that will be labeled, for example mouse. As Ab are mostly produced abroad, its commercial classification will be written in English, therefore, the primary Ab in question will be marketed as *Monoclonal Mouse IgG1 Anti-Human CD34*, that is, it is a primary, monoclonal Ab, produced in mice, it is of class IgG1, specific for the Cd34 molecule of humans. In addition to this classification, every commercialized Ab comes with manufacturer's specifications that will have to contain information on cross-reactivity with proteins from other species, whether it is a reabsorbed Ab and for which species it was reabsorbed. Another important piece of information is how Ab should be stored, as most are valid for six to twelve months, among other specifications.

The choice of primary Ab also depends on the specificity of the secondary Ab, as well as the choice of secondary depends on the type and class of the primary Ab. In the example above, since the primary is an IgG1 immunoglobulin produced in mice, the secondary has to be specific anti-IgG1 against mice. As we saw earlier, there are several formats marketed for primary and secondary Ab. In the present example, we can use a mouse IgG1-specific anti-Fab or anti- $F(ab')_2$ secondary that will bind to the Fab chain of this molecule. The same happens for the anti-Fc γ specific to the gamma heavy chain (which characterizes the IgG molecule) and anti-IgG resorbed to other classes of molecules of the same species of interest (and from other species that may have cross-reactions), all of them bind in the Fc portion of the IgG1 primary given as an example. Abs that are reabsorbed for a given species are advised when there is nonspecific labeling due to cross-reaction with molecules of the cells of the species to be labeled. In our example above, if there is cross-reactivity, the use of a resorbed Ab for human is indicated. However, this procedure is more used when it is known

that there are human immunoglobulins (which cause cross-reactions) and when the epitope is not very reduced in the sample to be labeled. It will often be necessary to mark proteins that are inside some intracellular organelle, some researchers resort to Fab or F(ab')₂ chains which are smaller and, therefore, easier to penetrate. Sometimes it is not known what the class of a primary Ab is, so one can turn to an anti-IgG secondary (H+L) that reacts with immunoglobulins of other classes, since they share the same light chain class κ and λ .

This is the simple procedure for choosing the specificity of Ab. On the other hand, the choice of structure will depend on whether it is necessary to be more specific, more permeable or if it needs to reduce the background, so you should consult above which configuration fits best, if specific for Fc, Fab or complete molecule. This type of concern must be taken into account, for example, when we make multiple appointments.

The dilution of the use of both the primary and secondary is suggested by the manufacturer, however, it will always be necessary to standardize the marking, titrating an optimal concentration that minimizes nonspecific markings and maximizes specific ones. Many factors influence the standardization of Ab concentration, such as fixation, permeabilization, incubation time, temperature, whether the protein is abundant or scarce, whether internal or membrane, the cell type and the technique to be used as immunocytochemistry or immunohistochemistry, and the analysis used as microscopy or cytometry, among other techniques.

Table 1

Various types of primary Abs and their abbreviations

<i>Hu = human</i>	<i>Rb = rabbit</i>	<i>Chaos Knight = chicken</i>
<i>Ms = mouse</i>	<i>Shp = sheep</i>	<i>Bov = bovine</i>
<i>Gt = goat</i>	<i>Hrs = horse</i>	<i>Sw = Swine</i>
<i>GP = guinea pig</i>	<i>Sy Hms = Syrian Hamster</i>	

4 ANTIBODY-CONJUGATED MOLECULES

Fluorochrome is used in fluorescence microscopy for visualization of individual structures and molecules and in cytometry for cell classification, both by the immunofluorescence technique. Fluorochrome is a molecule that has the property of absorbing light energy at a certain wavelength (excitation) and emits fluorescent light at a wavelength longer than excitation. This occurs due to the loss of energy between absorption

and emission (**Figure 3**). The physicochemical characteristics of fluorochrome are what define which wavelength of light it is excited and which wavelength of light it emits.

Figure 3

In the process called fluorescence, when a beam of light, of a certain wavelength, for example, in the blue range, falls on a fluorochrome, it absorbs photons, and the electrons of the molecule that were in a current state gain energy and are raised to a higher energy layer (1). Due to energy losses by a process called vibrational relaxation, which generates heat for the environment, the excited electrons fall into a less energetic electron shell (2). As this electronic state is unstable, the electrons return to their original position releasing energy in the form of emitted light (3). In this case, the emitted light has a shorter wavelength (green, for example) than the excitation light due to the loss of energy to the environment

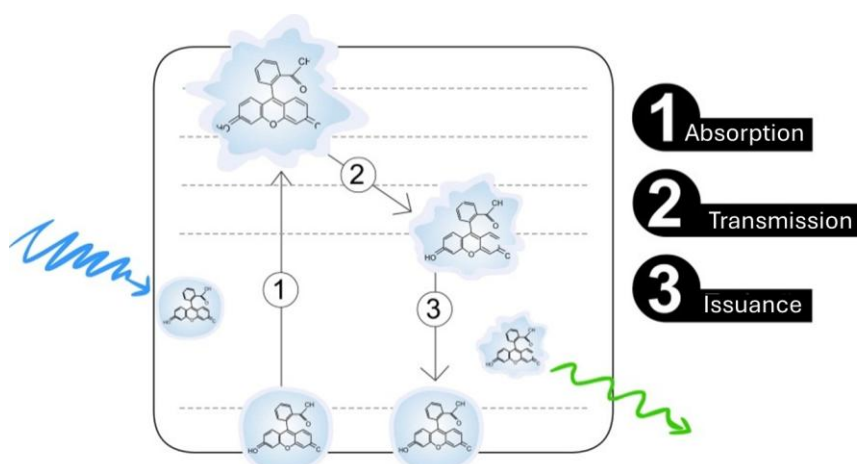
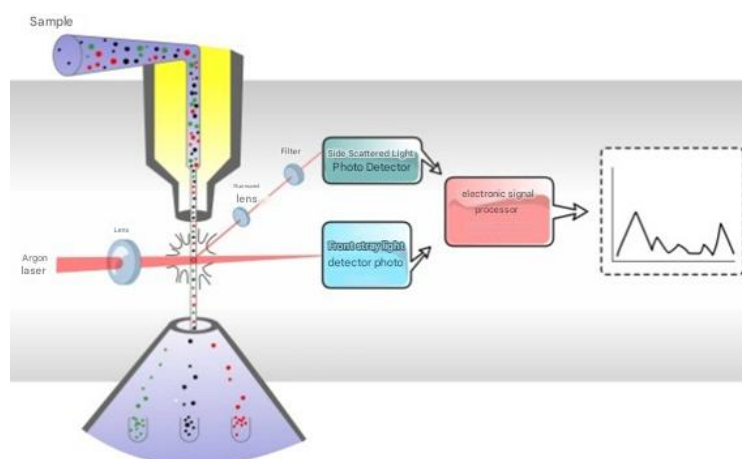


Table 2

Description of the characteristics of the most commonly used fluorochromes



In addition to fluorescence microscopy working with the property of antibody-antigen specificity, there are molecules that have affinity for certain cellular structures, such as DAPI and Propidium Iodide (PI), which are DNA intercalators and are routinely used to mark nuclei and perform cell viability tests, as is the case with PI.

It is also possible to visualize fluorescence in live cells. GFP, a green fluorescent protein found in jellyfish, can be used, along with the recombinant DNA technique. The gene for this protein can be introduced into cells in culture. The cells will produce the GFP protein and emit a green fluorescence when excited.

Stem cells transfected with the GFP gene can be injected into animals intravenously or intraperitoneally (for example) and, subsequently, the location of these cells in different organs and tissues of the body is verified, showing the capacity to graft a certain type of stem cell.

Another example of the usefulness of fluorescence microscopy is the detection of pH or Ca^{2+} concentration in the cell interior. *Acridine Orange* (AO) in an acidic environment, such as that of lysosomes, has an emission wavelength in the red range, while in a more neutral environment, such as the cytosol, it emits in an emission wavelength in the green range. AO is used to assess lysosomal loss. The fura-2 molecule also changes the emission wavelength when bound with Ca^{2+} , used to check the intracellular concentration of Ca^{2+} .

5 FIXATION AND PERMEABILIZATION

Before moving on to immunofluorescence protocols, it is necessary to understand a little about fixation and permeabilization methods. The first step for cell labeling, after culture, is to fix the cells to prevent degradation and preserve the quality of the cellular components by immobilizing the antigens while retaining cellular and subcellular structures through cross-linking of methylene bonds and Schiff bases between the bases of the amino acid residues of proteins. The main factors that influence the quality of the marking are the time, until the fixation occurs, the concentration of the fixative and the temperature at which the process occurs. A very long fixation time can mask the epitopes of the molecule of interest and prevent Ab binding; Each fastener has its ideal minimum and maximum time.

In the fixation process, what is mandatory is to fix the cells as soon as possible, to avoid degradation. Throughout the fixation process, the cells die, but the structures are preserved. In fluorescence microscopy, there are analyses with live cells (or non-fixed cells) where, during the process, the cells are kept in a small chamber that keeps them at a

concentration of 5% CO₂, in a sterile environment, on a heating stage that maintains the temperature at 37°C. But here, we will only address the methods that use fixed cells, which are important for cell characterization.

Good fasteners have to have some desirable characteristics: good penetration capacity, enabling the fixation of the material completely; the coagulation of proteins has to be total and non-violent, but promote immediate cell death; it must not alter cell morphology and structures, maintain soluble elements in cells and tissues; and preventing the appearance of artificial structures (artifacts that can generate false analyses).

The choice of fixator will depend on the structure to be studied. There is no ideal fastener and often mixtures of different fasteners are used where the characteristic of each one will meet the needs of each type of structure to be observed. In the study of some nuclear structures such as chromatin, nucleolus and spindle filaments (during cell division), acid fixatives are used; and for the study of nucleoplasm, mitochondria and vacuoles, basic fixatives are used.

The best known and most used fixative is formaldehyde. In immunohistochemistry it is commonly used at a concentration of 10% (for histological specimens) and in cytochemistry at a concentration of 1 to 4% (for cells adhered in a monolayer on coverslips, petri dishes, or culture bottles); In flow cytometry, it is used at a concentration of 1 to 2% (for cells in suspension). Formaldehyde is marketed in a 37% solution, however, we consider it as 100% and from there the dilution is made, so a 10% solution prepared for fixation will actually have a concentration of 3.7% formaldehyde. Fixation occurs by the covalent cross-linking between tissue proteins (primarily by the amino acid lysine), conferring rigidity to the cytoskeleton. It is an excellent fixative, as it preserves the morphology of the cells, especially the cytoplasmic environment, and the cells can be stored for a long period, a few months, at 4°C (it is recommended to change the fixative weekly, never letting it dry and keeping the cells always immersed). Paraformaldehyde, which is also widely used for the preparation of fixing solutions, is a polymerized form of formaldehyde that is depolymerized after heating.

As many factors influence fixation, different fixatives can be tested to optimize antigen preservation, distribution, and morphology of other cellular constituents. For example, some epitopes are lost on aldehyde fixation but conserved on alcohol fixation, and vice versa. Fixatives and alternative methods should be employed to improve the quality of the fixed sample, such as the use of methanol at -20°C (for 5 minutes) or formaldehyde fixation followed by a brief (1 minute) exposure to methanol at 0°C. Fixation with methanol is most

effective for localizing elements of the cytoskeleton. Alcohols work by extracting lipids and precipitating remaining protein, while aldehydes react by promoting cross-links that better preserve membranous structures.

In practice, we often realize that the material, even if properly fixed, the epitope is not accessible to Ab. In this case, the material undergoes a permeabilization process that permeabilizes the cell membrane, allowing Ab to penetrate the cell, reaching its interior and the interior of cytoplasmic organelles. Permeabilization reagents are basically detergents that make the membrane porous and denature the fixed protein, exposing the epitope. Among the permeabilizers are saponins, Triton X-100 from 0.2 to 0.5% or SDS that are always used after the fixation process. Alcohols such as methanol and ethanol are widely used as permeabilizers, while they are used as fixatives, having a double role. Often a short treatment with these reagents prior to Ab incubation is sufficient to expose the epitope. Special attention should be directed towards ensuring that access to the epitope is the same if the protein has undergone a displacement: for example, the protein that moves between the cytoplasm and the nucleus is not always equally accessible to the Ab.

Fixation using organic solvents such as alcohols removes lipids (a property that allows you to skip the permeabilization step) and dehydrates the cells; precipitation and denaturation also occur, in which the solubility of protein molecules is reduced and the hydrophobic interactions that give many proteins their tertiary structure are disrupted. The most common precipitation fixative is ethanol and methanol, mainly for the preservation of frozen materials and smears. Acetone is also widely used. Protein denaturants, methanol, ethanol and acetone, are rarely used alone for cell and tissue fixation, except when studying only nucleic acids. Acetic acid is a denaturant that is sometimes used in combination with the other precipitation fixers. Alcohol, by itself, is known to cause considerable shrinkage and hardening of tissues during fixation, while acetic acid is the only one associated with tissue swelling, combining the two can result in better preservation of tissue morphology.

Immunofluorescence used in conjunction with microscopy is and remains the best way to locate and determine the distribution of proteins within cells. The preparation of the cells for labeling with the primary Ab follows two important steps: 1) fixation with formaldehyde or paraformaldehyde, which aims to stabilize soluble and insoluble proteins in their native locations, followed by washing with detergents for permeabilization, but which can remove some soluble proteins that have not been well fixed; and 2) permeabilization and fixation with

organic solvents such as ethanol and methanol, which allows the precipitation of soluble and insoluble proteins in their original locations.

Fixation with formaldehyde or paraformaldehyde prior to permeabilization should preserve protein distribution, however, soluble proteins may undergo cell redistribution during the process of this technique. Many proteins that have a uniform cytoplasmic distribution have a coarse, punctual distribution and in some cases reticular appearance. It is common to observe a redistribution where proteins have a punctual and concentrated form around the nucleus, and often inside the nucleus. The cell type influences a lot, where in some cases the redistribution of proteins does not occur and in other cases it occurs.

The use of alcohols to fix and permeabilize tends to precipitate structural and soluble proteins, avoiding loss. However, this method also leads to redistribution of proteins, presenting a characteristic of reticular and fibrous texture, and redistribution into or around the nucleus, as well as to the nucleolus. A decrease in fluorescence is also observed when compared with labeled proteins in living cells.

The study of the genetic arrangement in the cell nucleus requires preservation of native nuclear structure and visualization of genetic regions using chemically modified DNA probes for FISH. The use of confocal microscopy provides the most accurate information about the nuclear structure. However, the penetration of DNA probes into cell nuclei and the preservation of native infrastructure is sometimes limited by the bulky cytoplasm and plasma membrane. These difficulties can be avoided if the relative position of the regions of interest of the chromosomes is not changed in nuclei prepared by the usual method in cytology, which consists of fixation by methanol and acetic acid. This attachment damages the plasma membrane and eliminates the cytoplasm, allowing easier penetration of DNA probes into the nucleus. However, at the same time, it induces dehydration of the nucleus, which can result in the breakdown of the chromosomal structure.

On the other hand, the fixation of nuclei with methanol and acetic acid causes substantial increase in the nuclear diameter. This probably occurs by widening the contact between the core and the blade, widening and flattening the core. Chromosomes from the regions that are closest to the nuclear membrane will be displaced, away from the nuclear center in these nuclei. On the other hand, the regions that are closest to the nuclear center are not much influenced by this flattening.

In flow cytometry, unfortunately, there is still no consensus regarding an optimal cell fixation for the multiparameters to be analyzed. Some strategies are employed to improve

the quality of a sample marking. The use of paraformaldehyde prior to fixation with alcohols follows the premise that the cross-links formed prevent the exit of proteins from the cell after permeabilization with methanol. The same was observed with the use of ethanol. It was observed that the use of methanol as a permeabilizer in place of Triton X-100 helped both in membrane permeabilization and in morphological preservation by measuring the light *scatter* parameter in a cytometer. This is very important since in cytometry it is interesting to select cell populations by morphology, as when we study circulating blood cells.

Both the paraformaldehyde concentration and the fixation temperature affect the immunofluorescence of intracellular proteins, the properties of light scattering cell, and cell DNA fluorescence in measurements using propidium iodide. As observed, the increase in intracellular protein immunofluorescence occurs at high concentrations of paraformaldehyde (2%), at a fixation temperature of 37°C. However, these are recommendations for single-parameter analysis for the measurement of intracellular proteins using immunofluorescent Abs. In multiparameter studies, such as light scattering and DNA content analyses, concentrations of 0.25% paraformaldehyde and fixation temperatures below 37°C are recommended, which improves the quality of the labeling in relation to the appearance of false aneuploidy, probably caused by a differential chromatin condensation and different degrees of nuclear protein cross-linking and/or DNA denaturation induced by paraformaldehyde. To better situate the difficulty of labeling DNA content, aneuploidy is the alteration in the amount of DNA that can be caused by the increase of chromosomes in transformed cells, as occurs in tumor cells. Changing the amount of genetic material also changes the intensity of the immunofluorescence of the marker used to mark DNA. If the interest is to study only the cell content, it is recommended to fix it using only ethanol, which avoids the appearance of false aneuploidies.

Formaldehyde is more used when we want to visualize cytoplasmic structures and preserve cell morphology, while alcohols are more requested in sample preparation when the compartment of interest is the nuclear content. However, one should always test both techniques or both together to define which method best represents the nature of the living cell. One must always take into account the molecule to be observed, its location and the cell type studied; and to use common sense due to the empiricism of fixation techniques.

5.1 SOME EXAMPLES OF FIXATION AND PERMEABILIZATION

Acetone

Fix cells in acetone at -20°C for 5-10 minutes. No permeabilization steps required after fixing acetone.

Methanol

Fix cells in methanol at -20°C for 5-10 minutes. No permeabilization step required to fix methanol next.

Ethanol

Fix cells in 95% ice-cold ethanol and 5% glacial acetic acid for 5-10 minutes

Methanol and acetone.

Methanol and acetone 1:1. Make the mixture at the time of use and fix the cells at -20°C for 5-10 minutes.

Methanol and ethanol

Methanol and ethanol 1:1. Make the mixture at the time of use and fix the cells at -20°C for 5-10 minutes.

Paraformaldehyde and Triton permeabilization

Fix at 2-4% paraformaldehyde for 10-20 minutes. Wash 2X with PBS for 5 min. Permeabilize with 0.5% Triton X-100 for 10 minutes. Paraformaldehyde and Methanol

Fix at 4% paraformaldehyde for 10-20 minutes. Wash 2X with PBS for 5 min. Permeabilize with methanol at -20 °C for 5-10 minutes.

6 FLUORESCENCE MICROSCOPY

Fluorescence microscopy is a great technique for localizing cellular components, either in living cells or in fixed cells. This technique relies on labeling with a fluorescent compound (fluorochrome) following immunohistochemical or immunocytochemical procedures for fluorescence analysis, as mentioned earlier. A fluorescent compound absorbs light at a certain wavelength (excitation) and emits fluorescent light at a longer, more specific wavelength. Fluorescence microscopes have a set of filters that allow only light to pass through with the desired wavelength.

Fluorescence optical microscopes are typically configured for both the bright light field (transmitted light) and fluorescence microscopy. Both methods use the same principle of optical treatment: the transmitted light is produced by a tungsten lamp, focused on the sample by the capacitor, following the trajectory to the observer; The light for fluorescence is produced by a mercury lamp that is impeded, transmitted, or reflected by a set of filters and

mirrors. The focus of the sample always begins with brightfield microscopy, in which clear light (white) allows the visualization of the structure of the cells that have or are not marked by immunological techniques or staining. After the sample is focused, the microscope configuration can be changed for fluorescence analysis.

As seen earlier, the researcher chooses the molecule, protein, enzyme or structure to be observed and the mark with a specific Ab, which is associated with a fluorochrome and which corresponds to a color to be visualized. The technique for fluorescence microscopy allows the visualization of more than one cell marking, it is up to the researcher to make the best combination of markers that emit colors at wavelengths that can be separated by the filters available in the microscope where the observation will be made.

The most commonly used light source in fluorescence microscopes is the mercury lamp or xenon lamp, which emit light at wavelengths (e.g., 365, 400, 440, 546 and 580 nm) that cover most of the absorption characteristics of the most commonly used fluorochromes. The light emitted by the light source passes through an excitation filter that has the ability to let a certain wavelength pass through (bound to the chosen fluorochrome and which specifically absorbs this wavelength). Then the beam of light is reflected by a filter or dichroic mirror towards the sample. The light emitted by the sample (with a length longer than the emission light, due to the loss of energy to the environment) will be isolated by the emission filter to the observer or captured by a camera. Following an example, fluorescein (FITC) and rhodamine are widely used fluorochromes, and as a result fluorescein returns to the observer the color green and red respectively, so we can distinguish two markings in the same sample.

Fluorescein has maximum absorption at a wavelength of 490 nm and emits most efficiently at a length of 525 nm; rhodamine absorbs at 550 nm and emits at 580 nm. A double tagging with these two fluorochromes requires that a set of filters be combined for each tag. In the case of fluorescein, the excitation filter (BP 490/30 nm) prepares the beam of light emitted by the lamp with a wavelength of 490 nm, which is the absorption range of this fluorochrome; a dichroic mirror (MD 510 nm) will reflect the emitted light towards the sample; due to the energy decay the sample will emit light at the longer wavelength of 525 nm, a low-pass emission filter (LP 520 nm) will ensure it will eliminate other light components that are not desired; The same dichroic mirror that reflected the light emitted from 490 nm to the sample will now let through the light with a wavelength of 525 nm that will be viewed by the observer or captured by a camera attached to the microscope. The same will occur for

rhodamine, which will have a set of filters suitable for its range of light absorption and emission.

The disadvantage is that we have the limitation of the image not being seen with both markers simultaneously, as it is only possible to use one filter configuration at a time – the overlapping of both colors (or more, in other cases) is only possible after the acquisition of images of the same field for each fluorochrome, which is done by an image manipulation program.

The objective in fluorescence microscopy has the function of condensing, augmenting and collecting the fluorescence emitted by the fluorochrome of a sample. These and other points, such as the numerical aperture, the wavelength it can transmit, and the immersion medium used, must be taken into account before observing a sample. All of these features work together to determine a good image of the observed sample. The numerical aperture (NA) is the characteristic of the objective collecting light: the higher its value, the greater the amount of light collected by the lens; and it is associated with the proximity of the objective to the sample.

As the light is refracted by the medium between the sample and the objective, depending on the distance, when very close to each other (which occurs in the use of high-magnification objectives, with 100X) it is necessary to use immersion oil to correct the refraction of the emitted light and, consequently, improve the efficiency with which the light is collected by the objective, increasing the NA and the amount of light collected. Resolution, which by definition is the shortest distance between two objects that can still be distinguished as two separate objects, is linked to NA and wavelength: the larger the NA and the shorter the wavelength, the smaller the distinguishable distance between two objects, the higher the resolution.

Enlargement or enlargement is the ability to make the image larger than it is. Usually, the maximum magnification is 1000X (100X the magnification of the objective times 10X the magnification of the eyepiece). The magnification and the NA are related, because the more the image is amplified, the more it loses brightness, however, this can be compensated for the higher the NA

7 CONFOCAL MICROSCOPY

The confocal microscope is a more sophisticated fluorescence microscope, it has the same optical principle as the fluorescence microscope, however, the main difference is the

use of laser as a light source. The confocal microscope turns out to be more sensitive due to the laser that produces a more directed beam of light and waves at the length of light dedicated to the excitation of certain fluorochemicals, increasing its efficiency. Thus, we have lasers in the range of: Ultraviolet (excites in the ultraviolet range 405 nm), Argon (excites the range of violet and blue – 488 nm), Helium-Neon (excites in the green range – 543 nm), for example. The use of laser for excitation gives greater focusing power to the microscope, which makes it possible to explore the cell in depth. With the help of software and the electromechanical system of the confocal microscope, it is possible to perform "cuts" of images in different layers of the cell or tissue.

8 PROTOCOL FOR IMMUNOFLUORESCENCE UNDER MICROSCOPY.

8.1 MATERIALS

- Cells growing in culture with approximately 70 to 80% confluency.
- 2 to 4% formaldehyde (the more concentrated the better the fixation, however, it increases background autofluorescence).
- Buffer Solution: PBS (*Phosphate Buffer Saline*), pH7.4.
- Blocking solution: PBS/BSA, pH7.4 with 5% bovine albumin (BSA).
- 0.1% Triton 100X in buffer solution.
- Culture medium appropriate to the cell of interest.
- Trypsin
- Primary ab .
- Secondary Ab (specific to the type of Ig of the species from which the primary Ab was obtained) bound to a fluorochrome.
- Mounting medium.
- 35mm Petri dishes.
- Blade and coverslip.
- Becker (two)
- Distilled water
- Tissue
- Tongs.
- Enamel

8.2 PROCEDURE (DIRECT AND INDIRECT DIALING)

The difference between **direct** and indirect **dialing** is described in step 11 of this procedure. All equipment, material and reagent that will come into contact with living cells must be previously sterilized.

1. Disaggregate the cells in culture using trypsin.
2. On 35 mm plates, place the coverslips (previously treated with poly-L-lysine).
3. Seed the cells on the coverslip and complete with cell type-specific culture medium up to 2 mL. Leave adhering for 24 hours.

The cells adhere within 4 hours, but leaving it overnight ensures a morphology more suitable for appreciation after fixation. The confluency of 70 to 80% helps with morphology in most cell cultures.

4. Vacuum medium and wash 2 X with PBS.

Washes include gentle cell resuspension and spin for 5 min at 300g (approximately 1000 rpm). It is interesting to calculate the speed in rpm of each centrifuge.

5. After washing, add 1 mL of 2% formaldehyde to each well. Leave the cells to fix for 15 min at room temperature (TA). Fixation can also be done by solvents such as acetone absolute and 90% methanol or 70% ethanol at -20°C for at least 5 min.

In the case of using acetone or alcohols, there is no need for permeabilization since these solvents fix and permeabilize at the same time. That way, go directly to item 8.

If you use formaldehyde and want to stop the procedure here, the fixation can last up to a month at 4°C as long as you change the fixative every week.

Formaldehyde is interesting for membrane and protein labeling of cytoplasmic compartments, in addition to preserving cell morphology well. When you want to mark chromatin, the ideal fixatives are alcohols.

6. Vacuum the fixative and wash 2 X with PBS, for 5 min, each wash.
7. Permeabilization can be done with detergent using 0.1% of Triton X-100 for 10 min. Solvents such as absolute acetone or 90% methanol or 70% ethanol can be used at -20°C for 5 min, if the fixation has been done with formaldehyde.

If you want to label proteins within membrane-enveloped compartments such as vesicles, endoplasmic reticulum, or Golgi, you can increase the permeabilization time to up to 20 min. In this case, it is necessary to standardize to find the ideal time. When you want to mark chromatin, the ideal fixatives are alcohols.

8. Vacuum the fixative and wash 2 X with PBS, for 5 min, each wash.

9. After washing, add 1 mL BW/BSA and leave to block for 10 to 30 min at RT.

Blocking is done to reduce non-specific bonds with the primary Ab, avoiding non-specific markings. During the blockage do not let the cells dry out, add more blocker if necessary.

10. While the cells are blocked, dilute the primary Ab (at the dilution recommended by the manufacturer or at the concentration found after titration of the Ab in the labeling standardization process) in 25 μ L of 5% PBS/BSA.

11. Aspirate the blocker and add the 25 μ L of diluted Ab over the coverslip area (use a 200 μ L tip, letting a drop form at the tip and touching the drop on the surface of the coverslip, with contact the drop spreads). Cut out a piece of the parafilm the size of the coverslip and place it lightly over the coverslip – this will prevent the solution from evaporating. Incubate the cells for 1h to TA, protected from light. The control group should take only PBS/BSA and accompany the experiment group throughout the process.

If the primary Ab is already conjugated with a fluorochrome the procedure performed is called **direct labeling**, so go straight to step 14. If there is a need to use a secondary Ab conjugated with a fluorochrome, the procedure performed is called **indirect labeling**, so follow the next item.

In some cases, a long incubation period will be necessary, even for convenience. In these cases, to avoid evaporation and maintain a humid environment, a container with buffer solution should be used, closed, and left at 4°C, where incubation can extend for one night.

12. With the aid of tweezers, carefully remove the parafilm, aspirate the solution with the primary Ab and wash 3 X with PBS or TBS for 5 min.

TBS can be used in place of PBS, it has Tween 20 which is a detergent that facilitates the permeabilization and washing of cells.

13. Dilute the secondary Ab in 25 μ L of PBS or TBS according to the manufacturer's recommended dilution or at the concentration found after Ab titration in the labeling standardization process.

14. After washing, repeat in the same way as step 11, apply 25 μ L of Ab dilution and place a piece of parafilm on the coverslip and incubate for 1 h at TA, protected from light.

15. Wash the coverslips as in step 12, finishing with the addition of 1 mL PBS.

16. Setting a 20 or 200 μL pipette to approximately 15 μL is enough to mount the blade with the mounting medium. Add the mounting medium on a clean blade so that the drop formed on the ferrule is just deposited on the blade and leave it on the bench.

17. With the help of tweezers, hold the coverslip and immerse it in distilled water (use two Beckers to make two washes). This step should be done very gently so that the breakdown of the coverslip and the loss of cells does not occur.

The removal of the coverslip from the bottom of the well, with the help of the forceps, is easier if the well has PBS. The fact that the coverslip is submerged in the PBS prevents the cells from drying out.

18. Vertically, touch the ends of the coverslip on an absorbent paper so that all the water is absorbed.

19. Carefully touching one end of the coverslip over and next to the edge of the droplet of the mounting medium, the medium will contact the entire end of the coverslip. Lay the coverslip, with the side where the adhered cells are, towards the slide. Notice that the middle fills the space under the coverslip so that it does not form bubbles and spreads the excesses.

20. Carefully place an absorbent paper on the blade to remove excess from the mounting medium.

This procedure prevents the mounting medium from preventing the application and drying of the enamel.

21. Apply the enamel around the coverslip in order to seal the cells that are between the coverslip and the blade. The slides can be stored for a few months at 4°C , but no more than a year.

This procedure prevents oxidation and drying of the cells. Commercial mounting media allow for better conservation of fluorescence intensity (check with manufacturer). If using a medium formed with glycerol and water, it is suggested that the cells should be analyzed within one to two weeks.

22. Take the slides for analysis under a fluorescence microscope.

Tip: Prolonged exposure of the labeled cells under the microscope's fluorescence excitation light depletes fluorochrome's ability to produce fluorescence.

Often at the end of the protocol the marking is nonspecific or very weak, one of the causes is the concentration too high or below the ideal. In this case, the concentration of primary and secondary Abs should be standardized through several dilutions until the ideal

one is found. Other causes for a weak marking may be insufficient permeabilization that did not allow Ab to enter intracellular compartments – in many cases smaller fragments of Ab are used to facilitate reaching the antigen; for nonspecific labeling perhaps the error is in the blocking step, the fixative may also cause increased autofluorescence, or perhaps the use of Ab more specific can solve the problem. Molecule redistribution can often occur, that is, soluble molecules are displaced from their natural regions to other different regions, in which case different types of fixatives or the use of double fixation should be tried.

8.3 REAGENTS & SOLUTIONS

Coverslips treated with Poly-L-lysine

Apply 25 μ L of 1 mg/mL of poly-L-lysine on each coverslip, leave on at RT for 10 min. Gently wash the coverslips 3 X with water and let them dry.

PBS (Phosphate-buffered saline)

0.144g H_2PO_4

8.0 g NaCl

0.2 g KCl 1.44 g Na_2HPO_4

Dissolve everything in 800 mL of H_2O

Adjust pH to 7.4 with HCl

Complete with H_2O for 1 L

Store at room temperature.

Formaldehyde, 2%

As commercial formaldehyde comes in a 37% solution, its dilution is done considering this solution as 100%. Thus, dilute 2 mL of the commercial formaldehyde solution in 98 mL of PBS, pH 7.4. If you wish to use paraformaldehyde, dissolve 4 g of paraformaldehyde powder in 10 mL of distilled water and heat to 60°C. Dilute in a 1:1 ratio with 2x concentrated PBS, pH 7.4.

Always prepare before use, it is not interesting to stockpile.

Methanol 90%

Just dilute in the proportion of 90% methanol and 10% distilled water.

Always prepare before use, it is not interesting to stockpile.

Ethanol 70%

Only dilute in the proportion of 70% ethanol and 30% distilled water.

Always prepare before use, it is not interesting to stockpile.

TBST (Tris-buffered saline with Tween-20)

Initially prepare Tris· Cl, 1 M

Dissolve 121 g Tris Base in 800 ml H₂O

Adjust pH 7.5 with concentrated HCl

Adjust the volume to 1 L with H₂O

Filter if necessary

Store up to 6 months at 4°C or TA

100 mM Tris-Cl, pH 7.5

0.9% NaCl

0.1% Tween-20

Store for up to 2 months at 4°C

BSA 5% (Bovine serum albumin)

5g BSA

100mL PBS

Prepare on the spot, do not stock up.

Triton X-100, 0.1%

99.9 mL PBS

0.1 mL Triton X-100

Store for up to 6 months at TA and protected from light.

Mounting Medium

Prepare the ratio of 50% glycerol to 50% PBS. Since glycerol is very viscous, check if the pipette has pulled in all the desired amount of glycerol and homogenize several times so that all the glycerol comes out of the pipette and is diluted in the PBS. Store at 4°C.

9 FLOW CYTOMETRY

Flow cytometry is a technique used to count, examine, and classify microscopic particles suspended in a flowing liquid medium. Flow cytometry has the following concepts: cytometry (cells), metry (measure), and flow (movement). Its principle is primarily based on a fluid system that allows cellular individualization, an optical system capable of detecting the light scattered as it passes through a cell and the wavelength emitted by a fluorochrome, and an electronic system for (physical-virtual) conversion, processing, organization and manipulation of data.

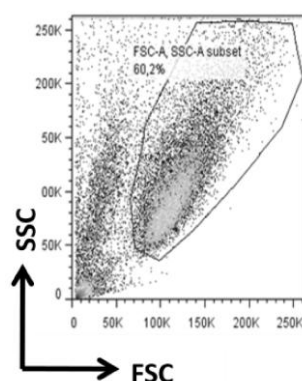
The flow cytometer device has optical-electronic detection as its principle, identifying different cells by detecting the light they scatter and the fluorescence they emit (if they are labeled with fluorochromes) when they pass through a laser beam (**Figure 4**). It allows the measurement of several parameters simultaneously, making it possible to analyze the physical and chemical characteristics of a single cell. This device is similar to a fluorescence microscope, however, instead of producing an image of the cell, it offers quantitative and qualitative data of a large number of cells in a short period of time, being possible to detect up to 10000 cells per second.

The cytometer basically has:

- A hydrodynamic flow system: which individualizes and directs cells to the point of incidence of the laser.
- A light radiation source: usually these are either a mercury lamp (different wavelengths) or Argon (488nm), Helium-Neon (HeNe, 543 nm) and Ultraviolet (UV, 405 nm) lasers.
- Filter system: intended for filtering the color spectrums emitted by fluorochrome (ultraviolet, blue, green and red, basically).
- Detectors (photodiodes or photomultipliers) for detection of scattered or emitted light.
- A unit for data processing and signal analysis, transforming the electrical signals emitted by the detectors into graphs that can be interpreted (machine-user interphase).

Figure 4

Principle of flow cytometry



9.1 WORKING PRINCIPLE AND ANALYSIS

The cells, through a fluid system, are directed to a point (question mark) where they are intercepted by a beam of light, of a certain wavelength. Optical detectors, which

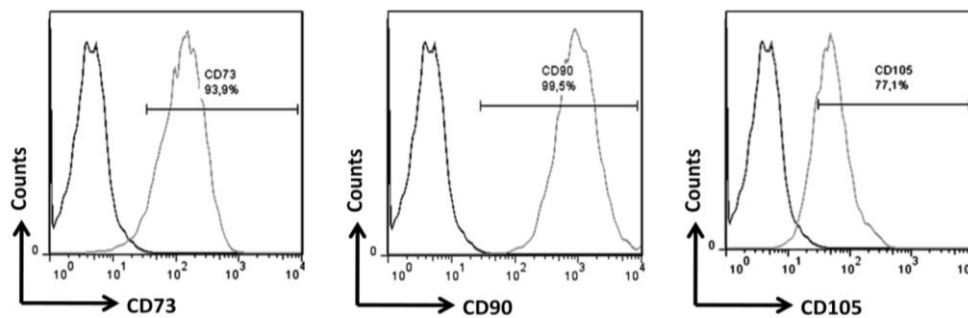
correspond to certain parameters, are pointed at the point of intersection. In flow cytometry, a parameter is understood as characteristics such as volume, cell complexity, and wavelength emitted by a fluorochrome. There are three types of detectors, one positioned in the line of the light beam (*Forward Scatter* or FSC) that detects the scattered light frontally; one positioned perpendicular to the direction of the light beam, responsible for detecting the light scattered laterally (*Slide Scatter* or SSC); and other types of detectors, each responsible for detecting a certain wavelength emitted by a fluorescent substance, and also positioned perpendicular to the light beam (**Figure 4**).

The cells of interest prepared for flow cytometry analysis should be suspended in a 5 mL round-bottomed polystyrene tube, suitable for flow cytometry. A system, which uses positive pressure, collects the cells from the tube and takes them to the flow chamber. The cells, upon entering the chamber, suffer an effect called hydrodynamic focus. The chamber fluid (*sheath fluid*) has a higher velocity in relation to the sample fluid, the difference in the velocity of the two fluids and the narrowing of the chamber allows the flow to behave in a laminar way, which leads to acceleration and concentration of cells in the center of the flow as the sample fluid gains speed and becomes narrower. As the cells are accelerated, they move away from each other, allowing them to pass through the question mark, where they are hit by a beam of light (**Figure 4**).

The cells are focused by the beam of light in the question mark. The beam of light when it hits the cell undergoes frontal and lateral dispersion. There is a detector for frontally scattered light that is in the line of the light beam; and a detector for sideways scattered light that is perpendicular to the light fixture; these detectors are represented by the FSC and SSC parameters, respectively. Thus, the FSC detector will provide characteristics on cell size and volume while the SSC detector will provide characteristics on intracellular complexity related to the amount of membranes such as nucleus, vesicles, Golgi complex, cytoplasmic reticulum, membrane roughness and cytoplasmic granules. Thus, we can obtain information in the form of graphs, on the computer screen, such as populations of cells classified in relation to their physical characteristics. For example, we can distinguish the different types of leukocytes by analyzing the population of cells found from the peripheral blood collected, or any other type of cells of interest, such as stem cells, always according to their size and the complexity of the membranes that constitute the cell body (**Figure 5**).

Figure 5

The combination of SSC (y-axis) and FSC (x-axis) allows a very good distinction between cell population and leukocyte residues or cellular remains. The stem cells shown have cell size and volume (FSC) and membrane complexity (SSC), such as organelles and nucleus. These cells are easy to notice, being shifted to the right. To the left, there are points that represent cell debris: small parts or remnants of membrane, small or large, but of low volume, therefore displaced closer to the y-axis



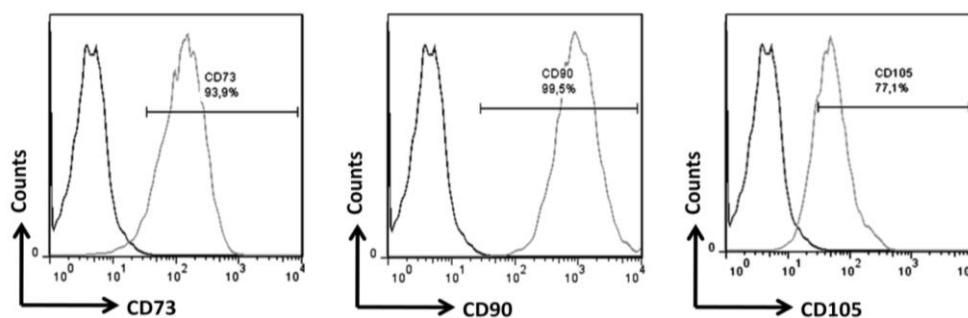
This type of approach to detecting cell populations uses a lot of graphical representation called *dot plot*. In this mode it is possible to check two parameters simultaneously. In the graph above (**Figure 5**), the x-axis represents the cell volume by the FSC parameter and the y-axis the SSC cell complexity parameter. In addition to the two defined parameters, the *dot plot* provides a third piece of information, which is the number of cells, where each point on the graph represents a single measured cell. Another much simpler mode of graphical representation is the histogram. In this mode it is possible to check the information of intensity and number of cells, as well as their proportion. In the example below (**Figure 6**), the intensity of the markers of cell molecules is represented on the x-axis and the number of cells is on the y-axis.

The flow cytometer also allows us to analyze cell populations that express certain types of molecules that can be labeled through the immunofluorescence technique with Ab linked to fluorochromes. The different types of fluorochromes, when excited by the light beam, emit certain wavelengths that are optically filtered and detected by detectors dedicated to a certain color range. More modern flow cytometers may have more fluorescence detectors, but at a minimum, they all come equipped with wavelength detectors in the green (FL1), orange (FL2), and red (FL3) range. For example, the FL1 detector detects the fluorochrome FITC, FL2 the fluorochrome PE and the FL3 fluorochrome APC. In stem cell research, this

approach becomes interesting because surface molecules are used to classify the state of differentiation and cell potency. Figure 6 shows a histogram of the number of cells by markers of cell potency.

Figure 6

Stem cells are shown to compare the expression of markers related to mesenchymal origin. The curve with the darkest stroke is the control, showing that this group of cells are not marked with Ab. The control serves to adjust the position of cells that do not have fluorochromes, thus presenting little fluorescence. The curve with a clearer line shows the cells that have undergone the immunofluorescence process: if the cells present the protein of interest, depending on the concentration of this protein, if in large quantities, the more Ab will bind to the cells, the stronger the intensity of the fluorescence and the more displaced to the right will be these cells. The y-axis shows the number of cells; The X-axis shows the intensity of the fluorescence emitted by the fluorochromes. In this case, the graphs show that the cells are positive for the molecules or markers for mesenchymal cells CD73, CD90 and CD105. The percentage shows the proportion of labeled cells for a given mesenchymal protein, with the unmarked control cells as the cutoff limit. Tip: even though the cells are not labeled, as is the case with the unlabeled negative control, they have their own fluorescence intensity detected by the flow cytometer. This should be calibrated so that the histogram of the control group is very close to zero on the x-axis, i.e., leaning against the y-axis



Another point to be observed is how the signal will be amplified, as there are linear and logarithmic amplifiers. The form of amplification is much more linked to the practical sense of observing the signs. The log form is commonly used for fluorescence, as it expands weak signals and compresses strong ones by visually eliminating extreme values, as it is used for marking analysis for stem cells. The Linear form is used when you want to analyze the signals as a whole – this type of amplification is widely used for cycle analysis.

9.2 APPLICATIONS OF FLOW CYTOMETRY

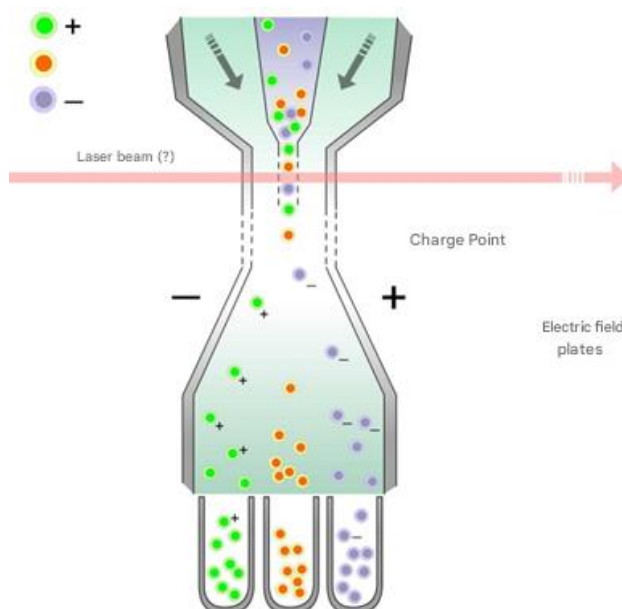
There are several possible applications using flow cytometry. The parameters that can be measured are: cell volume and morphological complexity, cell pigments such as chlorophyll, in cancerology (detection of a pathological cell; measurement of an abnormal DNA content), DNA and cell cycle (distribution of cells in the different phases of the cycle, presence of cells with abnormal DNA content, cell type analysis, cell kinetics, proliferation, etc.), RNA, analysis and classification of chromosomes, proteins, cell surface antigens (markers for identification of immune cell subtypes, for example), intracellular antigens (various cytokines, secondary mediators, etc.), nuclear antigens, enzyme activity, pH, intracellular ionized calcium, magnesium, membrane potential, membrane fluidity, apoptosis (quantification, measurements of DNA degradation, mitochondrial membrane potential, changes in permeability, caspase activity), cell viability, monitoring of cell electropermeabilization, pharmacology (characterization of multidrug resistance in tumor cells), glutathione, hematology (diagnosis, detection or identification of cell subtypes), various combinations (DNA/surface antigens, etc.). This list is very long and constantly expanding.

9.3 FLUORESCENCE ACTIVATED CELL SORTER (FACS)

FACS is a technique based on flow cytometry with the objective of selecting one cell among thousands. A given cell that has an antigen of interest can be separated from others that do not have this antigen, if an Ab specific for this antigen is labeled with a fluorochrome. The FACS computer system associates the wavelength (color) of the fluorochrome as an event (in this case, a cell) that must be separated (**Figure 7**). In this way, a certain cell, with a specific marking, and that we want to separate, will receive an electric charge and, when passing through an electromagnetic field, this cell will be deflected towards one of the plates of the electromagnetic field, depending on the charge that this cell has received. The FACS technique is usually used to isolate different types of leukocytes. T cells, for example, have CD3 and Thy1.2 antigens; these molecules can be labeled with Ab conjugated with specific fluorochrome and associated electrical charge and the cells can be selected by this technique.

Figure 7

Fluorescence-activated cell separation (FACS). The cells are separated according to their marking and associated electrical charge. Thus, there are three possibilities: positive, negative or neutral charge



9.4 IMMUNOFLUORESCENCE PROTOCOL IN FLOW CYTOMETRY

For antigen labeling in flow cytometry, it is necessary that the procedure begins with the cells in suspension. We often work with cells that grow in suspension, but we also experiment with adhered cells. Regardless of the type of culture, after the experiment of interest, whether it is the addition of a substance, a drug, or the submission of the cell to some physical process such as irradiation, or simply reading the proliferative behavior or marking antigens for characterization, the cells must be resuspended and counted so that they can be read in the flow cytometer. The ideal number of cells for reading should be around 1×10^6 cells in total, but it is possible to read cells from 1×10^5 cells. The quantity is important because, during the cell antigen labeling procedure, the cells underwent several washes that include centrifugations and resuspensions in buffers to remove excess Ab and successive transfers to different tubes, procedures where a lot of cell loss occurs.

9.5 MARKING FOR SURFACE ANTIGEN DETECTION

The surface antigen labeling is performed with the live cells in suspension and at the end, if necessary, we fix it with 2% formaldehyde, in case the cytometer analysis cannot be performed immediately.

The procedure below is indicated for cell labeling in order to characterize the cells. Although the protocol below uses indirect labeling, in flow cytometry direct labeling is more attractive, as it avoids washing steps and incubation periods where more cell loss can occur.

Materials

Cells growing in culture with approximately 70 to 80% confluency.

Buffer Solution: PBS (*Phosphate Buffer Saline*), pH7.2, with 0.5% bovine albumin serum (BSA) and 2 mM Na₂EDTA.

This buffer solution with EDTA is useful to prevent cell aggregation.

Culture medium appropriate to the cell of interest.

Formaldehyde at 2%.

Trypsin.

Primary ab .

Secondary Ab (specific to the type of Ig of the species from which the primary Ab was obtained) bound to a fluorochrome.

Pipettes.

15 mL conical tubes.

1.5 mL conical tubes.

5 mL round-bottom tubes (for flow cytometry).

Procedure (direct and indirect dialing)

1. Disaggregate the cells in culture using trypsin.
2. Centrifuge the cells for 5 min at a speed of 300xg (approximately 1000 rpm) with the aid of the 15 mL conical tube.

It is interesting to calculate the speed in rpm of each centrifuge.

3. Resuspend the cells and count them. Subdivide them into 1.5 mL conical tubes in order to contain a quantity above 1x10⁵ cells in total.
4. Resuspend the cells at 50 to 100 µL and add 10 µL of the diluted primary Ab at the concentration indicated by the manufacturer or at the concentration found after titration of the Ab in the labeling standardization process. Gently mix and incubate the cells at 4°C for 10 to 20 min or at the time indicated by the manufacturer.

5. Wash the cells by adding 1 to 2 mL of buffer solution.

Washing includes a gentle cell resuspension and centrifugation at 300xg for 8 min.

6. (Optional) Wash one more time.

If the marking is indirect, the procedure for adding the secondary Ab should be the same as it was done with the primary. If there is a need for multicolored marking, each Ab should be added independently, following the sequences of steps 4 through 6. Another option is to make a mixture of primary Abs and apply them to the cells simultaneously (as long as there is no interference between antigens; this is a procedure widely used when you have primary Abs already conjugated with fluorochromes).

7. Resuspend the cells in 300 μ L, transfer them to a 5 mL round-bottomed tube, and keep them at 4°C if the reading is taken soon after. If you need to postpone the reading, you can fix the cells in 2% formaldehyde and keep them at 4°C – take the reading in less than a week.

When fixing the cells, first suspend in buffer solution and then add the formaldehyde so that the final concentration is 2%. This procedure prevents the cells from being aggregated if the cells were resuspended directly with the fixator.

9.6 LABELING FOR INTRACELLULAR ANTIGEN DETECTION – FIXATION AND PERMEABILIZATION

Many antigens of interest that we wish to label are inside the cell, in the cytoplasm, or in intracellular compartments such as endoplasmic vesicles and reticulum, even in the nucleus. In order for Ab to interact with the antigen that is inside the cell, it needs to enter the cell. To do this, the cell membrane must be permeabilized and the pores then formed must remain open. Therefore, initially, the cell must be fixed, which leads to cell death.

Materials

The materials required are the same as those used in the surface antigen labeling procedure described above, with the addition of the permeabilizer:

Permeabilization solution: 0.2% (v/v) Tween 20

Procedure (direct and indirect dialing)

1. Disaggregate the cells in culture using trypsin.
2. Centrifuge the cells for 5 min at a speed of 300xg (approximately 1000 rpm) with the aid of the 15 mL conical tube.

It is interesting to calculate the speed in rpm of each centrifuge.

3. Resuspend the cells and count them. Subdivide them into 1.5 mL conical tubes in a total of 1×10^6 cells.

In this experiment, it is advisable to use a total of 1×10^6 cells per tube, since the process of fixation, permeabilization and subsequent washing will result in much greater cell loss than the procedure of cell surface antigen labeling.

4. Centrifuge the cells and remove the supernatant. Add 875 μ L of iced buffer solution and mix gently. Add 125 μ L of the fixing solution and mix again. Incubate for 30 min at 4°C.
5. Centrifuge and remove the supernatant. Add 1 mL of permeabilization solution to the cells. Incubate for 15 min at 37°C.
6. Add 1 mL buffer solution, centrifuge and remove the supernatant.
7. Add the primary Ab diluted appropriately in 100 μ L of buffer solution to the cells. Mix gently and incubate for 30 min at 4°C.

A blockade step can be accomplished by incubating the cells for 1 min with 50 μ L of human AB serum inactivated by heating. Lock before adding the primary Ab. This procedure reduces non-specific markings. If a membrane immunoglobulin test is performed, this step should not be performed.

8. Add 1 mL buffer solution and centrifuge for 5 min at 300xg.
9. Wash the cells once more by adding 1 mL of buffer solution.
10. If it is necessary to mark the primary Ab with a secondary conjugated with a fluorochrome (**indirect marking**), repeat steps 7 through 9. If Ab is already conjugated (**direct dialing**) go to the next step.

The Ab indicated as secondary is the F(ab')₂ fragment format, because it is smaller, penetrates better into the cell, and eliminates the possibility of binding to Fc receptors.

11. Suppress the cells at 300 μ L, transfer to a 5 mL round-bottomed tube, and keep them at 4°C if the reading is taken soon after. If you need to postpone the reading, you can fix the cells in 2% formaldehyde and keep them at 4°C – take the reading in less than a week.

Reagents

Formaldehyde, 2%

As commercial formaldehyde comes in a 37% solution, its dilution is made considering this solution as 100%. Therefore, dilute 2 mL of the commercial formaldehyde solution in 98 mL of PBS pH 7.4.

If you wish to use paraformaldehyde, dissolve 4 g of paraformaldehyde powder in 10 mL of distilled water and heat to 60°C. Dilute in a 1:1 ratio with 2x concentrated PBS, pH 7.4.

Always prepare before use, it is not interesting to stockpile.

Permeabilization solution: 0.2% (v/v) Tween 20

Mix 200 µl of Tween 20 with 100 ml PBS.

Store in amber vial for less than 1 month at 4 °C. Use it at room temperature.

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**SCIENTIFIC STRENGTHENING ACTIONS AS A MEANS OF CONTROLLING
ANTIMICROBIAL RESISTANCE IN THE CONTEXT OF SDG 12.A**

**AÇÕES DE FORTALECIMENTO CIENTÍFICO COMO MEIOS DE CONTROLE DA
RESISTÊNCIA MICROBIANA NO CONTEXTO DO ODS 12.A**

**ACCIONES DE FORTALECIMIENTO CIENTÍFICO COMO MEDIO PARA
CONTROLAR LA RESISTENCIA A LOS ANTIMICROBIANOS EN EL
CONTEXTO DEL ODS 12.A**

 <https://doi.org/10.56238/sevened2025.036-048>

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ABSTRACT

Microbial resistance to conventional therapy antibiotics (RAM) is one of the two biggest challenges of the 21st century. From different years, the beginning of the present series marks a definition of an important agenda for human development. Two 17 objectives, the one that deals with development brings together a series of goals that converge as the theme "microbial resistance". Goal 12.4 deals with technological development, strengthened by scientific promotion and partnership between nations. This text presents an analysis of the topic, pointing out the intimate relations between the technical-scientific development with the crisis of two antibiotics, proposing a discussion on how this scenario can contribute to the reduction of deaths due to microbial infections. The text was produced by Master and Doctorate students of two Post-Graduation programs, as part of the final exercise of the discipline that deals with this topic.

Keywords: Sustainable Development Goals. Antimicrobial Resistance. Industry and

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Technology.

RESUMO

A resistência microbiana aos antibióticos da terapia convencional (RAM) é um dos maiores desafios do século XXI. A partir de diferentes ações, o início do presente século marcou uma definição de agenda importante para o desenvolvimento humano. Dos 17 objetivos, aquele que trata do desenvolvimento reúne uma série de metas que convergem com o tema “resistência microbiana”. A meta 12.4 trata do desenvolvimento tecnológico, fortalecido pelo fomento científico e parceria entre as nações. Este texto faz uma análise do tema, apontando as relações íntimas entre o desenvolvimento técnico-científico com a crise dos antibióticos, propondo uma discussão sobre como este cenário pode contribuir com a redução das mortes por infecções microbianas. O texto foi produzido por discentes de Mestrado e Doutorado de dois programas de Pós-Graduação, como parte do exercício final da disciplina que trata deste tema.

Palavras-chave: Objetivos de Desenvolvimento Sustentável. Resistência Microbiana. Indústria e Tecnologia.

RESUMEN

La resistencia antimicrobiana a la terapia antibiótica convencional (RAM) es uno de los mayores desafíos del siglo XXI. A través de diversas iniciativas, el inicio de este siglo marcó un hito importante en la agenda de desarrollo humano. De los 17 objetivos, el de desarrollo reúne una serie de metas que convergen en el tema de la "resistencia a los antimicrobianos". La Meta 12.4 aborda el desarrollo tecnológico, fortalecido por el desarrollo científico y las alianzas entre naciones. Este texto analiza el tema, destacando la estrecha relación entre el desarrollo técnico y científico y la crisis de los antibióticos, y propone un debate sobre cómo este escenario puede contribuir a la reducción de las muertes por infecciones microbianas. El texto fue elaborado por estudiantes de maestría y doctorado de dos programas de posgrado como parte del ejercicio final del curso sobre este tema.

Palabras clave: Objetivos de Desarrollo Sostenible. Resistencia a los Antimicrobianos. Industria y Tecnología.

1 INTRODUCTION

Microbial antibiotic resistance (AMR) represents one of the greatest threats to public health in the context of infection prevention and treatment. It occurs when microorganisms undergo changes when exposed to antimicrobials, becoming resistant and, as a result, the drugs lose their effectiveness, infections persist and spread. As a growing global public health problem, coordinated action by all government and society sectors is needed (PAHO, 2025). This health crisis is intrinsically linked to human activities and presents particular challenges for developing countries, where limited scientific and technological infrastructure increases population vulnerability. Sustainable Development Goal 12.a (SDG 12.a) aims to support developing countries in strengthening their scientific and technological capacities for more sustainable patterns of production and consumption (BRASIL, 2015; UN BRAZIL, 2015). The convergence between human activities, the emergence of resistant microorganisms and the need for sustainable technological innovation configures a field that needs multidisciplinary analysis and coordinated strategies to safeguard both therapeutic efficacy, in the context of human disorders, and environmental sustainability.

2 HUMAN ACTIVITIES AS DRIVERS OF ANTIMICROBIAL RESISTANCE

In 2021, AMR was listed as one of the top 10 threats to global public health (WHO, 2021), with human activities being identified as the main driver of the evolution and spread of AMR through multiple interconnected mechanisms, such as the irrational use of antibiotics (WHO, 2019). Projections for the future put the total number of deaths from drug-resistant diseases close to 10 million by 2050 if action is never taken to curb AMR (Tangcharoensathien *et al.*, 2021). This irrational use by the general public and health professionals emerges from a low level of knowledge and awareness about antibiotic use and microbial resistance (WHO, 2019). Thus, AMR arises as a result of mutations in pathogens and selection pressure from antibiotic use, which generates a competitive advantage for altered lineages (Esmaeili-khoshmardan *et al.*, 2024).

Allel *et al.* (2023) observed high rates of microbial resistance in several regions of the world, even in places where antimicrobial use is relatively low. This suggests that the incorrect use of antibiotics may represent only one of the risk elements, and not necessarily the most determinant, so effective strategies to cope with AMR must transcend the simple reduction of this misuse. Thus, integrated policies should be incorporated that involve the strengthening of sanitary and epidemiological surveillance, and basic sanitation.

Climate change alters the environment, facilitating the persistence and spread of resistant bacteria, especially due to increased temperature, changes in rainfall patterns, which impairs sanitation and increases the transmission of pathogens. Industrialization intensifies the problem by releasing pollutants such as pharmaceutical residues and heavy metals, contaminating ecosystems and creating selective pressures for bacterial resistance (Oyelayo *et al.*, 2025).

Heavy metals are important environmental contaminants that favor co-resistance between these compounds and antibiotics through shared genetic mechanisms, facilitating the spread of resistant genes in the environment and potentially in clinical settings. Polluted ecosystems act as reservoirs of resistance, increasing AMR and impacting global public health (Ezeonuegbu *et al.*, 2024). Inadequate hospitals, pharmaceutical industries, and wastewater treatment systems also release significant concentrations of antimicrobials into the environment, creating so-called "selection zones" where microorganisms develop resistance (Esmaeili-khoshmardan *et al.*, 2024).

2.1 TECHNOLOGICAL CAPACITY AND FOOD SAFETY

According to the Food and Agriculture Organization of the United Nations (FAO), the term food security designates a condition when everyone, at all times, has physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and dietary preferences to enjoy an active and healthy life (FAO, 2024). Achieving this feat is a duty of each country and reinforced by international objectives, as evidenced by the 1996 World Food Conference (WCF). The CMA presents the agreement of the participating countries to reduce the number of people facing hunger by using integrative actions between the environment, politics, production and trade.

The boost in the agricultural sector is evidenced by the increase in its production scale over the years, however, problems related to access to food and its quality reveal inconsistencies in achieving the desired goals (EMBRAPA, 2018; Marchioni *et al.*, 2025). Countries in Latin America and the Caribbean are still one of the most affected by hunger in the world (FAO, 2024). In the national context, Brazil has public programs to combat hunger, in addition to programs that work on the redistribution of income that, as a consequence, improve access to safe food, but which, due to economic and sociopolitical changes, do not achieve their goal of eradicating hunger (Cabral *et al.*, 2014; Lins; Baptist; Espinoza, 2023).

Technological development can be a key to improving the quality of the food that reaches the population. Technologies such as whole-genome sequencing can be used to ensure the quality of the production chain and combat the spread of resistant microorganisms (FAO, 2018). However, developing countries face difficulties in ensuring technological development, as technological fragility for significant innovations is still one of the main obstacles to faster economic growth and better development indices (Leal; Figueiredo, 2021).

The indiscriminate use of antimicrobials in animal production, a common practice since the 1940s, has contributed significantly to the worsening of AMR worldwide, especially in developing countries. In these contexts, surveillance systems are fragile and regulation is deficient. In addition, the use of antibiotics as growth promoters or in subtherapeutic doses is a frequent practice, intensifying the selection of these microorganisms (Ansari *et al.*, 2020; EMBRAPA, 2021).

AMR poses a threat to global public health as different pathogens, such as *Escherichia coli* ESBL, *Salmonella* spp. and *Staphylococcus aureus* MRSA can be found in foods of animal origin, and can be transmitted to humans through meat, vegetables irrigated with contaminated water, and inadequate food hygiene practices (CFS, 2024; Founou *et al.*, 2016). The problem is even worse when sanitary inspection is insufficient. In addition, developing countries face challenges such as intensive production systems and scarce investments in biosafety, favoring the spread of AMR. FAO (2017) highlights that the food chain is an important vector of resistance, and that exposure to antimicrobials in livestock, agriculture and aquaculture contributes to the problem. Agricultural practice is also an aggravating factor, as the frequent and preventive use of antibiotics against phytopathogens, especially bacteriosis, has accelerated the selection of resistant strains (Machado; Luna, 2025).

The economic impact of AMR is significant: resistant infections, such as multidrug-resistant *Salmonella*, generate annual costs in excess of 365 million dollars in the US alone. If these numbers and the problem are extrapolated to countries with less health infrastructure, they can have even more serious consequences (Food Safety Brazil, 2024). In view of this, coordinated global actions are urgent, but especially in developing countries, it is essential to strengthen public policies, technical training, promotion of sustainable practices and the implementation of alternatives to the use of antimicrobials

2.2 SCIENTIFIC AND TECHNOLOGICAL STRENGTHENING IN THE CONTEXT OF SDG 12.A

Technical-scientific training has been shown to be a limitation and challenge faced by low- and middle-developed countries in coping with AMR (Kajumbula *et al.*, 2024). The lack of qualified professionals in areas such as microbiology, epidemiology, pharmacology, and health surveillance compromises everything from the collection and analysis of clinical samples to the interpretation of epidemiological and genomic data. This deficit is aggravated by inadequate laboratory infrastructure, absence of quality systems, shortage of reagents, and disarticulation between the technical and political levels (Okolie *et al.*, 2025).

Kajumbula *et al.* (2024) discussed in their study that only 1.3% of laboratories in 14 African countries perform basic microbiological tests, while the average compliance with quality standards is less than 50%. Additionally, in the Americas, it was observed that even in countries with active academic centers, such as Colombia and Jamaica, the dependence on external partnerships for specialized training is still high, evidencing the fragility of autonomous research networks (Kilmarx *et al.*, 2024).

In the Brazilian context, the development of public policies aimed at the prevention and control of antimicrobial resistance has played a central role in tackling this problem, structuring actions ranging from the promotion of the rational use of drugs to the implementation of microbiological surveillance systems (Aguiar *et al.*, 2023). Through historical programs such as the National Immunization Program and the control of hospital infections, to more recent strategies, such as the National Action Plan for the Prevention and Control of Antimicrobial Resistance (PAN-BR) (Brasil, 2022), the country has consolidated initiatives that aim to integrate efforts in the human, animal, and environmental sectors (Aguiar *et al.*, 2023).

With technological and scientific advances, many solutions for monitoring, prevention, diagnosis, and treatment have been proposed to combat bacterial resistance. Brown *et al.*, (2020) developed an automated, compact and low-cost system for microbial susceptibility testing, based on an optical system and machine learning. This system is particularly suitable for use in developing regions. From another perspective, the Oswaldo Cruz Foundation coordinates the structuring of a national network for genomic surveillance of multidrug-resistant bacteria. The institution trains professionals in genetic sequencing techniques for these bacteria. In addition, the use of nanoparticles, monoclonal antibodies, bacteriophages,

and vaccines is being studied as a promising therapeutic approach in the fight against AMR (Elbehiry *et al.*, 2022).

2.3 TECHNOLOGICAL INNOVATION FOR SUSTAINABLE PRODUCTION AND CONSUMPTION

The adoption of sustainable consumption and production patterns is crucial to mitigate environmental risks that compromise public health and environmental integrity. However, the implementation of these practices faces challenges, notably in developing countries. In these contexts, economic growth is often prioritized as the main vector for improving the population's living conditions, which can result in the adoption of measures with an adverse impact on sustainability. Urbanization and the expansion of urban centers is an example. By attracting large companies and the acceleration of industrialization, there is an increase in job search, *per capita* income and improvements in essential services such as health and education. In view of the above, the search for economic growth often overlaps with the adoption of a more sustainable development model.

On the other hand, developing nations have tools conducive to the implementation of an economic model capable of reconciling financial progress with sustainability. This is particularly relevant in the context of bacterial resistance, often aggravated by the improper disposal of industrial, hospital and agricultural waste into the environment. The adoption of the circular economy emerges as a promising solution to mitigate improper disposal. This concept, formalized in 1989 by British economists David W. Pearce and R. Kerry Turner, aims to extend the useful life of consumer goods and reduce the generation of waste from the conception of products. In the environmental context and the mitigation of AMR, this economic paradigm proves to be more advantageous than the current linear model (extraction, production, consumption and disposal), as it contributes to the reduction of waste that contaminates soils, rivers and lakes, favoring the regeneration of ecosystems. (Pearce, Turner, 1989).

Environmental management alternatives play a crucial role in mitigating bacterial resistance. Effluents from hospitals, slaughterhouses, and agricultural centers represent significant foci of Antibiotic Resistant Bacteria (ARB) and Antibiotic Resistance Genes (ARG) (Harth, 2025). This issue is particularly acute in least developed countries (LMICs), where the discharge of hospital effluents and other sources occurs directly into the environment, without adequate prior treatment. Given this scenario, it is imperative to implement accessible

technologies aimed at reducing this problem (Hounmanou, *et al.* 2025). Advanced technologies, such as Advanced Oxidation Processes (AOPs), have shown great potential in wastewater treatment. These processes are based on the generation of free radicals, especially hydroxyl ($\text{-OH}\cdot$), which have high oxidizing power and, consequently, high pollutant degrading properties (Divyapriya *et al.*, 2022).

3 STRENGTHENING COOPERATION AND TECHNOLOGY TRANSFER

As previously mentioned, AMR predominantly affects less developed countries, due to limited access to health services, inappropriate use of antimicrobials, and reduced focus on environmental issues, points related to the scarcity of resources. In view of this scenario, the collaboration of developed or high-income nations is imperative to control the spread of AMR, since it transcends the local scope, configuring itself as a global problem. Technology Transfer initiatives are fundamental for supporting poorer nations, establishing a model of cooperation between them and developed countries. This process enables access to high-cost and complex technologies, making them more accessible to countries with limited resources, as well as adapting their use to local specificities, independent of external support, but fostering self-sufficiency, as well as the development of scientific reasoning and the ability to overcome AMR (Harris; Tanner, 2000).

The diversity of technologies available to help combat bacterial resistance covers several sectors of research and development, including the design of rapid and more specific tests with molecular scope. Such tests can contribute to reducing the detection time of resistant bacterial species, thus speeding up the start of treatment (IDSA, 2011). The development of new antimicrobials with innovative mechanisms of action, such as metal-based compounds, is also crucial in this context, given that the speed of discovery of new antimicrobials is inversely proportional to the speed of emergence of new resistant strains. (Baker, *et al.* 2018) Low- and middle-income countries often have a vast biodiversity, and the support and cooperation of more developed countries in capacity building and technologies can be considered an incentive.

4 CONCLUSION

AMR represents a complex crisis, directly related to the unsustainable patterns of production and consumption addressed by SDG 12. The inadequate management of pharmaceutical waste and heavy metals highlights the need for environmentally safe

practices. In addition, in addition, the 12th proposes to strengthen scientific and technological capacities, especially in developing countries. These actions are essential to generate sustainable production systems. The "One Health" approach aligns with the systemic vision of SDG 12. Tackling AMR requires profound changes in global production and consumption patterns. Only with this transition can it be possible to avoid alarming projections of deaths from infections caused by resistant pathogens and meet the commitments of SDG 12. This perspective is essential to understand that antimicrobial resistance is not a phenomenon isolated to the clinical use of antibiotics, but the result of complex interactions between environmental, socioeconomic, and governance factors.

ACKNOWLEDGMENT

The authors would like to thank the Graduate Programs in Cellular and Molecular Biology (PGBCM/CCEN) and Natural, Synthetic and Bioactive Products (PgPNsb/CCS) of the Federal University of Paraíba.

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**HUMAN ACTIVITY AND ANTIMICROBIAL RESISTANCE IN THE CONTEXT OF
SDG 12: TARGET 12.4**

**A ATIVIDADE HUMANA E A RESISTÊNCIA MICROBIANA NO CONTEXTO DA
ODS 12: META 12.4**

**ACTIVIDAD HUMANA Y RESISTENCIA A LOS ANTIMICROBIANOS EN EL
CONTEXTO DEL ODS 12: META 12.4**

 <https://doi.org/10.56238/sevened2025.036-049>

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ABSTRACT

The United Nations supports 17 Sustainable Development Goals (SDGs), self-described as ambitious and interconnected, aimed at addressing a range of development challenges facing countries worldwide. SDG 12 aims to "ensure sustainable consumption and production patterns" through 11 targets. In this context, this paper proposes a link between the antibiotic crisis and item 4 of SDG 12 and presents anthropogenic factors related to the goal not being achieved by 2020. Although regulated, the paper addresses the contexts of the agricultural and food industries, as well as arbitrary waste management, which allow the spread of resistant microorganisms in the environment. This paper was produced by students from two postgraduate programs as a final project for their course and proposes to discuss antimicrobial resistance as a public health problem in light of SDG 12, focusing on target 12.4 as the guiding principle.

Keywords: Antibiotic Crisis. Sustainable Development Goals. Environmental Contamination.

RESUMO

A Organização das Nações Unidas apoia os Objetivos de Desenvolvimento Sustentável (ODS) que totalizam 17, autodenominados como ambiciosos e interconectados, com o

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objetivo de enfrentar uma agenda de desafios de desenvolvimento enfrentado pelos países em todo o mundo. O ODS 12, visa “assegurar padrões de produção e de consumo sustentáveis” por meio de 11 metas. Neste contexto, o presente trabalho propõe uma relação da crise dos antibióticos com o item 4 do ODS 12, e apresenta fatores antropogênicos relacionados à meta não ter sido alcançada até o ano de 2020. Embora sob regulação, são abordados contextos da indústria agropecuária, alimentícia e do manejo de resíduos de forma arbitrária que permitem a disseminação de microrganismos resistentes no ambiente. Este trabalho foi produzido por discentes de duas Pós-Graduações, como trabalho final de Disciplina e propõe discutir a resistência microbiana como um problema de saúde pública à luz do ODS 12, com foco na meta 12.4 como eixo condutor.

Palavras-chave: Crise dos Antibióticos. Objetivos do Desenvolvimento Sustentável. Contaminação Ambiental.

RESUMEN

Las Naciones Unidas apoyan 17 Objetivos de Desarrollo Sostenible (ODS), que se describen como ambiciosos e interconectados, y que buscan abordar diversos desafíos de desarrollo que enfrentan los países de todo el mundo. El ODS 12 busca "garantizar modalidades de consumo y producción sostenibles" a través de 11 metas. En este contexto, este documento propone un vínculo entre la crisis de los antibióticos y el punto 4 del ODS 12, y presenta los factores antropogénicos relacionados con la imposibilidad de alcanzar el objetivo para 2020. Si bien está regulado, el documento aborda los contextos de las industrias agrícola y alimentaria, así como la gestión ineficaz de residuos, que permiten la propagación de microorganismos resistentes en el medio ambiente. Este documento, elaborado por estudiantes de dos programas de posgrado como proyecto final de su carrera, propone debatir la resistencia a los antimicrobianos como un problema de salud pública a la luz del ODS 12, centrándose en la meta 12.4 como principio rector.

Palabras clave: Crisis de Antibióticos. Objetivos de Desarrollo Sostenible. Contaminación Ambiental.

1 INTRODUCTION

Microbial resistance (MR) can be defined as the ability of bacteria, fungi, viruses, and parasites to resist the action of antimicrobial drugs, making conventional treatments complex clinical challenges (Silva; Nogueira, 2021). This problem addresses one of the greatest threats to global public health in the twenty-first century, becoming increasingly responsible for deaths throughout the year (Ho *et al.*, 2025). It is estimated that about 9% of all deaths are caused by microbial resistance. In 2019 alone, about 5 million deaths were reported worldwide (Murray *et al.*, 2022). According to these data, these deaths were associated with 33 microbial pathogens, with emphasis on *Staphylococcus aureus*, *Escherichia coli*, *Streptococcus pneumoniae*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa*, responsible for more than half of the deaths (GBD 2019 ARC, 2022).

According to the Ministry of Health, the situation in Brazil is similar to that observed in the rest of the world and has recorded serious infections caused by *E. coli*, *S. aureus* and *K. pneumoniae* in hospitals and large urban centers. Such infections make treatments difficult and increase costs by prolonging hospitalizations (Brasil, 2024). This problem is highly linked to the pattern of human behavior, such as indiscriminate use of antibiotics, improper disposal of medicines and disinfectants, contamination of soils and rivers, among others, contributing to the dissemination of resistance genes in the environmental microbiota (Carney *et al.*, 2019; Klein *et al.*, 2024).

Faced with this problem, it is essential to adopt an integrated approach, as proposed by the concept of "*One Health*". This perspective is key to understanding and addressing microbial resistance effectively and sustainably (Musicha *et al.*, 2024). In this sense, the UN Sustainable Development Goals (SDGs) offer an important framework for action. SDG 12, "Responsible Consumption and Production," highlights the need to reduce waste, improve waste management, and promote sustainable practices across sectors. Target 12.4, in particular, proposes to achieve environmentally sound management of chemicals and wastes, reducing their release into the air, water and soil (UN, 2025).

2 EXCESSIVE USE OF ANTIMICROBIALS IN AGRICULTURE AND ITS CONSEQUENCES

Modern agriculture, in the quest to maximize productivity and meet the growing demand for food security, has established itself as one of the main consumers of antimicrobials on a global scale (Van Boeckel *et al.*, 2015). This scenario is especially intensified in developing countries, where the increase in demand for animal protein

encourages intensive farming practices and the indiscriminate use of drugs that are often associated with the presence of antibiotic residues in animal products (Manyi-Loh *et al.*, 2018). It is estimated that more than 70% of the antibiotics consumed worldwide are destined for animal production, being used not only for therapeutic purposes, but predominantly as growth promoters and for infection prevention (Boeckel *et al.*, 2017). This widespread use has generated serious health and environmental implications, by favoring the selection and dissemination of resistant microorganisms in the environment (Tiseo *et al.*, 2020).

Different classes of antimicrobials widely used in agriculture, on a global scale, have aroused growing scientific concern due to their potential adverse effects and the complexity of risk management steps. Among these classes, tetracyclines, aminoglycosides, beta-lactams, lincosamides, macrolides, pleuromutilins and sulfonamides stand out (Baynes *et al.*, 2016; Finley *et al.*, 2013). These drugs share similar mechanisms of action or belong to the same therapeutic classes as antibiotics used in antibiotic therapy in humans, making their use, judicious in livestock, essential, given the possibility of transfer of resistant microorganisms between animals and humans (Gelband *et al.*, 2015).

The continuous use of antimicrobials in livestock, often in subtherapeutic doses, exerts constant selective pressure on the microbiota of these animals, favoring the selection and proliferation of resistant cells (Gelband *et al.*, 2015). These microorganisms can be transmitted to humans by different routes, either through the consumption of contaminated food or derivatives, or through direct contact with animals or by exposure to contaminated environments. In addition, antibiotic residues are commonly detected in animal waste, widely used as organic fertilizers, a practice that contributes to soil and water contamination (Manyi-Loh *et al.*, 2018).

From a broader perspective, the intensive and sometimes indiscriminate use of antimicrobials in animal production directly undermines the principles established by SDG 12, which seeks to promote sustainable production and consumption patterns. Item 12.4 proposed as a goal the significant reduction in the release of hazardous chemicals and waste into the environment by the year 2020. However, even after the deadline has passed, many countries still lack effective public policies to regulate the use of antimicrobials in livestock, as well as robust environmental surveillance systems aimed at monitoring microbial resistance (Van Boeckel *et al.*, 2015).

The inefficiency in the management of livestock waste containing antimicrobials constitutes a direct violation of the principles of environmentally safe management, as

recommended in item 12.4 of SDG 12. When disposed of without proper treatment, these residues contribute to the transformation of agricultural soils and water bodies into reservoirs of resistance genes, forming the so-called environmental resistomes. These genes can be transferred horizontally between different microorganisms, including human pathogens, through mechanisms such as conjugation, transduction, and transformation, significantly exacerbating the global antimicrobial resistance crisis (Pal *et al.*, 2016).

In addition, the global scenario of antimicrobial resistance is aggravated by the absence of standardized and uniform regulations among countries. While European Union nations have adopted, since the early 2000s, strict restrictions on the use of antibiotics as growth promoters in livestock (Schmerold *et al.*, 2023). On the other hand, many developing regions still make indiscriminate use of antimicrobials, as classes considered critical by the World Health Organization (WHO) in human therapeutics (Adebowale *et al.*, 2016; Moyane *et al.*, 2013). Consumption in these contexts is often driven by abusive practices, such as the acquisition of antimicrobials without a medical prescription, facilitated by unregulated supply chains and over-the-counter sales in commercial establishments (Ayukekbong *et al.*, 2017). This normative disparity favors the emergence of critical points of microbial resistance, whose impacts go beyond geographical boundaries through international food trade, the movement of live animals, and the global flow of travelers (Maron *et al.*, 2013).

Global projections reinforce the seriousness of this scenario: Van Boeckel *et al.* (2015) estimated that the consumption of antibiotics in the BRICS countries should practically double in the coming years. This increase is associated with the intensification of large-scale animal production systems, which require the routine use of antimicrobials to ensure productivity and prevent diseases, in response to growing consumer demand for animal products. Antimicrobial resistance, therefore, constitutes an inevitable and cumulative side effect of the excessive and abusive use of these drugs (Williams-Nguyen *et al.*, 2016).

The critical analysis of this scenario shows a worrying mismatch between scientific advances in the understanding of microbial resistance mechanisms and the effective implementation of public policies aimed at mitigating them. While antimicrobial resistance is essentially a natural phenomenon, its acceleration by unsustainable human practices poses a growing threat to global public health (You; Silbergeld, 2014). Industrial agriculture, when devoid of regulations based on sustainability, acts as a silent but persistent vector in the spread of resistance genes (Schmerold *et al.*, 2023).

In this context, it is urgent that countries adopt stricter control measures on the use of antimicrobials in animal production, promote investment in sustainable alternatives, such as vaccines, probiotics, and good sanitary management practices. Additionally, it strengthens environmental surveillance systems (Salam *et al.*, 2023). Incorporating these strategies into the SDG 12.4 agenda is essential to curb the advance of microbial resistance and ensure that antimicrobial efficacy is preserved for future generations.

3 HOSPITAL AND PHARMACEUTICAL WASTE: FROM CURE TO ENVIRONMENTAL CONTAMINATION

Investments in health on a global scale have reached unprecedented levels and continue to grow annually. In 2017, health spending was estimated at approximately US\$ 7.8 trillion, corresponding to about 10% of the world's GDP (Kenny; Priyadarshini, 2021). Health care, a rapidly expanding industry driven by therapeutic advances and the growth in cases of chronic diseases, is responsible for generating a significant amount of waste. This scenario has intensified the demand for efficient waste management (Abosse *et al.*, 2024).

Hospitals, laboratories, medical centers, veterinary clinics, research institutions, morgues, blood banks, and nursing homes are among the main culprits for the generation of healthcare waste (Janik-Karpinska *et al.*, 2023). This waste from health services can be classified into two distinct categories. The first fraction is similar to household waste, composed of materials such as paper, cardboard packaging, glass, food scraps and inert substances. The second fraction, of a hazardous nature, is made up of toxic, harmful, potentially carcinogenic elements and agents at risk of infection (Assemu *et al.*, 2020).

The technologies currently used in the treatment and final disposal of health service waste (HSW) can be grouped, in general, into three major classes: thermal processes, chemical processes and irradiation-based methods. In addition to these approaches, complementary methods are also used, such as disposal in landfills, safe reuse after reprocessing procedures, and recycling of materials (Kenny; Priyadarshini, 2021).

Incineration is widely adopted as the preferred technique for the disposal of waste from health services, since it enables a rapid and significant reduction in the residual volume, which can reach up to 90%. However, in the absence of appropriate technologies, this method can pose environmental and human health risks, especially due to the release of air pollutants and the formation of toxic byproducts (Chistholm *et al.*, 2021). Only modern incinerators, with emission control and operating at high temperatures (850-1100 °C), meet international

standards for dioxins and furans. Alternative methods, such as autoclaves, microwaves, and steam treatment with internal mixing, should be considered in places with adequate resources, as they reduce the release of pollutants (WHO, 2024).

The disposal of waste from health services in landfills is also widely used, and can cause relevant environmental impacts, especially the contamination of water resources as a result of leaching (Lee; Lee, 2022). Prior decontamination of chemical and pharmaceutical waste is essential before its final destination in landfills (Chi *et al.*, 2020).

The inadequate management of pharmaceutical waste represents a challenge, especially due to the lack of adequate guidance to the population on the correct ways of disposal. As a consequence, it is common for expired or unused medicines to be discarded in household garbage or flushed down toilets, which contributes to the presence of these compounds in landfills, water systems, and sewage networks, promoting environmental contamination (Endale; Mathewos; Abdeta, 2023). Residues in subinhibitory concentrations, from expired or degraded drugs, favor the adaptation of environmental microorganisms, stimulating the development of antimicrobial resistance mechanisms (Stanton *et al.*, 2020).

In this context, the continuous application of manure and organic waste as fertilizers can lead to the absorption of antibiotics by plants. This is due to soil contamination, the use of polluted water in irrigation, or the use of untreated manure. This practice represents a potential pathway of human exposure to subtherapeutic amounts of antimicrobials through the food chain (Zalewska *et al.*, 2021). This cycle, which results in environmental contamination, leads to an increase in microbial resistance, posing a serious risk to human health, in an era where antibiotics are less developed and infections become increasingly serious and pose a real threat.

According to WHO (1997), engineered landfills are the safest and most environmentally appropriate alternative, as long as the waste is previously subjected to immobilization processes, such as encapsulation or inerting, ensuring the containment of contaminants. Controlled landfills, in turn, are considered acceptable only on a transitional basis, and should also receive only immobilized waste. Uncontrolled landfills, on the other hand, because they pose significant risks to public health and the environment, are strongly discouraged. Its use is exceptional and restricted to emergency contexts, as long as the waste is properly encapsulated and there is a record of the site for future remediation.

Therefore, the reduction in the generation of waste from health services should be treated as a priority, as it considerably reduces the demand for treatment and final disposal.

Effective strategies include sustainable procurement of inputs, preference for products with eco-friendly packaging, use of reusable items whenever possible, rationalization of the purchase of medicines according to actual demand, and the adoption of recycling practices (WHO, 1997).

In summary, the management of waste from health services represents a growing challenge, especially in view of the increase in production and the complexity of discarded materials. The adoption of appropriate technologies, combined with the education of the population and the implementation of effective public policies, is essential to mitigate environmental impacts and protect public health. Sustainability in the health sector depends, therefore, on integrated actions based on scientific evidence.

4 INDUSTRIES AND ENVIRONMENTAL POLLUTION: WHEN PRODUCTION FUELS THE PROBLEM

One of the most notable threats to global public health is characterized by microbial resistance, causing a series of repercussions that are not limited to medicine, but include socio-environmental and economic aspects. Although there is recognition of the indiscriminate use of antibiotics as a determining factor, the responsibility of the industry in this process cannot be disregarded. Specifically considering the role of the agricultural and pharmaceutical industry in the dumping of antimicrobial residues into the environment, its role as an expressive vehicle in the dispersion of resistance can be seen (Larsson, 2014; Silva *et al.*, 2020). In light of target 12.4 of SDG 12, it is necessary to debate how the industry feeds this problem.

Manufacturing effluents, especially from pharmaceutical plants, have high concentrations of active ingredients that are not completely removed by conventional sewage treatment methods (Larsson, 2014; Rizzo *et al.*, 2013). This results in environmental contamination and may benefit the selection and dissemination of antimicrobial-resistant bacteria, which in turn can transfer their genes to other species through transformation and conjugation mechanisms (Rizzo *et al.*, 2013). Some antibiotics, such as ciprofloxacin, have been detected in high concentrations in industrial wastewater (Larsson, 2014). In addition, the improper disposal of industrial solid waste acts as reservoirs for microorganisms, which increases the risks of contamination of soils and groundwater (Souza *et al.*, 2018).

Therefore, resolutions to combat microbial resistance must consider its multifactoriality, considering the relationship of several stages of the production system,

application, and commercialization of antimicrobials, with consequences for the different industrial and economic sectors (Silva *et al.*, 2020). From production, distribution, and final consumption, each link in this web can cooperate to select and disperse resistant microorganisms. In this context, it is of paramount importance to use approaches encompassing competent public policies, thorough regulation, instruction of health professionals and other sectors such as agriculture. In addition, the need to encourage research, update therapeutic alternatives and sustainable conducts is highlighted (Anvisa, 2017).

The impacts generated by the industries are not limited to the production and disposal of drugs. With regard to the food industry, there are several ways to ensure greater safety and quality of products, despite this, outbreaks of foodborne diseases continue to affect populations worldwide, resulting in high health costs (Damião *et al.*, 2023). In this context, bacterial resistance to disinfectants used in the food industries stands out. Since the intensive and often inappropriate use of these compounds can select resistant microorganisms, able to resist hygiene processes (Langsrud *et al.*, 2003). Among the substances authorized to compose sanitizing products with antimicrobial functions, some belong to the class of phenolics, aldehydes, inorganic chlorine-releasing agents and quaternary ammonium. Subinhibitory concentrations of these biocides, in addition to contributing to the development of resistance, can also lead to cross-resistance to antibiotics (Santos; Goals, 2021).

In addition, cross-contamination stands out as a critical factor in food industries, since it is constantly related to the formation of biofilms by pathogenic microorganisms such as *Salmonella enteritidis*. These biofilms, which form easily on porous or hard-to-clean surfaces, such as wood and certain plastics, give high resistance to disinfectants commonly used in industrial routines. These microbial structures can resist, functioning as a reservoir of pathogens and favoring the transfer to ready-to-eat products (Carrascosa *et al.*, 2021).

From this perspective, resistance to disinfectants in the food industry is related to environmental pollution, since, if not properly treated before disposal, the waste generated during sanitization processes can reach soils, rivers, and sewage systems, affecting the natural microbiota of aquatic and terrestrial ecosystems, promoting the environmental dissemination of resistance genes. This context highlights the need for effective hygiene strategies, combined with the correct selection of materials in contact with food and the continuous training of handlers, as part of good manufacturing practices.

The agricultural industry also contributes significantly to this scenario. The use of antimicrobials as animal growth promoters generates waste that, when released into the environment without adequate treatment, exerts selective pressure on natural microbial communities (Silva *et al.*, 2020; Silva *et al.*, 2025). This aspect plays a relevant role in the emerging public health crisis, especially in antibiotic resistance. Although most of the use of antibiotics is carried out in agricultural systems, it is noteworthy that their use in livestock deserves significant attention as it contributes to the general issue of antibiotic resistance (Landers *et al.*, 2012).

Given this scenario, it is understandable that the absence of strict regulations in developing countries makes the situation even more aggravating. Many industries are installed in regions with poor environmental inspection, taking advantage of gaps in local legislation to operate with disposal standards below the recommended (Laxminarayan *et al.*, 2013; Silva *et al.*, 2020).

Therefore, it is of paramount importance to rethink industrial production models. It is necessary to search for alternative ways that minimize the impacts generated during these processes. In this context, clean technologies, such as bioremediation and advanced effluent treatment systems, should be encouraged through public policies and subsidies (Bengtsson-palme; Kristiansson; Larsson, 2018; Larsson, 2014). In addition, it is necessary to strengthen environmental surveillance and demand transparency from industries regarding the composition of their waste. International cooperation is also crucial, especially in the sharing of technologies and the agreement of regulatory standards (Larsson, 2014; Laxminarayan *et al.*, 2013).

5 SOCIAL AND ECONOMIC IMPACTS OF MICROBIAL RESISTANCE ASSOCIATED WITH HUMAN ACTIVITY

The accelerated urban growth has evidenced the absence of planning and infrastructure capable of keeping up with population expansion. Among the consequences, the increase in the generation of Urban Solid Waste (MSW) stands out, whose management is often neglected or treated as of minor importance. Despite representing a growing public health problem on a global scale, these difficulties are particularly pronounced in low- and middle-income countries, such as Latin America (Corrêa *et al.*, 2022).

In Brazil, the management of MSW is now regulated by Law No. 12,305/2010, which establishes the National Solid Waste Policy (PNRS), covering the political, economic,

environmental, cultural and social spheres. However, its effectiveness is still far from being achieved. (Brazil, 2010)

Capitalism, as the dominant economic model, encourages unbridled consumerism, generating mountains of MSW and impacting the ecosystem. The *International Solid Waste Association* (ISWA, 2022) estimates that waste generation will increase worldwide, reaching 3.4 billion tons in 2050. This expansion will be especially seen in low-income countries, where generation is expected to triple. The management of USW in small cities is also insufficient, since municipal leaders point out difficulties in keeping waste away from the urban area, which contributes to the emergence of environmental and public health problems (Silva; Zanchi; Lopes, 2023).

The negative impacts of MSW extend to many aspects in terms of environmental impact. Among the consequences are the advance of AMR, aggravated by the excessive or inappropriate use of antibiotics, as well as climate change and problems related to hygiene and basic sanitation (Brasil, 2025). In addition, AMR is one of the greatest public health challenges today, being considered one of the ten leading causes of death in the world. It is estimated that by 2030, global GDP could lose US\$ 3.4 trillion per year due to AMR, and 24 million people could be pushed into extreme poverty by 2050. With the growing increase in resistance, treatments become more expensive, with longer duration and less availability (Brasil, 2025).

With the increase in environmental imbalance caused by garbage, it becomes an environment conducive to the development of pathogenic microorganisms. Mphasa *et al.* (2024) evidenced the presence of pathogenic microorganisms in organic materials, fabrics, and plastics recovered from waste piles, increasing the risk of human exposure.

The systems for the treatment and disposal of MSW considered less harmful to the environment demonstrate positive results, both in the recovery of secondary matter for reuse and in the generation of economic return. In addition, they contribute to reducing the volume of garbage discarded in nature. Among the technologies used in the treatment and final disposal of MSW, landfills, systems for collecting and using or burning biogas, as well as drainage and leachate treatment, in addition to continuous environmental monitoring (Abrema, 2023), stand out.

Despite these advances, it is still common to use inappropriate places, such as dumps, controlled landfills, ditches, dumps and similar areas, unsuitable for the ecosystem and its resources. According to ISWA (2022), the precariousness in the proper disposal of waste is

largely due to the low coverage of collection, as well as the absence of appropriate disposal for all waste, pollution caused by irregular disposal, open fires, formation of dumps, and the presence of hazardous substances. In addition, the lack of funding and resources for the theme, as well as the low demand for secondary raw materials, also contribute significantly to the obstacles faced.

6 FINAL CONSIDERATIONS

Microbial resistance is a silent crisis that grows every year, driven by the inappropriate use of antimicrobials in medicine, agriculture, and industry. Incorrect waste disposal, environmental contamination, and lack of enforcement contribute to the spread of resistance genes in different ecosystems. This scenario compromises the effectiveness of treatments and threatens global health, requiring urgent and coordinated responses across sectors. The "One Health" approach is essential to understanding the connections between human, animal and environmental health. In addition, sustainable consumption and production must be prioritized as a way to contain this advance. Microbial resistance is not just a technical problem, but an ethical and structural challenge.

In this context, target 12.4 of SDG 12 highlights the fundamental axis to promote the environmentally safe management of chemicals and waste. For this to happen, it is necessary to strengthen health and environmental surveillance, regulate the use of antimicrobials, invest in clean technologies, and encourage sustainable practices in all sectors involved. Reducing microbial resistance depends on education, research, political commitment, and long-term integrated actions. Without these measures, there is a risk of significant setbacks in modern medicine. Therefore, preserving the efficacy of antimicrobials is a collective responsibility that must be addressed as a global priority.

ACKNOWLEDGMENTS

The authors would like to thank the Graduate Programs in Cellular and Molecular Biology (PGBCM/CCEN) and Natural, Synthetic and Bioactive Products (PgPNSB/CCS) of the Federal University of Paraíba.

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CITY AND URBAN HISTORY: NOTES

CIDADE E HISTÓRIA URBANA: APONTAMENTOS

HISTORIA URBANA Y DE LA CIUDAD: NOTAS

 <https://doi.org/10.56238/sevened2025.036-050>

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ABSTRACT

This article aims to present a theoretical debate about the approach, from a historical point of view, to the peripheral spaces of a city that, throughout its four centuries, has been marked by a history of valuing its founding nucleus, the “Praia Grande” neighborhood. Throughout the 20th century, books, magazines, guides, albums and audiovisual productions sought to reproduce representations of the city through its historic center. In order to overcome this limitation, through the contributions of Certeau, Bresciani, Bodei and Reis, we sought to develop an itinerary in which we considered all the social actors involved in the construction of urban trajectory, through the convergence of relations between objects and the links between the public and the private are essential for reading everyday life in urban space.

Keywords: City. Territory. Periphery.

RESUMO

Esse artigo busca apresentar um debate teórico acerca da abordagem, sob o ponto de vista histórico, dos espaços periféricos de uma cidade que, ao longo de seus 4 séculos, é marcada por uma trajetória de valorização de seu núcleo fundacional, o bairro da “Praia Grande”. Ao longo do século XX, livros, revistas, guias, álbuns e produções audiovisuais buscaram reproduzir as representações da cidade por meio de seu centro histórico. A fim de superar essa limitação, por meio das contribuições de Certeau, Bresciani, Bodei e Reis, buscamos elaborar um itinerário no qual se considerou todos os atores sociais envolvidos na construção da trajetória urbana, por meio da convergência das relações entre objetos e os vínculos entre o público e o privado são essenciais para a leitura da vida cotidiana no espaço urbano.

Palavras-chave: Cidade. Território. Periferia.

RESUMEN

Este artículo propone un debate teórico sobre el enfoque histórico de los espacios periféricos de una ciudad que, a lo largo de sus cuatro siglos, se ha caracterizado por una trayectoria de valoración de su núcleo fundacional, el barrio de Praia Grande. Durante el siglo XX, libros, revistas, guías, álbumes y producciones audiovisuales buscaron reproducir representaciones de la ciudad a través de su centro histórico. Para superar esta limitación, y basándonos en las contribuciones de Certeau, Bresciani, Bodei y Reis, desarrollamos un itinerario que considera a todos los actores sociales involucrados en la construcción de la

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trayectoria urbana, mediante la convergencia de relaciones entre objetos y los vínculos entre lo público y lo privado, esenciales para comprender la vida cotidiana en el espacio urbano.

Palabras clave: Ciudad. Territorio. Periferia.

1 INTRODUCTION

The urban history of the four-hundred-year-old São Luís (MA) is marked, from the seventeenth century to the twentieth century, by the valorization of its foundational nucleus, whose urban elaboration is attributed to the chief engineer Francisco Frias de Mesquita, at the beginning of the seventeenth century. including from the point of view of the urban organization of towns and cities (Macêdo, 2014). This legislation was in force in Brazil between the seventeenth and nineteenth centuries. The territory known as Praia Grande³, had its layout defined according to the interest of meeting the demands of export farming, through its port; in the background, to meet the need to create means of permanence of a nascent local elite – although, this group was closely linked to Lisbon, and, later, to Paris and the Court, in Rio de Janeiro.

Throughout the eighteenth and nineteenth centuries the city was characterized by being a trading post, a link between the large plantation of sugar cane and cotton (produced in the valleys of Itapecuru and Pindaré) and national and sometimes international trade. With the income from this trade, the city expanded and became a space for the experience of its elite, through the knowledge and practices of this group, and a supposed humanistic and civilizational vocation of this city – despite the non-humanistic slavery. According to Costa (2016), the local elite sought to create a tradition of distinction and uniqueness, based on the epithet of the Brazilian Athens – a stronghold of poets, intellectuals and figures of political expression. The focus of this text, however, is not to delve into the reasons for its creation, nor the uses and disuses of the concept of Athens. We are interested in the association of this concept with space, its streets, its stone and lime houses, seen as an archetype of a civilized and progressive city.

The arrival of the republican regime did not represent ruptures, since the interpretations of the city still revolved around the valorization of the icons of a supposed "civilization". The second half of the twentieth century, still tributary from this perspective, sought to value, in various aspects, the elitist tradition of the city. Books, magazines, guides, albums and audiovisual productions⁴, to a greater or lesser extent, reproduced this

³ Consisting of about 3.5 thousand buildings, it occupies an area of approximately 250 hectares. It was approved by the National Institute of Historical and Artistic Heritage, IPHAN, in 1974. Cf. SELBACH, 2009, p. 23.

⁴ From the second half of the twentieth century, the editorial production on the city of São Luís – and its 'historic' center was amplified, especially with the listing of the city by the Institute of National Historical and Artistic Heritage, IPHAN, in 1974. In view of this, events emerged that sought to value this space and several materials were produced for this purpose, such as tourist and sentimental guides, photo albums, postcards and newsreels, which met the interests of valuing these spaces with great success.

perspective, through metonyms that saw the totality of the city, being represented – according to a political project – by its old center, whose definition was "the most beautiful and complete architectural ensemble of colonial Brazil". And to the peripheries... what remained was silence and the unsaid!

In view of the many zones of opacities of the unsaid, it is therefore up to the historians of the city, according to the contributions of Maria Stella Bresciani (2002), to elaborate historical paths on the political and philosophical ideas that guided the construction and interventions in urban spaces, in order to understand the multiple dynamics of the city.

2 WHAT DEFINES A CITY?

What is a city? Until the moment when the question is asked of us, we usually define it in the most varied ways without, however, having greater precision in its meanings. Because it is an imprecise concept and used by almost all human beings, we tend not to problematize it and ignore the multiple nuances involved in its conceptualization. The Michaelis dictionary defines city in the following ways: a) an agglomeration of people in a geographical area, in which social, economic, industrial, commercial, cultural, administrative and political activities are developed; b) a group of inhabitants of the same geographical area; c) a shopping center; d) the oldest or most central location of a given urban agglomeration; e) municipal headquarters, where administrative activities are concentrated; f) hectic, dynamic life.

We are interested in scrutinizing items *a* and *d*, whose definitions converge with most definitions of the *latu sensu* type of city. From the economic and social point of view, the first definition is associated with a human agglomeration, in which social, economic, industrial, commercial, cultural and administrative activities are developed; Such a concept is tempting, due to its approximation with the image of European cities, originating from the urban and commercial revolution, at the beginning of the second millennium of the Christian era. However, the cities of the new world, which emerged from the sixteenth and seventeenth centuries onwards, followed a different trajectory and followed European aspects and indigenous elements, as well as enslaved groups, brought to America. Due to this trajectory of centuries, of our urban agglomerations, a definition that takes into account only aspects of their European ancestry is quite limited.

Item *d*) refers us to the historical dimension, which demarcates the spaces of political and social valorization. With the broad use of this concept, São Luís is transformed into a

"historic city", whose definition aimed, according to Rossini Corrêa (1993), to preserve the historical aspect and tradition, through the uses and disuses of the myth of Athens, by an intellectual elite and linked to agro-export and its architectural and urban complex, arising from this context.

Michel de Certeau (2003) points out that the city serves interests, sometimes unconfessable, that fulfill the role of conforming everyone, in an urban model, in which the clash of perspectives, looks and fragments, end up converging in the same physical space, marked by tensions and clashes, concealed in the traditional definitions of city. In the face of these not always peaceful convergences, what Certeau called "stubbornness and insistent traditions" are diluted in countless elements – always alive and present in the urban space, marked by intense transformations.

These "stubbornness", which certain groups make use of, here and there, clash with the modern norms of urbanism (new public environment) represent the synthesis of the various values that converge in the city. These questions were addressed by Pierre Nora (1993), who called them the "problematic of places", in which history, with its universalist perspective and at the same time, vocalizing the interests of those who write it – and govern it – confront the memory of those who live and make the city. Memory is always lived and woven by living groups; it is in permanent evolution and open to the dialectic of remembrance and oblivion; unaware of its successive deformations – or stubbornness – are unconscious. In view of this, the study of cities and their compartmentalizations (explicit and implicit) is marked by ambiguity, located at the crossroads, between the material, symbolic and functional dimensions, in which the most diverse relationships woven in space are anchored, condensed and expressed, especially in moments of transformation and imposition of new ways of living, live and move around the city.

This imposition of ways and ideas of the city is related to a certain "curiosity for the places where memory crystallizes" (Nora, 1993, p. 1) voiced by a group of interpreters of the city – journalists, writers, intellectuals, who recommended to their readers, through poetic, tourist and sentimental guides⁵, the correct ways to walk through the city. On the other hand, these same albums, guides and texts neglected the peripheries, which should be avoided

⁵ These editorial, artistic and imagery productions, whose target audience was the local elite, fulfilled the function of creating and fixing the traditional images of the historic city. Among them, we can mention the productions of Gaudêncio Cunha, the photos of the Teixeira Typography, through the albums of 1923 and the one produced by the journalist Miécio Jorge, in 1950 to the tourist guides of Astolfo Serra (1963), Domingos Vieira Filho (1975) and Jomar Moraes (1989). The newsreels produced by the National Agency, in addition to the Amaral Netto program, recorded on the streets of São Luís, in 1978.

and seen as the space of alterity, confrontation, the unsaid and the contestation – sometimes unpleasant – of the positions contained in the narratives of the official/traditional/sentimental urban space.

The narratives of the official/traditional urban space of São Luís, throughout the twentieth century, were widely defended by journalistic and literary texts, iconographic productions, in which the urban space and its houses of stone and lime were the central topic. Almost all of these editorial, artistic and imagery productions sought to recreate a very delimited urban space of São Luís, confirmed to a tiny portion of the city: the neighborhood of Praia Grande (also called the Historic Center, whose *historical name* suggests a possible "absence" of history from the other regions. To the other regions, neighborhoods and, more recently, to the invasions, there was invisibility – or insistent stubbornness.

In view of these, it is necessary that other historical truths, as observed by José Carlos Reis (2005) be laid bare, in addition to those related to the city of stone and lime and tradition. And what would be the "truths" from the urban point of view, which would be reproduced by the writing of the city's history? And what interests did this writing serve and serve? Our proposal is precisely to raise questions related to the city, its history and the political uses of its urban trajectory. This is our "principle of choice", according to Reis, in dealing with the issue of the city and its multiple territories. And, for this, it is necessary to make a new writing of the history of the periphery – and of its subjects and spaces made invisible by traditional narratives. It is up to this new writing to interpret the city having as one of its premises, which alerted Reis and his "understanding that historical knowledge is a "reflection", a "meditation" on human living in time" (2005, p. 336) – and in the city.

3 THE MEANINGS OF THE URBAN HISTORY OF SÃO LUÍS

The text by the Italian historian Remo Bodei (2002) presents us with a fundamental question for historiographical making: "what is the meaning of history?" And he goes on to question: "what are the assumptions that anchor the explanatory intention of history?" With regard to urban history – the focus of this text: what are the meanings, uses and interpretations that our writing confers to the city? It is up to the new approaches to urban history to explain the trajectory of the city, focusing on the peripheries – and, of course, their relations with the center, with the poles that induce the city's norms. The most appropriate itinerary for this purpose lies in accessing the memories contained in its spaces of sociability, since "it is in the city that history is exhibited, it is in it that history is built, in the space and in

the public building; in these spaces, possibilities of action are established by the collective presence of social actors" (Bresciani, 2003, p 30).

Urban history, since its advent in the nineteenth century, is an interdisciplinary field, where dialogue with various other types of knowledge contributed to its development. With regard to the craft of historians, it is up to us, according to the observation of Maria Stella Bresciani (2002), to elaborate historical paths on the political and philosophical ideas that guided the construction and interventions in urban spaces, in order to understand the multiple dynamics of the city, from a historiographical point of view. In this regard, Luís Octávio da Silva (2002) observes that "relevant contributions have emerged, in which the urban appears as an element of historical interpretation" (Silva, 2002, p. 76) on the role of cities in capitalist development, for example.

According to Bernardo Secchi (2009) "the history of the twentieth century is rich in pre-established bifurcations, abandoned paths and unforeseen ruptures. Urban studies go further, by considering that a street, an avenue, a square, a building are not able, by themselves, to induce profound changes in the urban space; Only the interaction of these spaces, with human dynamics, with their struggles and tensions, can promote more complex and instigating historical processes.

The city, in this way, fulfills the function of catalyst of the memories contained in its spaces of sociability, streets, monuments; in the relationships of its actors, in which ample possibilities are established. The city, according to Secchi (2009), is always the result of a process with multiple variants. And the product of this equation cannot be attributed to just one thing, be it state induction or the ways in which communities react to these phenomena.

Reflection on the fragments of the past is fundamental. Cultural and popular history – that is, with the popular strata as an object – has as its motto to abolish urban restrictions or ethnocentrisms and stigmas between the popular regions of the city, based on the analysis of the relations of power and domination and/or negotiation between popular culture and the dominant culture, from the prism of the occupation and uses of urban space. Popular history, a theme raised by Chartier (2007) has the potential to scrutinize elements submerged in the sea of official history. Without neglecting or abolishing traditional subjects and approaches – useful to the extent that it is necessary to establish relations, many comparative, between the center and the periphery – it is necessary to overcome possible ethnocentrist or reductionist approaches to the urban question, based on the treatment of the cultures of the periphery, as a coherent set of symbolic systems, which is ordered according to a logic implicitly

imposed by the centers of cultural and political power. This itinerary has the tools to address the relations of domination and the intense inequalities of the social world, through the intricate process of tensions, in respect to the dominate culture.

From these relationships, it is possible to unravel the thread of the urban history of São Luís and its popular neighborhoods - areas seen as "non-historical". The many transformations of the urban fabric, designed and applied in the late 1960s, intended to create an urban model, in which the elite, with their political projects, made use of a set of instruments to standardize a new space; Such norms had as their goal, the conformation of the subjects, victims of the displacements, of the removals that would form the new neighborhoods, giving them a certain degree of participation in the "progress", in this city in constant evolution, even if in a subordinate way.

The understanding that progress had the properties of solving social problems was prevalent throughout the 1960s and 1970s. At that time, Maranhão and its capital – which was the epicenter of this process – experienced what would come to be called the "Maranhão miracle", that is, the culmination of a set of actions to modernize the institutions – whose one of the focuses was the urban planning of São Luís. One of the strongest imagetic representations of this period was presented in the newsreel "The Miracle of Maranhão", directed by Romanian filmmaker Isaac Rosenberg⁶. The images, as they reinforced the epithet of historic city, sought to link São Luís to the signs of modernity – the bridge, the port, the dam, electricity – they could transform the urban space into a land of progress. Although the city is represented in an avant-garde way, the unspoken become evident, due to the silencing of a real city. In his first few seconds, the announcer says: "... and the miracle happened... machines have arrived to accelerate progress; a young team, led by young people, came to provide better days for the people of Maranhão" (O Milagre do Maranhão, 1970).

In this context of forced modernization, the city, in the process of recreation by the elite, represents the difficulty of "aging" and the preservation of its pasts. These new spaces, due to their iconoclastic nature, have a conflicting relationship with the past, in which the "old" has its space symbolically delimited. It is up to historical knowledge to scrutinize the interests at stake about the construction of the urban history of the city. The basic text "The invention

⁶ The newsreel "The Miracle of Maranhão" (1970) was directed by the Romanian filmmaker, based in Brazil since the 1930s, Isaac Rosenberg. The short film is part of the series "Coisas do Brasil", whose intention was to exalt the achievements of the military governments and the achievements of the José Sarney government (1966-1970).

of everyday life" by Michel de Certeau, indicates that historical knowledge has the complex task of summoning the past, through the study of urban practices and has as its starting point, two perspectives: a) one that privileges the analysis and observation of the physical elements of the city – its urban design, its architecture, its topography, flow of displacements – seen as material and administrative impositions in the territory, that is, in the periphery; b) the second perspective focuses on a socio-ethnographic analytical model of everyday life. These two perspectives, if worked in a watertight way and not associated, can cause confusion in the analysis of the urban process. On the one hand, there is the constant lamentation of the infrastructural limitations in the urban environment studied and, on the other hand, there is the disproportionate emphasis on the dimensions of everyday relationships, displaced from the larger structures that impose their existence.

In order to solve this dilemma, Certeau (2002) suggests that the method to be chosen should be the convergence between points of view, which contribute to the delimitation of the relations between objects and their links, between the private and public; "this is one of the conditions of possibility of daily life in the urban space, which decisively shapes the notion of neighborhood" (Certeau, 2002, p. 38).

The process of unfinished urbanization that Brazil has gone through – especially in its less dynamic regions – has been slower. "Without the possibility of contestation, this process is the engine of transformations in society" (Lefebvre, 2013, p. 54) where its effects, whether reduced or maximized, have led to a series of influences – economic, social, cultural – with which the most varied people have to live with these influences, adapt. Such adaptation to the urban and modern space, often mediated by violence, marked the experience of many subjects, especially São Luís in the 1960s and 70s. This process produced a series of memories, collective and/or individual, which, according to Roger Chartier (2007), confer a more powerful presence to the past than that established in history books.

An urban phenomenon – imposed from outside – is strongly influenced by the characteristics of the place in which it unfolds. The construction of a dam, for example, has limited influences on the transport and movement of people; But when it becomes a sign of progress and a link between the new and old city, the population configures this space, through political and symbolic purposes, whose meanings attributed by the population go beyond its merely utilitarian sense. For Milton Santos (1993), the intensification of this phenomenon occurred in the wake of the military coup of 1964, which created the conditions for a rapid integration of the country, into an internationalization movement that appeared to

be irresistible (Santos, 1993, p. 36).

During the 1970s, the capitalist system sought to constitute and expand "circuits of exchange, networks that allow transfers" (Lefebvre, 2013, p. 57) not only of money, but of equipment, people and knowledge and, above all, symbolic capital that would legitimize the urban transformations, planned in cities such as São Luís, which in the 1970s, with its 350 years, was already experiencing the effects of unequal and excluding urban growth. These actions sought to encourage economic development – even if exclusionary and aimed at serving a rapidly expanding consumer market. This technocratic and authoritarian growth model produced, even if in a limited and incomplete way, results, especially with the increase of a middle class, rocked by the maintenance of economic growth, between the 1960s and 1970s. On the other hand, this same model "maintained large population contingents, without access to basic social and civil rights, such as labor legislation, social security, housing, and sanitation" (Maricato, 2013, p. 21).

Avant-garde urban interventions, whose mission is to transform aspects of the city – such as the bridge, the highway, the port, the working-class neighborhood, contribute to the construction of what Michel de Certeau (2003) in the text "The Invention of Everyday Life: Arts of Making" called the "utopian city". This avant-garde space, of clashes between memory and the future, is crossed, from the urbanist point of view, by three elements, such as: the production of its own space; the establishment of a "no time" to replace and undermine the resistance and stubbornness arising from traditions; and finally, the attempt to create an anonymous "universal subject" integrated into the city, albeit in a peripheral way. Such elements marked, to a lesser or greater extent, the process of urban modernization, which São Luís went through, and especially the village of Anjo da Guarda, as a model "working-class neighborhood".

Disorganized urban expansion and the struggle for public services in peripheral areas marked this period. This was a time of changes in local governance, which influenced modern São Luís. In this way, the urban transformations of the city obey a history, organized by the political forces that control it and make the urban space meet their interests. On this point, the French sociologist Henri Lefebvre mentioned that "the city is the work of a history, that is, of well-defined people and groups that carry out this work in historical conditions" (Lefebvre, 2013, p. 13). According to Flávio Villaça (2001), a large part of the low-income strata began to occupy geographic regions stigmatized by the strata with higher purchasing power. The phenomenon of spontaneous occupation, generically called "invasions", provided the

formation of an infinity of communities in the interior of the island.

The path traced by the city – outlined by its leading forces – is part of a historical tradition, where the right to the city was neglected, in favor of a sanitized city that sought to make poverty invisible. During the nineteenth century, in the absence of a territorially extensive city, a large part of the population – especially enslaved individuals, was imposed a series of legal regulations, which hindered their citizenship status. With the decline of slavery (but not poverty) inflicted on the "brown" majority of the city, the curtailment of the right to the city became the rule, through codes of posture and police determinations, which considered the suburb as the habitat of these individuals, in a "tradition" originating in the nineteenth century.

4 FINAL CONSIDERATIONS

The urban history of São Luís is marked by the appreciation of the foundational nucleus, founded in the seventeenth century, whose neighborhood of Praia Grande was the greatest symbol of this space, which met the demands of export farming and housed the local elite. In the twentieth century, the reading of the city maintained its elitist tradition, without significant ruptures, in which the prevalence of historical interpretation and the identity of the city still linked it primarily to its foundational core – seen as the urban space that would represent the city as a whole.

From the 1960s and 1970s onwards, they were marked by the emergence of plans for the reformulation of the city, which had as a backdrop the integration of the city into national and international capitalist flows. It was up to the city leaders to lead this process of transformation and creation of various elements that are part of the city's structure, such as the Ring Road, the Embankment and the Bacanga Dam, in addition to the construction of popular houses via the BNH and the paving of the interior of the island. In the face of these impositions, the peripheral territories, inserted in a subordinate and limited way in the process of modernization of the city, produced a number of clashes, especially related to the right to the city and access to public services.

Urban history, from this point of view, is responsible for addressing more appropriately the meanings, uses and interpretations of societies – both those who control it and those who just live in it. However, as detailed above, it is up to the interpreters of urban history to focus on the broader dimensions of the city, especially the spatial, cultural and political relations, its disputes and tensions, especially the peripheries and their relations with the center. To

explain the trajectory of the city, it is essential to access the memories contained in its spaces of sociability, where history is exhibited and constructed, since the city, (Secchi, 2009), is the result of a process with multiple variants.

To this end, Michel de Certeau indicates that the task of summoning the urban past starts from two points; the first is related to the analysis and observation of the physical elements of the city – its urban design, its architecture, its topography, the flow of displacements – considered as material and administrative impositions on the territory, impossible to be neglected in the analysis of urban space; The second starting point focuses on the analysis of the daily life of communities. These points of view, if worked together, can contribute to the in-depth interpretation of the city.

Therefore, the city of the avant-garde, of the utopia of progress, of peripheral modernization and of urban transformation is a market for clashes between memory (tradition, stubbornness and insistence) and the future, seen as a space "not time" to replace and undermine traditions, whose ideal subject is seen as "universal" anonymous and integrated into the city, even if in a peripheral way – permeated by shocks and tensions. Such elements marked, to a lesser or greater extent, the process of urban modernization that São Luís went through, and especially the village of Anjo da Guarda, as a model "working-class neighborhood".

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**POWER FLOW PREDICTION USING RECURRENT NEURAL NETWORKS WITH
L.S.T.M. AND GENETIC ALGORITHM IN AN IEEE 30 BUS SYSTEM**

**PREDIÇÃO DE FLUXO DE POTÊNCIA USANDO REDES NEURAIS
RECORRENTES COM L.S.T.M. E ALGORITMO GENÉTICO EM UM
BARRAMENTO IEEE 30**

**PREDICCIÓN DEL FLUJO DE POTENCIA MEDIANTE REDES NEURONALES
RECORRENTES CON LSTM Y ALGORITMO GENÉTICO EN UNA RED IEEE DE
30 BARRAS**

 <https://doi.org/10.56238/sevened2025.036-051>

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ABSTRACT

Accurate forecasting of active (P) and reactive (Q) power in electrical networks is fundamental to improving operational reliability and planning in modern power systems. This article proposes a forecasting model based on Long Short-Term Memory (LSTM) neural networks to estimate load demand in an IEEE 30-bus system. The model considers the active and reactive power supplied by the generators as input variables, while the power components of the loads are used as target variables for prediction. To improve performance, a Genetic Algorithm (GA) was used to optimize hyperparameters, which reduced the Mean Absolute Error (MAE) and increased the accuracy of the predictions. The results demonstrate that the proposed approach provides stable predictions of load behavior, highlighting its potential for application in smart grids and microgrid management systems.

Keywords: Power Flow Forecasting. LSTM. Genetic Algorithm. Active Power. Reactive Power. Smart Grids.

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RESUMO

A previsão precisa das potências ativas (P) e reativas (Q) em redes elétricas é fundamental para aprimorar a confiabilidade operacional e o planejamento nos sistemas de potência modernos. Este artigo propõe um modelo de previsão baseado em redes neurais do tipo Long Short-Term Memory (LSTM) para estimar a demanda de carga em um sistema IEEE de 30 barras. O modelo considera como variáveis de entrada as potências ativas e reativas fornecidas pelos geradores, enquanto os componentes de potência das cargas são utilizados como variáveis-alvo de previsão. Para aprimorar o desempenho, foi empregado um Algoritmo Genético (GA) na otimização de hiperparâmetros, o que reduziu o Erro Absoluto Médio (MAE) e aumentou a precisão das previsões. Os resultados demonstram que a abordagem proposta fornece previsões estáveis do comportamento das cargas, evidenciando seu potencial de aplicação em smart grids e em sistemas de gerenciamento de microrredes.

Palavras-chave: Previsão de Fluxo de Potência. LSTM. Algoritmo Genético. Potência Ativa. Potência Reativa. Smart Grids.

RESUMEN

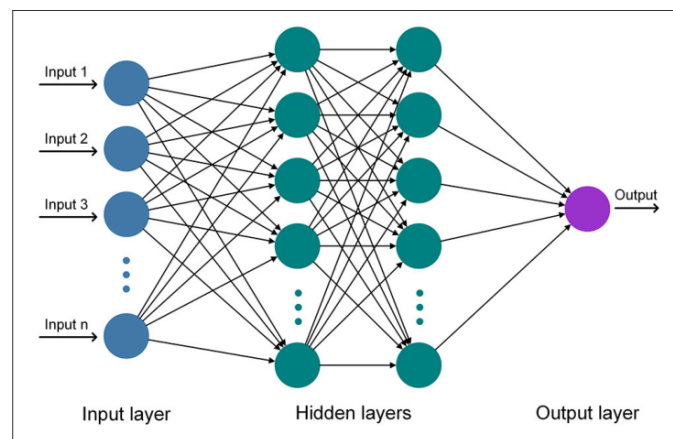
La predicción precisa de la potencia activa (P) y reactiva (Q) en las redes eléctricas es fundamental para mejorar la confiabilidad operativa y la planificación en los sistemas de potencia modernos. Este artículo propone un modelo de predicción basado en redes neuronales LSTM (Long Short-Term Memory) para estimar la demanda de carga en un sistema IEEE de 30 barras. El modelo considera la potencia activa y reactiva suministrada por los generadores como variables de entrada, mientras que los componentes de potencia de las cargas se utilizan como variables objetivo para la predicción. Para mejorar el rendimiento, se empleó un algoritmo genético (AG) en la optimización de hiperparámetros, lo que redujo el error absoluto medio (MAE) y aumentó la precisión de las predicciones. Los resultados demuestran que el enfoque propuesto proporciona predicciones estables del comportamiento de la carga, lo que destaca su potencial aplicación en redes inteligentes y sistemas de gestión de microrredes.

Palabras clave: Predicción de Flujo de Potencia. LSTM. Algoritmo Genético. Potencia Activa. Potencia Reactiva. Redes Inteligentes.

Figure 2 illustrates the general architecture of the proposed LSTM network, highlighting the temporal sequence of the inputs (active and reactive powers of the generators) and the outputs corresponding to the predictions of the active (P) and reactive (Q) powers of the selected load.

Figure 2

Diagram of the LSTM architecture

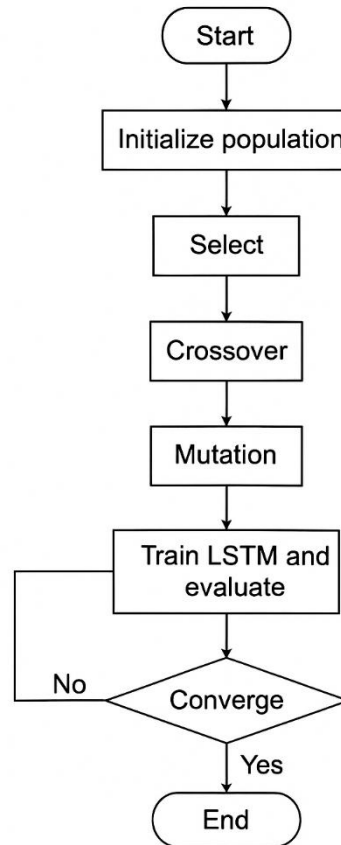


Source: Researchgate.

Finally, Figure 3 presents the flow of the optimization process conducted by the Genetic Algorithm. The GA acts on the hyperparameters of the LSTM (number of neurons, learning rate, number of layers, among others), evaluating performance based on the lowest MAE obtained during validation.

Figure 3

Optimization process flow conducted by the Genetic Algorithm



Source: The authors.

In this scenario, the present article proposes the development of an algorithm based on recurrent neural networks (RNN) with LSTM units for the prediction of the behavior of loads in the IEEE 30-bar system, using historical data of power injections in the busbars. LSTM-based RNNs stand out for their ability to capture complex temporal patterns in sequential data, increasing the accuracy of predictions even under highly dynamic operating conditions. Previous work has shown that accurate load forecasts directly impact the efficiency of the operation of electrical systems, especially when integrated into distributed generation structures, allowing the optimization of energy costs and the increase of the penetration of renewable sources in the grid [3].

To understand the state of the art and contextualize the technical challenges involved, a review of previous studies on time series forecasting in electrical systems and their impacts on operational planning was carried out. In our analysis, different prediction scenarios were tested using real power flow data combined with machine learning approaches. The learning capacity of LSTM proved to be highly effective in capturing temporal dependencies, showing

promising results even when using a reduced set of input variables, such as the active and reactive powers of the generators, to predict the active and reactive demand of individual loads. The forecasts were updated every 10 moments of time, simulating a realistic operational horizon.

In the context of industrial and commercial applications, accurate load forecasting not only optimizes the operation of distributed resources, but also contributes to the stability of the power grid in regions with high penetration of renewable sources. Studies such as [4] highlight the potential of Artificial Neural Networks in predicting losses in distribution networks. Similarly, load forecasting with LSTM can act as a central element in reducing technical losses in distribution systems when integrated with advanced load management and energy storage strategies. This work advances over existing models by introducing innovative approaches to deal with the variability and complexity of load data. For this, a robust data set was built, contemplating various operating conditions of the IEEE 30-bar system. The data set used in this work was composed of the operating conditions of its generators and the 21 connected loads. Specifically, the input variables of the model corresponded to the active and reactive powers provided by the generators, while the output variables could, in principle, be the active and reactive powers of each of the 21 loads. However, for the experiments conducted in this study, only load 2 was selected as the prediction target. This choice aimed to reduce the initial complexity of the problem, allowing the methodology to be validated in a controlled scenario. Thus, even though the complete database includes all system loads, the forecast model was trained and evaluated considering exclusively the active and reactive demand of load 2. The data were pre-processed and normalized for training and validation of the prediction model.

Another novelty presented in this work was the use of a Genetic Algorithm (GA) to optimize the hyperparameters of the LSTM network, increasing the convergence speed and reducing the mean prediction error.

In conclusion, this study represents a significant contribution to the development of predictive techniques applied to the operation of electrical systems, with direct implications for the electricity sector and for sustainable energy planning. Future research may investigate the inclusion of additional operational variables, as well as the impact of extreme events and contingencies, with the aim of further improving the proposed predictive models.

2 MATERIAL AND METHOD

2.1 THEORETICAL FOUNDATION

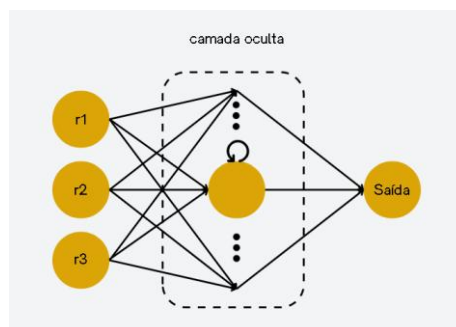
2.1.1 Rnn

Recurrent Neural Networks (RNNs) are a class of artificial neural networks specifically designed to handle sequential data. Unlike traditional *feedforward* networks, RNNs incorporate feedback loops that allow information from previous instants to influence the current output. This characteristic makes them particularly suitable for forecasting tasks, in which temporal dependencies and correlations play a key role [5].

However, traditional RNNs often face limitations, such as *vanishing* and *exploding gradients* when trained on long sequences. These problems reduce the grid's ability to capture long-term dependencies, which are essential for accurate forecasting in electrical systems.

Figure 4

Recurrent Neural Networks (RNN)



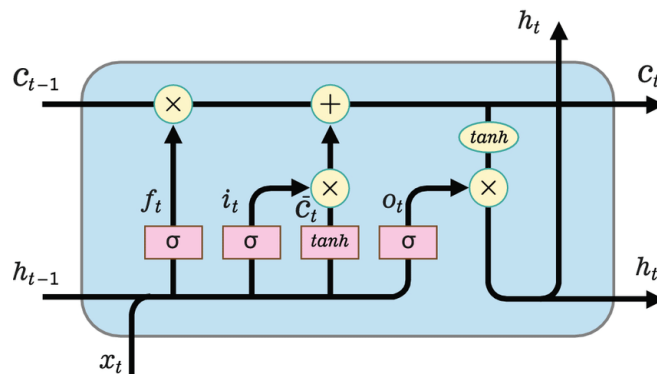
Source: The author.

2.1.1.1 LSTM

Each cell in the hidden layer corresponds to a Long Short-Term Memory (LSTM) unit, illustrated in Figure 4. This is a variation of recurrent neural networks designed to handle long-term dependencies on data sequences. Its main objective is to avoid problems such as the disappearance or explosion of gradients, common in traditional RNNs. To do this, LSTM uses a structured mechanism of gates that control the flow of information over time, allowing the network to decide what information to keep, discard, or update.

Figure 5

Long Short Term Memory (LSTM)



Source: Researchgate

In general, the LSTM cell maintains two main states: the cell state (C_t) and the hidden state (h_t). The state of the cell is responsible for storing information over time, while the hidden state serves as the output at each instant. These states are dynamically updated through three main ports: oblivion port, inlet port, and outbound port.

2.1.1.1.1 Door of Oblivion (f):

Determines which previous state information (C_{t-1}) should be discarded. To do this, a sigmoid function is applied, which generates values between 0 (discard) and 1 (keep). These values are calculated from the combination of the previous hidden state (h_{t-1}) and the current input (x_t).

$$f_t = \sigma(W_f * [h_{t-1}, x_t] + b_f) \quad (1)$$

2.1.1.1.2 Gateway (i) and Candidate Information ($\tilde{C}_t$):

Defines what new information will be added to the cell state. First, a sigmoid function calculates the update coefficients. Next, candidate information ($\tilde{C}_t$) is generated through the hyperbolic tangent function ($\tanh$), which produces values between -1 and 1. These two steps ensure that only relevant information is incorporated.

$$i_t = \sigma(W_i * [h_{t-1}, x_t] + b_i) \quad (2)$$

$$\tilde{C}_t = \tanh(W_c * [h_{t-1}, x_t] + b_c) \quad (3)$$

2.1.1.1.3 Cell State Update (C_t):

The current state is updated by combining the previous state with the new candidate information. The oblivion port regulates how much of the previous state will be retained, while the gateway defines the proportion of candidate information that will be incorporated.

$$C_t = f_t \odot C_{t-1} + i_t \odot \tilde{C}_t \quad (4)$$

Here, $\odot$ represents element-by-element multiplication, ensuring a dynamic adjustment of the flow of information.

2.1.1.1.4 Exit Port (o):

Defines which current state information (C_t) will be used to generate the hidden state (h_t). The combination of the previous hidden state and the current input goes through a sigmoid function, which controls the fraction released. Then, the cell state is activated with the $\tanh$ function and multiplied by the output port values:

$$o_t = \sigma(W_o * [h_{t-1}, x_t] + b_o) \quad (5)$$

2.1.1.1.5 Calculation of the Hidden State (h_t):

Finally, the hidden state is calculated as the element-to-element product between the output of the output port (o_t) and the activated version of the cell state ($\tanh(C_t)$).

$$h_t = o_t \odot \tanh(C_t) \quad (6)$$

2.1.1.2 HeatMap

HeatMap is a widely used data visualization tool to represent the values of a matrix or table through color variations. This technique makes it easier to identify patterns, trends, or correlations between variables in complex data sets. In the context of time series and machine learning, HeatMaps are often employed to explore relationships between different variables or to analyze the behavior of data over time.

The operation of a HeatMap is based on assigning colors to numerical values, usually following a continuous scale, such as gradients ranging from blue (for low values) to red (for high values). Each cell of the map represents the intersection between two variables, allowing for an intuitive visualization of their interactions. For example, in a correlation matrix, the HeatMap is used to display the strength and direction of linear relationships between pairs of variables.

Additionally, HeatMaps are useful for identifying anomalies or seasonal patterns in the data. In practical applications, such as time series forecasting, they can be used to analyze the relevance of input variables, identify periods of greater concentration of extreme values, or understand the influence of external factors on the analyzed data. HeatMaps can be implemented in tools such as *Seaborn* or *Matplotlib*, which allow the customization of color scales, labels and annotations, expanding the ability to interpret the results.

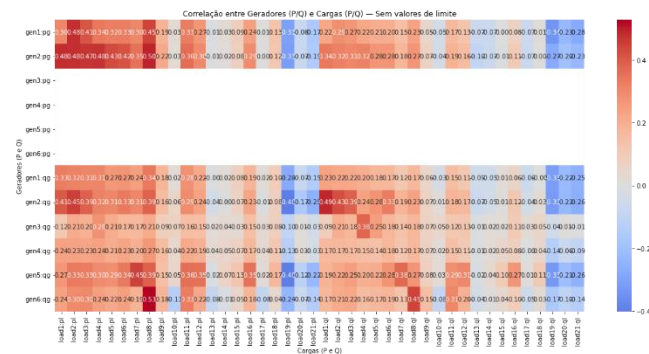
In this way, the use of HeatMaps provides a powerful visual approach to understand and communicate complex information, being an essential tool in studies that require the analysis of large volumes of data and their interrelationships.

The choice of input data in the RNN architecture, illustrated in Figure 4, was based on the analysis of the correlations between the system variables. The HeatMap, presented in Figure 6, shows the correlation relationships between different variables, making it possible to identify those with the greatest impact on the behavior of the system and, therefore, more relevant to the model.

Thus, the power sources were chosen as the input variables for the training, and one of the loads (in this case, Load 2) was selected as the grid output variable.

Figure 6

HeatMap



Source: The author

2.1.1.3 TensorFlow and Keras

TensorFlow and Keras are essential tools for developing *deep learning* models, especially for time-series tasks such as predicting power flow variables in power grids.

TensorFlow, powered by Google, is a highly scalable and efficient open-source library designed to perform complex mathematical operations and support model training on high-performance hardware such as GPUs and TPUs. Keras, integrated as TensorFlow's high-level API, provides a modular, easy-to-use interface for building neural networks, allowing researchers to focus on the conceptual and experimental aspects of modeling.

In the model developed in this work, several features of TensorFlow and Keras were explored for their simplicity and efficiency in implementation. The architecture was built using the Sequential class, which organizes the layers in a linear fashion and is suitable for neural networks that process sequential data, such as the LSTMs employed in this study. The LSTM layers formed the backbone of the model, designed to capture temporal patterns and long-term dependencies on the input data. This capability is critical in time series analysis in power systems, as current load values are strongly influenced by past variations of active and reactive powers.

To enhance the learning process, a Bidirectional layer was added, which allows LSTM to analyze the data both in the direct and inverse direction of time. This approach is particularly advantageous in power flow forecasting, where future operating conditions can also be influenced by past interactions between generation and demand.

In addition to the LSTM layers, Dense layers were included, responsible for performing linear and nonlinear transformations in the internal representations, connecting the LSTM outputs to the final predictions. The output layer was configured with two neurons, corresponding to the active (P) and reactive (Q) powers of the selected load, ensuring that the model produced predictions aligned with the physical quantities of interest.

For the training, the model was compiled using the Adam optimizer, which is known for its efficiency in *deep learning tasks* due to adaptive adjustment of the learning rate. The loss function chosen was the Mean Absolute Error (MAE), which is suitable for regression problems and provides a direct interpretation of the mean of the differences between predicted and actual power values.

After training, the predictions were generated with the Keras predict function, integrated into the processing flow. Overall, TensorFlow and Keras stood out not only for their ease of use, but also for offering advanced solutions to complex problems, such as capturing temporal dependencies in the operation of electrical systems. These frameworks were instrumental in ensuring the efficiency, flexibility, and scientific rigor of the proposed forecasting model.

2.1.1.4 Genetic Algorithm for Hyperparameter Optimization

Genetic Algorithms (GAs) are a class of stochastic optimization techniques inspired by the principles of natural selection and genetics. Initially proposed by John Holland in the 1970s, AGs are widely used to solve optimization problems where the search space is complex, nonlinear, or difficult to approach by traditional gradient-based methods. Their robustness and adaptability make them suitable for a wide variety of engineering applications, including machine learning and power system analysis.

At their core, AGs operate on a population of candidate solutions, called individuals, that are represented by chromosomes (often encoded as binary chains, real value vectors, or more complex structures, depending on the problem). Each chromosome corresponds to a potential solution, the quality of which is evaluated through a fitness function that measures how well it meets the optimization objective.

The process of a GA follows the following key steps:

- Initialization: A population of candidate solutions is randomly generated within the defined search space. In the context of hyperparameter optimization in neural networks, these candidates can represent configurations such as number of LSTM cells, *dropout* rates, learning rate, and number of training epochs.
- Selection: Individuals are selected based on their fitness scores, favoring those who perform best. Strategies such as roulette, tournament, or ranked selection ensure that the strongest individuals are more likely to pass on their traits to the next generation.
- Crossover: Pairs of selected individuals exchange parts of their chromosomal representations to generate offspring. This process mimics biological reproduction, promoting the combination of advantageous characteristics of different solutions.
- Mutation: Random changes are introduced into the chromosomes of offspring with a small probability. The mutation ensures diversity in the population, avoiding premature convergence to suboptimal solutions.
- Replacement: A new population is formed, usually combining the best individuals from the previous generation with the newly generated offspring. The cycle of evaluation, selection, crossover, and mutation is repeated for a set number of generations or until the convergence criteria are met.
-

2.1.1.4.1 Application in this work

In the present study, the Genetic Algorithm was employed to optimize the hyperparameters of the LSTM-based prediction model developed for the IEEE 30-bar system. Instead of manually selecting parameters through trial and error, AG performed an automatic search for the best combination of hyperparameters that would minimize prediction error.

The following hyperparameters were encoded in the AG chromosomes:

- Number of LSTM units per layer: AG explored different configurations of hidden neurons, balancing the complexity of the model and its ability to generalize.
- Number of training seasons: By optimizing this parameter, AG ensured efficient convergence without causing *overfitting* or *underfitting*.
- Dropout rate: AG adjusted the level of regularization to avoid *overfitting*, which is particularly important in sequential models with high representation capacity.

- Learning rate: although it has been fixed in part of the experiments, this parameter can also be optimized by the AG to refine the speed of convergence and the stability of the training.

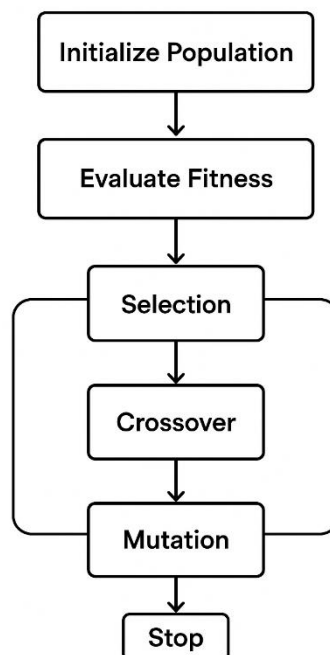
The fitness function was defined as the Mean Absolute Error (MAE) between the predicted and actual load values (active and reactive powers), after training the model with a certain set of hyperparameters. Lower MAE values indicated better performance, guiding the evolutionary search towards more suitable configurations.

With the integration of the AG into the modeling process, the model achieved a final MAE of 0.0507, a result higher than that of reference models with manually adjusted hyperparameters. This performance highlights the efficiency of AGs in exploring large search spaces and their ability to adaptively identify optimal solutions to complex problems, such as time series forecasting in electrical systems.

Figure 7

Genetic Algorithm Schematic

Genetic Algorithm



Source: the authors

3 CASE STUDY AND RESULTS OBTAINED

Once the methodology for the implementation of power flow forecasting was established, its validation necessarily depended on the comparison of the model's performance in relation to a reference case derived from a real distribution feeder.

The code was implemented in Python to predict the active (P) and reactive (Q) powers of a selected load, using as inputs the generation data and auxiliary variables of the system. This approach allows the model to capture temporal and operational patterns inherent in the dynamics of power systems, ensuring accurate short-term forecasts. Such forecasts are crucial for the planning and operation of modern electrical systems, especially in scenarios with distributed generation and fluctuating demand. The procedure adopted and the considerations on the results obtained are presented below.

3.1 SPLITTING THE DATASET

Splitting the dataset is a critical step in ensuring that the model learns reliable patterns and is able to generalize to unseen data. In this study, a temporal division was adopted, allocating 80% of the samples for training and 20% for testing. This division preserves the chronological order of events, avoiding data leakage, a fundamental aspect in time series forecasting. Unlike random splits, which are often used in other machine learning tasks, time sequence maintenance better reflects the model's real-world applications in operational scenarios.

3.2 CONSTRUCTION OF THE SEQUENCES

Since LSTM networks are designed to process sequential data, the code employed a sliding window strategy to construct the temporal sequences. Specifically, each input sequence was composed of 20 consecutive instants of system operation, while the output corresponded to the active and reactive power values of the target load at the subsequent instant. This configuration provides the model with enough historical context to learn the temporal dependencies on the payload's behavior.

3.3 NEURAL NETWORK ARCHITECTURE

The neural network architecture is designed to capture both the temporal and nonlinear dependencies present in the power flow data. It is composed of stacked layers of Bidirectional LSTM, fully connected dense layers, and a linear output layer. Unlike fixed

architectures, the configuration of this model — such as the number of LSTM units per layer and the number of training epochs — was not chosen arbitrarily. Instead, a Genetic Algorithm (GA

Bidirectional LSTM layers: two bidirectional layers with different unit numbers (e.g., 64, 128) were tested, allowing the network to learn temporal dependencies in both forward and reverse. This is especially relevant in electrical systems, where current conditions may depend on both past and evolving states.

Dropout regularization: a *dropout rate* of between 1% and 5% was applied in order to mitigate *overfitting* and ensure that the model generalized well to unseen operating conditions.

Dense Layer: after LSTM, a dense layer of variable size (optimized by the AG) was included to refine the representations learned before the final output.

Output Layer: the final layer contained two neurons, corresponding to the active (P) and reactive (Q) power predictions of the selected load.

3.4 OPTIMIZATION OF HYPERPARAMETERS WITH GENETIC ALGORITHM

The Genetic Algorithm played a central role in choosing the optimal configuration of the model. The candidate solutions (chromosomes) encoded hyperparameters such as the number of LSTM cells per layer and the number of training times. AG evolved these solutions over the generations, through the processes of selection, *crossover*, and mutation, converging on architectures that minimized validation error. This evolutionary approach proved to be efficient in balancing the complexity of the model and its predictive accuracy.

It is important to highlight that the hyperparameters obtained represent the best configuration for the dataset and operational conditions of this study. However, different datasets or electrical system scenarios may require alternative configurations, reinforcing the flexibility of combining LSTM networks and evolutionary optimization techniques such as Genetic Algorithms.

3.5 MODEL COMPILATION AND CONFIGURATION

After defining the architecture, the model was compiled with the following elements:

- **Loss Function:** the Mean Absolute Error (MAE) was used. Unlike Mean Square Error (MSE), which penalizes large deviations more severely, MAE provides a more direct

interpretation metric in the context of power flow, representing the average magnitude of forecast errors in both active and reactive powers.

- Adam Optimizer: Adam (Adaptive Moment Estimation) was adopted, which combines advantages of RMSProp and Stochastic Gradient (SGD). Adam dynamically adjusts the learning rate of each parameter based on first- and second-order estimates (mean and variance), accelerating convergence and ensuring stability in the training of complex sequential data.

3.6 MODEL TRAINING

The training was carried out over 15 seasons, with a batch size of 32 samples. During the training, the following strategies were applied:

Adaptive Learning Rate: although the `ReduceLROnPlateau` *callback* was not explicitly used, the learning rate was adjusted empirically and also by the Genetic Algorithm, ensuring convergence without significant oscillations.

Loss Function Monitoring: training and validation losses were tracked at each time in order to detect signs of *overfitting* or *underfitting*. The evolution of these losses is shown in Figure 7 (Training and Validation Loss Graph), confirming the stable learning process of the model.

3.7 MODEL EVALUATION

After training, the model was evaluated in the test set to measure its generalizability. The evaluation involved the following steps:

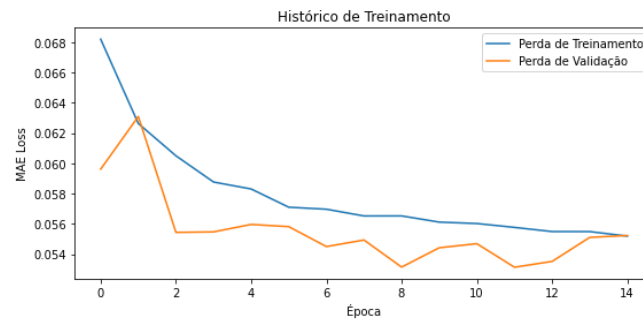
Denormalization: Both the predicted and actual values have been rescaled to their original units using the adjusted *MinMaxScaler* objects. This ensured that the evaluation metrics were interpretable within the physical context of the power flow.

Mean Absolute Error (MAE): the final MAE obtained was 0.0507, reflecting a high degree of accuracy considering the active and reactive power scale in the IEEE 30-bar system. This low error demonstrates the robustness of the model and its ability to capture complex temporal and nonlinear relationships.

Visualization of Forecasts: comparative graphs were generated between actual and predicted values for the active and reactive powers of the target load. These graphs, presented in Figures 8 (Active Power – P2) and 9 (Reactive Power – Q2), highlight the

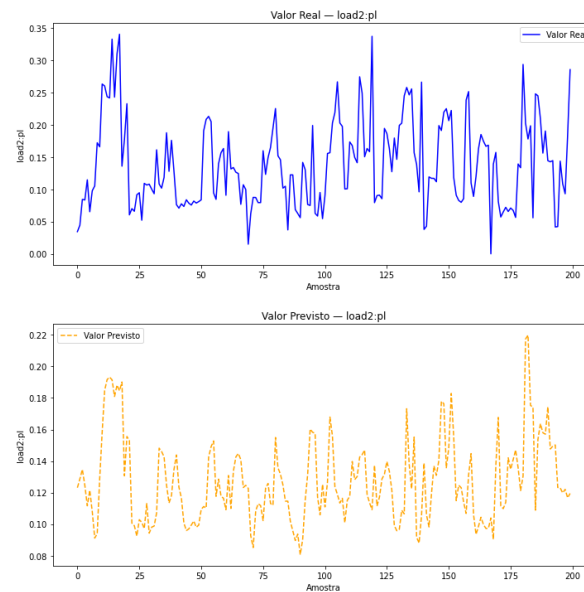
model's ability to follow trends and fluctuations, confirming its effectiveness in short-term prediction of load behavior.

Figure 8
Loss chart



Source: the authors.

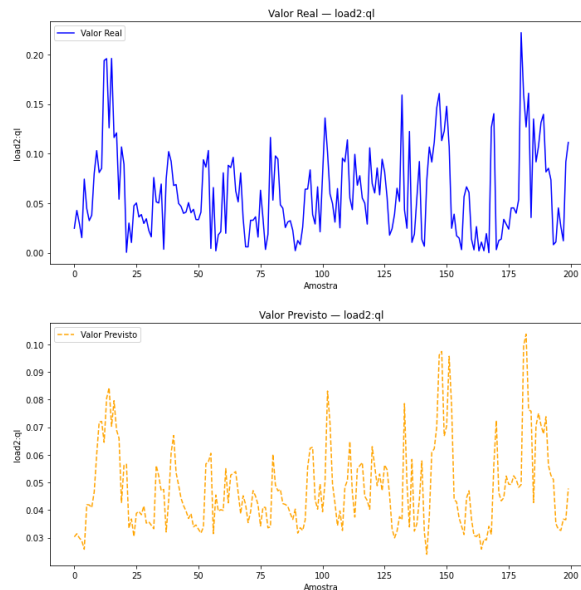
Figure 9
Comparison of actual and forecasted data from P2



Source: the authors.

Figure 10

Comparison of actual and forecasted data from Q2



Source: the authors.

4 STRENGTHS AND LIMITATIONS OF THE STUDY

Most studies that analyze predictions in electrical power systems do not combine recurrent neural network techniques with long-term memory units (LSTM) and Genetic Algorithms (AG) for hyperparameter optimization in load prediction problems. As a strong point of our study, we highlight precisely the use of this integrated approach, which allowed an automatic adaptation of the neural network and reduced subjectivity in the choice of training parameters. In addition, we emphasize that the analysis was performed using data derived from a standard system widely accepted in the literature (IEEE 30 bars), ensuring the reproducibility and comparability of the results. Another positive aspect is that the results achieved a relatively low mean absolute error (MAE), which reinforces the robustness of the proposed model and its practical usefulness for forecasting applications in the electricity sector. Thus, we believe that the results of this study are of great relevance, as they offer initial evidence on the applicability of deep learning techniques combined with evolutionary algorithms in power flow scenarios.

However, we recognize that our study also has limitations. First, it was conducted considering only the prediction of the active and reactive power of a specific load, which restricts the generalization of the results to the entire system. In addition, although the results were satisfactory, the use of simulated data limits the external validity, since noise, measurement failures or contingencies typical of real systems were not considered. Another limiting point is the computational cost associated with the Genetic Algorithm, which can become high in real-time applications or in larger systems. Other limiting factors include the reduced temporality of the analyzed database and the absence of testing under extreme event scenarios or anomalous operating conditions. Although the model has shown predictive capacity under normal conditions, it has not yet been validated in situations of greater variability or electrical disturbances, which are common in real networks.

Therefore, additional research is suggested, especially those involving larger systems and real operation data, to assess the robustness of the model under more challenging conditions. It is also recommended to investigate other optimization metaheuristics, as well as to expand the scope to multiple simultaneous loads, in order to increase the applicability and generalization of the proposed method.

5 CONCLUSIONS

The results obtained in this study demonstrate the effectiveness of Recurrent Neural Network (RNN) models, with Long Short-Term Memory (LSTM) units, for the prediction of load power (active and reactive components) in the IEEE 30-bar system. The proposed model, optimized by means of a Genetic Algorithm for the selection of hyperparameters, achieved a Mean Absolute Error (MAE) of 0.0507, which indicates a high level of accuracy in capturing temporal patterns from historical power flow data.

While the model is designed to predict the active and reactive power of a single load, the methodology can be easily extended to multiple loads and more complex grid configurations. The use of the active and reactive powers of the generators as input variables proved to be sufficient to model the dynamics of the selected load, reducing computational complexity and, at the same time, maintaining a robust predictive performance.

The integration of the Genetic Algorithm was particularly important, as it enabled an automatic search for optimal hyperparameters — such as the number of LSTM cells per layer and the number of training epochs — resulting in higher convergence speed and lower prediction error compared to manually tuned models.

This work represents a significant contribution to the development of intelligent forecasting techniques applied to power systems, offering a solid foundation to improve operational planning, reliability and efficiency in smart grids. Future research may explore the application of this approach to all loads of the IEEE 30-bar system, the inclusion of stochastic renewable sources, and the use of hybrid optimization techniques, with the aim of further refining the predictive capacity of neural network-based models in applications in the electricity sector.

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RELIGION AND THE PUBLIC SECTOR IN BRAZIL: CHALLENGES AND OPPORTUNITIES IN THE ERA OF RELIGIOUS DIVERSITY

RELIGIÃO E SETOR PÚBLICO NO BRASIL: DESAFIOS E OPORTUNIDADES, NA ERA DA DIVERSIDADE RELIGIOSA

LA RELIGIÓN Y EL SECTOR PÚBLICO EN BRASIL: RETOS Y OPORTUNIDADES EN LA ERA DE LA DIVERSIDAD RELIGIOSA

 <https://doi.org/10.56238/sevened2025.036-052>

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ABSTRACT

In Brazil, freedom of belief is a guaranteed right, although there is still discrimination motivated by stereotypes and prejudices. This study addresses the concepts of religion and religious institutions, emphasizing the importance of pluralism and religious freedom for Brazil. The relationship between religion and the public sector is marked by the secular nature of the State and, at the same time, by interference in public policies. Brazil's religious diversity is characterized as broad and dynamic, expressing its history and culture. Education and public policies must foster respect, inclusion and appreciation of the plurality of plurality. The secular nature of the State is to guarantee religious freedom and the neutrality of public space, and to face permanent and constant challenges, to create and preserve impartiality. Religious and cultural pluralism is a wealth and needs to be celebrated and defended, requiring continuous actions to strengthen tolerance and social cohesion.

Keywords: Religion. Diversity. Science. Freedom. Society.

RESUMO

No Brasil, a liberdade de crença é um direito garantido, embora ainda haja discriminação motivada por estereótipos e preconceitos. Este estudo aborda os conceitos de religião e instituições religiosas, enfatizando para o Brasil a importância do pluralismo e da liberdade religiosa. A relação entre religião e setor público é marcada pela laicidade do Estado e, ao mesmo tempo, por interferências nas políticas públicas. A diversidade religiosa do Brasil caracteriza-se como ampla e dinâmica, expressando a história e sua cultura. A educação e as políticas públicas devem fomentar o respeito, a inclusão e a valorização da pluralidade

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da pluralidade. A laicidade do Estado é garantir a liberdade religiosa e a neutralidade do espaço público, e enfrentar desafios permanentes e constantes, para criar e preservar a imparcialidade. O pluralismo religioso e cultural é uma riqueza e precisa ser celebrado e defendido, exigindo ações contínuas para fortalecer a tolerância e a coesão social.

Palavras-chave: Religião. Diversidade. Ciência. Liberdade. Sociedade.

RESUMEN

En Brasil, la libertad de pensamiento es un derecho garantizado, si bien persiste la discriminación motivada por estereotipos y prejuicios. Este estudio aborda los conceptos de religión e instituciones religiosas, enfatizando la importancia del pluralismo y la libertad religiosa para Brasil. La relación entre la religión y el sector público está marcada por el carácter laico del Estado y, a la vez, por la injerencia en las políticas públicas. La diversidad religiosa de Brasil se caracteriza por ser amplia y dinámica, y expresa su historia y cultura. La educación y las políticas públicas deben fomentar el respeto, la inclusión y la valoración de la pluralidad. El carácter laico del Estado garantiza la libertad religiosa y la neutralidad de la esfera pública, y enfrenta desafíos permanentes para crear y preservar la imparcialidad. El pluralismo religioso y cultural constituye una riqueza que debe celebrarse y defenderse, lo que requiere acciones continuas para fortalecer la tolerancia y la cohesión social.

Palabras clave: Religión. Diversidad. Ciencia. Libertad. Sociedad.

1 INTRODUCTION

After World War II, human beings had freedom of religion, as Bittencourt Filho points out⁵. The Government is prohibited from carrying out any religious political persecution, thus protecting the religious freedom of each one, even so it is not proven in a general way, the guarantee of elimination of forms of religious discrimination. The authorities, or the public, present a stereotype that a religion needs, for example: to behave, or to dress. They may not even meet the basic requirements, seeming not to fit into that category, according to religious tolerance, that is, they face accusations that they are acting under the law.

With the needs of changes in modern society, in the religious and spiritual sphere, it is surprising the consequences of the process of any social organization, prevailing social justice, personal fulfillment, self-knowledge and the application and strengthening of religion as an orientation for the positive side of life.

The objective of this article is to analyze the relationship between religion and the public sector in Brazil, highlighting the influence of modernity and the need for inclusive public policies that respect religious diversity. It is intended to understand how religion adapts to social and spiritual changes and how religious pluralism can be a powerful tool for building a more just and inclusive society. The specific objectives are: to investigate how the development of science and technology has impacted religious practices and beliefs in Brazil; to identify the challenges and opportunities generated by the coexistence of different religious traditions, and to discuss the importance of the secularity of the State, in guaranteeing religious freedom and the neutrality of public space.

This study adopts a qualitative approach, based on a literature review and critical analysis of secondary sources. The research is descriptive and exploratory, aiming to understand the complexity of the relationship between religion and the public sector in Brazil. Consult the works of authors such as Peter Berger and José Bittencourt Filho, among others, to support the theoretical analysis.

With these varieties developed by the new religions, which present scientific guidelines of today's society, they use science to achieve goals for spiritual purposes, reflecting on religious diversity, appearing as entrails or distorted, as it was in the past.

The relationship between religion and the public sector is a complex and multifaceted issue, which involves issues of religious freedom, secularity of the State, and the influence of

⁵BITTENCOURT FILHO. José. *Brazilian religious matrix: religiosity and social change*. 2. ed. Vitória: Unida, 2019, p. 30.

religious institutions on public policies. This chapter presents a series of broad quotations that explore these interactions, highlighting the importance of dialogue between the sacred and the profane in the context of public service.

2 RELIGION AND THE PUBLIC SECTOR

Religion for Berger encompasses two aspects: religion in the consciousness and behavior of individuals. The concept of religion compared to superstition, of "unleashing the world, while rationality swept away the old mysteries."⁶ Religion is influenced by modernity, since the development of modern social science there has been the prejudice of the Enlightenment regarding religion. Not being anti-religious in the philosophical version, but that "modernity and religion were empirically antagonistic – to put it simply: the more modernity, the less religion".⁷

The concept of religion according to Berger does not correspond to reality, "but that it is useful in that it allows us to reality, but that it is useful in that it allows us to classify real phenomena and to discover empirically where classifications fail."⁸

According to Berger "an institution is a program and behavior that, when properly internalized, makes the individual act spontaneously and without much or no reflection in the relevant sector of social life".⁹ This behavior depends on each individual, on his conduct, on his relations with society, that is, on social relations and the reality of each one, "[...] the behavior in religious practice until this behavior becomes habitual".¹⁰

Religious institutions struggle with religious freedom, especially "when they claim to possess divinely revealed truths, and even more so when they once had a monopoly position in a society," according to Berger¹¹. In the present day the Modern Catholic Church is extremely instructive, one can identify the fullness of truth.

Corroborating Bittencourt Filho, "From the perspective of the expansion of the religious field, what draws the most attention is the race of religious organizations to have a significant space in the media". For a long time with global development "the medium is the message"

⁶ BERGER, L. Peter. *The multiple altars of modernity: towards a paradigm of religion in a pluralistic era*. Petrópolis: Vozes, 2017, p. 48.

⁷ BERGER, 2017, p. 50.

⁸ BERGER, 2017, p. 47.

⁹ BERGER, 2017, p. 77.

¹⁰ BERGER, 2017, p. 78.

¹¹ BERGER, 2017, p. 84.

adapting to electronic media, in fact the tendencies of the very simple, utilitarianism and exceptional seclusion of religion, a phenomenon of post-modernity¹².

At the time when we are witnessing an unprecedented effervescence in the Brazilian religious field, it is necessary to expand the theoretical collection available if the proper interpretation of the phenomena is desired. More than ever, Brazilian religious pluralism is demanding a concerted effort to be understood. We intend to situate and incorporate not the *a priori* in the religious experience, but according to the sociological nature of the work, to point out the *a priori* dimension of the religiosity of the average Brazilian and to take this dimension as an additional theoretical tool in the hermeneutic effort of the religious panorama in our country, especially in the recent past. [...] to discuss the factors that make the religiosity of the majority of Brazilians unique and original, despite the fact that the Brazilian social formation was and is subordinated to economic, political and cultural determinants common to so many other peoples and nations¹³.

According to Berger, [...] the two effects of pluralism go together – faith as based more on individual choice than on fate or the chance of birth, and faith as institutionalized in form with voluntary modernity."¹⁴ There is a broad affinity with modernity, that is, an affinity that weakens what is taken for granted in institutions, not only religious ones.

For Bittencourt Filho "We live in an intellectual climate that shows a special sympathy for the denaturalization of traditional categories, for decentralization and for a certain view that prioritizes the boundaries of cultural institutions [...]"¹⁵element. Over the years, an internal plurality of Christianity is perceived, making them more complex, or even more problematic, can generate self-reflection.

When pluralism and religious freedom coincide, a specific type of market emerges, so that economic concepts can be applicable. Religious freedom deprives religious institutions of previous monopolistic privileges. Instead, they are forced to compete without resorting to coercion. There will be pressures to control competition, which makes a degree of cooperation practical¹⁶.

Corroborating it further, Bittencourt Filho highlights.

[...] because forms, religious conducts, styles of spirituality and uniform religious conducts, evidence the influential presence of a religious-cultural substrate that we call

¹² BITTENCOURT FILHO, 2019, p. 36.

¹³ BITTENCOURT FILHO, 2019, p. 38-40.

¹⁴ BERGER, 2017, p. 104.

¹⁵ BITTENCOURT FILHO, 2019, p. 32.

¹⁶ BERGER, 2017, p. 102.

the Brazilian Religious Matrix. This expression must be understood in its broad sense, that is, as something that seeks to translate a complex interaction of religious ideas and symbols that have come together in a multi-secular course, therefore, it is not *stricto sensu* a category of definition, but an object of study. This multi-secular process had, as its main development, the gestation of an average religious mentality of Brazilians, a collective representation that goes beyond even the situation of a class in which it is found¹⁷.

With the official Roman Catholicism contributing, his papacy has diversified its strategies in relation to the guidelines, directly directing the Brazilian social space, in relation to the sacred. Roman Catholicism was a protagonist and has currently sought to achieve this position again, but it realized that the alliances of some social movements, in this case, Poles with ecclesiastics, caused confrontations with the old regime, in the cultural and political spheres¹⁸.

"The contemporary world, with few exceptions, is as intensely religious as any other in history."¹⁹

According to Bittencourt Filho "[...] the existence, in the midst of the cultural matrix, of a religious matrix, which provides a collection of characteristic religious and symbolic values, as well as providing a broad and diffuse religiosity among Brazilians".²⁰ However, this certainty reinforces the presence of cultural plurality, values and Brazilian religiosity that persist, despite the changes that occur in society, and that need to continue to be articulated and reproduced.

Thus, religious and cultural forms rejected as idolatrous and/or demonic are considered as a camouflaged religiosity, that is, adapted by itself as an instrument of resistance and preservation of identity in the face of aggression.²¹

Public services, such as health and education, must be provided in a way that respects the religious diversity of users. This includes ensuring that everyone has access to services that meet their specific needs, regardless of their religious beliefs²².

Religion and the public sector in their relationship are not unrelated to challenges and controversies. Issues such as religious education in public schools, the celebration of religious festivities in public spaces, and the participation of religious leaders in political

¹⁷ BITTENCOURT FILHO, 2019, p. 40-41.

¹⁸ BITTENCOURT FILHO, 2019, p. 32.

¹⁹ BERGER, 2017, p. 55.

²⁰ BITTENCOURT FILHO, 2019, p. 17.

²¹ BITTENCOURT FILHO, 2019, p. 57.

²² OLIVEIRA, Ana Paula. *Religious diversity and citizenship*. Brasília: University of Brasilia, 2019a, p. 104.

debates are topics that often generate controversy. It is essential that the State maintains a balance between the protection of religious freedom and the guarantee of the neutrality of public space, respecting the rights of all citizens²³.

Religious institutions are very significant and relevant in society, influencing the values and morals of the city and at the same time in the elaboration of public policies. The Catholic Church in Brazil, since colonial times, has always been involved in social issues, such as education, health and social assistance. This influence can be positive, that is, promote values of solidarity and justice, but it can also, in practice, harm, when religious interests hurt secular principles of the State²⁴.

3 RELIGIOUS DIVERSITY

Brazil is a country characterized by extensive cultural diversity, whose various traditions, religious beliefs, and ethnicities respect each other. Since this is one of the most important characteristics of what is part of our nation. Indigenous, African or European and Asian, all cultures have their influence in Brazil, which is a true melting pot of cuisine that reflects on: music, dance, cuisine and festivities. At the same time, this cultural richness not only enriches us in material possessions, but also compels us to make society a more inclusive and tolerant place, so that all voices can be heard and respected²⁵.

It is essential that Brazilian religious diversity be considered a complex phenomenon, reflecting the history and culture of the country. Whether through the religious mosaic of African-based terreiros and religious syncretism, or through influences from Catholicism, or rising evangelical churches, Brazilian religious diversity has been its contribution to religious myths and practices. The understanding of art itself is fundamental to foster inclusion for everyone, for everyone regarding their religious difference from society. The country, however, is religious diversity in Brazil does not remain, as it has its own trajectory and time permeates its development through social, economic and political considerations²⁶. As this approach needs to be not strict, but an all-encompassing display, to tumultuous it is clear that it is religious voices that must be followed.

²³ SOUZA, Carlos Alberto. *Religion and State: challenges and controversies*. São Paulo: Contexto, 2021, p. 90.

²⁴ PEREIRA, João Carlos. *Religion and politics in contemporary Brazil*. Rio de Janeiro: Civilização Brasileira, 2018, p. 78.

²⁵ SILVA, João. *Brazilian pluralisms*. São Paulo: Brasiliis, 2018, p. 23.

²⁶ COELHO JR., A. G.; MAHFOUD, M. *The spiritual and religious dimensions of human experience: distinctions and connections*. São Paulo: Casa Amarela, 2001, p. 45.

The public sector must promote religious diversity and guarantee all citizens the right to practice their own religion and/or faith without discrimination. This can be achieved through the formulation of public policies that respect and value religious diversity, in addition to the incorporation of educational programs that present the different religious traditions existing in the national territory. Religious diversity represents a cultural richness, which must be celebrated and safeguarded²⁷.

Education exerts an essential diversion in promoting understanding and respect for religious diversification, which is why it is essential that, in a country like Brazil, characterized by religious diversity, schools and educational institutions address this issue in an inclusive and respectful way, thus involving the training of educators who have the skills very well involved to work with religious plurality and the learning of religious that value the diversity of religious and practical curricula. Education for religious diversity is not restricted to formal education, it must permeate all spheres of school life in order to promote an environment of respect and inclusion. In addition, it should also be considered that educational policies need to consider and value the contribution of different religious traditions, and the ability to be recognized and valued for the cultural and moral constitution of students²⁸.

Public policies must consider religious diversity as an essential element for the construction of inclusive citizenship. Educational and social programs that promote respect and understanding between different religious traditions are crucial for social cohesion²⁹.

Interfaith dialogue in the public sector is a powerful tool for conflict resolution and the promotion of peace. Initiatives that encourage collaboration between different religious communities can contribute to the construction of a more harmonious and just society³⁰.

Religious diversity is a reflection of human plurality and the continuous search for meaning and transcendence. In Brazil, plurality is even richer, from indigenous and Afro-Brazilian traditions, to the various Christian denominations and different world beliefs. In this sense, the Brazilian social and cultural construction is enriched and created, enabling inter-religious dialogue and the capacity for tolerance among the race. Peaceful coexistence around the different religions is a challenge and an opportunity; however, it is perhaps the

²⁷ OLIVEIRA, 2019a, p. 123.

²⁸ ABRAMOWICZ, Anete; RODRIGUEZ, Tatiane. *Religious diversity and education: challenges and opportunities*. Brasília: University of Brasilia, 2013, p. 78.

²⁹ OLIVEIRA, 2019a, p. 82.

³⁰ OLIVEIRA, 2019a, p. 128.

bedrock of a more tolerant, inclusive society. Brazil's religious diversity is not like its fetish in terms of tolerance, but of acceptance of differences, which enrich spiritual culture³¹.

4 RELIGIOUS FREEDOM AND SECULARITY OF THE STATE

Religious freedom is the fundamental basis of democracy. In Brazil, the Federal Constitution of 1988 ensures the inviolability of freedom of conscience and belief, as well as the free exercise of religious cults. However, the secularity of the State imposes limits on the direct intervention of religious institutions in public policies, ensuring that the public space is neutral and inclusive for all citizens, regardless of their beliefs³². However, the secularity of the State is a fundamental principle that guarantees religious freedom for all citizens. In a secular state, no religion is privileged, and all are respected and protected³³.

The secularity of the State is fundamental to guarantee equality and religious freedom in a plural society. The public sector must act neutrally, respecting the diversity of beliefs and not privileging any particular religion³⁴.

Religious freedom is an essential human right that must be protected by the state. Secularism ensures that all individuals can practice their faith without interference or discrimination³⁵.

Education in a secular state must promote respect for religious diversity and understanding between different faiths. Educational programs that encourage interreligious dialogue are important for the formation of conscious and tolerant citizens³⁶. However, while secularism is an essential principle for religious freedom, it faces constant challenges. A continuous effort is needed to ensure that the state remains neutral and impartial in religious matters³⁷.

Thus, the secularity of the State is the basis for a healthy religious pluralism, in a pluralistic society, the diversity of beliefs is seen as a richness, and secularism then ensures that all are respected³⁸.

Brazilian religious pluralism was generated by our history of syncretism and miscegenation. From indigenous religions to the nations of Candomblé and Umbanda,

³¹ Arendt, H. *The human condition*. 8. ed. Rio de Janeiro: Editora Polity Press, 2002, p. 120.

³² SILVA, Maria das Graças. *Law and religion in Brazil*. São Paulo: Saraiva, 2020, p. 45.

³³ OLIVEIRA, 2019a, p. 32.

³⁴ OLIVEIRA, 2019a, p. 56.

³⁵ OLIVEIRA, 2019a, p. 45.

³⁶ OLIVEIRA, 2019a, p. 68.

³⁷ OLIVEIRA, 2019a, p. 80.

³⁸ OLIVEIRA, 2019a, p. 92.

including all Christian religions and doctrines, Brazil is a mosaic of religious beliefs and practices. Diversity, however, is a wealth to be celebrated and defended. So it generates challenges, even with the application of interreligious dialogue and free worship to the entire population, even for those who have no religion. The secularity of the State is essential to ensure that all religions are respected and that none of them is favored³⁹.

The political system in Brazil is characterized by the diversity of parties and ideologies, which are reflected by the opinions and interests of society. This political pluralism is necessary for democracy and to ensure that different voices are heard and represented. However, there are major challenges for governance, where party fragmentation can hinder the formation of consensus and the execution of effective public policies. Dialogue between the different political actors must be facilitated, as a permanent effort, so that pluralism serves to cooperate with the country's growth⁴⁰.

Several cultural aspects contribute to the national formation of Brazilian identity. Cultural pluralism serves as a threat and a force that helps enrich our intangible heritage, as a society challenges us to create a more tolerant and inclusive society. From popular celebrations such as carnival and June festivals, to artistic and literary manifestations, cultural diversity exists in almost all spheres, of Brazilian human action. However, it is necessary to know that this diversity is also accompanied by challenges, thus involving social inclusion and combating discrimination. Education is one of the methods that help to overcome these differences in respect and understanding of existing cultural groups⁴¹.

On the one hand, pluralism brings with it many challenges, despite being a richness. It is an undeniable fact that sharing with other cultural, religious and political groups requires a continuous effort to develop dialogue and mutual respect. In this scenario, it is necessary to take into account public policies that value diversity and combat approaches to discrimination. Education for global citizenship, which learns tolerance and respect successively in people, is important, to build a more just and inclusive society. Brazilian pluralism offers a great opportunity to learn about differences, where everyone can achieve the right to live in harmony and equality⁴².

³⁹ SANTOS, Maria. *Religious diversity in Brazil*. Rio de Janeiro: Carioca, 2017, p. 45.

⁴⁰ OLIVEIRA, Carlos. *Political pluralism in Brazil*. Brasília: Capital, 2019b, p. 67.

⁴¹ PEREIRA, Ana. *Identity and pluralism in Brazil*. Salvador: Baiana, 2020, p. 89.

⁴² RIBEIRO, Luís. *Challenges of Brazilian pluralism*. Belo Horizonte: Mineira, 2016, p. 112.

5 FINAL CONSIDERATIONS

The interaction between religion and the public sector is a dynamic and constantly evolving field, that is, it presents multifaceted complexities that reflect social changes. Religious freedom and the secularity of the State are fundamental principles, which must be balanced, to guarantee a just and inclusive society. Religious institutions have an important role to play, but it is very important that the public sector promotes religious diversity, respects the rights of all citizens, creates an inclusive society and poses challenges to peaceful coexistence, regardless of their beliefs.

On the other hand, modernity meant adaptation of religious institutions to the way religions are structured, as a result of social and cultural changes. Science and technology have played an important role in religious beliefs, involving people to seek new approaches to spirituality, in accordance with contemporary values. Thus, this adaptation is a condition for the survival and expenditure of religions in their current context.

People form social, political and economic institutions, because they think and act according to their ideological convictions, consolidating the thought that predominates in the development of their cultural and socio-affective formation, as well as their religious construction. The legal precepts are always remembered through their rules, or doctrines used in the religious field. The view related to religious ideology, even with the relationship of referring to the process of achieving its result, that is, integrating oneself into a Christian religion, can be highlighted: Catholics, Protestants, Evangelicals, Spiritists and Afro-Brazilian religions, thus directing the construction of morals and ethics.

With contemporaneity, the changes that have occurred in the present day, the beliefs and practices in the religious field, have become deliberative, some perhaps identical, but the faith has not changed at all. Thus, religious institutions establish "behavior in religious practice until this behavior becomes habitual, that is, taken for granted" is what Berger describes⁴³.

Therefore, the religious field in Brazil guides us that being Brazilian automatically refuses to be Catholic, but that a large part is Christian. It means the existence of controlling and boosting mobility, ecumenisms and syncretisms/hybridisms, but also religious exclusivism, divergences, ideological or political intolerance and religious racism. There is deinstitutionalization and institutionalization and, simultaneously, the non-religious. Then, he

⁴³ BERGER, 2017, p. 78.

declares that the "Brazilian religious field" is superior to a complex issue, it is a mined percentage, in which the concept itself is at permanent risk.

Religious diversity in Brazil constitutes a broad and dynamic mosaic, composed of its diversity of beliefs and practices, which reflect our culture and history. Religious plurality is a characteristic feature of Brazilian society, involving indigenous and Afro-Brazilian traditions, the various Christian denominations and the various religions of the world. However, this diversity creates challenges, particularly with regard to coexistence and mutual respect between different religious traditions. However, this context brings challenges, with regard to peaceful coexistence and respect for diversity among practitioners of the religion.

The relationship between religion and the public sector is broad, and involves the influence of religious institutions, public policies and social life. The secularity of the State is fundamental to guarantee religious freedom and the neutrality of the public space, ensuring that all beliefs are respected and protected. This study highlighted the importance of inclusive public policies that promote respect and inclusion of religious diversity, contributing to social cohesion and the construction of a more just and harmonious society.

To achieve the proposed objectives, it is essential to engage in educational strategies and public policies that emphasize the appreciation of religious diversity and that stimulate interreligious dialogue. The educational process is a fundamental instrument for the formation of conscious and tolerant citizens in relation to cultural and religious differences. Educational programs that promote dialogue and understanding between different religious traditions are indispensable for building an inclusive society.

In this way, religious diversity in Brazil is a cultural wealth, which should be celebrated and safeguarded. The secularity of the State is important, in the sense of guaranteeing religious freedom and the neutrality of the public space, to establish an environment of coexistence and inclusion. Through inclusive public policies and educational strategies that value religious diversity, we can build a more egalitarian and harmful society, where all voices are respected and heard.

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CHILD CARE IN VULNERABLE TERRITORIES: AN INTEGRATIVE REVIEW

O CUIDADO ÀS CRIANÇAS EM TERRITÓRIOS DE VULNERABILIDADE: UMA REVISÃO INTEGRATIVA

EL CUIDADO DE LOS NIÑOS EN TERRITORIOS DE VULNERABILIDAD: UNA REVISIÓN INTEGRADORA

 <https://doi.org/10.56238/sevened2025.036-053>

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ABSTRACT

Objective: To analyze the main types of care provided to children living in vulnerable territories.

Methodology: This is an integrative, descriptive, and exploratory review with a qualitative approach, developed through the analysis of scientific articles published between 2019 and 2024. The search was conducted in the MEDLINE, BDENF, LILACS, and SciELO databases, accessed via the Virtual Health Library (VHL). Study selection followed the PRISMA protocol, and the data were examined using Thematic Analysis, based on Bardin's Content Analysis method.

Results: Three thematic categories emerged: (1) Care for vulnerable children exposed to situations of violence; (2) Interaction methods for providing care to children; and (3) Government strategies aimed at child care in contexts of vulnerability.

Conclusion: The study highlighted the multiple levels of vulnerability faced by children and the need to expand care strategies that promote welcoming, qualified listening, and protection. It also emphasized the importance of coordination among the State, health professionals, and the community to ensure effective and integrated actions in support of childhood.

Keywords: Child. Vulnerability. Care.

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RESUMO

Objetivo: Analisar os principais cuidados prestados às crianças em territórios de vulnerabilidade.

Metodologia: Trata-se de uma revisão integrativa, descritiva e exploratória, com abordagem qualitativa, desenvolvida por meio da análise de artigos científicos publicados entre 2019 e 2024. A busca foi realizada nas bases MEDLINE, BDENF, LILACS e SCIELO, acessadas pela Biblioteca Virtual em Saúde (BVS). A seleção dos estudos seguiu o protocolo PRISMA, e os dados foram analisados por meio da Técnica de Análise Temática, conforme o método de Análise de Conteúdo proposto por Bardin.

Resultados: Emergiram três categorias temáticas: (1) O cuidado à criança vulnerável em situação de violência; (2) Métodos de interação para a prestação de cuidados à criança; e (3) Estratégias governamentais voltadas ao cuidado da criança em contextos de vulnerabilidade.

Conclusão: O estudo evidenciou os múltiplos níveis de vulnerabilidade enfrentados por crianças e a necessidade de ampliar estratégias de cuidado que promovam acolhimento, escuta qualificada e proteção. Ressalta-se, ainda, a importância da articulação entre Estado, profissionais da saúde e comunidade para garantir ações efetivas e integradas em prol da infância. Incluir o resumo.

Palavras-chave: Criança. Vulnerabilidade. Cuidado.

RESUMEN

Objetivo: Analizar los principales cuidados brindados a los niños en territorios de vulnerabilidad.

Metodología: Se trata de una revisión integradora, descriptiva y exploratoria, con enfoque cualitativo, desarrollada a través del análisis de artículos científicos publicados entre 2019 y 2024. La búsqueda se realizó en las bases de datos MEDLINE, BDENF, LILACS y SciELO, accesadas a través de la Biblioteca Virtual en Salud (BVS). La selección de los estudios siguió el protocolo PRISMA, y los datos fueron examinados mediante la Técnica de Análisis Temático, conforme al método de Análisis de Contenido propuesto por Bardin.

Resultados: Surgieron tres categorías temáticas: (1) El cuidado del niño vulnerable en situación de violencia; (2) Métodos de interacción para la prestación de cuidados al niño; y (3) Estrategias gubernamentales orientadas al cuidado del niño en contextos de vulnerabilidad.

Conclusión: El estudio evidenció los múltiples niveles de vulnerabilidad enfrentados por los niños y la necesidad de ampliar estrategias de cuidado que promuevan acogida, escucha calificada y protección. Asimismo, se resalta la importancia de la articulación entre el Estado, los profesionales de la salud y la comunidad para garantizar acciones efectivas e integradas en favor de la infancia.

Palabras clave: Niño. Vulnerabilidad. Cuidado.

1 INTRODUCTION

Thinking about the child's territory goes beyond simple geographical delimitation. It implies considering the space where they live and interact with their family and community, which is the concrete and symbolic scenario of health care. Reflecting on the territory requires understanding its multiple meanings in the social sciences and collective health, in addition to the practical implications for child care (Souza Prado & Caetano, 2024).

Territorialization in health initially involves revisiting the historicity of the concepts of "territory" and "territoriality", especially in their appropriation by the health sector. Etymologically linked to land possession and symbolic domination, territory has carried material and symbolic dimensions of power since its origin. In the current context, it is also understood as a space of existence, identity, and belonging (Fiocruz, 2023).

In the field of collective health, the territory is seen as a socially produced space, permeated by political, cultural, and economic relations that directly influence living and health conditions. This approach goes beyond a merely technical-administrative view and promotes a broader reading of social flows, structural determinants, and collective identities (Souza Prado & Caetano, 2024; Silva & Oliveira, 2021).

This broader conception also emphasizes that territory is both physical space and "territoryexistence": a place of identity, belonging, and everyday life (Fiocruz, 2023).

In this context, territorialization is configured as an analytical method and strategic practice in primary care. It allows us to know local realities, identify needs, plan interventions, and reveal critical inequalities among children in vulnerable contexts (Ferreira & Lima, 2022; Fiocruz, 2023). By mapping social determinants, such as housing, income, education, and access to services, it promotes more equitable and contextualized actions (Silva & Oliveira, 2021).

Children's social vulnerability reflects inequalities in the social determinants of health (SDH) and a lack of effective policies. Programmatic vulnerability, on the other hand, points to the limitations of the health system and other public policies in ensuring full protection. Children in vulnerable situations face structural and symbolic barriers that compromise their development, citizenship, and well-being (Souza Prado & Caetano, 2024; Ferreira & Lima, 2022).

In this scenario, the strategic role of primary care is strengthened, with qualified teams, capable of working in vulnerable territories in dialogue with communities. The Family Health Strategy, in line with the guidelines of the National Policy for Comprehensive Child Health

Care (PNAISC), defines responsibilities by territory, adjusting the population load according to local vulnerability (Brasil, 2021).

The training of professionals, with teaching-service integration, is fundamental: it requires data systematization, territorial analysis, and permanent education to strengthen a critical approach to health work processes (Silva & Oliveira, 2021; Fiocruz, 2023).

Despite the relevance of the theme, there are still few studies that discuss the organization of comprehensive child health care from the perspective of territorialization and care networks, with a focus on situations of vulnerability. There is, therefore, a scientific and political gap to be addressed.

In this context, the present study is justified by its timeliness and novelty, by proposing a reflective analysis of child care in territories marked by vulnerability. This is a relevant contribution to collective health and nursing, evidencing the strategic role of professional performance in promoting the health of child populations in contexts of risk and inequality.

Therefore, the objective of this study is: To analyze the main care provided to children in vulnerable territories.

2 METHODOLOGY

Study Type

A literature review was carried out of a quantitative nature in relation to the number of selected articles and qualitative in relation to the discussion of the articles (Pereira et al., 2018; Gil, 2017).

This is a bibliographic research of the integrative, descriptive and exploratory review type, with a qualitative approach, which aims at a deep understanding of the phenomenon studied through the analysis of previously published articles (Souza; Silva; Carvalho, 2010).

The integrative review followed six stages: identification of the theme and formulation of the research question by the acronym PICo; establishment of inclusion and exclusion criteria; categorization of studies; evaluation of the selected articles; interpretation of results and synthesis of knowledge (Mendes; Scott; Galvão, 2008).

Search Strategy

To elaborate the research question, the PICo strategy was used, defined as population (children), intervention (care) and context (territories of vulnerability).

Health Sciences descriptors (DeCS) were selected: child, vulnerability, and care, in addition to the MeSH terms: child, care, and vulnerability, combined by the Boolean operator "AND" to optimize the search in Portuguese, English, and Spanish.

Data Collection

Data collection took place electronically between March and April 2024, in the Latin American and Caribbean Literature on Health Sciences (LILACS), Nursing Databases (BDENF), MEDLINE, and Online Scientific Electronic Library (SCIELO) databases, accessed electronically through the Virtual Health Library (VHL). This study used the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) instrument, which consists of a flowchart for the selection of articles, promoting a systematization of the data in order to obtain greater clarity in the research.

Articles available in full and free of charge, which adhered to the theme/objective of the study, scientific articles in Portuguese, English, and Spanish, and in the time frame of the last five years, between 2019 and 2024, were considered.

Duplicate studies, identified by the Rayyan software, studies outside the child age group, and those that did not describe a context of vulnerability were excluded.

Data Analysis

For data analysis, the Thematic Analysis Technique based on the Bardin (2011) method was applied, involving three phases: pre-analysis, exploration and inference. Initially, the collected material was read and organized; then, the recurring themes were identified; and, finally, there was the selection and categorization of the themes, culminating in the critical interpretation of the results (Santos, 2012). The categories were elaborated 'a priori', and the analysis allowed us to evaluate the production of knowledge and discuss the findings.

Ethical Aspects

As this is an integrative review, without direct contact with human beings, submission to the Ethics Committee is waived, according to Resolution No. 466/2012 of the National Health Council. It should be noted that copyright was respected in accordance with Law No. 12,853/2013.

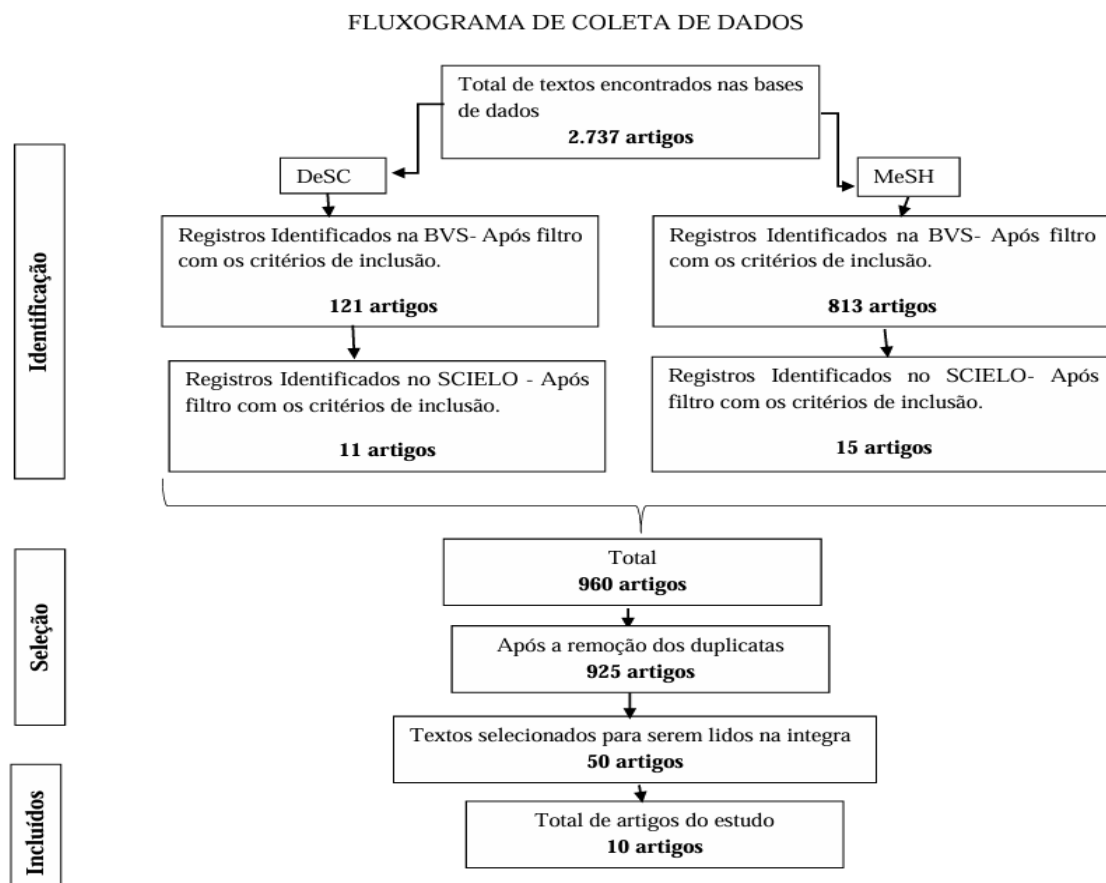
3 RESULTS

Initially, 2,737 articles were identified in the databases, after filtering, 960 remained. Among these, after the elimination of duplicates, through the Rayyan application, 50 were selected to be read in full and of these 10 were selected to compose the study. The screening

process and the number of publications obtained in each stage are exposed in the demonstrative flowchart, shown in Figure 1.

Figure 1

Flowchart demonstrating the search strategies in the databases



Source: Prepared by the authors.

A synoptic table was prepared in order to synthesize the main information of the selected articles. Thus, it became possible to view the title, author, year, objective, method, and journal of publication of the articles included in the review, as described in Chart 1. The articles, when cited in the tables, are represented by the alphanumeric symbology A1, A2... A10.

Table 1

Characterization of the articles analyzed in the integrative review on the care of children in vulnerable territories. Salvador – Bahia, Brazil, 2024, (n=10).

No.	Title	Author	Year	Journals	Goal
A1	Brazilian and Portuguese guidelines for the protection of children vulnerable to violence in the COVID-19 pandemic.	Cabral, L.E. et al	2021	Anna Nery School	Identify and analyze measures to protect children/adolescents vulnerable to violence in the COVID-19 epidemic in Brazil and Portugal.
A2	Psychosocial care for children and adolescents who are victims of sexual violence: perceptions of psychologists from a Creas/Paefi	Martins, J.S; Santos, D.K.	2022	Psychology Science and Profession	To problematize the perceptions of psychologists from a Creas/Paefi in the metropolitan region of Florianópolis about psychosocial care for children and adolescents in situations of sexual violence.
A3	Narratives of child care in a FHSC: The conversation circle strategy	Alaion, AR; Machado, A.M.	2021	Psychology and Society	Contextualize the territory and the implementation of the developed strategy - the Conversation Circle held in a NASF.
A4	Speech-Language Pathology and Audiology performance in a social project: a preliminary study	Puygserver, R.M.M. et al.	2020	Communication Disorders	Propose a speech-language pathology intervention project in a childcare institution; collect data about the children's language before and after the speech-language pathology intervention; to make it possible to overcome language alterations.
A5	Medical student in action: promoting protective factors against sexual violence in vulnerable children	Touso, M.F.S. et al.	2021	Rev. Medicine	To analyze the repercussions of health education activities on sexual violence against children in situations of social vulnerability, enabling a reflection on the exercise of child protection in medical education.
A6	Representations of oral health care for vulnerable children in a city in northeastern Brazil	Cavalcante, P.S.; Gonzalez, R.H.	2022	Health and Society	To analyze the social representations of oral health care for vulnerable children

A7	RISC Units: a strategy for assessing health risks in children in contaminated communities	León-Arce, M. et al.	2023	Rev Panamericana de Salud Pública	Assess and mitigate health risks in children living in areas with environmental contamination.
A8	Full-time education: from deprivation to protection	Rodrigues, M.R.; Santiago, E.J.F.; Rota Júnior, C.	2021	Educational Psychology	To investigate how school education professionals, directly involved with this proposal and who have experienced the daily work in the context of full-time education, have apprehended such changes and, above all, how they perceive the public with which they are dealing: children and adolescents.
A9	Developmental Health in the context of an early childhood program in Brazil: the experience of better early childhood	Gonçalves, T.R.; Duku, E.; Janus, M.	2019	Public Health Notebook	The objective of this study was to identify family and child characteristics associated with developmental health outcomes in children aged 4 to 6 years who participated in Primeira Infância Melhor (PIM), a home visiting program in the state of Rio Grande do Sul, Brazil.
A10	Children and adolescents in situations of social vulnerability in Brazil	Rezende, K.; Cappellari, H.C.L.; Pagani, L.A.G.	2022	Research, Society and Development	To analyze the situation of social vulnerability in our country, through the study of the concepts of social vulnerability, life in society and the meaning of dignity of the human person, in order to understand what the situation of social vulnerability is, as well as the ways to detect it, the pictures as it presents itself in our daily lives.

Source: Prepared by the authors.

Finally, a descriptive analysis was carried out, adopted for the organization and discussion of the evidenced results, in which a synthesis of each study included in the review was presented, organized into thematic categories.

Thematic Categories

Categorization, according to Bardin (2011), aims to simplify raw data through condensation, organizing them into a system of categories. This process can be carried out in two ways: by "boxes" (a priori categories), in which the categories are defined before the analysis based on theoretical foundations, or by "miles" (a posteriori categories), in which the

categories emerge after the analysis of the content. Also, according to the author, good categories should be mutually exclusive, homogeneous, pertinent, objective, faithful and productive.

In view of this, the deductive method (a priori) was chosen. Based on the theoretical foundations, the information was carefully analyzed in line with the specific objectives of this review. Thus, three categories emerged, presented in Chart 2.

Table 2

Analytical categories that emerged from the integrative review on the care of children in vulnerable territories. Salvador – Bahia, Brazil 2024 – Dates

Categories	Title
Category 1	Care for vulnerable children in situations of violence
Category 2	Methods of interaction for child care
Category 3	Government strategies for the care of children in vulnerable situations

Source: Prepared by the authors.

4 DISCUSSION

Care for vulnerable children in situations of violence

Violence against children — physical, psychological, sexual and neglect — constitutes a serious violation of human rights and a challenge to public health. According to Cabral et al. (2021), these forms of aggression affect different age groups and can occur both in the domestic environment and outside it. The situation of social isolation, as experienced during the Covid-19 pandemic, intensified the exposure of children to intrafamily violence, demanding more incisive responses from health and assistance services.

During the pandemic, the protection measures recommended in Brazil included actively listening to victims, removing aggressors, monitoring by health and social assistance professionals, and encouraging reporting through social networks and institutional channels. These strategies were essential, especially in contexts of social vulnerability, in which children already had a history of rights violations (Cabral et al., 2021).

Among the various types of violence, sexual violence is considered the most impactful in childhood. To address it, public policies such as the Specialized Reference Center for Social Assistance (CREAS) and the Specialized Protection and Care for Families and

Individuals (PAEFI) play a fundamental role in the care of victims and their families, with a focus on qualified listening and the construction of protective bonds (Martins & Santos, 2022).

Methods of interaction for child care

Health care for children in vulnerable situations requires the adoption of diverse care technologies, which go beyond equipment (hard technologies), incorporating knowledge (light-hard) and, mainly, interpersonal relationships (soft technologies), such as bonding and welcoming (Alaion & Machado, 2021).

In this sense, strategies such as playful games, conversation circles and the use of drawing as a symbolic expression were pointed out as effective instruments to establish communication with children and collect relevant data about their health. For example, Puygserver et al. (2020) used playful activities to assess children's oral language before and after the speech-language pathology intervention, promoting early diagnosis and appropriate follow-up.

Conversation circles, held in Family Health Support Centers (NASF), also proved effective in addressing topics such as child mental health, enabling a collective space for reflection and listening (Alaion & Machado, 2021). Touse et al. (2021) highlight the importance of health education through playful dynamics, especially in coping with sexual violence, allowing children to recognize risk situations and express their experiences safely.

Another relevant example is the use of the drawing-story technique, reported by Cavalcante and Gonzales (2022), as a tool for understanding children's perceptions of oral care, promoting a space for subjective expression about everyday health practices.

Government strategies for the care of children in vulnerable situations

Given the complexity of the factors involving child vulnerability, intersectoral government strategies become fundamental. León-Arce et al. (2023) propose, for example, the creation of Child Risk Units in Contaminated Areas (RISC), aimed at caring for children exposed to contexts of syndemic vulnerability, which involve overlapping environmental, social, and health risks.

Another essential factor for the child's care is nutritional status. According to Baptista (2019), childhood anemia, associated with poverty, impairs physical, cognitive, and emotional development. In this context, programs such as the National Iron Supplementation Program (PNSF) and Bolsa Família have contributed to improving the nutritional status of children served by the Family Health Strategy.

At the interface between education and health, the More Education Program seeks to extend the school day and strengthen the curriculum in schools with low development indexes, located in vulnerable territories (Rodrigues, Santiago & Rota Junior, 2021). These actions aim not only at school performance, but also at the social protection of children at risk.

In this sense, Primeira Infância Melhor (PIM), a state program of home visits, focuses on the integral development of the child from pregnancy to six years of age. Studies such as the one by Gonçalves, Duku and Janus (2019) reveal positive impacts of PIM on children's development, especially at the time of transition to schooling, reflecting the importance of early care in vulnerable territories.

Finally, despite all the state apparatus aimed at protecting the rights of children and adolescents, the study by Rezende, Cappellari and Pagani (2022) concludes that it is essential that society is sensitized to this reality and acts in accordance with current legal norms. The collaboration of all is essential to promote the integration and protection of this group, respecting their rights and particularities. In this way, in addition to ensuring the healthy development of these — who represent the future — it contributes to the continuity of life in society and to the strengthening of the future of the nation.

5 FINAL CONSIDERATIONS

The analysis of the literature shows that child care in vulnerable territories demands interdisciplinary, intersectoral and territorialized approaches, capable of articulating public policies in the areas of health, education and social assistance.

It is essential to have continuous and qualified training of primary care professionals, so that they can act sensitively and effectively in the face of the multiple expressions of child vulnerability.

The reviewed studies reinforce the importance of strategies that not only guarantee physical care, but also promote the welcoming and active listening of children, respecting their singularities and considering the social contexts in which they are inserted. It is also emphasized the need for accessible and integrated interventions in the territory, which recognize and enhance local resources.

The articulation between the State, health professionals and the community is essential for the implementation of sustainable and transformative actions, capable of promoting equity in child care.

Although this study has limitations regarding the time frame of the publications analyzed, it contributes with relevant subsidies for the understanding of the complexity involved in the care of children in contexts of vulnerability and points out ways to build more integrated and humanized practices.

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**REMOTELY PILOTED AIRCRAFT SYSTEM IN URBAN SOLID WASTE
LANDFILLS (USWL)**

**SISTEMA DE AERONAVE REMOTAMENTE PILOTADA EM ATERROS DE
RESÍDUOS SÓLIDOS URBANOS (ARSU)**

**SISTEMA DE AERONAVES PILOTADAS A DISTANCIA EN VERTEDEROS
URBANOS DE RESIDUOS SÓLIDOS (USWL)**

 <https://doi.org/10.56238/sevened2025.036-054>

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ABSTRACT

Technological progress has expanded the capacity for observing geographic space. Drone technology, or Remotely Piloted Aircraft Systems (RPAS), has been widely disseminated. With the increasing use of RPAS, there is a growing application of this technology for monitoring, inspection, and planning purposes, as well as for obtaining aerial imagery for terrain studies, with special attention to environmental impacts. The use of this aircraft can significantly contribute to reducing environmental damage. The objective of this study is to take advantage of RPAS technology and its generated products to plan safety measures for combating fires in massive urban solid waste deposits. The study addressed the challenge of managing fire control in solid waste landfills, presenting RPAS as a valuable tool for surveying and monitoring these areas, especially during large-scale fire events. It is considered that this work and the proposed methodology were both appropriate and innovative, as they provided a tool-oriented approach for data collection to support fire prevention planning. The results showed that the use of RPAS for area mapping can be useful for fire-fighting planning, particularly in the context of the ARS-Aurá and Guamá sites.

Keywords: Technologies. Overflight. Urban Waste. Fire.

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RESUMO

O progresso tecnológico tem proporcionado uma ampliação da capacidade de observação do espaço geográfico. A tecnologia dos drones ou Sistema de Aeronaves Remotamente Pilotadas (SARP) está sendo amplamente difundida. Com o aumento do uso das SARP, há uma crescente utilização desta tecnologia para monitoramento, fiscalização e planejamento, além da obtenção de imagens aéreas para estudos do relevo, com especial atenção aos impactos ambientais. A utilização dessa aeronave pode contribuir significativamente para a redução dos danos ambientais. O objetivo deste trabalho é aproveitar o SARP aproveitando os recursos dessa aeronave e os produtos que podem ser gerados, visando planejar medidas de segurança para o combate a incêndios em massa de resíduos sólidos urbanos. O trabalho apresentou o desafio de gerenciar o combate ao fogo em aterros de resíduos sólidos, sendo uma ferramenta valiosa para o levantamento e monitoramento dessas áreas, especialmente durante a ocorrência de incêndios em massa. Considera-se que este trabalho e a metodologia proposta foram adequados e inovadores, pois forneceu uma orientação de ferramenta para coleta de dados para o planejamento contra incêndios. Os resultados mostraram que o uso de SARP, para mapeamento de área pode ser útil para o planejamento de combate a incêndios, neste contexto, dos ARS-Aurá e Guamá.

Palavras-chave: Tecnologias. Sobrevoos. Lixo Urbano. Fogo.

RESUMEN

El progreso tecnológico ha ampliado la capacidad de observación del espacio geográfico. La tecnología de drones, o Sistemas de Aeronaves Pilotadas a Distancia (RPAS), se ha difundido ampliamente. Con el creciente uso de RPAS, se observa una aplicación cada vez mayor de esta tecnología para fines de monitoreo, inspección y planificación, así como para la obtención de imágenes aéreas para estudios del terreno, con especial atención a los impactos ambientales. El uso de estas aeronaves puede contribuir significativamente a la reducción del daño ambiental. El objetivo de este estudio es aprovechar la tecnología RPAS y sus productos generados para planificar medidas de seguridad para combatir incendios en grandes depósitos de residuos sólidos urbanos. El estudio abordó el desafío de la gestión del control de incendios en vertederos de residuos sólidos, presentando a los RPAS como una valiosa herramienta para el estudio y monitoreo de estas áreas, especialmente durante incendios de gran magnitud. Se considera que este trabajo y la metodología propuesta fueron apropiados e innovadores, ya que proporcionaron un enfoque orientado a herramientas para la recopilación de datos que apoya la planificación de la prevención de incendios. Los resultados mostraron que el uso de RPAS para el mapeo de áreas puede ser útil para la planificación de la lucha contra incendios, particularmente en el contexto de los sitios de ARS-Aurá y Guamá.

Palabras clave: Tecnologías. Sobrevuelo. Residuos Urbanos. Incendio.

1 INTRODUCTION

The technological advancement of the last decades has transformed the way human beings observe and understand geographical space. Among the most relevant innovations are Remotely Piloted Aircraft Systems (SARP), known as drones. The term "drone", of North American origin, designates remotely controlled aircraft (DE QUEIROZ et al., 2022). SARP is the translation of the term Unmanned Aircraft System (UAS), adopted by the International Civil Aviation Organization (ICAO) (SANTOS, 2019).

Initially aimed at military purposes, SARPs have become widely used in civilian activities, such as environmental monitoring, infrastructure, mining, civil construction, and agriculture (CHOMSKY; VLTCHEK, 2022). This technology makes it possible to obtain accurate information on the earth's surface, at low cost and with high quality, especially revolutionizing geographic mapping (SANTOS, 2021). There are different types of SARPs depending on the purpose: rotary-wing, more popular, and fixed-wing SARPs, with greater autonomy and range.

According to Santos et al. (2020), SARPs provide quick and detailed data, being useful in mapping landfills and dumps, areas frequently affected by fires and fires that cause explosions and environmental and public health damage. Quintas (2005) highlights that the intensity of fires and inadequate landfill infrastructure can cause serious environmental impacts and risks to human health, requiring effective preventive measures.

The National Solid Waste Policy (PNRS), instituted by Law No. 12,305/2010 and regulated by Decree No. 7,404/2010, defines solid waste as materials discarded from human activities that must be managed in a technical, economically feasible and environmentally sustainable manner (BRASIL, 2010). This concern has its roots in the Industrial Revolution, a period in which production and disposal patterns intensified (SEARA et al., 2013), but the issue dates back to the Middle Ages, with the first urban sanitary problems (CÂNDIDO et al., 2009).

Currently, there is a crisis in the management of Urban Solid Waste (MSW), aggravated by accelerated urbanization and the lack of infrastructure. Marques (2011) points out that the inadequate disposal of USW is one of the greatest municipal challenges, due to the lack of resources and technical knowledge. This mismanagement generates impacts such as soil degradation, water contamination, air pollution, and vector proliferation (JACOBI et al., 2021).

In the Metropolitan Region of Belém (RMB), the situation is critical. Belém, Ananindeua and Marituba collect about 40 thousand tons of garbage per day, resulting in bad smells, contamination and inconvenience to the population. Household waste alone corresponds to about 1,620 tons per day (VALE et al., 2015). The inadequate disposal and the risk of reactivation of the old Aurá dump aggravate the local "garbage crisis", intensifying fires in waste masses (PORTELLA, 2014).

Urban Solid Waste Landfills (ARSU) are areas of permanent risk due to the possibility of fires caused by the accumulation of flammable materials, operational failures and climatic factors. Therefore, it is essential to use effective monitoring, control, and prevention methods. In Belém, ARSU have a high risk of combustion, even without receiving hazardous waste, which can cause atmospheric pollution and soil and water contamination.

The use of drones equipped with optical, thermal, and multispectral sensors allows for agile and safe aerial monitoring, identifying hot spots and accurately assessing fire behavior. Thus, the use of SARPs in landfills represents a significant technological innovation, contributing to fire planning, inspection, and prevention, in addition to supporting environmental monitoring (SANTOS, 2021).

Thus, this dissertation aims to analyze the use of SARPs in Urban Solid Waste Landfills (ARSU), highlighting their technical resources and products for the planning of fire prevention and fighting measures. It is intended to demonstrate how this technology can contribute to a safer, more efficient and sustainable management of urban solid waste, integrating technological innovation and environmental responsibility.

2 METHODOLOGY

The research is of a bibliographic, qualitative and descriptive nature, based on the analysis of references on the use of Remotely Piloted Aircraft Systems (SARP) in the management and monitoring of Urban Solid Waste Landfills (ARSU). Books, articles, dissertations and theses on waste management, remote sensing, photogrammetry, geoprocessing and fire prevention were consulted (BRASIL, 2010; GOUVEIA, 2011; FLORENZANO, 2016; SANTOS, 2021). The methodology comprised three stages: data collection, data analysis and fieldwork, integrating remote sensing information and on-site observations.

2.1 DATA COLLECTION

The collection was carried out in the ARSU of the Metropolitan Region of Belém (RMB) using the SARP DJI Mavic 2 Enterprise Advanced, equipped with GNSS L1, IMU, 20 MP RGB and thermal camera, autonomy of 25 minutes and range of 4 km. The experimental flyby took place at 1 pm, under favorable weather conditions measured by the UAV Forecast application (FLORENZANO, 2016). The planning and execution of the flights were done in DroneDeploy® (DD), which allows configuring routes, altitude, and image overlay (DA SILVA et al., 2021). At ARS–Aurá, the flight was carried out at 100 m altitude, with a frontal overlap of 75% and a lateral overlap of 65%, covering 0.217 km² in 13 minutes and generating 252 images. All flights followed the rules of ANAC, DCEA, ANATEL, ANTAQ and ANEEL, according to Santos (2021). The products obtained subsidized the elaboration of high-resolution digital maps for the planning of firefighting actions.

2.2 DATA ANALYSIS

The captured data was processed in DroneDeploy®, with checkpoint verification to improve the accuracy of the orthomosaic and 3D models. Products such as 2D orthomosaic, NDVI, MDE, MDT, thermal model (MIT) and 3D model (M3D) were generated, later integrated into QGIS. This integration allowed spatial manipulation and analysis, resulting in thematic maps at the scale of 1:5,000, used in the planning of firefighting actions (IBAM, 2015). The maps identified buildings, structures and risk areas, providing technical support for operational monitoring.

2.3 FIELDWORK

The fieldwork was essential to validate the data obtained by remote sensing and refine the planning of the flights. The Avenza Maps app was used to mark ground control points and risk areas. Direct observations and photographic records were also carried out to characterize the areas of waste deposition, evaluating variables such as soil type, slope, drainage and occupied area.

In addition, a fire drill and evacuation was conducted at the Urban Waste Processing and Treatment Center (CPTR-Marituba), with the support of the 25th Military Firefighter Group (GBM). The activity made it possible to recognize the operational conditions of the landfill and to prepare a safety plan for preventing and fighting fires and landslides, in accordance with current regulations (SANTOS, 2021). During the exercise, an operational

checklist was applied for flying with SARP, essential for mission planning and support for CBMPA actions.

4 RESULTS AND DISCUSSIONS

The aerial survey carried out with the DJI Mavic 2 Enterprise Advanced model generated products that provided detailed information about the Urban Solid Waste Landfills of the Metropolitan Region of Belém (ARSU-RMB). The first product generated by the remotely piloted aircraft was the digital model, or orthomosaic, which results from the union of several scenes (orthophotos) captured in the ARS-Aurá. The ARS-Aurá orthomosaic consists of a georeferenced aerial image, produced using the DroneDeploy (DD) image processing platform. This means that the spatial elements in the orthophotos — such as the embankment, the massifs, the trees and the buildings — have positions corresponding to their actual geographic location.

The orthomosaic of landfills can be used to collect information, mainly visual and updated, about these areas. It is an essential product for daily use in the activities of ARSU-RMB, and can be used by various sectors, such as engineering, topography, energy, mining, agriculture and, especially, by the Military Fire Department of Pará (CBMPA).

This product is widely used in the construction of image maps and maps, for carrying out inspections, georeferencing, area measurements, map comparison and monitoring of the evolution of projects. In addition, it has direct application in the planning of firefighting actions in the massifs. Figure 1 shows the ARS-Aurá orthomosaic, which enables the pre-mapping and identification of strategic points for firefighting planning, as well as the analysis of other relevant data for understanding the risks and threats in the ARSU-RMB.

Figure 1

Orthomosaic or georeferenced orthophoto of the ARS of Aurá



Source: Author, 2024

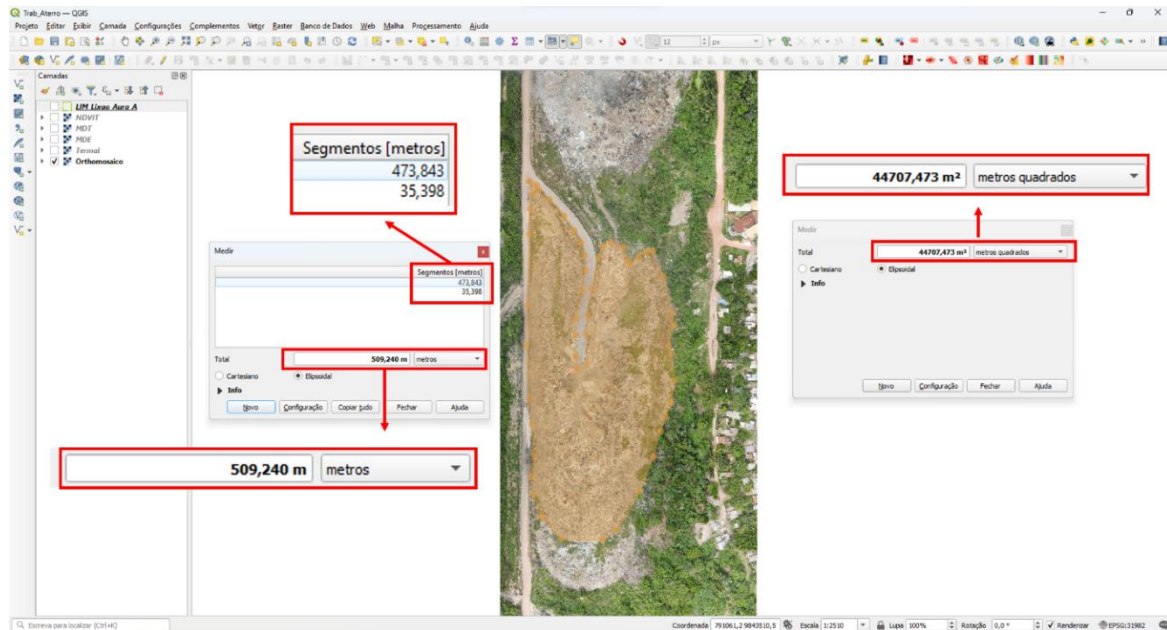
The ARS-Aurá orthomosaic provides a complete vertical view of the area, favoring the performance of forensic examinations and facilitating the collection of information with less intervention and exposure of surveyors or experts. Thus, the use of Remotely Piloted Aircraft Systems (SARP) for the collection of preliminary data in these locations is highly recommended, as it is a tool capable of obtaining, quickly and accurately, a large volume of high-quality data, in addition to allowing the collection of spatial coordinates.

In general, the orthomosaic is the main product generated by SARP, since, through software that joins orthophotos based on common points identified in two or more images — such as DroneDeploy and the Geographic Information System (GIS) QGIS® —, it is possible to carry out direct measurements of distances, areas and angles, in addition to preparing thematic maps or situation plans. with precision, agility and low cost.

With the insertion of the ARS-Aurá orthomosaic in the GIS (Figure 2), measurements, demarcations and analyses become feasible for the tactical and operational use of firefighting and for the establishment of the command post by the Military Fire Department of the State of Pará. The orthomosaic can also serve as a basis for fire and explosion forensics. In the context of planning actions against fires in solid waste landfills, the implementation of QGIS facilitates the manipulation of images captured by SARP, such as the orthomosaic, for the purposes of topographic survey, analysis of the volume of waste in the massif, evaluation of water bodies, positioning of vehicles and implementation of the Incident Command System (SCI). among others. Figure 2 illustrates the application of GIS tools used to measure segments and areas of the ARS-Aurá in the orthomosaic image, as well as in other products automatically obtained by SARP via DroneDeploy (DD).

Figure 21

QGIS interface with ARS-Aurá orthomosaic image



Source: Author, 2023

In the QGIS® SIG, it is also possible to prepare an Image Chart (IC) of the solid waste landfills of the RMB, with the objective of defining strategic points of fire fighting. In addition, this tool enables the detailed identification of structural characteristics, which are fundamental for the composition of technical reports on fire prevention in ARSU-RMB. The ARS-Aurá orthomosaic, with a spatial resolution of 2.04 cm, is a high-precision raster image, which allows the complete visualization of the landfill area and the production of Image Maps (IC) or Digital Maps (DM). These products are used both for surveying spatial information and for the updated visualization of regions of interest, especially in areas subject to fire occurrences in the solid waste massif.

Through the ASRS-Aurá maps (Figure 14), it is possible to carry out inspections, georeferencing, measurements of burned areas and monitor the evolution of firefighting actions carried out by CBMPA. Thus, Figure 3 illustrates the application of the Geographic Information System (GIS) QGIS, with the image of the solid waste landfill of Aurá, used to define strategic firefighting points, in addition to enabling the identification of structural characteristics relevant to the preparation of technical reports on fires.

Figure 32

Image Letter (CI) of ARS-Aurá for the Survey of information of interest



Source: Author, 2024.

Consequently, an Image Chart (IC) generated from the orthomosaic produced by SARP (drone) constitutes a cartographic representation that allows the full and detailed visualization of the mapped area. Among its main benefits, the time savings, the richness of details and the precision in the identification of real points and obstacles on the terrain stand out, which can interfere with the movement of vehicles to the fire outbreaks, contributing significantly to the efficient planning of firefighting.

The cartographic resource can also be viewed through mobile applications, such as Avenza Maps, which has tools for spatial location in an agile and intuitive way, in addition to allowing the exchange of information in real time between the garrisons involved in the occurrences. This resource also helps in the structuring of the Incident Command System (SCI). Figure 4 shows the ARS-Guamá Image Chart viewed in the Avenza Maps application. Thus, the CI, generated in the GIS and exported to the application, assists in decision-making as to the type and amount of resources to be sent to the occurrence, in addition to subsidizing the operational planning of the CBMPA based on updated images, which can be transmitted in real time to the SCI.

Figure 43

CPTR-Marituba (ASRS-Guamá) situation plan on the Avenza Maps App

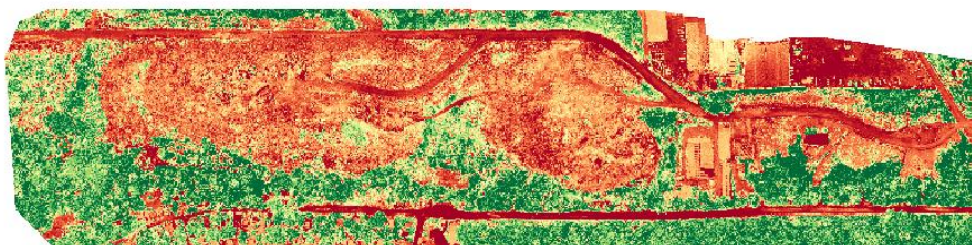


Source: Author, 2024

The Soil and Plant Interaction Image (NDVIT), also generated by SARP, results in the differentiation between occupied and vegetated areas, in a practical and effective way. Figure 16 shows the area of the ARS-Aurá, in which the red color indicates regions without vegetation cover or occupied by structures. The image presented in Figure 5 is an example of the application of Remote Sensing with SARP. In the case of the ARS-Aurá NDVIT, the product represents an essential resource for the characterization and spatialization of the physical environment, serving as a basis for the planning of firefighting actions in landfills. The NDVIT assists in the identification and characterization of soils, vegetation and access roads, which is essential for the planning of CBMPA vehicle positions, since it allows differentiating roads, streets and areas devoid of vegetation.

Figure 5

Georeferenced Soil and Plant Interaction (NDVIT) of the ARS of Aurá



Source: Author, 2024.

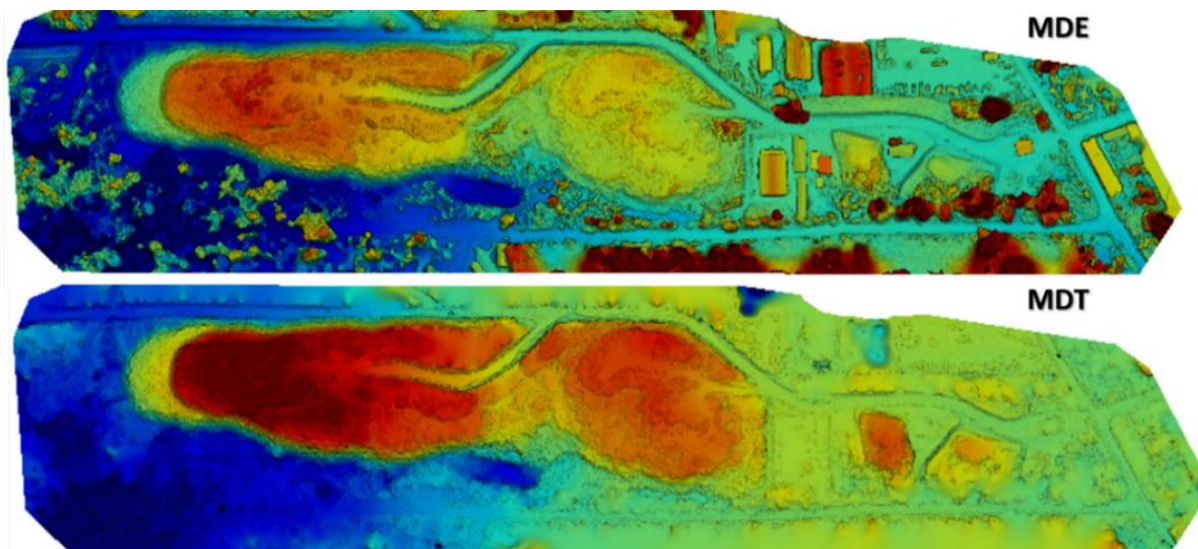
The ARS-Aurá Digital Elevation Model (MDE) and Digital Terrain Model (DTM) are SARP-generated products that represent the surface and terrain in three dimensions, including information on elevation and ground height, vegetation, and man-made structures.

The DEM, also known as the Digital Surface Model (SDM), represents all above-ground objects, such as buildings, trees, vehicles, and people. Although the MDE is not suitable for high-precision altimetry projects, it provides CBMPA with an overview of the ARS-Aurá elevation plan, constituting a valuable resource for firefighting planning. Based on this model, it is possible to build altimetric plans of specific areas, considering elements such as vegetation and buildings, which contributes to safer and more efficient tactical analysis.

In addition, the joint use of the MOU and the MDT of the ASRS-Aurá makes it possible to identify more efficient access routes for CBMPA combat vehicles, taking into account the topography of the terrain. From this information, containment barriers can be planned to prevent the spread of fire in the massif. Figure 6 shows that the MDE and MDT products of the SARP in the ARS-Aurá can be widely used in the planning of firefighting actions. These models must be analyzed in conjunction with other tactical and strategic information defined by the Commander of the Socorro (CMD of SOS). It can be seen in the images that it is possible to identify lower and higher regions of the terrain, as well as areas with the presence of watercourses, which can be used to refuel CBMPA tanker vehicles.

Figure 6

Georeferenced Digital Elevation Model (MDE) and Terrain Model (DTM) of the ARS of Aurá



Source: Author, 2024

The SARP thermal camera is a device that uses infrared technology to capture images containing temperature information. Unlike conventional RGB cameras, which record visible light, thermal cameras detect the infrared radiation emitted by objects based on their temperatures (Figure 18). In this way, this resource generates the thermal imaging product,

which has several applications in firefighting planning in solid waste landfills, enabling the mapping and monitoring of areas.

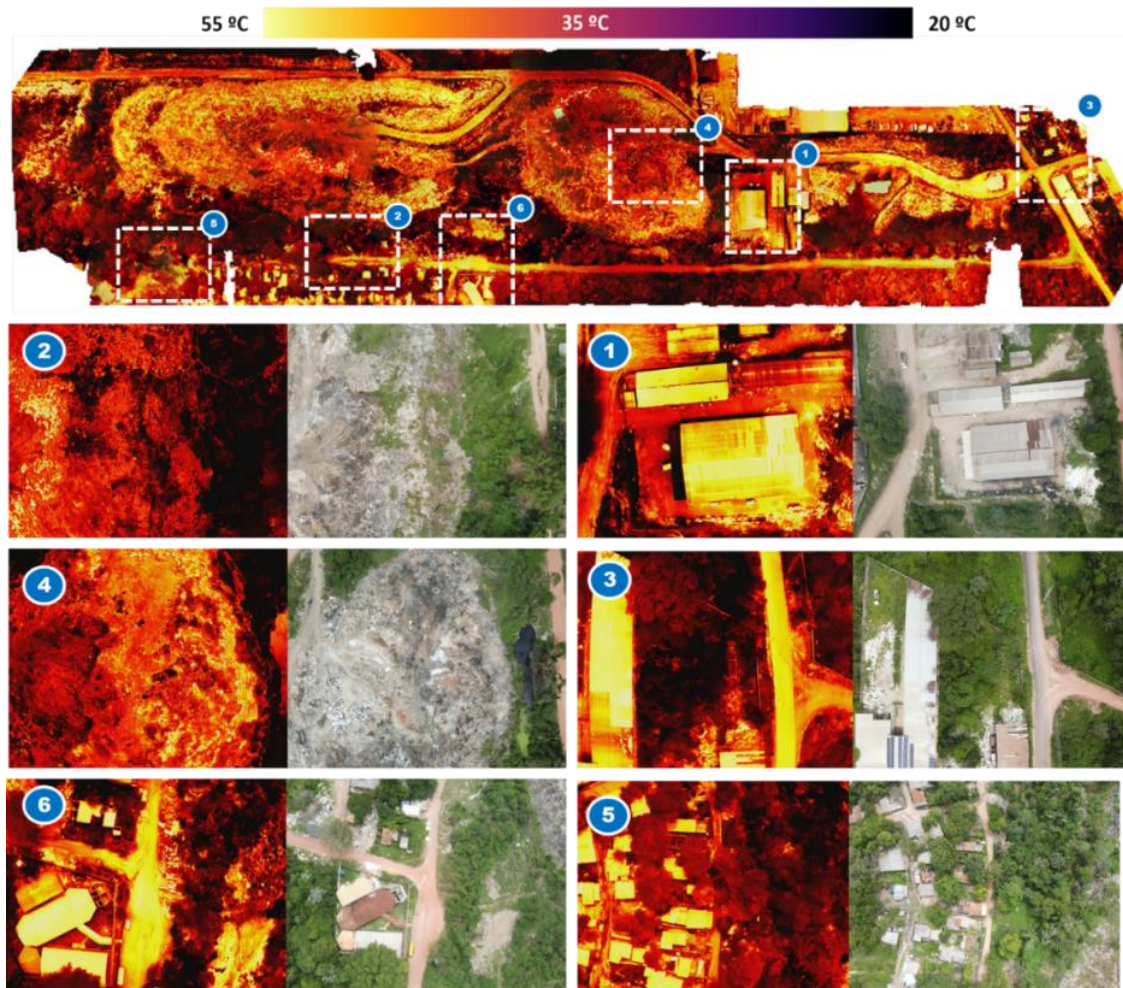
This type of image makes it possible to identify temperature variations and, consequently, thermal patterns, in addition to recognizing hot and cold spots and places that are difficult to access due to thermal intensity. In addition to supporting firefighting planning, the SARP thermal camera can be used in different contexts, such as search and rescue operations, inspections of massif infrastructures (points 2 and 4) and buildings (points 1, 5 and 6), as well as environmental and safety monitoring (point 3) of ARSU-RMB facilities.

The thermal camera applied in the ARS-Aurá captured thermal information that offers valuable perspective in low-visibility situations where conventional optical cameras may not be sufficient, such as at night or in densely vegetated environments. In the context of the ARSU of the RMB, thermal cameras play a fundamental role in the preventive monitoring of hot spots and fires, through the analysis of temperature variations in buildings, roads and homes. Regions in redder tones indicate the presence of high heat or flames, allowing quick and effective responses to prevent the spread of fire.

Figure 8 shows the three-dimensional image of the Solid Waste Landfills of Aurá (ARS-Aurá), with identification of points of interest for firefighting, such as existing buildings, streets, roads and massifs. This representation also helps in locating natural drainage points, which can be used to direct water to the burned areas. The Three-Dimensional Terrain Model (M3D) generated by SARP constitutes a detailed visual representation of the terrain, allowing fire crews to plan more effective combat strategies during and after the event.

Figure 74

Georeferenced Thermal Image of the ARS of Aurá

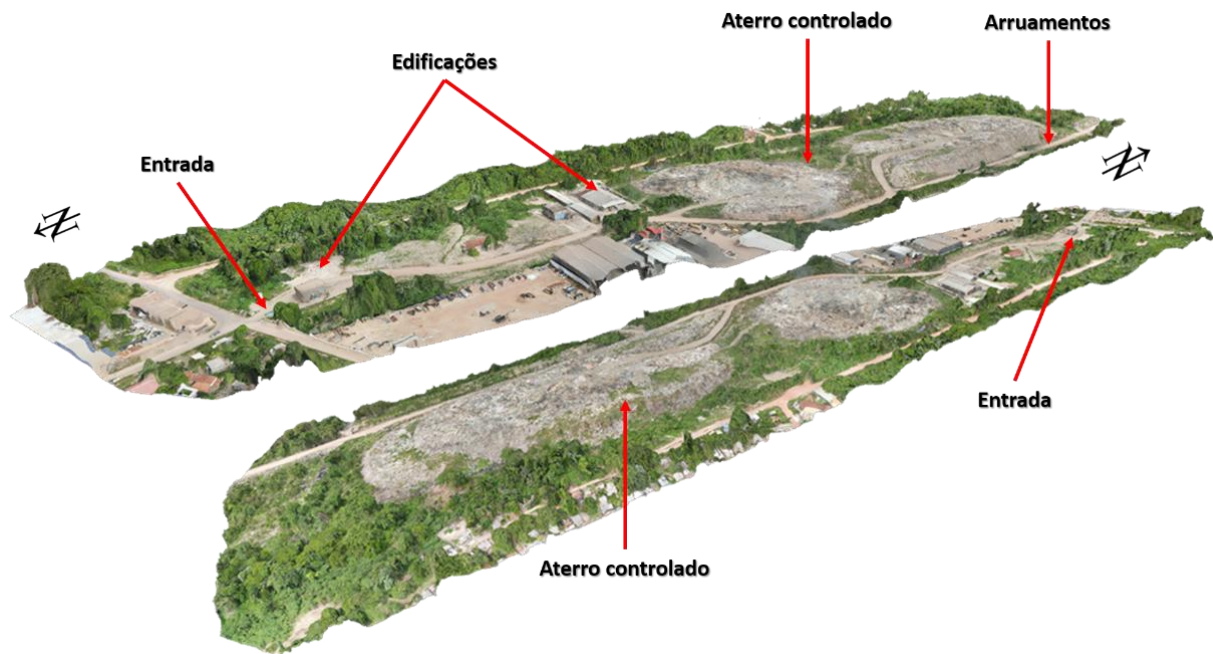


Source: Author, 2024

The 3D model is particularly useful for identifying efficient access routes for combat vehicles, taking into account the topography of the terrain of the ARS-Aurá. With the 3D image of the ARS-Aurá, together with the MDE and the MDT, firefighters can define appropriate combat techniques, such as the application of misty jets of water in rapid and controlled pulses, optimizing the cooling of the massif. M3D stands out, therefore, by allowing the visualization of access points, buildings, roads and natural barriers, which can both hinder the fight against fire and prevent its propagation, as shown in Figure 8.

Figure 8

Three-dimensional Terrain Model (M3D) of ARS-Aurá

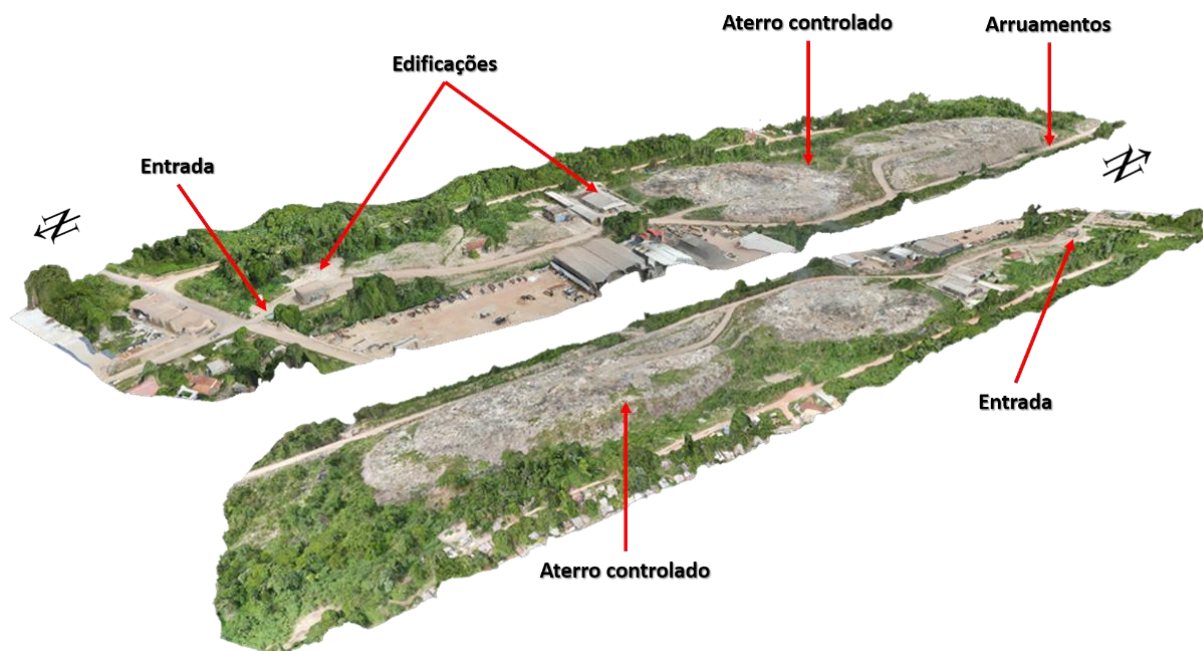


Source: Author, 2024

In Figure 9, it is possible to identify several characteristics and structural elements of the landfill, including buildings susceptible to risk during fires, with the possibility of gauging their heights. The streets and internal paths are clearly visible in the M3D, which is useful for the traffic management of CBMPA vehicles during emergency situations. Finally, with M3D, CBMPA obtains a three-dimensional view of land use, allowing the location of residential, commercial and industrial areas around ARS-Aurá.

Figure 95

Three-dimensional model of the ARS-Aurá structures



Source: Author, 2024.

In Figure 10, still with the 3D image of the ARS-Aurá, vegetated regions and the differentiation of multi-storey buildings are observed, in addition to the estimate of the volume of the landfill. This information is useful for assessing the amount of material needed to cover areas affected by fires. The ARS-Aurá 3D model is extremely valuable for the planning of actions in urban solid waste landfills, as it allows a detailed visualization of the site, facilitating the identification of risk areas and the elaboration of fire prevention and fighting strategies by CBMPA.

Figure 10

Three-dimensional model of the embankments and roads of the ARS-Aurá



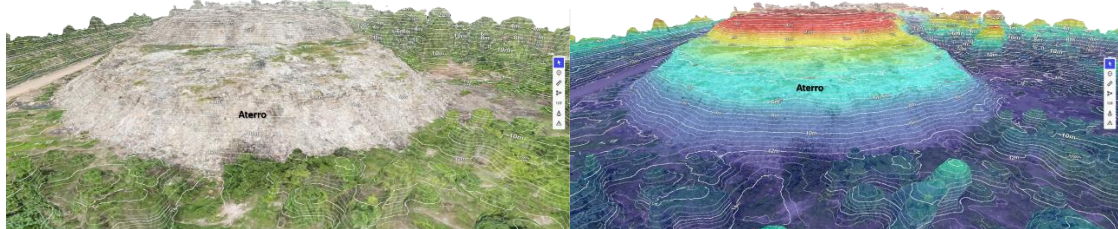
Source: Author, 2024

However, it is important to emphasize that the effectiveness of M3D depends directly on the accuracy of the data collected and the proper processing of the images. The planned flights at an altitude of 100 meters allowed the generation of detailed comparative models, enabling a refined analysis of the earth's surface and the identification of strategic zones for the positioning of combat vehicles. From the georeferenced orthomosaic, combined with other products, such as the Digital Elevation Model (MDE), it is possible to visualize slope values and contour lines, creating an altimetric profile of the ARS-Aurá.

Figure 11 shows the contour lines of the massif, which graphically represent the altitudinal variation of the embankment — essential information for planning access and combat routes, in addition to supporting the evaluation of safe areas for evacuation, when necessary. Thus, the SARP allowed to represent the variation in elevation of the terrain both in the massif and in the surroundings of the landfill. Figure 11 shows the orthomosaic and the MDE of the ARS-Aurá obtained by SARP overflight, associated with the contour lines generated in DroneDeploy, with a spacing of 2 meters between them.

Figure 116

Three-dimensional and elevation model of ARS-Aurá

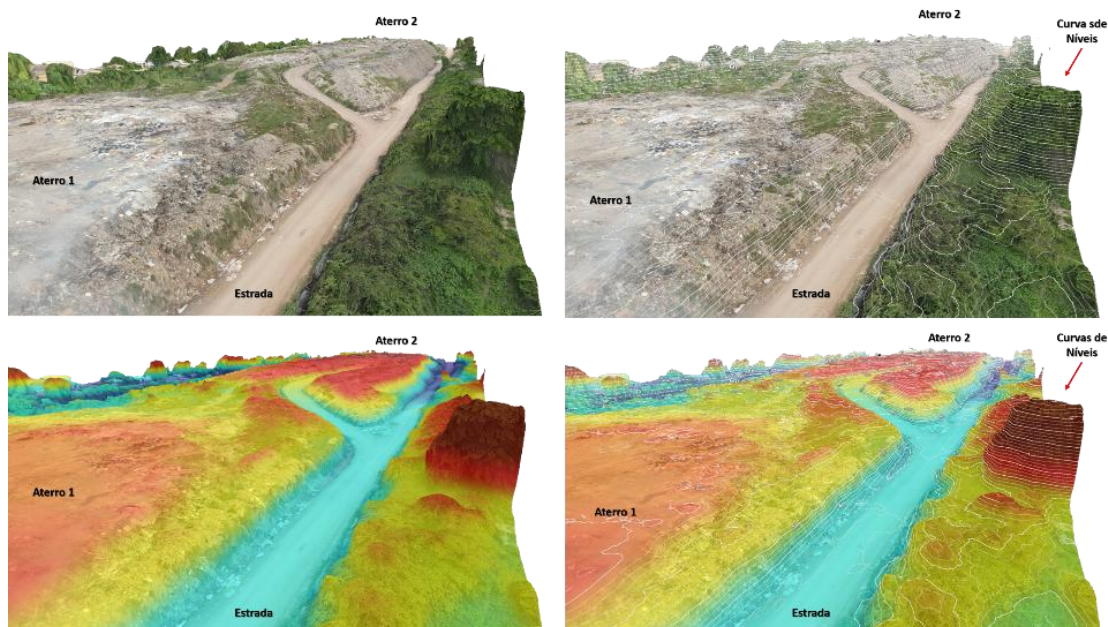


Source: Author, 2024

The products generated by the SARP overflight — such as the M3D, the MDE and the MDT — are widely applicable to firefighting planning, involving several stages of analysis. In this sense, Figure 12 presents an integrated interpretation of the terrain of the ASRS-Aurá, based on the use of orthomosaic, the MDE and the MDT, allowing the identification of areas of greater risk, as well as the planning of access routes for combat vehicles of the CBMPA and the Civil Defense.

Figure 12

Three-dimensional and elevation model of the ARS-Aurá



Source: Author, 2024

The interrelated analysis of SARP products applied to the Urban Solid Waste Landfills of the Metropolitan Region of Belém (ARSU-RMB) contributes significantly to decision-making during dynamic firefighting actions. The configuration of the massif presented in the

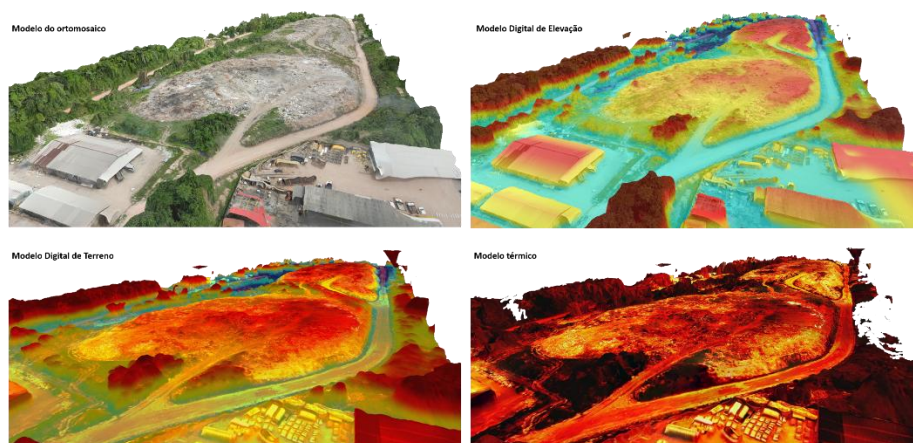
M3D, MDE, MDT models and in the contour lines provides data on height, width and slope, essential factors to assess the structural stability of the terrain and define safe conditions for combat, as illustrated in Figure 13.

In the case of ARS-Aurá, the integrated analysis of SARP products over a specific area facilitates the identification and quantification of objects, such as buildings, including altimetric information. The thermal camera can, in this context, be used to monitor the surface temperature of the landfill during and after fires, especially in regions of greater combustion or potential risk of explosion.

Figure 13 shows that the interrelation of the products generated by the SARP — particularly the high-resolution thermal and orthogonal images — allows for a detailed analysis of the condition of the ARS-Aurá terrain. The association between SARP products should be seen as a strategic tool to support CBMPA, as it enables the monitoring of fire propagation, considering topography, land use and thermal intensity, all from a safe position. This information guides the efficient targeting of combat efforts, taking into account the altimetry achievable by vehicles over the massif and avoiding the exposure of teams to risky situations. Thus, the interrelated use of SARP products in ARSU-RMB provides valuable real-time information, enhancing the safety and effectiveness of firefighting operations.

Figure 137

General SARP products of the ARS of Aurá Metropolitan Region of Belém (RMB)



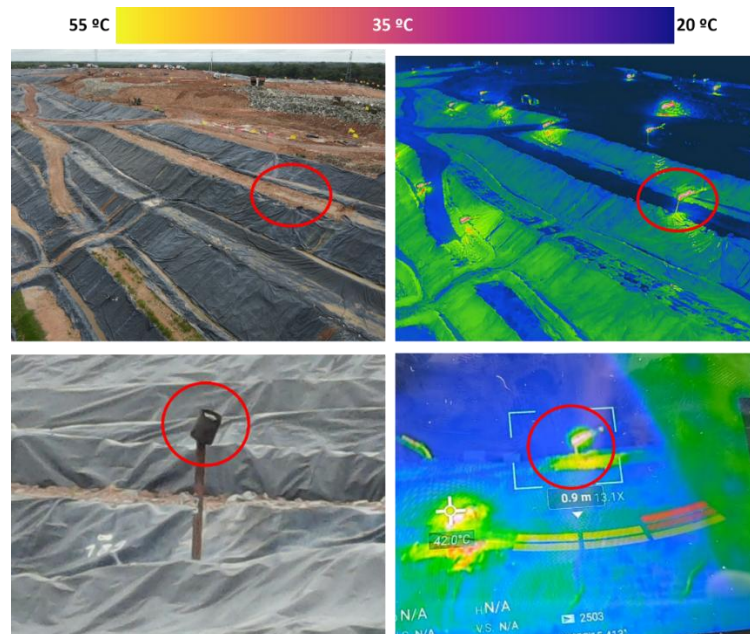
Source: Author, 2024

Specifically in relation to the SARP thermal camera applied to the data collection in the ARS-Guamá, a highly satisfactory performance was observed, especially due to the ability to detect hot spots in the massif, coming from the gas drainage systems. In the case of the ARS-Guamá massif, the flight carried out with the thermal camera made it possible to easily identify the network of vertical drains, interconnected to horizontal drains built at the base of the landfill, used for the controlled burning of the gases generated.

The vertical drain system plays an essential role in reducing the internal pressures of the massif, resulting from the generation of biogas, in addition to conducting the effluents to the appropriate treatment site. Figure 25 shows the vertical drain system of the CPTR-Marituba (ARS-Guamá), as well as the temperature measured by the SARP thermal camera. At the end of the biogas drainage system, a temperature of 42°C was recorded.

Figure 14

ARS-Guamá biogas drainage systems in the SARP thermal chamber



Source: Author, 2024

The thermal camera technology embedded in the SARP represents, therefore, an effective solution for reading and locating heat, through the detection of infrared radiation emitted by objects, allowing to accurately determine the point of thermal origin. This information is crucial for fire attack planning, contributing to quick decision-making and, consequently, saving lives. In this way, the SARP thermal camera allows you to clearly visualize heat sources, consolidating itself as an essential tool in search, rescue, and

firefighting operations in landfills. With the SARP overflight equipped with a thermal camera, it is possible to perform an initial diagnostic image, identifying hot spots in the massif and monitoring temperature changes on the surface of the ARS-Guamá. This diagnosis is obtained by capturing the infrared radiation emitted by the biogas drainage systems, resulting in an accurate thermographic image.

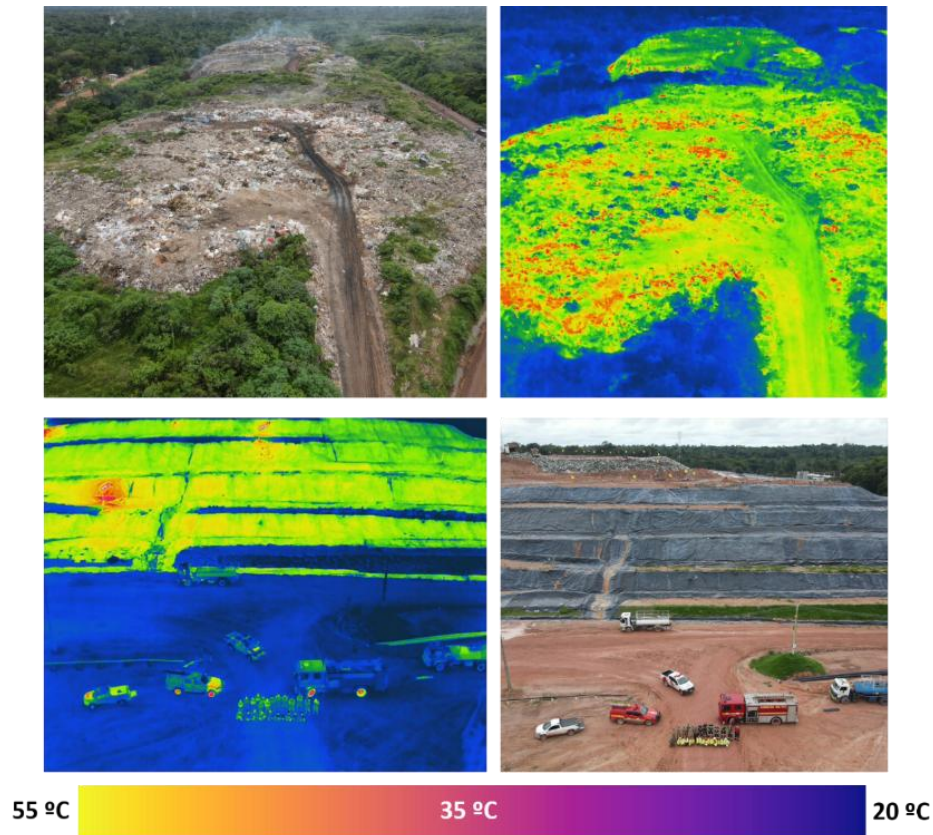
SARP infrared thermography is a fast and low-cost method for detecting hot spots or fire, allowing the targeted displacement of fire crews to carry out fire control and extinguishing actions. The thermographic examination, in the context of this work, has as its main objective to verify the different temperatures in the massif and to provide subsidies for the operational combat action.

The SARP, equipped with a thermal sensor, makes it possible to accurately identify the areas of active flames, represented by the red spots. Also in Figure 15, the massifs of the ASRS-Aurá and ASRS-Guamá landfills stand out, represented in a lateralized RGB image (Red, Green, Blue) — the conventional camera present in all SARPs, which captures images in the visible spectrum of light (the colors perceptible to the human eye). The RGB image is therefore similar to those recorded by ordinary cameras. However, although the RGB camera allows quantitative data to be obtained from the surface, it is not sensitive to temperature variations, which limits its use for thermal analysis.

In this context, SARP thermal images presented a significant advantage, by allowing the rapid detection of hot spots that indicate possible fire outbreaks, enabling more agile and targeted responses to risk situations. Figure 15 illustrates the monitoring overflight carried out in the areas of ARS-Aurá and ARS-Guamá, with RGB and thermal cameras, intended to identify fire outbreaks or abnormal thermal changes, which may indicate conditions of imminent risk during the positioning of CBMPA vehicles to fight the fire.

Figure 15

Application of SARP thermal camera in ARSU-RMB

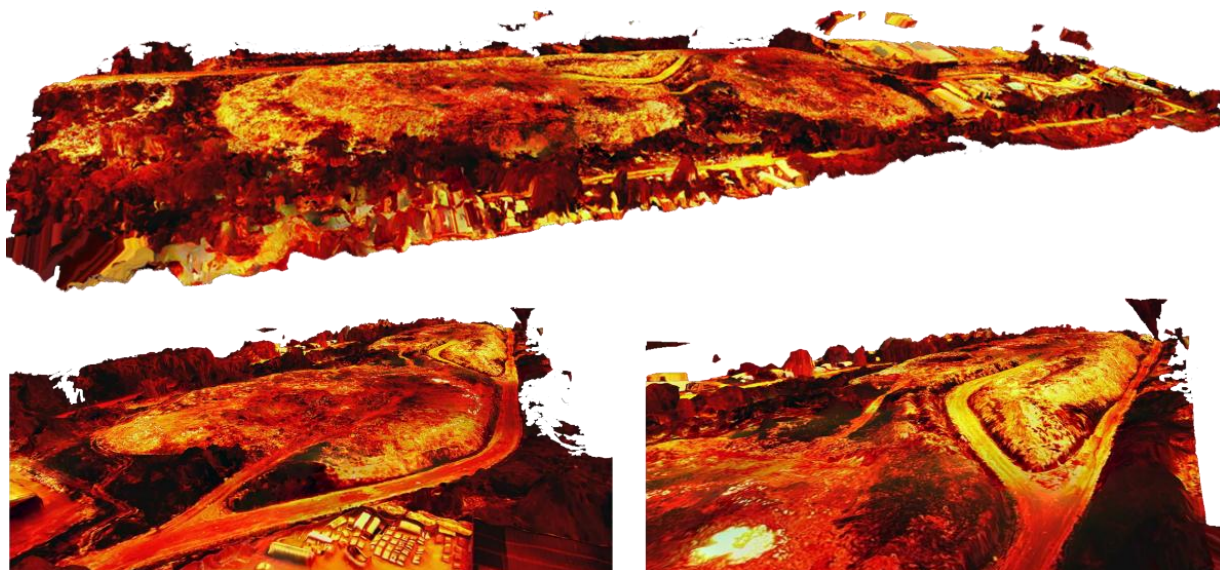


Source: Author, 2024

Also with the use of scheduled overflights with the SARP equipped with a thermal camera, it is possible to generate the Three-Dimensional Model (M3D), which provides a general and detailed view of the landfill, including in areas of difficult access. This model provides comprehensive coverage of the ARSU of the RMB, allowing the identification of strategic access points and the planning of tactical firefighting actions based on three-dimensional information. Figure 16 shows the thermal M3D of the ARS-Aurá, which provides a three-dimensional view of the extension of the land and the strategic access points to the areas of interest, including the streets of the site.

Figure 168

Application of SARP thermal camera in ARS-Aurá



Source: Author, 2024.

The results obtained from the interrelated analyses of SARP products, both in ARS-Guamá and ARS-Aurá, represent significant advances in compliance with fire safety standards, as well as for monitoring and inspection conducted by the Military Fire Department of Pará (CBMPA). Based on the products presented and analyzed in an integrated manner, it is possible to understand more accurately the reality of the ARSU of the RMB, especially from the perspective of the prevention of large fires. These methodologies can also be expanded and applied to other complexes or risk areas, consolidating a model of preventive monitoring and rapid response.

The three-dimensional mapping of the ARSU of the RMB generates high resolution and detailed products, allowing the visualization of elevations, slopes and obstacles existing in the terrain. Such SARP resources and applications directly assist the planning of firefighting operations, by allowing teams to visualize the topography of the terrain and identify critical and risk points. This approach contributes to more efficient allocation of resources by the CBMPA, since teams can be directed based on accurate and up-to-date information provided by the SARP. As a result, there is a reduction in operational response time and optimization of financial and human resources during firefighting operations in RMB landfills.

5 FINAL CONSIDERATIONS

The present work addressed the challenge of managing and fighting fire in urban solid waste landfills, proposing an innovative approach based on the application of the Remotely Piloted Aircraft System (SARP) as a technological tool to support the actions of the Military Fire Department of the State of Pará (CBMPA). This technology has proven to be highly effective in generating high-resolution geospatial products, useful for tactical and operational firefighting planning, with significant gains in efficiency, safety, and accuracy of information.

The use of SARP in the Urban Solid Waste Landfills (ARSU) of Aurá and Guamá proved to be a robust and innovative technical strategy, which allowed the survey, mapping, diagnosis and detailed monitoring of these areas. The proposed methodology proved to be adequate to local conditions and efficient in the collection, processing and analysis of georeferenced data, applicable to the planning of fire fighting and prevention in the Metropolitan Region of Belém (RMB). The results obtained proved the potential of using SARP in the mapping of risk areas and in the production of high-precision geospatial information, with low operational cost and great temporal and spatial flexibility. The products generated, such as orthomosaics, digital elevation models (MDE), terrain models (DTM), three-dimensional models (M3D) and thermal images, proved to be essential for the detection, analysis and monitoring of thermal events, and can be used before, during and after fire occurrences. This capacity increases the efficiency of monitoring and response actions, ensuring greater safety for CBMPA teams and professionals involved in operations.

The aerial surveys carried out with the SARP made it possible to build accurate and up-to-date space bases, with delimitation of the perimeter of the affected areas and generation of image maps and digital maps. These products showed high technical quality and reliability, allowing for rapid data collection and significantly reducing human exposure to risk areas. In addition, they showed potential for application in forensic investigations, enabling a detailed survey of burned areas, the measurement of waste volumes and the analysis of structural damage in the massif and in the surroundings of the landfill.

The integration of thermal and optical images provided a global and dynamic view of the fire scenario, contributing to the efficiency of the Incident Command System (SCI). The real-time monitoring of the evolution of the flames, the identification of multiple hot spots and the analysis of the spread of the fire offered fundamental subsidies for the strategic decision-making of the CBMPA. This integration optimized planning and operational response,

reducing the time of operation and increasing the security of the garrisons and the effectiveness in the use of available resources.

The study demonstrated a pioneering proposal of great practical relevance for the Military Fire Brigade of Pará, by introducing the systematic use of SARP equipped with thermal cameras in the planning and execution of firefighting actions in urban solid waste landfills. This technologically advanced approach has proven to be efficient in the early detection of fire outbreaks and in the management of complex environmental emergencies, contributing directly to the modernization of security and civil defense practices.

The incorporation of the geospatial products generated by the SARP into the operational planning of the CBMPA represents a significant advance in its institutional activities. The data obtained provides accurate and up-to-date information in real time, supporting tactical decision-making, environmental preservation, and the safety of field operations. These products strengthen the integrated management process, allowing CBMPA to act with greater predictability and precision in emergency response actions. Thus, this research reinforces the importance of using emerging technologies of remote sensing and geoprocessing as fundamental tools for the modern and sustainable management of critical areas.

In the context of the Metropolitan Region of Belém, which faces structural challenges in waste management, with the interdiction of the ARS of Guamá and the reactivation of the ARS of Aurá, still classified as an open-air dump, the use of SARP is configured as an innovative, sustainable and indispensable solution to improve operational efficiency and environmental safety in the fight against fires in urban solid waste landfills.

It is therefore concluded that the use of SARP in the management of fires in urban solid waste landfills represents not only a technological and scientific advance, but also a concrete contribution to public safety, environmental management and the protection of life. The proposed methodology serves as a model for the integrated application of geotechnologies aimed at monitoring, prevention, and response to environmental emergencies, reaffirming the commitment to innovation, efficiency, and sustainability in the operations of the Military Fire Department of the State of Pará and other civil defense institutions in the country.

6 FUTURE WORK

Considering the results achieved and the potentialities observed in this research, it is recommended to expand studies involving the use of Remotely Piloted Aircraft Systems (SARP) in the management and monitoring of Urban Solid Waste Landfills (ARSU). The possibilities for improvement include both the technological advancement of data acquisition tools and the integration of new methodologies for spatial analysis and computational intelligence.

First, it is suggested to improve SARP surveys, through the use of multispectral and hyperspectral sensors, capable of increasing the accuracy in the detection of gases and thermal hotspots associated with the combustion and decomposition of waste. This approach can contribute to the early prevention of fires and to the assessment of the environmental impacts resulting from the release of toxic and greenhouse gases.

Another relevant perspective is the integration of the data obtained by the SARP with Geographic Information Systems (GIS) platforms in real time, through Internet of Things (IoT) systems and cloud-based models, which would allow the continuous and automated monitoring of ARSU. The adoption of these technologies would enable the creation of intelligent operational control centers, capable of issuing automatic alerts and optimizing decision-making by the teams of the Military Fire Department of the State of Pará (CBMPA) and civil defense agencies.

It is also recommended to carry out controlled experimental tests to validate the efficiency of thermal detection models in different environmental conditions, such as seasonal variations, solar intensity, relative humidity and wind speed. These experiments may contribute to the development of standardized protocols for SARP operation in emergency scenarios, increasing the reliability of data and the safety of flight missions.

Additionally, it is proposed to apply artificial intelligence (AI) and machine learning techniques for the automated processing of aerial images, in order to improve the classification of critical areas, the identification of thermal patterns and the automatic recognition of fire outbreaks. This approach can reduce operational response time and offer real-time analytical support to CBMPA's field actions.

Finally, it is recommended the establishment of institutional partnerships between universities, environmental agencies, city halls and the Fire Department, aiming at the implementation of public policies for monitoring and waste management based on remote sensing and applied geotechnologies. Such partnerships could contribute to the

modernization of landfill management and the mitigation of environmental risks, especially in the Metropolitan Region of Belém, which still faces serious structural challenges in the final disposal of urban solid waste. In summary, the advancement of studies in this area tends to consolidate the use of SARP as strategic tools to support environmental management and public safety, promoting a more efficient, sustainable and technically based action in the fight against fires in urban solid waste landfills.

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SOCIOECONOMIC REALITY OF INFORMAL CAREGIVERS OF DEPENDENT INDIVIDUALS AT HOME: SCOPE REVIEW

REALIDADE SOCIOECONÔMICA DE CUIDADORES INFORMAIS DE PESSOAS DEPENDENTES EM DOMICÍLIO: REVISÃO DE ESCOPO

REALIDAD SOCIOECONÓMICA DE LOS CUIDADORES INFORMALES DE PERSONAS DEPENDIENTES EN EL HOGAR: REVISIÓN DEL ALCANCE

 <https://doi.org/10.56238/sevened2025.036-055>

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ABSTRACT

An informal caregiver is someone who assumes this role due to an emotional or kinship bond with the person needing assistance, without receiving training or payment. To understand how financial burdens affect the lives of caregivers of dependent adults, it is essential to know the economic reality of these individuals and the financial difficulties they face, especially regarding the expenses necessary for adapting to and maintaining care over time. The objective is to map the available evidence in the literature on the socioeconomic reality of informal caregivers of dependent individuals at home. This is a scoping review, based on the guidelines proposed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR). The guiding question used was: "What is the socioeconomic reality of informal caregivers of dependent adults?" The searches were conducted in the MEDLINE, EMBASE, Web of Science, SCOPUS, LILACS, BDENF databases and on the ProQuest platform to include grey literature using the descriptors "family caregiver", "financial stress", "home care" and "adult". Twenty-four studies were selected, and it was observed that the caregivers were adults, mostly over 40 years old, women, with low income/education levels, and spouses of the patients. Furthermore, they were mostly unemployed, resided in urban areas, and faced difficulties related to social isolation. The patients were adults whose dependency was related to dementia, cancer,

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mental illness, disabilities, or the use of invasive medical devices. It is concluded that the results can improve the knowledge of professionals on this topic, aiming to enhance care and provide support for the development of policies aimed at this population.

Keywords: Caregivers. Financial Stress. Home Nursing. Adult.

RESUMO

O cuidador informal é aquele que assume tal função devido ao vínculo afetivo ou de parentesco com a pessoa que necessita de assistência, sem receber treinamento ou pagamento. Para compreender como os encargos financeiros afetam a vida dos cuidadores de adultos dependentes, é essencial conhecer a realidade econômica desses indivíduos e as dificuldades financeiras enfrentadas, especialmente diante das despesas necessárias para a adaptação e manutenção dos cuidados ao longo do tempo. Objetiva-se mapear as evidências disponíveis sobre a realidade socioeconômica de cuidadores informais de pessoas dependentes em domicílio. Trata-se de uma revisão de escopo, baseada nas orientações propostas pelo *Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews* (PRISMA-ScR). Como pergunta norteadora: “Qual a realidade socioeconômica dos cuidadores informais de adultos dependentes?” As buscas ocorreram nas bases de dados MEDLINE, EMBASE, Web of Science, SCOPUS, LILACS, BDENF e na plataforma ProQuest para inclusão da literatura cinzenta através dos descritores “cuidador familiar”, “estresse financeiro”, “assistência domiciliar” e “adulto”. Foram selecionados 24 estudos, observa-se que os cuidadores eram adultos, majoritariamente acima de 40 anos, mulheres, baixa renda/escolaridade e cônjuges dos pacientes, além disso encontravam-se majoritariamente desempregados, residiam em áreas urbanas e enfrentavam dificuldades com relação ao isolamento social. Os pacientes eram adultos, cuja dependência relacionava-se a demências, câncer, doenças mentais, deficiências ou uso de dispositivos médicos invasivos. Conclui-se que a partir dos resultados pode-se aprimorar o conhecimento de profissionais sobre a temática, visando qualificar a assistência e fornecer subsídios para o desenvolvimento de políticas destinadas a essa população.

Palavras-chave: Cuidadores. Estresse Financeiro. Assistência Domiciliar. Adulto.

RESUMEN

Un cuidador informal es alguien que asume este rol debido a un vínculo emocional o familiar con la persona que necesita asistencia, sin recibir capacitación ni remuneración. Para comprender cómo las cargas financieras afectan la vida de los cuidadores de adultos dependientes, es fundamental conocer la realidad económica de estas personas y comprender las dificultades financieras que enfrentan, especialmente en lo que respecta a los gastos necesarios para adaptarse a la situación y mantener los cuidados a lo largo del tiempo. El objetivo es analizar la evidencia disponible en la literatura sobre la realidad socioeconómica de los cuidadores informales de personas dependientes en el hogar. Se trata de una revisión exploratoria, basada en las directrices de la extensión PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). La pregunta guía fue: “¿Cuál es la realidad socioeconómica de los cuidadores informales de adultos dependientes?”. Las búsquedas se realizaron en las bases de datos MEDLINE, EMBASE, Web of Science, SCOPUS, LILACS y BDENF, así como en la plataforma ProQuest para incluir literatura gris, utilizando los descriptores “cuidador familiar”, “estrés financiero”, “cuidado domiciliario” y “adulto”. Se seleccionaron veinticuatro estudios y se observó que los cuidadores eran adultos, en su mayoría mayores de 40 años, mujeres, con bajos ingresos y

nivel educativo, y cónyuges de los pacientes. Además, la mayoría estaban desempleados, residían en zonas urbanas y enfrentaban dificultades relacionadas con el aislamiento social. Los pacientes eran adultos cuya dependencia se debía a demencia, cáncer, enfermedad mental, discapacidad o el uso de dispositivos médicos invasivos. Se concluye que los resultados pueden mejorar el conocimiento de los profesionales sobre este tema, con el objetivo de optimizar la atención y brindar apoyo para el desarrollo de políticas dirigidas a esta población.

Palabras clave: Cuidadores. Estrés Financiero. Atención Domiciliaria de Salud. Adulto.

1 INTRODUCTION

The dependent person is one who needs assistance to perform basic activities of their daily life and, therefore, requires supervision, help and special care, regardless of the cause that has led to their dependence. In the elderly population, several reasons for dependence are observed, such as cognitive loss or loss of muscle mass, prolonged hospitalizations, falls, or complications resulting from chronic non-communicable diseases (Magalhães *et al*, 2024).

However, there is currently an increase in the number of young people who are dependent, mainly due to external causes, such as accidents or violence. In addition, in the global scenario, the significant increase in young adults affected by conditions that were more common among the elderly population, such as stroke and cardiorespiratory arrest, factors linked to a sedentary lifestyle, inappropriate habits, and high levels of stress (Demoner *et al*, 2025), is worrying.

In this context, caregivers are indispensable figures in the care of dependent people, and can be classified as formal and informal. The formal caregiver is one who has training, remuneration and follows defined schedules to perform their duties. The informal or family caregiver is the one who assumes care due to the affective or kinship bond with the person who needs assistance, performing this activity without training or payment, often dedicating himself fully to this function (Leite *et al*, 2023).

In Brazil, there is no specific aid from the federal government for informal caregivers. Within the disability retirement, an additional 25% is offered to patients who need constant help. This benefit is exclusive to retirees with permanent disability who prove the need for assistance in daily activities such as feeding, dressing, bathing, and getting around (Rozendo *et al*, 2023).

Although intended for dependent patients, not all caregivers are entitled to this benefit, being exclusive to retirees due to disability. Considering the context of informal care and the absence of adequate support for this population, this reality can result in physical exhaustion, anxiety, and overload for caregivers, due to the lack of preparation to meet the high demands required in providing care to a dependent family member, not only emotionally but also financially (Rodrigues *et al*, 2022).

Therefore, in addition to the difficulties related to learning care and the caregiver's personal and family organization, the question arises about how the caregiver organizes himself to deal with care-related expenses. This is because, in addition to the pre-existing financial burdens with their own subsistence and health, they start to assume the expenses

with consultations, exams, hospitalizations, and supplies necessary for the person being cared for (Brito *et al*, 2025).

To understand how financial burdens affect the lives of informal caregivers of dependent adults, it is essential to know the economic reality of these individuals. This sheds light on the financial difficulties faced by families and caregivers, especially in the face of the expenses necessary for the adaptation and maintenance of care over time. It is essential to explore the characteristics of caregivers in the context of home care, with an emphasis on financial issues.

In addition, understanding the main expenses and strategies used by caregivers to obtain the necessary resources can provide valuable information to support the formulation of public policies that offer greater support to this population. Therefore, the objective of this study was to map the evidence available in the literature on the socioeconomic reality of informal caregivers of dependent people at home.

2 METHODOLOGY

2.1 TYPE OF STUDY

This is a scoping review, which followed the guidelines proposed by the *Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews* (PRISMA-ScR) (Page *et al*, 2021). For the construction of the research question, the mnemonic PCC (P-population, C-concept and C-context) was used. Being considered: P- informal caregivers of dependent adults, C-financial reality, C-home care: What is the socioeconomic reality of informal caregivers of dependent adults? Auxiliary questions were used to deepen the review: What are the consequences brought to the caregiver's life in the face of financial complications?

2.2 SELECTION OF STUDIES

The inclusion criteria were: scientific articles published in full, available free of charge, with a quantitative focus; official materials; regardless of the language of publication (Concept); in individuals over 18 years of age who are dependent on care (Population); in a home care environment; regardless of the country of origin and/or language of publication (Context), in addition to Course Completion Work, Dissertations and/or Theses included through the grey literature. Qualitative studies and study protocols were excluded, with no publication of results.

2.3 DATA COLLECTION

For the initial search, combinations of terms available in the *Medical Subject Headings* (MeSH) were used: *Caregivers*, *Financial Stress*, *Home Nursing*, *Adult* in the PUBMED, EMBASE, Web of Science, SCOPUS, Latin American and Caribbean Literature on Health Sciences (LILACS), Nursing Database (BDENF) and the ProQuest platform to include gray literature. In the Virtual Health Library (VHL), the following Health Sciences Descriptors (DeCS) were used: Family caregiver, Financial stress, Home care, Adult. In order to increase the number of articles, a cross-search was used between the keywords using the Boolean connector *AND* following the same combination in all search locations, namely: "*Caregivers AND Financial Stress AND Home Nursing AND Adult*". Data collection took place between October and November 2024.

2.4 DATA ANALYSIS AND PROCESSING

According to the adaptation of the PRISMA-ScR recommendations (Page *et al*, 2021), data selection occurred in the following steps: 1) Initial search in search strategies; 2) Analysis of title and abstract and exclusion of those who did not fit any of the criteria; 3) Full reading of the selected works; and 4) Evaluation of the reference list of sources selected from the full text and/or included in the review.

To facilitate the extraction of the information presented in the studies, the free online platform RAYYAN® was used, which helps in conducting reviews by exporting the information from the databases, creating a selection of content from the articles that facilitate their choice, namely: identification, title, year of publication, indexing base, journal, level of evidence, objective, study design, main results and conclusion.

For the level of evidence, the following were considered: level I systematic reviews or meta-analyses of Randomized Controlled Clinical Trials (RCTs); level II evidence obtained from at least one well-designed RCT; level III well-designed clinical trials without randomization; level IV study with a non-experimental design such as descriptive correlational research or case studies; level V obtained from systematic reviews of descriptive or qualitative studies; level VI from a single descriptive or qualitative study; and level VII evidence originating from the opinion of authorities and/or a committee of experts (Galvão, 2006).

The data were mapped in a descriptive way, using simple frequency counting of concepts, populations, and other characteristics that contemplate the research questions. A

descriptive qualitative analysis of the content was also conducted, including basic data coding. From the analysis of the articles, a conceptual map was constructed to outline the results. The articles were identified with the letter A (article) and the number corresponding to their availability in the text. Example: A1

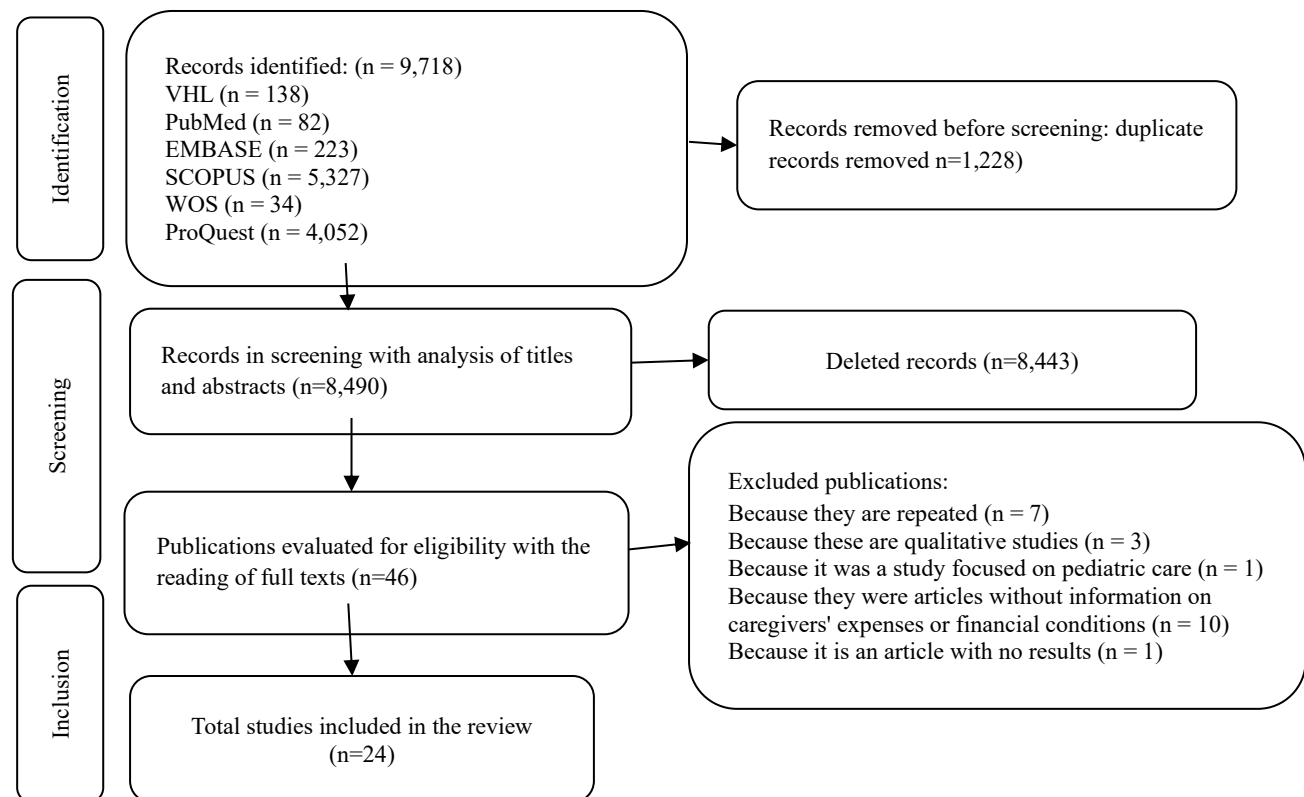
The project was registered in the *Open Science Framework* (OSF) Platform, as it is a scoping review carried out from public domain data, it was not submitted to the Human Research Ethics Committee, but all the ethical principles contained in Resolution No. 466/2012 were followed.

3 RESULTS AND DISCUSSIONS

Among the 9,718 articles located in the databases, 24 were part of this review. The selection of articles is described in the following flowchart (Figure 1).

Figure 1

Flowchart according to PRISMA-ScR criteria. Maringá, PR, Brazil 2024



Source: Adaptation of the PRISMA-ScR flowchart (Page *et al*, 2021).

All studies (n=24) were published in English, with a mainly cross-sectional study design. The population of informal caregivers was adult, mostly over 40 years of age (mean of 51.9). The number of caregivers included in the surveys ranged from 29 to 3,047 (mean 352), most of them women, being spouses or daughters of the patients.

Regarding the care recipient, all were dependent and adults over 18 years old. As a diagnosis that led them to dependence, we find mainly dementia, stroke, cancers, patients with mental illnesses who need help in activities of daily living, as well as individuals with disabilities, whether resulting from accidents or chronic issues.

In addition to dependence, some patients used enteral nutrition, home mechanical ventilation, and hemodialysis and outpatient chemotherapy treatments, which required locomotion and availability of follow-up by caregivers, factors that were predictive of increased expenses. The characterization of the articles selected for review is presented in the following table (Table 1).

Table 1

Characterization of the articles that make up this review (n=24). Maringá, PR, Brazil, 2025

ID	Author/Journal/Year/Country	Type of study/ Sample	Main results	Level of evidence
A1	Papastavrou et al Adv Nurs Cyprus 2007	Descriptive cross-sectional study/172 dyads	Regarding education, elementary school graduates had a higher burden compared to master's/doctoral holders. Regarding income, caregivers with high income had lower scores on the burden scale.	IV
A2	Güneş et al HealthMED Turkey 2012	Cross-sectional descriptive study/102 caregivers	Low education and being the patient's spouse were associated with a higher level of financial burden.	IV
A3	Akpan-Idiok et al Pan Afr Med J Nigeria 2014	Cross-sectional descriptive study/210	The caregivers studied had trivial burden or no overload. Informal caregivers experienced the following forms of burden: physical, psychological,	IV

		caregivers	financial and social, with the psychological and social forms of burden being the ones of greatest magnitude.	
A4	Aggar et al ACT Australia 2014	Cross-sectional study/119 caregivers	Approximately one-quarter (24%) provided care for more than 40 hours per week. Most caregivers (80%) provided transportation assistance for their frail elderly relative. Assistance with communication (37%) and self-care (36%) were the least frequent support activities provided	IV
A5	Dhandapani et al Surg Neurol Int India 2015	Descriptive cross-sectional study/70 caregivers	87% of caregivers reported that caregiving contributed to financial strain; Caregiver burden was significantly higher among caregivers who were unemployed, had low incomes, could not meet their needs comfortably, spent <8 hours a day on caregiving activities, and those who were ill.	IV
A6	Hartnett et al Clin J Oncol Nurs USA 2016	Cross-sectional descriptive study/50 caregivers	Caregivers who reported an income of less than \$90,000 per year noted greater financial burden. Participants without a college degree had higher levels of financial burden. Unemployed or retired caregivers reported higher levels of schedule disruption than those who were employed. Most were not prepared for the potential changes in their lives, such as time demands, adjustments in work schedules.	IV
A7	Nortey et al Int J Equity Health Ghana 2017	Retrospective cross-sectional study/108 caregivers	Approximately 62% of caregivers indicated that their finances worsened as a result of caregiving. The average time of care per month was estimated at 219.5 (±25.9) hours.	IV
A8	Liu et al	Observational	Caregivers reported increased medical	IV

	Medicine Taiwan 2017	study/160 caregivers	bills and expenses with hiring a caregiver, resulting in a frugal lifestyle.	
A9	Crouch et al RRH USA 2017	Cross-sectional study/1,248 caregivers	Other factors associated with fair/poor health included caregiver burden, employment status, and income. Caregivers with a high level of burden were more likely to report poor to fair health. Employed caregivers had lower odds of reasonable to poor health than caregivers who were not employed. Finally, the odds of self-reported fair/poor health decreased with income. Caregivers with high levels of caregiving burden were more likely to experience financial strain, emotional strain, and physical strain.	IV
A10	Strange et al UoR USA 2018	Correlational study/29 caregivers	Most of the participants had two other adults living in the household. The results showed that there was no statistically significant difference between income levels (48%).	IV
A11	Wu et al Ann Palliat Med China 2020	Cross-sectional study poll/242 dyads (patient and caregiver)	For family members who directly cared for disabled stroke patients, 22.7% felt that the stress of care was too high, and 26.9% of respondents answered that the financial pressure of hospitalization was heavy. The proportion of family members who had financial pressure was more extensive than those with caregiving stress;	IV
A12	Tough et al Int J Equity Health Switzerland 2020	Cross-sectional study/118 dyads	Caregivers with higher incomes, educational level, and subjective social position, and those who owned their own home or who did not indicate any financial hardship reported a lower	IV

			propensity for caregiver burden.	
A13	DiGiacomo et al ACT Australia 2020	Cross-sectional study/3,047 caregivers	132 caregivers reported that they experienced one or more types of financial stress. The demographic variables that were found to be associated with the experience of financial stress were having a spouse/partner, owning/buying housing, not having a paid job, and a family income of \$60,000 (AUD) or less. Of the 132 caregivers who reported financial stress, (n=49) reported more than one type of financial stress. The most commonly reported stress-related indicator was seeking help from community organizations or friends/family (n=88) followed by inability to pay bills on time (n=58).	IV
A14	Chhetri et al JNMA Nepal 2020	Cross-sectional descriptive study/123 caregivers	Most caregivers (60) had mild to moderate burden and 53 had moderate to severe burden. The overall mean overload score was 39.30 ± 11.68 .	IV
A15	Chiari et al Dement Geriatr Cogn Dis Extra Italy 2021	Cross-sectional study/92 dyads	Longer duration of illness, being a wife or partner, and having more days off work reduced caregiver distress and, consequently, burden. Likewise, financial suffering increased psychological suffering and, consequently, overload. On the other hand, the delay in diagnosis, the age of the caregiver and the representatives of the family or social network had a 100% direct effect on the caregiver's burden.	IV
A16	Schaffler-Schaden Brain Sci Austria	Multicenter cross-	Regarding employment, caregivers who work part-time had a higher burden of	IV

	2021	sectional study/113 caregivers	financial stress than caregivers who work full-time. There were no male caregivers who worked part-time. In general, working caregivers had a lower burden than retired caregivers	
A17	French et al Clin Nutr United Kingdom 2022	Multicenter cross-sectional study/339 caregivers	Employment status, type of illness, number of nights on PNH (home enteral nutrition), time on PNH, and number of hours on PNH were not associated with subjective workload.	IV
A18	Zhang et al BMC Geriatr USA 2023	Longitudinal study/1,065 caregivers	After multivariate adjustment, caregivers of PCD in the high burden class of comorbidity scored 0.46 points higher of burden of physical care than those in the class of low burden of comorbidity.	IV
A19	Metin et al Support Care Cancer Turkey 2023	Cross-sectional study/113 caregivers	In assessing the financial situation of caregivers, 69% paid extra fuel costs, 60.2% paid taxi or public transportation costs, 48.7% made additional payments for medications covered by health insurance, and 44.2% paid exam fees to receive treatment for their patients. It was found that 42.5% of caregivers experienced financial and economic difficulties due to the costs of treating and caring for their patients.	IV
A20	Folwarski et al Clin Nutr Poland 2024	Multicenter cross-sectional study/90 caregivers	Individual perceptions of quality of life were significantly correlated with financial satisfaction, life satisfaction, income per person in the household, sleep quality, and depression. 51.2% of caregivers were dissatisfied with their financial situation.	IV
A21	Plaszewska-Żywko et al BMC Nurs Poland	Cross-sectional study/58	Caregivers scored significantly higher in the general strain domain than caregivers. Considering the financial	IV

	2024	caregivers	situation, no statistical significance was revealed in the general strain subscale; however, differences were observed in the distribution of the isolation and disappointment variables between the groups of financial situation.	
A22	Agyemang-Duah et al BMC Prim Care Ghana 2024	Cross-sectional study/1,853 caregivers	Compared to urban caregivers, rural caregivers reported that they had no financial problems due to loss of income; There was an association between caregivers' income and burden. Lastly, participants without financial support needs have a reduced stress load compared to those with financial support needs.	IV
A23	Marega et al SPPE Gambia 2024	Cross-sectional descriptive study/161 caregivers	The results show that most caregivers (n=100) had financial problems, (n=63) missed work, (n=60) had difficulty concentrating at work, and (n=136) had unexplained treatment expenses almost always. Regarding the degree of financial burden (n=89), they presented high levels of financial burden.	IV
A24	Edward et al Psycho-Oncol USA 2024	Cross-sectional study/34 dyads	Most participants had COST scores $\leq$ 24. More than half of the dyads were made up of married couples. Other caregivers included adult children (26%), friends (12%), or someone else (38%). More than half of the dyads indicated that a caregiver in the dyad had taken paid or unpaid time off to care for the patient.	IV

Source: The authors (2025).

The results will be presented in two strands, firstly the socioeconomic information of the caregivers, such as monthly/annual income, level of education, employment, expenses

related to care and financial help received and then the variables that impact the financial reality.

Regarding the socioeconomic characterization of caregivers, not all articles provided detailed and numerical information on family income and care-related expenses, which is a difficulty found in the study.

Among the articles that included this information, the caregivers had a monthly income between US\$ 99.50 (R\$ 240) (A8) and US\$ 4,773 (R\$ 45,751) (A13); and annually between US\$ 75,000 (R\$ 462,375) (A10) and US\$ 90,000 (R\$ 553,743) (A7).

An interesting finding was observed with regard to caregivers who reported higher education, and an increase in the number of caregivers who had completed higher education and complementary training such as specializations and postgraduate studies was identified in the most recent studies (A7; A12; A4; A19).

Caregivers who lived in rural areas generally had a lower level of education than those living in urban areas. In addition, they were more frequently unemployed when compared to those who lived in urban centers (A16; A23; A10).

With regard to employment, most caregivers were unemployed (A4; A8; A6; A22; A24; A20). In addition, it was identified that a significant portion was retired, which is justified by the fact that most of them were in an older age group (A18; A5).

The comparison between employed men and women revealed that the majority of female caregivers worked part-time and received lower wages. Consequently, they had a lower monthly income than male caregivers and faced greater difficulties in dealing with the expenses associated with home care (A17).

Regarding expenses related to the needs of the family member under their care, many caregivers reported independently bearing the health costs of patients. In addition, they showed discomfort and concerns about their ability to meet their own needs, those of their families and the demands of care (A12; A6). Only two studies reported that caregivers received help from other family members or some type of government assistance to cover the costs of care (A12; A24).

Next, information related to the variables that impact the financial reality of the informal caregiver will be presented, namely: factors associated with socioeconomic status, increase in monthly expenses, loss of employment and lack of support network.

Caregivers who faced a greater burden of financial stress often associated this situation with economic difficulties. Those with lower incomes were more likely to obtain high

scores in questionnaires designed to measure stress levels, in addition to reporting a worsening of their financial condition after assuming the role of caregivers, closely linked to the increase in expenses and health conditions of their family members (A7; A2; A8; A21; A3).

Studies have also associated a greater financial burden with a lower level of education. It was observed that caregivers with complete higher education had significantly lower levels of stress related to their financial reality compared to those who had only completed high school (A7; A12; A2). The level of education had different reports, most caregivers had completed high school (A12; A4; A16; A15; A11).

The age of the family member cared for was also analyzed as a hypothesis. It was observed that, as age increases, the caregiver faces greater financial difficulties. These challenges are associated with increased care demands and the appearance of comorbidities typical of the aging process (A12; A2; A8; A16).

With regard to the individual cared for, the degree of proximity between him/her and the caregiver was identified as a predictive factor of greater financial stress. Being a woman and occupying the role of the patient's wife was pointed out as an element that intensifies the burden and financial difficulties faced, since, in general, women assume not only the role of caregiver but also the sole provider of the home (A8; A16; A3; A22).

Caregivers reported an increase in monthly expenses after taking on the role of caregiver, especially due to the need to hire help for domestic activities and the increase in expenses with medical consultations, exams, medications, transportation/fuel, and prolonged hospitalizations (A12; A8; A9; A20; A5).

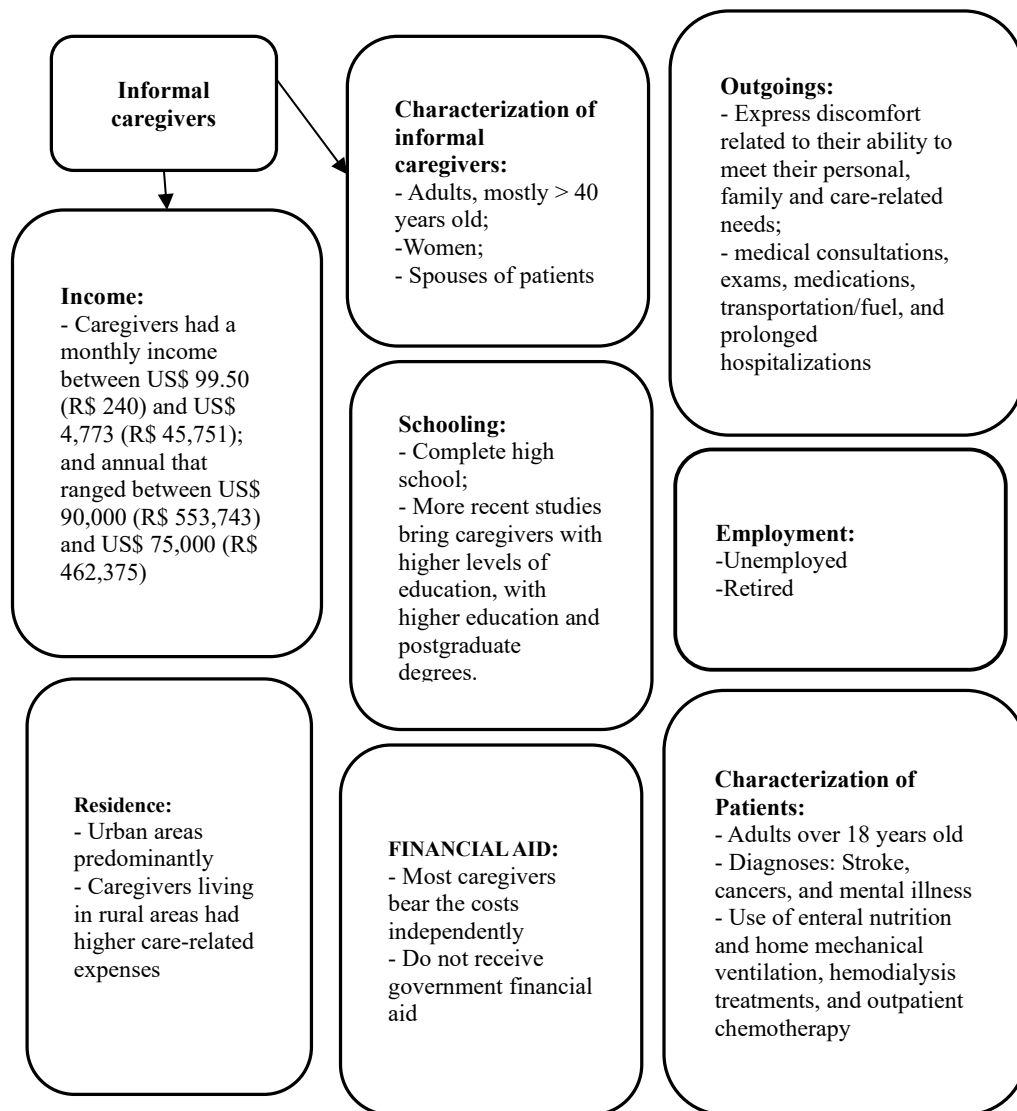
Finally, the place of residence and the number of hours dedicated to care were identified as a predictor for higher expenses related to the care activity. Caregivers living in rural areas reported significantly more financial hardship and expenses compared to those in urban areas (A16; A23; A10).

In addition, most caregivers were exclusively dedicated to care, without having an employment relationship. This situation is often attributed to lack of time and the high number of absences from work, which makes it necessary to quit work to meet the demands and needs of the family member under their care (A6; A5).

Based on data analysis, a conceptual map was constructed outlining the main information related to the financial reality of informal caregivers (Figure 2).

Figure 2

Conceptual map of the characterization of Informal Caregivers (n=24). Maringá, PR, Brazil, 2025



Source: The authors (2025).

According to the literature, four out of five informal caregivers are women, usually wives or daughters of patients. Historically and socially, the responsibility for care has been attributed more frequently to women, reflecting a cultural pattern sometimes based on machismo, which prepares them to assume this function and often judges them when they do not fulfill it, with men being placed in the position of caregivers generally due to the absence of women in the family who can assume such responsibility (Sousa *et al*, 2023; Sousa *et al*, 2024).

Concomitantly, the female population presents higher levels of stress and overload resulting from care, since in most cases they do not have an established support network that helps them and allows them to develop moments of leisure and rest, experiencing a loss of their freedom and autonomy and abandonment of their individuality and personal life to the detriment of informal care (Silva *et al*, 2025; Renk *et al*, 2022).

In the financial issue, it is observed that female caregivers face a greater impact in terms of dismissals, social isolation and financial difficulties. This scenario occurs mainly due to the fact that most male caregivers receive higher salaries and, when taking care of a dependent family member, dedicate fewer hours a day to this function, often having resources to hire formal caregivers, in addition to, in general, having a better structured support network, receiving help in sharing the care provided to the family member, being able to maintain their work activities (Gomes *et al*, 2023; Marques *et al*, 2024).

In addition, caregivers suffer, on a larger scale, the loss of employment compared to men. This fact is related to historical issues of prejudice and sexism, in addition to reflecting the reality of many women who dedicate themselves fully to home care. They are often dismissed from their jobs due to the high number of absences caused by the high demands associated with providing care to dependent family members, presenting difficulties in managing expenses related to care and adapting to the new reality (Méndez *et al*, 2024).

It can be observed that most caregivers were advanced in age (over 50 years old), and were mostly composed of people who were already withdrawing from the labor market and often had retirement as their only source of income. Considering that aging is associated with increasing limitations and reduced functional capacity, the presence of older informal caregivers can intensify financial stress and spending. In addition to bearing the expenses of the dependent family member, these caregivers remain responsible for their own health costs, such as medications, consultations, and exams, necessary due to advancing age (Teles *et al*, 2023; Bernardi *et al*, 2023).

Concomitantly, the advanced age of caregivers has the potential to worsen their quality of life and health and for the appearance of related diseases and bad life habits, a great load of stress and abandonment with their own health care, projecting their attention and income to prioritize the needs of their family members. Many caregivers report not having the time and conditions to seek care even for routine consultations or periodic exams related to maintaining their own health (Cavalcanti *et al*, 2025; Castanheira *et al*, 2025).

Caregivers living in rural areas generally have a lower level of education, which is associated with greater financial difficulties. In addition, they face social isolation, high care costs, especially related to commuting, and difficulties in finding a job, being more often unemployed, these caregivers have greater difficulties in adapting to extra expenses related to care. Being an informal caregiver in rural areas was also linked to a higher incidence of psychological problems, such as depression, anxiety, and burnout, related to social isolation caused not only by caregiving, but also by difficulties in leaving home, in addition to concerns about unemployment and income (Almeida *et al*, 2023; Silva *et al*, 2025).

As observed in practice, most caregivers were unemployed, having to resign their jobs mainly due to the need to dedicate many hours to care. A relationship between caregivers' unemployment and the time allocated to care can be observed, revealing that most of them dedicate themselves fully to this activity, presenting difficulties in the physical, psychological, social, and financial spheres, facing difficulties both in getting and maintaining a job (Costa *et al*, 2024).

Although informal care is provided free of charge, the financial costs associated with it can involve high expenses with consultations, exams, and procedures for both the family member under care and the caregiver. In addition, there are expenses with adaptations of devices for the home, medications, specific foods, enteral nutrition, oxygen therapy, among others (Lacerda *et al*, 2021).

Regarding monthly family income, few studies address this variable. In the literature, the financial reality of informal caregivers is usually superficially addressed, being associated only with the presence or absence of financial stress. When this information is included, it is commonly related to the economic stress of caregivers, but it does not detail what the specific costs are, how caregivers organize themselves to deal with these expenses, or what impact these financial burdens have on the lives and reality of caregivers (Regina *et al*, 2024).

It can be observed that, many times, the caregiver is prepared only to know how to handle certain devices and perform the necessary care for his family member at home, and it is unknown whether this individual has the financial conditions to maintain all the expenses arising from the demands of the care provision, in addition to maintaining his own quality of life. These caregivers, in general, give up expenses related to their own life to prioritize meeting the needs of their family members. What is often observed are caregivers who dedicate a good part of their income to the costs of caring for family members and end up sick due to concern about their income, stressed and lacking in the maintenance of their own

health, who sometimes cannot continue to take care of their family members and end up also becoming dependent at some point in their lives (Silva *et al*, 2022; Minayo *et al*, 202).

The review identified that 50% of the included studies were published between 2020 and 2024, reinforcing the typical profile of informal caregivers. Although this review is contemporary, it has some limitations. The heterogeneity of the studies is highlighted, all of which are classified as cross-sectional studies, in addition to the small number of the population evaluated. In addition, although the collection that made up this review is considerable and recent studies, there is a lack of research that brought robust information on the income of informal caregivers, expenses related to home care and how much of this income was destined to this care, in addition to better characterizing caregivers, bringing information related to previous comorbidities and other aspects that also impact their expenses.

4 CONCLUSION

From the above, it was possible to identify the main evidence about the socioeconomic reality of informal caregivers of dependent adults. The results showed that most caregivers were women >40 years old, with low income and schooling, and were mainly spouses or daughters of the patients, reiterating an already known stereotype. Regarding the financial reality, most faced difficulties related mainly to unemployment, costs with exams, hospitalizations and medication for the family member, in addition to difficulties in maintaining care for their own health, dedicating all energy, time and resources to the family member and their needs.

The results aim to contribute to the improvement of the knowledge of professionals on the subject, in order to qualify care and instigate the development of research that focuses on understanding this aspect of informal care, aiming to provide subsidies for the development of policies and financial aid for this population.

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BIOTECHNOLOGY PATENTS AND PATENT INTELLIGENCE IN THE AMAZON BIOECONOMY: AN INTEGRATIVE NARRATIVE LITERATURE REVIEW

PATENTES DE BIOTECNOLOGIA E INTELIGÊNCIA PATENTÁRIA NA BIOECONOMIA AMAZÔNICA: UMA REVISÃO NARRATIVA INTEGRATIVA DA LITERATURA

PATENTES DE BIOTECNOLOGÍA E INTELIGENCIA PATENTARIA EN LA BIOECONOMÍA AMAZÓNICA: UNA REVISIÓN NARRATIVA INTEGRATIVA DE LA LITERATURA

 <https://doi.org/10.56238/sevened2025.036-056>

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ABSTRACT

In this integrative narrative review, with an analytical-critical orientation, we examine how patent information in biotechnology can leverage the Amazon bioeconomy. Three axes are integrated: the technical-legal foundations of patentability and compliance (IPL; SisGen; IN 118/2020; INPI/CPAPD Technical Note 01/2023; WIPO ST.26; WIPO Treaty 2024); methods and best practices for patent landscaping; and an applied analysis of the guaraná, açaí, and copaíba value chains. The findings show that the systematic use of patents—combined with IPC/CPC classifications, family-based analysis, and claim interpretation—enhances technological diagnostics and reduces search biases. Opportunities emerge in bioactives, bioprocesses, functional ingredients, and nanoformulations, conditioned by governance of access and benefit-sharing and by rules regarding digital sequence information. It is concluded that institutionalizing patent intelligence within the R&D&I cycle is essential for transforming biodiversity into responsible innovation, strengthening regional capacities, and avoiding rework.

Keywords: Patents. Amazon Bioeconomy. Biotechnology. Patent Intelligence. Genetic Resources.

RESUMO

Nesta revisão narrativa integrativa, de caráter analítico-crítico, examinamos como a informação patentária em biotecnologia pode alavancar a bioeconomia amazônica. Integram-se três eixos: fundamentos técnico-jurídicos de patenteabilidade e conformidade (LPI; SisGen; IN 118/2020; Nota Técnica INPI/CPAPD 01/2023; WIPO ST.26; Tratado OMPI

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2024); método e boas práticas de panorama patentário; e uma leitura aplicada a cadeias de guaraná, açaí e copaíba. Evidencia-se que o uso sistemático de patentes, combinado a IPC/CPC, análise por famílias e leitura de reivindicações, qualifica o diagnóstico tecnológico e reduz vieses de busca. Oportunidades emergem em bioativos, bioprocessos, ingredientes funcionais e nanoformulações, condicionadas à governança de acesso e repartição de benefícios e às regras sobre informações de sequência digital. Conclui-se que institucionalizar a inteligência patentária no ciclo de P&D&I é condição para transformar biodiversidade em inovação responsável, fortalecer capacidades regionais e evitar retrabalhos.

Palavras-chave: Patentes. Bioeconomia Amazônica. Biotecnologia. Inteligência Patentária. Patrimônio Genético.

RESUMEN

En esta revisión narrativa integrativa, de carácter analítico-crítico, examinamos cómo la información patentaria en biotecnología puede impulsar la bioeconomía amazónica. Se integran tres ejes: los fundamentos técnico-jurídicos de patentabilidad y conformidad (LPI; SisGen; IN 118/2020; Nota Técnica INPI/CPAPD 01/2023; WIPO ST.26; Tratado OMPI 2024); el método y las buenas prácticas para la elaboración de panoramas patentarios; y una lectura aplicada a las cadenas de valor de guaraná, açaí y copaíba. Se evidencia que el uso sistemático de patentes—combinado con IPC/CPC, análisis por familias y lectura de reivindicaciones—califica el diagnóstico tecnológico y reduce sesgos de búsqueda. Surgen oportunidades en bioactivos, bioprocesos, ingredientes funcionales y nanoformulaciones, condicionadas a la gobernanza de acceso y reparto de beneficios y a las reglas sobre información de secuencias digitales. Se concluye que institucionalizar la inteligencia patentaria en el ciclo de I+D+I es condición para transformar la biodiversidad en innovación responsable, fortalecer capacidades regionales y evitar retrabajos.

Palabras clave: Patentes. Bioeconomía Amazónica. Biotecnología. Inteligencia Patentaria. Patrimonio Genético.

1 INTRODUCTION

The bioeconomy has been consolidated, in recent decades, as a strategic framework to articulate life sciences, biological processes and renewable raw materials in response to global challenges, with monitoring by economic, social and environmental indicators in official systems of the European Commission, through the Joint Research Centre (EUROPEAN COMMISSION; JOINT RESEARCH CENTRE, 2024). In

In Brazil, the agenda has gained density with studies by the National Confederation of Industry and recent policies that reposition the bioeconomy as a vector of decarbonization and innovation based on biodiversity (CNI, 2020). For the Amazon, the scenario is no longer propositional and has become effective instruments: Decree No. 12,044/2024 instituted the National Bioeconomy Strategy and determined the preparation of the National Bioeconomy Development Plan. In this context, the Financier of Studies and Projects (Finep) launched the call 'Finep Amazônia – Bioeconomy and Regional Development' (BRASIL, 2024; FINEP, 2024).

In parallel, global indicators show an increase in the use of the patent system and relevant geographic displacements, reinforcing technological competition (WIPO, 2024a). In 2024, Member States approved a treaty that makes it mandatory to disclose the origin of genetic resources and associated traditional knowledge in patent applications, changing expectations for compliance in sociobiodiversity-related research (WIPO, 2024b). For biotechnology, the adoption of WIPO ST.26 has imposed, since July 1, 2022, the filing of XML sequence listings with specific redaction, numbering, and search rules, with direct implications for prospecting, writing, and examination (WIPO, 2022; INPI, 2022).

In Brazil, there is still low appropriation of patent documents as an informational source: in 556 theses and dissertations in the health area, only 2.87% cited patents (PIMENTA, 2017); in a convergent way, a recent survey in Engineering I indicates that about 33% of researchers use patent databases and more than 65% do so mainly to verify the possibility of patenting, not to guide research (GRUNEVALD, 2024).

This work integrates foundations, methods and evidence to transform patent literature into actionable intelligence for Research, Development and Innovation, partnerships and policies, applying it to chains such as guarana (*Paullinia cupana*), açaí (*Euterpe spp.*) and copaiba (*Copaifera spp.*).

1.1 FUNDAMENTALS AND REGULATORY FRAMEWORK

The governance of biotechnology research depends less on the letter of the law and more on how compliance is operationalized. In practice, disclosure of origin, regularity in SisGen, and traceability of Digital Sequence Information (DSI) shift management from the declaratory plan to the evidentiary plan, recommending checklists and evidence records from conception so that Access and Benefit-Sharing (ABS), DSI, and WIPO ST.26 do not become late barriers to filing and transfer.

Industrial Property Law (LPI), Law No. 9,279/1996: Article 10 establishes that discoveries, literary, artistic, and scientific works, presentations of information, computer programs themselves, and methods of surgical, therapeutic, or diagnostic treatment are not considered inventions, among others; Article 18, III prohibits the patenting of living beings, except for transgenic microorganisms that meet legal requirements (BRASIL, 1996, arts. 10; 18, III). IN INPI/PR No. 118/2020 details novelty, inventive step, and descriptive sufficiency in biotechnology; INPI/CPAPD Technical Note No. 01/2023 harmonizes the understanding of transgenic plants and "elite events". Since July 1st. 2022, applications with sequence require XML listing according to WIPO ST.26, via WIPO Sequence (INPI, 2022; WIPO, 2022). In research with genetic heritage or associated traditional knowledge, SisGen (Law No. 13,123/2015; Decree No. 8,772/2016) and the automatic requirement of regularity by the BPTO are decisive. At the international level, DSI advances in a multilateral mechanism (CBD, 2024), and the 2024 WIPO Treaty imposes disclosure of origin (WIPO, 2024b).

2 MATERIALS AND METHODS

An integrative narrative review with an analytical-critical emphasis was adopted, according to methodological references (MENDES; SCOTT; GALVÃO, 2008; ROTHER, 2007; DIXON-WOODS et al., 2006). Legal documents, international standards, sectoral studies and recent scientific literature were integrated.

This was followed by good patent landscape practices: scope delimitation; searches by keywords and IPC/CPC classes; analysis by families (INPADOC); mapping of actors/jurisdictions; qualitative reading of claims (WIPO, 2015; VAN RIJN; TIMMIS, 2023). Retrieval techniques with natural language processing (NLP) were considered to mitigate biases (ALI et al., 2024). Integrating SisGen conditions and LPI guidelines, in addition to IN 118/2020, Technical Note INPI/CPAPD 01/2023 and the guidelines on WIPO ST.26 (INPI, 2020, 2022, 2023).

3 FINDINGS

Trends and patterns: global filing intensification and geographic displacement; source disclosure tends to reconfigure R&D&I and due diligence routines; WIPO ST.26 normalized listings and impacted redaction, examination, and search (WIPO, 2024a, 2024b, 2022; INPI, 2022).

National diagnosis: low use of patents in academia indicates surveillance gaps and risk of rework; sectoral studies point to potential in bioprocesses, ingredients and bioinputs (PIMENTA, 2017; CNI, 2020; GRUNEVALD, 2024).

Applications in prisons: guarana — interest in functional formulations and processes with sustained claims (TALIK; ZARÓW; BUČKO, 2024); açaí — lipids, polyphenols, and the use of by-products (seeds) for ingredients and functional materials (SANTOS et al., 2024); copaiba — advancement in nanoformulations and toxicological evaluation with a focus on release and safety (BEZERRA et al., 2024).

Regulatory implications: requirement of regularity in SisGen focuses on writing and exam; DSI and disclosure of origin increase traceability (BRASIL, 2015; BRAZIL, 2016; CBD, 2024; WIPO, 2024b).

Interpretative reading: The densification reduces space for research outside the Patent Cooperation Treaty (PCT) and makes Freedom to Operate (FTO) and jurisdictional choices central; consortium arrangements are recommended to scale search, redaction and filing.

Compliance: It's not bureaucracy, but alignment between science, protection, and apportionment; each project must provide for a due diligence plan that synchronizes schedules, regulatory deadlines, and optimal filing windows.

4 DISCUSSION

Patent intelligence is risk governance, when it enters the R&D&I cycle early and dialogues with ABS, DSI and WIPO ST.26, it reduces rework and increases predictability of publication, partnership and licensing. Compliance is opportunity cost: the initial learning curve (e.g., ST.26) reduces rejections and uncertainty down the line. For Amazonian chains, we advocate portfolios that combine areas of technological concentration (hotspots) and white spaces (white spaces), in guarana, functional formulations and stabilization; in açaí, waste valuation and microencapsulation; in copaiba, controlled release and toxicological safety. Institutionally, we propose: minimum prospecting protocols by family/classes,

integration between data management–SisGen–legal before the bench, and continuing education in ST.26 drafting and compliance.

5 FINAL CONSIDERATIONS

Patents are public knowledge infrastructures that, when handled with method and responsibility, raise the quality of choices in science and innovation. To convert biodiversity into responsible innovation and expand technological autonomy, it is recommended: i) to institutionalize surveillance routines integrating IPC/CPC, families and legal events; ii) couple ABS, DSI and WIPO ST.26 from the design of the project; iii) prioritize agendas that combine areas of technological concentration and white spaces in guaraná, açai and copaiba; iv) measure results not only by deposits, but by partnerships, licenses and benefit sharing effectively implemented.

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**THE IDENTITY OF THE TEACHING PROFESSIONAL: THEIR TRAINING AND
REFLECTIONS IN THE STATE OF GOIÁS**

**A IDENTIDADE DO PROFISSIONAL DOCENTE: SUAS FORMAÇÕES E
REFLEXÕES NO ESTADO DE GOIÁS**

**LA IDENTIDAD DEL PROFESOR PROFESIONAL: SU FORMACIÓN Y
REFLEXIONES EN EL ESTADO DE GOIÁS**

 <https://doi.org/10.56238/sevened2025.036-057>

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ABSTRACT

This article analyzes the evolution of the professional identity of teachers and its relationship with initial and continuing education in the State of Goiás. It is based on the premise that teaching constitutes a socially and culturally mediated practice, whose knowledge is formed at the intersection of theory and practice. Teaching is not limited to the mere transmission of knowledge, but rather involves the formation of individuals for the progress and transformation of society. The research, of a bibliographic and documentary nature, is based on authors such as Gatti (2016), Nóvoa (1992, 2017), Pimenta (1999), Sacristán (1995), and Tardif (2002), as well as documents such as the National Education Plan (PNE) and the Goiás State Education Plan (PEE 2015–2025). Public policies and concrete working conditions shape teacher identity, and continuing education can act as a key element in professional development and career advancement for teachers.

Keywords: Teacher Identity. Initial Training. Continuing Education. Goiás. Educational Policies.

RESUMO

Este artigo analisa a evolução da identidade profissional docente e suas relações com as formações iniciais e continuadas no Estado de Goiás. Parte-se do pressuposto de que a docência constitui uma prática social e culturalmente mediada, cujos saberes se formam na intersecção entre a teoria e a prática. A docência não se restringe somente à mera transmissão de conhecimento, mas sim na formação das pessoas para o progresso e a transformação da sociedade. A pesquisa, de natureza bibliográfica e documental, baseia-se em autores como Gatti (2016), Nóvoa (1992, 2017), Pimenta (1999), Sacristán (1995) e Tardif (2002), além de documentos como o Plano Nacional de Educação (PNE) e o Plano Estadual de Educação de Goiás (PEE 2015–2025). As políticas públicas e as condições concretas de trabalho moldam a identidade docente e a formação continuada pode atuar como eixo articulador do desenvolvimento profissional e da valorização da carreira docente.

Palavras-chave: Identidade Docente. Formação Inicial. Formação Continuada. Goiás. Políticas Educacionais.

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RESUMEN

Este artículo analiza la evolución de la identidad profesional docente y su relación con la formación inicial y continua en el estado de Goiás. Se parte de la premisa de que la docencia es una práctica mediada social y culturalmente, cuyos conocimientos se forman en la intersección entre la teoría y la práctica. La docencia no se limita a la mera transmisión de conocimientos, sino que consiste en la formación de las personas para el progreso y la transformación de la sociedad. La investigación, de carácter bibliográfico y documental, se basa en autores como Gatti (2016), Nóvoa (1992, 2017), Pimenta (1999), Sacristán (1995) y Tardif (2002), además de documentos como el Plan Nacional de Educación (PNE) y el Plan Estatal de Educación de Goiás (PEE 2015-2025). Las políticas públicas y las condiciones concretas de trabajo moldean la identidad docente, y la formación continua puede actuar como eje articulador del desarrollo profesional y la valorización de la carrera docente.

Palabras clave: Identidad Docente. Formación Inicial. Formación Continua. Goiás. Políticas Educativas.

1 INTRODUCTION

The discussion about the professional identity of teachers and the processes of teacher training has been consolidated as one of the central themes in contemporary educational research. In a scenario marked by rapid social, cultural and technological transformations, understanding the role of the teacher as a historical, critical and reflective subject has become an urgent and necessary task. In Brazil, and particularly in the State of Goiás, this debate gains relevance by highlighting the intrinsic relationship between initial training, continuing education and professional valorization, fundamental dimensions for strengthening teaching and improving the quality of basic education.

Authors such as António Nóvoa (1992), Maurice Tardif (2002) and Paulo Freire (1996) highlight that teacher identity is not a static attribute, but a dynamic process of construction, forged in the interaction between knowledge, practices and experiences. For Nóvoa (1992, p. 25), "continuous training should be integrated into the daily work of teachers and schools, and not be an isolated episode or a moment outside of time and professional space", showing that professional learning becomes effective when it is incorporated into daily life and becomes part of the teacher's own identity. Tardif (2002, p. 36) emphasizes that "teachers' knowledge is plural, it is composed of knowledge from their professional training, their life history and their daily practice", demonstrating that the teaching work is based on a set of heterogeneous and socially constructed knowledge, which form the basis of the teacher's professional identity. Freire (1996, p. 25), in turn, expands this conception by arguing that:

"Teaching is not transferring knowledge, but creating the possibilities for its own production or construction. Therefore, teaching requires ethics, aesthetics, lovingness, and commitment to social transformation."

In this context, discussing teacher training in Goiás implies understanding how public and institutional policies shape teacher professionalism and influence the constitution of their identity. In recent decades, the State has developed significant actions through the State Education Plan (PEE 2015–2025), which establishes goals for the appreciation and continuing education of educators, recognizing them as strategic agents in the educational process. Initiatives such as Pair Training, promoted by the Center for Studies, Research and Training of Goiás (CEPFOR), and the Formative Roots program, demonstrate advances in the search for collaborative, contextualized education focused on the reality of public schools. However, challenges remain related to the fragmentation between initial and continuing

education, the precariousness of working conditions and the need for effective articulation between universities and education networks, as pointed out by Gatti (2016) and Dourado (2015).

The relevance of this study lies, therefore, in the possibility of critically reflecting on the process of teacher training in the State of Goiás, articulating it with the construction of the professional identity of teachers. By understanding teaching as a complex social practice, crossed by ethical, political and pedagogical dimensions, it seeks to highlight the importance of an emancipatory and reflective education, which goes beyond the mere transmission of content and promotes the integral development of the educator.

The general objective of this article is to analyze how initial and continuing education contribute to the constitution of the professional identity of teachers in Goiás. As specific objectives, it is proposed: to discuss the theoretical foundations of teacher identity; to examine the role of initial and continuing education policies in the State; and to reflect on the tensions, challenges and perspectives that permeate the professionalization and appreciation of teachers in Goiás.

Methodologically, this is a qualitative research of a bibliographic nature, based on classic and contemporary authors in the area of teacher training and professional identity, such as Freire (1996), Nóvoa (1992, 2017), Tardif (2002), Pimenta (1999), Contreras (2002), Imbernón (2000), García (1999), Gatti (2016) and Dourado (2015). The analysis also considers official documents, such as the Law of Guidelines and Bases of National Education (Law No. 9,394/1996) and the State Education Plan of Goiás (2015–2025), seeking to establish relationships between theoretical propositions and training practices developed in the local context.

Thus, the introduction of this article situates the problem of the professional identity of teachers at the confluence between training and practice, theory and reality, valorization and autonomy. Throughout the article, the text deepens the discussion on the constitutive elements of teacher identity, examines the dynamics of initial and continuing education in Goiás, and presents critical reflections on programs and public policies aimed at teacher training, culminating in final considerations that reaffirm the centrality of teaching as a transforming axis of education and society.

2 THE PROFESSIONAL IDENTITY OF TEACHERS

The professional identity of teachers is a social, historical and cultural construct in permanent evolution. It is not something given, but a process of **continuous (re)construction**, which manifests itself in the articulation between **initial training, continuing education, pedagogical practice and life experiences**. For **António Nóvoa (1992)**, the teacher's identity cannot be understood as a fixed essence, but as the result of multiple interactions and personal and professional trajectories that are intertwined in time. The author argues that teaching should be understood as a "process of self-construction", a life project that is constantly redefined in dialogue with the school and sociocultural contexts in which the teacher works.

Similarly, Maurice Tardif (2002, p. 36) states that "teachers' knowledge is plural, it is composed of knowledge from their professional training, their life history and their daily practice", which demonstrates that the teacher's professional identity is structured on a set of heterogeneous and socially constructed knowledge. Thus, for the author, professional knowledge is not only theoretical or scientific, but also practical and experiential. It is knowledge produced in the daily relationship with students, colleagues and the school environment. This plural conception of knowledge breaks with the technician view of teaching, which reduces the teacher to a mere executor of prescribed methodologies, and recognizes him as an **epistemic subject** who produces knowledge from reflection on practice.

In the context of Goiás, this understanding gains particular relevance, as the teacher from Goiás is inserted in an educational field marked by **structural challenges, regional inequalities and public policies in constant transformation**. The concrete working conditions, the training guidelines and the processes of professional valorization directly influence the construction of their identity. According to the **Goiás State Education Plan (2015–2025)**, one of the main objectives is precisely to promote the professional development of teachers, articulating training and appreciation, as established in **Goal 17**, which aims to ensure quality continuing education for all basic education professionals.

Teacher identity is, therefore, the result of a **dialectic between the personal and the professional**, between the individual and the collective. According to **Claude Dubar (2000)**, professional identity is constructed in the tension between **"identity for oneself"**, how the subject perceives himself, and **"identity for the other"**, how he is socially perceived.

In the case of the teacher, this tension is evident, that is, on the one hand he recognizes himself as an educator, trainer of consciences, mediator of knowledge and on the

other hand, he faces the devalued social image of the profession, marked by low salaries, work overload and little autonomy in pedagogical decisions. Dubar (2000) calls this field of tensions **the "field of identity forces"**, in which teachers need to constantly negotiate between their personal convictions and the social and institutional expectations that fall on them.

This relational dimension of teacher identity is complemented by **José Gimeno Sacristán (1995)**, who understands teaching as a social and cultural practice loaded with intentionalities. For the author, the professional identity of the teacher is linked to his ability to critically interpret the curriculum and to adapt educational policies to the concrete reality of his school. Thus, being a teacher is not limited to mastering contents, but to **acting ethically in a specific social and political context**, recognizing oneself as an agent of transformation and a historical subject.

This critical conception of teacher identity is close to the reflections of **Paulo Freire (1987, 1996)**, for whom teaching is a political and liberating act. Freire argues that the teacher must assume a dialogical and problematizing posture in front of the world, developing what he calls **praxis**, the reflected and transforming action. In *Pedagogy of the Oppressed*, the author states that "there is no teaching without discency", that is, teaching requires continuous learning, and it is in this process that the teacher builds and resignifies his identity. Praxis, as reflection and action on the world to transform it, is the core of teaching professionalism, as it prevents both **"practicalism"** (action without reflection) and **"theoreticalism"** (theory without commitment to reality).³

In this regard, **Donald Schön (2007)** contributes by developing the notion of **"reflective professional"**, emphasizing that the teacher is a professional who learns from experience. For him, reflection in and on action is the central element of teacher training and improvement. Reflection in action occurs during the pedagogical practice, when the teacher adjusts his practice in the face of the challenges that arise in the classroom; On the other hand, the reflection on the action takes place later, when he critically analyzes his practice and extracts new lessons from it. This reflective spiral is what allows the development of a solid and autonomous professional identity, as it promotes a continuous movement of self-education.

³ The distinction between "practicalism" and "theoreticalism" was widely discussed by Freire (1987) and taken up by Schön (2007), both converging in the defense of a pedagogical praxis that unites action and reflection, overcoming both unreflective activism and abstraction detached from reality.

On the other hand, **Pimenta (1999) and Marcelo Garcia (1999)** argue that professional identity is also constructed collectively, in spaces of collaboration and dialogue among peers. Teaching, in this sense, is a profession that requires **community**, because it is in the sharing of experiences that the teacher consolidates his knowledge and reaffirms his identity. This perspective dialogues directly with the proposals for continuing education in Goiás, especially those that value work in pairs and collaborative training, as observed in the **Center for Study, Research and Training of Education Professionals (CEPFOR) model** and in programs such as **Raízes Formativas**⁴.

However, the construction of the teacher's identity does not occur in a linear way. Contreras (2002, p. 157) states that "the professional autonomy of teachers is crossed by multiple forms of administrative, curricular and evaluative control, which limit their possibilities of decision and reflection on their own work." In this way, the author draws attention to the tensions between autonomy and control that permeate the exercise of teaching, highlighting that the professional autonomy of teachers is constantly limited by administrative, curricular and evaluative mechanisms that restrict their freedom of decision. The author warns that, many times, educational policies impose norms and curricula that reduce pedagogical freedom, weakening the autonomy and, consequently, the professional identity of the teacher. To overcome this condition, he proposes the strengthening of **critical autonomy**, understood not as absolute independence, but as the capacity for reflection, choice, and ethical positioning in the face of institutional demands.

In addition to these individual and institutional dimensions, the **temporal dimension** of identity is also central. According to **Huberman (1995)**, the teaching career is composed of different phases, initial enthusiasm, stabilization, experimentation, disenchantment and maturity, and each of them implies different identity challenges. Professional identity, therefore, is also biographical, that is, it reflects the history of each teacher and their interactions with the teaching contexts.

In Goiás, this trajectory is manifested in the various generations of teachers who faced processes of expansion of the public network, curricular reforms and training policies that sometimes value, sometimes disregard the protagonism of teachers.

⁴ The courses of the "Formative Roots" project are offered by the Department of Education of Goiás (SEDUC-GO), in partnership with the Getúlio Vargas Foundation (FGV), with a focus on the continuing education of high school teachers in the state. Several courses are available, such as Portuguese Language, Mathematics, Art, Biology, Philosophy, Physics, Geography, History, English Language, Sociology and a track for trainers, with options in the Virtual School format. (Source: escolavirtual.educacao.go.gov.br)

In summary, the professional identity of teachers is a **multidimensional** phenomenon, which involves the intertwining of **subjective, institutional and sociopolitical** factors. In the case of Goiás, understanding this identity requires looking beyond the classrooms, in order to consider the role of public policies, educational institutions and concrete working conditions. It is in this context that **initial and continuing education** is presented as fundamental pillars for the strengthening of teacher identity.

3 BETWEEN INITIAL TRAINING AND CONTINUING EDUCATION IN GOIÁS

Teacher training is a central axis of educational policies and research in education in Brazil, being understood as a **continuous, unfinished and reflective process**, which accompanies the entire professional trajectory of the teacher. The **Law of Guidelines and Bases of National Education (LDB 9.394/96)** establishes higher education as a minimum requirement for the exercise of teaching, which reinforces the need for solid initial training and permanent continuing education.

However, as Gatti (2016, p. 47) states, "teacher training in Brazil still presents a fragile articulation between what is taught in universities and what is done in schools, revealing a worrying distance between academic theory and professional practice." In Goiás, this issue takes on particular contours, because the state, despite recent advances, still lives with regional inequalities, structural deficiencies and a heterogeneous educational network.

According to the **Goiás State Education Plan (2015–2025)**, teacher training is one of the strategic pillars to ensure the quality of basic education. The document proposes policies aimed at valuing teachers, expanding continuing education programs and strengthening training institutions.

However, the effectiveness of these goals depends on a real articulation between **universities, education departments and schools**, so that the training processes are not fragmented, but integrated into the daily practices of teachers.

Authors such as **Imbernón (2000)** and **Libâneo (2013)** reinforce that teacher education needs to overcome the transmissive and technicist model, approaching a **dialogical and reflective logic**, in which the teacher is seen as an active subject of his or her own education.

Initial training is the first institutionalized moment in the teacher's professional trajectory, representing the space in which the epistemological, pedagogical and ethical bases of the profession are built. In Goiás, this training is offered by public and private

institutions, especially the **Federal University of Goiás (UFG)** and the **State University of Goiás (UEG)**, which play an important role in the training of teachers for basic education. However, there is a consensus among researchers that initial training in Brazil faces a **persistent dichotomy between theory and practice**.

According to **Gatti (2016)**, teaching degree courses tend to prioritize the accumulation of theoretical content, often disconnected from school realities. As a consequence, many graduates report difficulties in adapting to the teaching routine, experiencing the so-called *reality shock*⁵, a term coined by **Huberman (1995)** to describe the impact of the entry of the beginning teacher into complex and challenging teaching contexts.

To overcome this fragmentation, Zeichner (2008, p. 542) proposes the idea of a practice-based education, "understood as a space for authentic learning, in which reflection and conceptual mastery have equal importance in the construction of teaching professionalism", arguing that teaching degree courses should promote significant experiences that articulate theory and practice. In this sense, the supervised internship ceases to be a bureaucratic moment to become a privileged space for the construction of knowledge.

In the context of Goiás, it is essential that universities strengthen **links with public education networks**, promoting extension projects, action research and institutional partnerships that integrate the academic environment with school realities. **Libâneo (2013)** argues that the university should take a critical stance towards educational policies, contributing to the training of autonomous, creative teachers committed to social transformation.

Thus, initial training should not be seen as a closed cycle, but as the **starting point of a permanent formative trajectory**, which finds its logical and epistemological continuity in continuing education.

Thus, continuing education is one of the fundamental pillars of teacher professionalization. Far from representing only a technical update, it constitutes a space for reflection, socialization of knowledge and **identity reconstruction**. According to **Imbernón (2000)**, continuing education should be understood as a process of **professional and**

⁵The term "reality shock" was introduced by Huberman (1995) to describe the emotional and professional impact experienced by teachers at the beginning of their careers when confronting the school reality with the expectations idealized during initial training.

personal development, in which the teacher learns from experience, from peers and from the social transformations that go through his practice.

In the State of Goiás, continuing education has been strengthened by initiatives of the **State Department of Education (SEDUC)** and related bodies, such as the **Center for Studies, Research and Training of Goiás (CEPFOR)**. These actions seek to bring training closer to the real needs of teachers, avoiding generic and decontextualized courses.

The **Pair Training** model, offered by CEPFOR, is a significant example of this collaborative approach. Inspired by the conceptions of **Nóvoa (2017)**, who understands training as a process of "self-invention", the program proposes that teachers learn from each other, collectively building knowledge and pedagogical practices. This methodology favors **autonomy, reflection and appreciation of the teaching experience**, fundamental elements for the strengthening of professional identity.

From a theoretical point of view, this perspective dialogues with **Garcia (1999)**, who defines the professional development of teachers as a process of **situated learning**, in which knowledge is produced within educational practices. For the author, continuing education must be articulated with the concrete conditions of the school, promoting a culture of collaboration and investigation into one's own practice.

Another relevant example in the context of Goiás is the Formative **Roots: Integration of Learning program**, a partnership between SEDUC and the Getúlio Vargas Foundation (FGV). Aimed at teachers of Portuguese Language and Mathematics, the project is based on the integration of knowledge and interdisciplinarity, seeking to strengthen the essential skills of teachers. Although it presents promising results, it faces challenges such as the need for greater continuity and the systematic evaluation of its impacts on pedagogical practices.

According to Pimenta (1999), continuing education cannot be restricted to specific actions or occasional courses; it must be configured as an organic and emancipatory process, guided by research and collective reflection. This perspective is also defended by Freire (1996, p. 39), when he states that "teaching requires loving-kindness and courage — the fear of taking risks is an obstacle to creation and freedom. Teacher training, therefore, must be an act of love and courage, committed to the transformation of the world."

Therefore, continuing education should be seen as a **political and ethical space of resistance**, in which the teacher recognizes himself as a historical subject capable of critically intervening in his practice. This understanding is essential for training policies in Goiás to

advance from a model of technical training to a project of **humanizing, critical and emancipatory training**.

In view of this, the articulation between initial training and continuing education is one of the most persistent challenges of Brazilian education. Often, the two processes are treated in a dissociated way, which compromises the continuity of the teacher's professional development. **Gatti (2016)** and **Dourado (2015)** point out that the absence of dialogue between universities and education networks results in fragmented and decontextualized training.

In Goiás, this fragmentation manifests itself when initial training does not dialogue with the real demands of public schools and when continuing education does not take advantage of the knowledge produced in universities. To meet this challenge, it is necessary to build a **"community of practice"** (Wenger, 1998), in which different educational agents share experiences and produce knowledge collaboratively.

The **National Curriculum Guidelines for the Training of Basic Education Teachers (2015)**, prepared under the coordination of Luiz Fernandes Dourado, reinforce the importance of teacher training that promotes the inseparability between theory and practice, teaching and research. The document proposes that education systems establish integrated policies for training and professional development, ensuring coherence between the various levels and stages of teacher training.

In addition, **Nóvoa (2017)** argues that professional development should be understood as a **formative spiral**, in which initial training feeds into continuing education, and this, in turn, feeds back into practice and higher education. In other words, it is not a matter of two separate stages, but of complementary moments of the same process.

In the case of Goiás, the creation of **mentoring and tutoring programs between beginning and experienced teachers** can represent a promising way to strengthen this articulation. This proposal dialogues with the idea of a **reflective and collaborative teacher**, defended by Schön (2007) and Pimenta (1999), who understand education as a shared social practice.

Overcoming the tensions between initial and continuing education also requires policies of professional appreciation and recognition. The precariousness of teaching work, low salaries and administrative overload make it impossible for teachers to effectively participate in training processes.

As Contreras (2002, p. 205) warns,

... It is not possible to talk about teachers' autonomy and professional development without considering the real conditions of their work. Precariousness and excessive control prevent teachers from actually exercising their autonomy and engaging in meaningful training processes.

Thus, to think about training without discussing working conditions is to perpetuate a structural contradiction in Brazilian education.

In summary, teacher training, both initial and continuous, should be conceived as a unitary, continuous and contextualized process. In Goiás, the consolidation of this perspective implies strengthening partnerships between training institutions and education systems, ensuring decent working conditions and fostering a culture of collaborative, reflective and emancipatory training.

4 REFLECTIONS ON THE OFFER OF INITIAL AND CONTINUING EDUCATION FOR TEACHERS IN THE STATE OF GOIÁS

Teacher training, both in its initial and continuing dimensions, constitutes the **structuring axis of the teacher's professional identity**. In the context of Goiás, this training reflects a complex web of policies, practices, and experiences that, while promoting significant advances, also highlight persistent gaps.

Reflecting on this dynamic is fundamental to understand how teaching is constituted and developed in a State that seeks to reconcile educational expansion, professional valorization and improvement of the quality of teaching.

According to **Nóvoa (2017)**, thinking about teacher training implies rethinking the profession itself, because training teachers is to form critical subjects, capable of interpreting and transforming reality. This understanding requires that training programs are not restricted to the transmission of techniques, but promote reflection, autonomy and teacher protagonism. It is in this sense that training policies in Goiás should be analyzed, considering their potentialities and limitations.

Positive points and convergences are observed, such as teacher training in Goiás, which presents advances that deserve to be highlighted. The offer of **teaching degree courses** in public institutions, such as the **Federal University of Goiás (UFG)** and the **State University of Goiás (UEG)**, in order to represent an important axis of democratization of access to higher education and training of qualified teachers. These institutions have invested

in curriculum updating, in the articulation between teaching, research and extension, and in the creation of pedagogical support programs aimed at teaching.

In addition, the **continuing education policies** implemented by the **State Department of Education (SEDUC)** and by specialized centers such as **CEPFOR** have sought to bring academic theory closer to school realities. The implementation of programs such as **Continuing Education in Pairs** and the project **Formative Roots: Integration of Learning** is an important milestone, as it signals a paradigm shift, that is, from a verticalized and prescriptive training to a **collaborative and reflective** approach.

According to Imbernón (2000, p. 47), "effective training is that which starts from the reality of teachers, recognizing them as active subjects in the construction of their own knowledge, capable of reflecting and transforming their practice." In this sense, the model of pair training is close to Schön's (2007) **conceptions** of the *reflective professional*⁶, by proposing spaces for dialogue and analysis of pedagogical practice. This methodology breaks with the idea of training as a "recipe" and provides the construction of professional knowledge based on experience and collective exchange.

Another positive point is the growing understanding that **teacher training is a continuous process**, which is in line with the thinking of García (1999, p. 139), who understands that "the professionalization of the teacher is a process that is built throughout life, articulating different formative moments, initial, insertion and continuous development, which feed back and give meaning to the teaching practice."

The **Goiás State Education Plan (2015–2025)** also recognizes this continuity by establishing specific goals for the consolidation of permanent training and professional development policies.

These initiatives express a **theoretical and political convergence** between academic discourse and institutional practices. The emphasis on interdisciplinarity, collaborative learning and the integration between theory and practice reveals a commitment to a broader conception of education, which goes beyond simple technical updating and focuses on the **integral development of the educator**.

However, as **Pimenta (1999)** and **Tardif (2002)** point out, the challenge is to transform these principles into sustainable practices, ensuring objective conditions for teachers to

⁶ The concept of "reflective professional", developed by Schön (2007), refers to the professional who learns in and about action, transforming his practice based on systematic reflection.

effectively participate in the training processes. It is at this point that the gaps and challenges of the Goiás system emerge.

Gaps and challenges that, despite the advances observed, teacher training in Goiás still faces, such as the obstacles that compromise its effectiveness. The first and most evident of them is the **fragmentation between initial and continuing education**, a topic already discussed by **Gatti (2016) and Dourado (2015)**. Universities often train teachers with a solid theoretical base, but without proper articulation with school practice, and the education networks, in turn, offer specific training, not always integrated with local demands. The result is a discontinuous and non-transformative training process.

Another challenge is the **instrumental nature** of some continuing education, which is limited to the presentation of decontextualized content or methodologies.

Imbernón (2000, p. 63) criticizes this model when he states that

... Teacher training cannot be conceived as a simple technical training, but must constitute a space for critical reflection on practice and reconstruction of teachers' knowledge, considering their experiences and real contexts of action.

When training is imposed, detached from school realities or guided by pedagogical fads, they end up generating demotivation and resistance among teachers.

The **precariousness of teaching work** is also a determining factor. Low salaries, overload of activities and absence of institutionalized time for study and reflection make it difficult to adhere to training processes. Contreras (2002, p. 199) argues that "teachers cannot be required to have autonomous and reflective attitudes when the working conditions imposed on them are based on distrust, devaluation and bureaucratic control of their practice." Teacher autonomy, therefore, must be accompanied by policies of professional valorization that ensure decent working conditions and social recognition.

In addition, the **impact assessment of training** is a point that has not yet been explored. In Goiás, although there are reports and administrative records, there are few studies that systematically analyze the effects of training on pedagogical practice and student learning. **Gatti (2010)** emphasizes that evaluation should not be restricted to the satisfaction of the participants, but should examine the effective transformations in the way of teaching and learning.

Another critical aspect concerns the **regional contextualization of policies**. The State of Goiás is marked by significant geographic and socioeconomic diversity, which

requires that training courses consider local specificities. The reality of rural schools, for example, differs profoundly from urban schools in the capital. An education that ignores this heterogeneity runs the risk of reinforcing inequalities and producing limited effects.

Finally, there is a cultural challenge, that of consolidating a **culture of permanent formation** in schools. As Nóvoa (1992, p. 25) points out, "continuous training must be integrated into the daily work of teachers and schools, and not be an isolated episode or a moment outside of time and professional space." This change in mentality requires incentive policies, time for collective study, and pedagogical leadership that values research and reflection.

The analysis of teacher training in Goiás shows that the evolution of **professional identity** is intrinsically linked to the quality and continuity of training policies. Teaching, as **Freire (1996)** and **Nóvoa (2017) point out**, is a social and political practice that requires reflection, ethical commitment, and collective engagement. Therefore, the strengthening of teacher training is not only a technical issue, but also **a matter of social justice and valuing educational work**.

The positive experiences observed in the **Peer Training** and **Formative Roots programs** reveal possible paths such as investment in collaborative practices, recognition of the knowledge of experience and the promotion of spaces for dialogue between teachers. However, for these programs to reach their fullness, it is necessary that they be incorporated as **a State policy**, and not just as one-off or temporary management actions.

In this sense, the consolidation of an articulated and continuous training policy requires the strengthening of partnerships between universities and education networks, the institutionalization of permanent spaces for reflection and teacher research in schools, as well as the material and symbolic valorization of teaching.

These measures not only qualify teaching, but also reaffirm teaching as an essential profession for human and social development. As Tardif (2002, p. 11) reminds us, "there is no profession without knowledge, and there is no knowledge without recognition of experience."

In summary, teacher training in Goiás is in the process of maturing. It is moving towards a more collaborative and reflective practice, but it still needs to overcome structural and cultural challenges. Only with an **integrated, continuous and contextualized training policy** will it be possible to consolidate a solid, critical and emancipatory teaching identity

that is capable of responding to the challenges of education in Goiás and contributing to the transformation of society.

5 FINAL CONSIDERATIONS

The professional identity of teachers, as demonstrated throughout this study, is a continuous process of evolution and reconstruction that reflects the historical, political and social conditions in which teaching takes place. This identity is not born ready-made, it is woven daily in the relationship between **training, practice and reflection**, permeated by tensions between autonomy and control, theory and practice, vocation and professionalization.

In Goiás, this process is particularly complex, as it involves the challenge of consolidating educational policies capable of articulating **initial training, continuing education and professional valorization** in a context of inequalities and emerging demands.

From the theoretical review and analysis of the training policies and programs of the State of Goiás, it was possible to verify that there are **significant advances**, especially in **collaborative continuing education** initiatives, such as **Peer Training** and the **Formative Roots** program, which demonstrate a paradigm shift by prioritizing dialogue, exchange of experiences and reflection on practice.

However, **structural and cultural gaps** remain that limit the scope of these initiatives. The fragmentation between initial and continuing education, the absence of institutionalized time for study and the precariousness of teaching work make it difficult to consolidate a permanent training culture. Thus, any training policy that ignores objective working conditions runs the risk of becoming merely rhetoric.

Public education policies, especially the **National Education Plan (PNE 2014–2024)** and the **Goiás State Education Plan (2015–2025)**, recognize the importance of teacher training as a strategic axis for the quality of basic education.

Reinforcing the commitment to valuing teaching and offering continuing education in all areas of knowledge depends on adequate funding, administrative continuity and systematic monitoring, elements that still constitute challenges in the Goiás scenario.

In this sense, it is essential to think of **teacher training as a State policy** and not as a government policy. This implies ensuring its **institutional sustainability**, so that advances are not lost with management changes.

Another important point is also the strengthening of **partnerships between universities, education departments and schools**, creating collaborative training and research networks that promote the integration between theory and practice, teaching and learning, knowledge and experience.

Teaching, according to **Freire (1996)**, is a political and ethical act that requires commitment to social transformation. The teacher, as a mediator of knowledge and agent of change, needs training and professional conditions that enable him to perform his function in a critical and autonomous way. It is, therefore, urgent to reaffirm that **the quality of education necessarily involves valuing teachers**, ensuring their integral training and recognizing their central role in society.

In view of this, this article reaffirms three strategic axes for the strengthening of teacher identity in Goiás, the first being the **integration between initial and continuing education**, through programs that promote dialogue between university and school and the exchange between beginning and experienced teachers. The second, the **valorization of the teaching work**, with salary and career policies and adequate conditions for study and reflection and, finally, the **institutionalization of permanent training**, in order to guarantee time and pedagogical space for teachers to develop research and reflective practice.

Only with the consolidation of these axes will it be possible to train teachers capable of critically understanding their profession, acting with autonomy and building a solid teaching identity, committed to public, democratic and emancipatory education.

In other words, and finally, strengthening the teacher's identity is strengthening the public school itself, that is, it is investing in a future in which education is, in fact, the path to social and human transformation in Goiás and throughout Brazil.

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 <https://doi.org/10.56238/sevened2025.036-058>

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ABSTRACT

The SEBRAE's ALI Productivity Program is a strategic initiative focused on boosting the innovation and competitiveness of micro and small enterprises (MSEs) in Brazil. This article analyzes the effectiveness of the Innovation Radar, the program's central tool, in the productive transformation of MSEs assisted by Local Innovation Agents (ALIs). Based on an MIT model and adapted by SEBRAE, the Radar is a comprehensive diagnostic tool that assesses everything from managerial controls to innovative practices, providing a complete business overview. By examining the Radar's application in Cycle 1, this research aims to prove its importance in the final evaluation of revenue, costs, and productivity. Companies that prioritized deficit areas such as ESG and Managerial Controls achieved success, maximizing their productivity. However, analyses of negative results revealed a critical disconnect between the deficiencies pointed out by the Radar and the action priorities chosen by the MSEs, emphasizing the need for greater awareness of essential practices. In summary, the success of the ALI Productivity Program does not depend solely on the quality of the tool, but on the commitment of the entrepreneurs. The program, combined with the strategic use of the Radar, can catalyze the positive transformation of MSEs, provided there is an active partnership between ALIs and companies for the effective implementation of action plans.

Keywords: SEBRAE. ALI Productivity. Micro and Small Enterprises (MSEs). Innovation Radar. Innovation.

RESUMO

O Programa ALI Produtividade, do SEBRAE, destaca-se como uma iniciativa estratégica visando fortalecer a inovação e competitividade das micro e pequenas empresas (MPEs) no Brasil. Este artigo focaliza a análise da eficácia do Radar de Inovação, ferramenta central do programa, na transformação produtiva das MPEs assistidas pelos Agentes Locais de Inovação (ALIs). Originado no MIT e adaptado pelo SEBRAE, o Radar é um diagnóstico abrangente que aborda desde controles gerenciais até práticas inovadoras, proporcionando uma visão completa do ambiente empresarial. Ao explorar a aplicação do Radar no ciclo 1 do ALI Produtividade, a pesquisa visa compreender a importância dessa ferramenta na

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avaliação final de faturamento, custos e produtividade. Empresas que priorizaram áreas deficitárias, como ESG e Controles Gerenciais, alcançaram sucesso na maximização da produtividade. Contudo, algumas empresas enfrentaram desafios ao não correlacionar adequadamente deficiências identificadas pelo Radar e prioridades de ação. Análises de empresas com resultados negativos destacaram uma desconexão entre deficiências apontadas pelo Radar e as prioridades escolhidas pelas empresas, enfatizando a necessidade de conscientização sobre práticas essenciais para a produtividade. O sucesso do ALI Produtividade não depende apenas da qualidade da ferramenta, mas também da compreensão e comprometimento das empresas atendidas. Em síntese, o programa, combinado ao eficaz uso do Radar, pode catalisar a transformação positiva das MPEs, contanto que haja uma parceria ativa entre ALIs e empresas para a implementação efetiva de planos de ação.

Palavras-chave: SEBRAE. ALI Produtividade. Micro e Pequenas Empresas (MPE's). Radar de Inovação. Inovação.

RESUMEN

El Programa ALI Productividad de SEBRAE se destaca como una iniciativa estratégica orientada a fortalecer la innovación y competitividad de las micro y pequeñas empresas (MPEs) en Brasil. Este artículo se centra en analizar la eficacia del Radar de Innovación, la herramienta central del programa, en la transformación productiva de las MPEs asistidas por los Agentes Locales de Innovación (ALIs). Originado en el MIT y adaptado por SEBRAE, el Radar es un diagnóstico integral que aborda desde controles gerenciales hasta prácticas innovadoras, ofreciendo una visión completa del entorno empresarial. Al explorar la aplicación del Radar en el ciclo 1, la investigación busca comprobar la importancia de esta herramienta en la evaluación final de facturación, costes y productividad. Las empresas que priorizaron áreas deficitarias como ESG (Ambiental, Social y Gobernanza) y Controles Gerenciales lograron el éxito, maximizando su productividad. Sin embargo, los análisis de resultados negativos revelaron una desconexión crítica entre las deficiencias señaladas por el Radar y las prioridades de acción elegidas por las MPEs, lo que enfatiza la necesidad de una mayor concienciación sobre prácticas esenciales. En resumen, el éxito del ALI Productividad no solo depende de la calidad de la herramienta, sino del compromiso de los empresarios. El programa, combinado con el uso estratégico del Radar, puede catalizar la transformación positiva de las MPEs, siempre y cuando exista una asociación activa entre los ALIs y las empresas para la implementación efectiva de los planes de acción.

Palabras clave: SEBRAE. ALI Productividad. Micro y Pequeñas Empresas (MiPyMEs). Radar de Innovación. Innovación.

1 INTRODUCTION

The ALI Productivity Program - Local Innovation Agents - Productivity is an initiative of SEBRAE (Brazilian Micro and Small Business Support Service) with the purpose of fostering a culture of innovation and improving the competitiveness of micro and small companies in Brazil (Sebrae, 2025).

In this program, the Local Innovation Agents, professionals highly trained by SEBRAE, play a fundamental role. They work directly with companies, offering specialized advice in areas such as management, innovation, and technology. In addition, they assist companies in identifying market opportunities and developing solutions to overcome specific challenges. A relevant point is that participation in the program is entirely free for the companies involved (Sebrae, 2025).

The ALI Productivity is aimed at micro and small companies that wish to innovate and improve their management, with a focus on maximizing productivity, increasing revenue, and reducing costs (Sebrae, 2025).

Among the various dimensions of the entrepreneurial world that Ali proposes to investigate is the Productivity indicator and the business areas: management controls, operations management, marketing management, innovation practices, digital transformation and ESG - Environmental, Social and Governance. All these aspects are observed through the Innovation Radar tool, which is considered the first crucial encounter between the Agent and the company, in order to observe and analyze weaknesses, strengths, threats and opportunities.

Based on these assumptions, this article proposes to analyze how the interpretation of the Radar instrument can be crucial in the application of the measured results of "meeting 9" (nine) of the Ali Productivity. It is in this sense that it is intended to:

- Analyze final measurements of revenue, variable costs and employed people in cycle 1 of the ALI Productivity and compare them with the initial measurement of the companies served by the N4 agents in the regional office of Presidente Prudente;
- Understand the importance of the Radar as a primary factor for the analysis of problems and action plans and the consequent success in the final measurement;
- Compare companies with increased productivity with those with decreased production and their respective radars.

2 THEORETICAL FRAMEWORK

2.1 THE INNOVATION RADAR

The ALI Productivity Journey takes place in cycles of up to six months, starting with the entrepreneur's interest in introducing innovation into their company. This journey is composed of the following stages: beginning of the journey; mapping of challenges and solutions; knowledge of indicators; knowing the means of testing; creation and testing of the prototype; implementation planning; implementation evaluation; completion of the workday; measurement of results (Sebrae, 2022).

Each stage has its relevance for organizational success and attack on the business bottlenecks listed, but the stage at the beginning of the journey has a relevant aspect in the sense of identifying the problems and in which aspects actions should be created for implementation.

The Innovation Radar plays a crucial role as it represents the first significant delivery of the ALI Project to the entrepreneur, providing a detailed analysis of the company's current situation. Each dimension of the ALI Radar has been carefully crafted based on a series of questions, serving as an essential guide for evaluating the practices adopted by the company. For effective application, it is imperative to thoroughly understand each topic and its issues, ensuring that, by collecting evidence, it is possible to assist the entrepreneur in classifying the current context of the company according to the corresponding degree of maturity (Sebrae, 2022).

The objective of the ALI Radar is to show the entrepreneur the company's potential and identify points for improvement. The presentation of evidence by the entrepreneur is essential to validate the indicated level. The answers and evidence must be registered in the system, which, in the end, will generate the result of the Radar (web) and a feedback proposal. After applying the Radar, the system will provide detailed feedback with the results of the answers provided by the entrepreneur. In addition, the application of the Radar will reveal the company's financial maturity, especially in the dimension of management by indicators (Sebrae, 2022).

If the company does not have a structured system to monitor revenue, as well as its variable and fixed costs, it is recommended to refer the entrepreneur to financial guidance, financial workshop, or another solution offered by the local Sebrae to address this issue (Sebrae, 2022).

According to Davila, Epstein and Shelton (2007), innovation can be categorized into two aspects: technological innovation and innovation in the business model. Both must occur simultaneously, however, it is up to the leadership to establish which models and tools will be used to ensure this simultaneity.

The Innovation Radar is a mechanism for diagnosis. It was originally conceived by researchers at the Massachusetts Institute of Technology (MIT), in the United States, and later adapted by Sebrae. This method addresses several dimensions in which a company can seek innovation. When performing this assessment, it is essential to understand that innovation is not an isolated event, but the result of a continuous process. Therefore, the analysis is not limited only to the number of innovations, but extends to the evaluation of the maturity of the innovation management process in companies, an essential factor for competitiveness in the market (Sebrae, 2013).

Currently, the Innovation Radar implemented has 24 questions that address 6 dimensions to be analyzed, each with 4 questions, they are: management controls; operations management; marketing management; innovation practices; digital transformation, and; ESG – environmental, social and governance. It should be noted that it has not always been the way it is implemented in the ALI Productivity, being developed and improved over time, without losing its essence, which is to investigate the strengths and weaknesses of organizations.

2.1.1 Innovation

For Schumpeter (1982), innovation can manifest itself in five different ways:

- a)** Launch of a new product or qualitative modification to an existing product;
- b)** Process innovation that represents a novelty for an industry;
- c)** Exploration of a new market;
- d)** Development of new sources for the acquisition of raw materials or other inputs;
- e)** Changes in the organizational structure of the industry.

The analysis of innovation in Micro and Small Enterprises (MSEs) implies understanding how their specific characteristics influence the manifestation of these ways of innovating in their activities. Due to the distinct differences between MSEs and large companies, the approach to innovation must also be adapted.

According to Silveira (2013), the act of innovating is not strictly linked to great discoveries. Innovation, as a factor of competitive differentiation, can be identified in practices to improve processes and services, in the implementation of new management approaches, in the exploration of new markets, in the offer of products and services valued by customers, in the resolution of customer problems, in the search for new market segments, in the search for alternative sources of revenue, in the development of new pricing systems, in the effective interaction with customers and partners, in the collaboration and refinement of the flow of information in the supply chain, and also in the creation of mechanisms such as suggestion programs to encourage the presentation of ideas by employees.

Oliveira (2007) argues that innovation is a long-term investment. Although, initially, innovation and changes may increase risks and uncertainties, reducing the company's efficiency and productivity, success in this process can result in benefits and competitive advantages in the future.

The importance of organizational innovation is highlighted by Lam (2005), challenging the traditional assumption of economists that organizational change is simply a response to technical change. On the contrary, Lam (2005) argues that organizational innovation can be an essential precondition for technical innovation.

According to the OECD (1997), innovation encompasses several activities that are not limited to Research and Development (R&D). This includes the final phases of development for pre-production, production, and distribution, development activities with a lower degree of novelty, support activities such as training and market preparation, as well as activities related to the development and implementation of innovations, such as new marketing methods or new organizational methods, that do not fall into the categories of product or process innovations. Innovation activities may also cover the acquisition of external knowledge or capital goods that are not part of R&D.

Over a given period, a company's innovation activities can be classified into three types:

- Successful, when they result in the implementation of an innovation, even if it is not necessarily commercially successful;
- In progress, when they have not yet resulted in the implementation of an innovation;
- Abandoned before the implementation of the innovation.

As an example, Paredes, Santana and Fell (2014) conducted a case study, using the Innovation Radar (IR), in a small company in the metallurgical sector. Although the authors highlight the lack of consensus on the most appropriate model to measure the degree of innovation of a company, the results revealed considerable improvements through the score attributed to the indicators, demonstrating that the tool used (IR) offers a comprehensive view of the innovation environment.

Exploring this same approach, Torchia, Silva and Bari (2016) examined a small business in the transport sector, with the aim of verifying the presence of innovative activity through the Innovation Radar. Adopting a quantitative perspective, each of the thirteen dimensions analyzed presented three characteristics that made up the fundamental concept of the innovation cycle: i) Business innovation is related to a new value, not just to a new thing; ii) Business innovation takes several forms; iii) Business innovation is systemic. Based on the results obtained, it was found that there was limited use and much to be developed with regard to the innovative activity in this segment.

In the following topic, the importance of a good interpretation of the Innovation Radar in the ALI Productivity will be addressed, describing how it has a crucial role in diagnosis and as a primary tool for change and implementation of internal corrective actions.

3 METHODOLOGY

The work will be in its essence as to its approach, a qualitative research, but it will be necessary in order to compare the results obtained in the TF (final measurement), tabulated information and quantitative data of results and innovation radars collected by the N4 Agents of the Regional Office of Presidente Prudente/SP.

As for the objectives, the article works as a documentary and explanatory analysis, where documents and reports will be observed, in order to explain the results presented by the agents through the field exploration of the problems of the companies.

In order to guide and explain the occurrences, SEBRAE manuals, bibliographic references such as scientific articles, e-books, notes, books, theses and dissertations, Sprints and Innovation Radars brought by Local Innovation Agents – BET N4 Scholarship, inserted in SisALI in cycle 1 of Productivity in 2022, will be used.

4 RESULTS AND DISCUSSIONS

As noted, Ali Productivity has as its methodology the search for ways to impact and create philosophies of business improvement, thus aiming at increased productivity, that is, leverage in revenue and/or variable cost cuts. It is important to point out that entrepreneurs are not always able to dedicate themselves to their own created action plans, where they often postpone or give up for various internal reasons.

Below is the list of 10 (ten) companies served by 10 (ten) ALI Agents, guided by their N6 at the SEBRAE Regional Office of Presidente Prudente, which serve 3 regions: Alta Sorocabana, Pontal do Paranapanema and Nova Alta Paulista. These companies have final measurement and were successful in calculating productivity. It should be noted that particularized aspects of each company were disregarded, such as those related to seasonal sales.

Table 1

Positive Productivity Measurements Cycle 1 – ER Presidente Prudente/SP

Agent	Companies	Branch	Problem	Prototyped Solution	Increased Productivity (greater than 15%)	Dimensions of the most deficient Radar
The	VB	Teaching Activities	Lack of leads (Marketing)	Lecture on how to speak on Instagram (Public Speaking Course offered by the company)	64,58%	2 – Innovation Practices; 2 – Management Controls
B	MS	Lighting panels	Difficulty in closing budgets	Institutional video of the company and send it to TV advertising	256,46	1 – Management Controls
C	KT	Paints and materials for painting	Lack of product promotion/ decrease in face-to-face sales	Carry out sales actions through "live commerce"	264,46	1 – Management Controls (no defined goals for indicators; no billing data and monthly costs. 1 – ESG (no communication channels).
D	ING	Constructor	Financial problems	Restructure business	296,66	2 – Operations

			(high accounts payable)	processes/hire accountant		Management ; 2 – Innovation Practices
And	GS	Diaper Sale	Low adherence of a diaper brand	Elaboration of a video demonstrating the brand and its benefits	157,38	1 – ESG; 2 – Operations Management ; 2 – Management Controls; 2- Digital Transformation
F	MC	Mini-market	Absence of structured marketing plan	Development of own products with packaging commemorating special dates	211,20	3 – Operations Management ; 3- ESG.
G	DT	Market	Needs to increase customer portfolio	Focus on social media with a posting schedule	198,77	1 – ESG; 2 – Management Controls; 2 – Operations Management ; 2 – Marketing Management ; 2 – Digital Transformation
H	RB	Computer services and sales of electronics and accessories	Problem of visibility, standardization and internal processes	Process Flow Table	73,46	2 – Management Controls; 2 – ESG
I	HR	Feeding	Employee management with checklist of tasks and obligations	Using the <i>Canva Happiness Tool</i>	60,16	1 – Innovation Practices; 1 - ESG
J	SC	Clothing	Lack of planning and assertiveness of purchases	Create defined processes, where the customer chooses the products he will	39,52	1 – Operations Management ; 1 - ESG

				purchase, before purchasing from suppliers		
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Source: Author (2025).

By analyzing the table, it is possible to understand that the Innovation Radar is an essential tool for creating internal improvement mechanisms and guiding the Agent's planning. It is possible to observe that the biggest problem concerns ESG and Management Controls.

Table 2

Most deficient dimensions

Companies	Radar Dimension
7/10	ESG
6/10	Management Controls
5/10	Operations Management
3/10	Innovation Practices
1/10	Marketing Management

Source: Author (2025).

From Table 1 it is possible to conclude that most of the companies that managed to adhere to the practices in their deficit areas, obtaining good results in the final measurement of productivity. It is clear that organizations are still unable to establish ESG practices, such as governance and sustainable philosophies, which often tend to generate an initial outlay.

Another point to highlight is the management controls that address aspects related to financial and operational indicators, goal setting, effective inventory control, and cash flow. The difficulty with this dimension is quite considerable, where many end up not having tools that can measure or even report the situation.

Table 3 shows the companies that did not present positive results in the TF (final measurement), worsening their productivity.

Table 3

Negative Productivity Measurements Cycle 1 – ER Presidente Prudente/SP

Agent	Companies	Branch	Problem	Prototyped Solution	Decrease in Productivity by 15% (%)	Dimensions of the most deficient Radar
The	VP	Food	Customer churn (no loyalty)	Post photos and videos of customers in the environment,	-2,56	2 – Marketing Management (does not analyze industry)

				on the company's social networks		trends, has no action planning, higher prices than most competitors).
B	AC	Variety store	Low clientele outside the dates considered commercial	Schedule of marketing actions on special dates	-54,26	1 – ESG (does not systematize its communication channels; does not have fast channels such as WhatsApp
C	FA	Maintenance and repair of electronic and optical equipment	Difficulty in attracting customers	CRM system for registration and lead capture	-22,35	1 – Operations Management; 1 – Innovation Practices; 1 – ESG.
D	SP	Water distributor	The company has other niches unknown to most of the clientele	Institutional video demonstrating its products	7,17	3 – Management Controls; 3 – Marketing Management; 3 – Innovation Practices; 3 – Digital Transformation; 3 – ESG.
And	TT	Cargo road transport	Operational problems (delay in arranging fuel payment)	Implement the online notes of gas stations in the system	-64,70	1 – Management Controls; 1 - Operations Management; 1 - Digital Transformation; 1 - ESG
F	BS	Sale of costume jewelry	Absence of relationship marketing	Implementation of loyalty card and regular makeup courses	-81,82	2 – Management Controls
G	DB	Pharmacy	Marketing Need (Disclosure)	Special commemorative date flyer	12,28	1 – ESG; 2 – Digital Transformation
H	MS	Footwear and travel goods	Low sales in e-commerce	Strategic outreach to the website through a	-64,27	3 – Management Controls;

				publication schedule		3 – Marketing Management; 3 - ESG
I	JP	Academy	Lack of organization and disclosure of monthly plans	Preparation of information catalog	1,10	1 – Operations Management; 1 – Innovation Practices
J	PL	Fishing/Feeding	They use money from another company to pay for their expenses/Mispricing	Variable Cost Control through inventory management (spreadsheet)	-3,67	1 – Management Controls; - Operations Management; - Marketing Management; 1 - ESG

Source: The authors(2025)

It should be noted that the view of this article disregards economic aspects, drop in sales and internal problems of these companies and specific sectors, which are quite common and tend to reflect in the results presented. Another important and large aspect is the non-commitment of some organizations to the Program and consequent non-application of the corrective measures suggested by the ALIs. These aspects guide the non-application of the measures or even non-follow-up or implementation of the ideas observed in the prototype.

In Table 3, it is possible to analyze that many of the problems prioritized by the companies in question do not match the deficiency pointed out in the application of the Radar. Let's look at some clear cases:

Table 4

Deficit dimension x prioritized focus

Enterprise	Deficit Dimension	Prioritized Focus
VP	Marketing Management	Customer churn
AC	ESG	Low clientele on ordinary days
F	Management Controls	Absence of relationship marketing
DB	ESG/Digital Transformation	Marketing Need (Disclosure)

Source: The authors(2025)

Table 4 highlights that despite observing that there are greater deficiencies in other dimensions, companies often tend not to prioritize these bottlenecks, either because they do not observe how much it impacts their productivity or because they do not want to make changes in specific areas (self-indulgence). This data is relevant, since of the sample of the

10 companies with negative results, 4 (40%) did not prioritize corrective actions to a problem that can generate more future benefits.

5 CONCLUSION

The ALI Productivity Program, promoted by SEBRAE, emerges as a strategic initiative to boost innovation and improve the competitiveness of micro and small enterprises (MSEs) in Brazil. Its Local Innovation Agents (ALI), trained professionals, play a crucial role in offering expert advice and focus on areas such as management, innovation and technology.

This article proposed an in-depth analysis of the effectiveness of the Innovation Radar, an essential tool of the program, in the productive transformation of MSEs served by ALI Productivity. The Radar, originated at MIT and adapted by SEBRAE, is a diagnostic mechanism that covers several dimensions, from management controls to innovation practices, providing a holistic view of the business environment.

By exploring the application of the Radar in cycle 1 of the ALI Productivity, this article sought to understand how the interpretation of this tool can be crucial for success in the final measurement of revenue, costs and productivity. The analysis of the companies served revealed that those that prioritized the most deficient dimensions, such as ESG and Management Controls, were successful in maximizing productivity.

However, it is notable that some companies have not correctly prioritized corrective actions, often not understanding the relationship between certain deficiencies and productivity. The results showed that the implementation of ESG practices and management controls is essential for organizational success, but many companies still face challenges in these aspects.

The analysis of the companies with negative results in the final measurement highlighted a disconnect between the deficit dimensions pointed out by the Radar and the priorities for action chosen by the companies. This discrepancy highlights the need for greater awareness of the importance of certain practices in achieving the desired productivity.

In this context, it is evident that the success of ALI Productivity does not depend only on the quality of the tool used, but also on the understanding and commitment of the companies served. It is imperative that they recognize the importance of areas such as ESG and management controls to promote significant changes in their productivity.

In short, the ALI Productivity Program, combined with the efficient use of the Innovation Radar, can be a catalyst for the positive transformation of MSEs. However, it is critical that

there is an active partnership between ALIs and companies, promoting a deeper understanding of the identified gaps and the effective implementation of action plans.

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**KNOWLEDGE MANAGEMENT IN THE DIGITAL AGE: TECHNOLOGICAL
ADVANCES AND THEIR IMPACT ON ORGANIZATIONAL PERFORMANCE**

**GESTÃO DO CONHECIMENTO EM TEMPOS DIGITAIS: AVANÇOS
TECNOLÓGICOS E SEUS REFLEXOS NA PERFORMANCE ORGANIZACIONAL**

**GESTIÓN DEL CONOCIMIENTO EN LA ERA DIGITAL: AVANCES
TECNOLÓGICOS Y SU IMPACTO EN EL DESEMPEÑO ORGANIZACIONAL**

 <https://doi.org/10.56238/sevened2025.036-059>

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ABSTRACT

This article aims to analyze how advances in digital technologies impact knowledge management (KM) models in organizations, with an emphasis on the contributions of these innovations to organizational development and to meeting the requirements of NBR ISO 9001. This is a qualitative research, developed through a Systematic Literature Review (SLR). Fourteen studies published between 2015 and 2025 were selected, extracted from the SciELO and CAPES Journals, with strict inclusion and exclusion criteria. The analysis sought to understand the interrelationships between KM, emerging technologies and quality standards. The results demonstrate that the integration between KM and digital technologies, such as artificial intelligence, big data, gamification and collaborative platforms, favors the systematization, dissemination and application of organizational knowledge. Furthermore, this synergy strengthens the culture of innovation, organizational learning, and compliance with the requirements of NBR ISO 9001:2015. Although the review included articles in Portuguese and English, the research was restricted to specific databases and time frames, which may have left out relevant studies from other sources. Furthermore, the lack of empirical data limits the practical application of the findings. Nevertheless, it provides support for future research and practical applications. The study contributes by highlighting KM as an essential strategy in the digital age and highlights the value of emerging technologies in strengthening organizational performance and compliance with normative quality standards.

Keywords: Knowledge Management. Digital Technologies. Organizational Innovation. NBR ISO 9001. Organizational Performance.

RESUMO

Este artigo tem como objetivo analisar como os avanços das tecnologias digitais impactam os modelos de gestão do conhecimento (GC) nas organizações, com ênfase nas contribuições dessas inovações para o desenvolvimento organizacional e para o atendimento aos requisitos da NBR ISO 9001. Trata-se de uma pesquisa de natureza

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qualitativa, desenvolvida por meio de uma Revisão Sistemática da Literatura (RSL). Foram selecionados 14 estudos publicados entre 2015 e 2025, extraídos das bases SciELO e Periódicos CAPES, com critérios rigorosos de inclusão e exclusão. A análise buscou compreender as inter-relações entre GC, tecnologias emergentes e normatizações da qualidade. Os resultados demonstram que a integração entre GC e tecnologias digitais, como inteligência artificial, big data, gamificação e plataformas colaborativas, favorece a sistematização, disseminação e aplicação do conhecimento organizacional. Além disso, essa sinergia fortalece a cultura da inovação, a aprendizagem organizacional e o cumprimento dos requisitos da NBR ISO 9001:2015. Embora a revisão tenha incluído artigos em português e inglês, a pesquisa se restringiu a bases e recortes temporais específicos, o que pode ter deixado de fora estudos relevantes de outras fontes. Além disso, a ausência de dados empíricos limita a aplicação prática dos achados. Ainda assim, oferece subsídios para futuras investigações e aplicações práticas. O estudo contribui ao evidenciar a GC como estratégia essencial na era digital e destaca o valor das tecnologias emergentes no fortalecimento da performance organizacional e na conformidade com padrões normativos de qualidade.

Palavras-chave: Gestão do Conhecimento. Tecnologias Digitais. Inovação Organizacional. NBR ISO 9001. Performance Organizacional.

RESUMEN

Este artículo analiza cómo los avances en tecnologías digitales impactan los modelos de gestión del conocimiento (GC) en las organizaciones, enfatizando las contribuciones de estas innovaciones al desarrollo organizacional y al cumplimiento de los requisitos de la norma NBR ISO 9001. Se trata de un estudio de investigación cualitativa, desarrollado mediante una revisión sistemática de la literatura (RSL). Se seleccionaron catorce estudios publicados entre 2015 y 2025 de las bases de datos de revistas SciELO y CAPES, utilizando criterios rigurosos de inclusión y exclusión. El análisis buscó comprender las interrelaciones entre la GC, las tecnologías emergentes y los estándares de calidad. Los resultados demuestran que la integración entre la GC y las tecnologías digitales, como la inteligencia artificial, el big data, la gamificación y las plataformas colaborativas, favorece la sistematización, la difusión y la aplicación del conocimiento organizacional. Además, esta sinergia fortalece la cultura de innovación, el aprendizaje organizacional y el cumplimiento de los requisitos de la norma NBR ISO 9001:2015. Si bien la revisión incluyó artículos tanto en portugués como en inglés, la investigación se limitó a bases de datos y períodos específicos, lo que pudo haber excluido estudios relevantes de otras fuentes. Además, la falta de datos empíricos limita la aplicación práctica de los hallazgos. Aun así, ofrece una base sólida para futuras investigaciones y aplicaciones prácticas. El estudio contribuye al destacar la gestión del conocimiento como una estrategia esencial en la era digital y enfatiza el valor de las tecnologías emergentes para fortalecer el desempeño organizacional y el cumplimiento de las normas de calidad.

Palabras clave: Gestión del Conocimiento. Tecnologías Digitales. Innovación Organizacional. NBR ISO 9001. Desempeño Organizacional.

1 INTRODUCTION

In recent decades, knowledge has come to be recognized as one of the main strategic assets of organizations. The transformation of the industrial economy into an economy based on information and knowledge has driven a reconfiguration of organizational practices, requiring more dynamic and collaborative approaches in the creation, systematization and application of knowledge. In this context, knowledge management (KM) emerges as a multidisciplinary field aimed at generating value from intellectual capital and continuous organizational learning (Nonaka & Takeuchi, 1997; Davenport & Prusak, 1998).

Technological evolution, driven by digitalization, the internet of things, artificial intelligence (AI), and data-driven systems, has been promoting profound transformations in the ways knowledge is produced, accessed, and shared. Digital platforms, collaborative environments, intelligent software, and methodologies such as gamification and *design thinking* have become part of KM processes, supporting innovation, decision-making, and organizational sustainability (Luiz et al., 2023). These technological tools not only optimize the flow of information, but also enhance the conversion of tacit knowledge into explicit knowledge, favoring organizational learning.

KM, in digital times, can no longer be thought of only as a set of internal practices, but rather as a process articulated with networks, systems, and platforms that transcend the physical limits of the organization. According to Probst et al. (2002), knowledge management involves identifying, acquiring, developing, sharing, using and preserving relevant knowledge. In the digital age, these steps are profoundly mediated by technological resources, which alter not only the speed, but also the depth and scale of the circulation of knowledge in organizations.

In the Brazilian scenario, however, several challenges are still perceived for the consolidation of KM as a structured practice. The disparity in access to technologies, the absence of an organizational culture focused on sharing knowledge, the scarcity of investments in innovation, and the turnover of professionals make it difficult to systematize institutional knowledge. Despite this, promising initiatives have emerged in sectors such as health, education, and services, which demonstrate the effectiveness of digital tools in improving communication, data management, and the formation of learning communities (Vaz & Landeiro, 2022).

At the same time, there is a movement of maturation of organizations regarding the valorization of knowledge as a factor of competitive differentiation. Knowledge is no longer

just an input and is now understood as an integral part of business strategy, with direct impacts on performance, innovation, and the ability to adapt to complex and unstable environments. Weingärtner and Romeiro (2024) highlight that digital transformations not only modify operational processes, but also resignify the way organizations learn, relate, and position themselves in the face of contemporary challenges.

In view of this panorama, this article aims to analyze how the evolution of technologies has impacted knowledge management models in organizations, with emphasis on the contributions of these innovations to organizational development and, secondarily, to compliance with the normative requirements of NBR ISO 9001. The analysis is conducted from a systematic review of the literature, with a reflective focus on classic and contemporary authors, seeking to understand the interfaces between knowledge, technology and organizational transformation.

2 THEORETICAL FRAMEWORK

Knowledge management (KM) can be understood as a set of practices that involve the creation, organization, sharing, and application of organizational knowledge. Several theoretical models, such as those of Nonaka and Takeuchi (1997), Davenport and Prusak (1998) and Probst et al. (2002), emphasize that knowledge should be treated as a strategic asset, and that its conversion from tacit to explicit form is essential.

With the acceleration of digital transformation, new technological tools have come to play a central role in KM processes. Integrated management platforms, digital repositories, software based on artificial intelligence, learning management systems, and gamified learning environments are examples of solutions that optimize the flow of knowledge within organizations (Barbosa, 2020).

These technologies have enabled greater agility in data capture, more accessibility to information, and collaboration between geographically distant teams. Thus, by incorporating these innovations, organizations not only increase their operational efficiency but also build an organizational culture that is oriented towards learning and innovation.

3 IMPACT OF DIGITAL TECHNOLOGIES ON KNOWLEDGE MANAGEMENT

Recent studies show that the use of digital technologies has contributed significantly to strengthening KM processes. Collaborative platforms, artificial intelligence, and big data

have been adopted to automate information flows, facilitate access to knowledge, and promote strategic data analysis (Weingärtner & Romeiro, 2024).

The adoption of methodologies such as *design thinking*, use of intelligent tutoring systems, and gamification, as pointed out by Pereira et al. (2022), has expanded the possibilities of organizational learning and integration of tacit knowledge. These interactive approaches reinforce employee engagement, in addition to contributing to the retention and dissemination of institutional knowledge.

Although there are challenges, such as resistance to change and the lack of technological culture, studies show that the combination of KM strategies and technological solutions tends to promote greater adaptability, innovation and competitiveness.

4 RELEVANCE OF NBR ISO 9001 CERTIFICATION AND CONTRIBUTIONS OF DIGITAL TECHNOLOGIES TO KNOWLEDGE MANAGEMENT

The ISO system was created in 1946 with the purpose of promoting international standardization and facilitating communication between countries. In 1947, the *International Organization for Standardization (ISO) was officially founded*, which currently has more than 22 thousand international standards published (ISO, 2018a). Among these standards, the NBR ISO 9000 family stands out, widely recognized in several sectors. It is composed of NBR ISO 9000, which presents the fundamentals and vocabulary; by NBR ISO 9001, the only certifiable one, which establishes the requirements for a quality management system; and by NBR ISO 9004, which offers guidelines for the improvement of organizational performance (Valls, 2005).

The NBR ISO 9001 certification, as pointed out by Godoy et al. (2009), provides benefits such as process improvement, indicator control and increased customer satisfaction. Data from a survey conducted by ACT Consultoria (2018), based on world records from 2008 to 2017, reveal that Brazil still has a long way to go to reach the certification levels of more consolidated countries, evidencing the need for greater awareness and preparation on the part of national organizations. Certification is often sought by companies that wish to meet supplier requirements, provide services with greater credibility or strengthen their internal management (UNIDO, 2016).

It is worth noting that, although the NBR ISO 9001 certification is not mandatory in all contexts, its adoption requires analysis of the organizational moment, level of maturity, team commitment, and clarity regarding the objectives to be achieved (ISO, 2015). According to

INMETRO (2018), the choice of a duly accredited certifying body is essential to ensure reliability in the certification process.

In this scenario, knowledge management (KM) starts to play a strategic role, especially from the inclusion of requirement 7.1.6 in NBR ISO 9001:2015, which requires organizations to create, maintain and make available the knowledge necessary for the effective operation of processes. The convergence between KM and normative requirements reinforces the importance of systematizing and valuing organizational knowledge.

Digital technologies, in this context, play a fundamental role in enabling greater accuracy, standardization, and traceability in knowledge management processes. Tools such as collaborative platforms, systems based on artificial intelligence, digital repositories and quality management software contribute directly to compliance with regulatory requirements. Companies that invest in these technological solutions tend to find it easier to obtain or maintain ISO certification, as they strengthen aspects such as documentation, internal communication, and continuous improvement.

5 METHODOLOGICAL PROCEDURES

RSL is a method indicated to examine a corpus of academic literature in order to obtain insights, critical reflections, in addition to generating new paths and research questions (Massaro et al., 2016). According to Sampaio and Mancini (2007, p. 2):

A systematic review, like other types of review studies, is a form of research that uses the literature on a given topic as a source of data. This type of investigation provides a summary of the evidence related to a specific intervention strategy, through the application of explicit and systematized methods of search, critical appreciation and synthesis of the selected information.

5.1 DELIMITATION OF THE QUESTION

In the face of the digital transformations that mark the contemporary organizational scenario, knowledge management (KM) has gained new contours, especially with the incorporation of specific technologies, such as digital platforms, artificial intelligence, big data, and collaborative environments. These tools have been consolidating themselves as strategic allies to optimize the storage, dissemination, and reuse of critical knowledge in organizations.

Despite the growing appreciation of KM, many institutions still face recurring challenges, such as high staff turnover, absence of systematic knowledge sharing

mechanisms, failures in preserving information, and lack of adequate digital structures for organizational knowledge management. Such gaps result in rework, loss of tacit knowledge, and low operational efficiency (Rossetti & Morales, 2007).

In order to obtain answers to the research objective and following the RSL method, two research questions were chosen with specific views on the theme, presented below:

Table 1

Research Questions

QP1	How has the evolution of digital technologies transformed knowledge management models in organizations?
QP2	How do these technological innovations applied to knowledge management contribute to organizational development and compliance with the requirements of NBR ISO 9001?

Source: Authors.

5.2 SELECTION OF DATABASES

Once the question of the study has been delimited, the databases consulted are presented to select the studies to be excluded and included in the systematic literature review to be carried out. In the course of the databases used for a systematic review of the literature, the following were presented:

- SciELO: Comprises the production of articles produced in several Latin American countries; It is "an electronic library that encompasses a selected collection of Brazilian scientific journals".
- Capes Journal: Capes is a foundation linked to the Ministry of Education of Brazil that works in the expansion and consolidation of stricto sensu graduate studies in all Brazilian states. The virtual library of Periódicos Capes has on its website "more than 45 thousand titles with full text, 130 reference databases, 12 databases dedicated exclusively to patents, in addition to books, encyclopedias and reference works, technical standards, statistics and audiovisual content" (CAPES, 2021).

5.3 ELABORATION OF THE SEARCH STRATEGY

In order to select relevant texts on the theme in question, the search strategy applied began with the selection of digital libraries to be used, which were selected for their relevance and recognition of quality in the academic environment.

Table 2

Digital Libraries

Library	Email address
Capes Journal	https://www.periodicos.capes.gov.br/
Scielo	https://www.scielo.br/

Source: Authors.

After the selection of the libraries, it is pointed out that each database contains individual rules and limitations, and it is necessary to observe different strategies to adapt the search. Thus, the next step was to define a *string* of search aligned with the objective and questions of the research.

Table 3

Search strings

Keywords	Search Strings
"Knowledge Management"	Knowledge Management and Evolution of Digital Technologies
"Knowledge management"	Knowledge Management and Organizational Innovation
"Knowledge Management"	Knowledge Management and ISO Standards

Source: Authors.

In addition to the *search string*, delimiting inclusion and exclusion criteria were established, including type of subject, period of publication, type of resource, and availability. The *strings* were entered in the search field of the Capes Journal portal and in Scielo, as shown in Table 4. Articles dated from the last 10 years (2015 – 2025) and in Portuguese and English were considered.

Table 4

Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Articles that address the theme of knowledge management in companies.	Articles that talk about knowledge management but without directing organizations and addressing digital transformations.
Articles that use technologies and programs in knowledge management.	Articles outside the research time frame (2010-2019).
Articles that address the use of digital transformations and changes in the quality and knowledge management of organizations.	Articles with restricted access, which do not allow full reading of the content for critical analysis.
	Systematic review articles

Source: Authors.

In the search carried out in the SciELO and CAPES Periodicals databases, 781 articles were identified, 491 in the SciELO database and 290 in the CAPES database. Among this total, 521 publications were excluded because they treated KM in a generic way, without applying technological resources to its development. 18 studies were also eliminated due to duplication between the databases, in addition to 108 studies classified as systematic literature reviews and 120 publications that were outside the period stipulated for analysis (2015 to 2025). After these filtering steps, a final set of 14 studies remained that fully met the established inclusion criteria.

As a way of organizing and presenting the results of the search in the databases, at the end of the entire process, Table 5 was elaborated, which presents the works selected for this RSL:

Table 5

Selected works

No.	Title	Author/Year	Summary	Methodology	Analysis of Results
1	Organizational learning strategies and information and communication technologies to support knowledge management in SMEs in the Cauca Valley, Colombia	Arango et al. (2020)	The article proposes strategies to strengthen knowledge management (KM) in SMEs based on its relationship with organizational learning and information and communication technologies (ICT). It is proposed to improve transfer mechanisms and practices and the implementation of virtual learning platforms.	This study with a quantitative approach, using a questionnaire applied to SMEs. The information obtained was analyzed using the SPSS software. The study was limited to companies located in the urban area of Cali with at least ten years of incorporation. It is characterized as a descriptive study that specified properties and characteristics. The expert judging technique was applied with five experts to validate the	The main results of the survey showed the lack of a formal area for knowledge management. SMEs have collaborative processes that facilitate knowledge sharing. Formal and institutional mechanisms for the transfer, documentation and adequate storage of knowledge have not been established. There is a weakness in the lack of organizational culture that fosters the exchange of knowledge. Strategies are proposed to strengthen KM practices aiming at strategic competitiveness

				content of the instrument. Cronbach's alpha test was performed for the reliability of the questionnaire.	
2	Knowledge Management in Organizations 4.0	Jala et al. (2023)	Knowledge Management (KM) comprises the construction of assertive strategies to streamline business decision-making, particularly in Industry 4.0, which is characterized by technical and economic innovation with a focus on artificial intelligence and accessibility to <i>big data</i> .	The information collection process took place in three stages: 1) semi-structured interviews with managers of different organizations 4.0 (qualitative information); 2) establishment of criteria and classification codes for content analysis; 3) elaboration of empirical and descriptive conclusions for the writing of theoretical and explanatory conclusions	Within the knowledge management category, subcategories such as "basic conditions" and "human talent" are associated. The subcategory "organizational learning" is "cause of" human talent. The anecdotes and episodes that employees remember the most are the characteristic that stands out in every organization, showing that experiences allow for adequate knowledge management in entities 4. The interviewees highlighted that KM manifests relevant characteristics for teamwork, self-management, and that experience and willingness to share are essential. Communication, commitment, collaboration, and experience strengthen organizational identity, facilitating business strategy and the use of technology.
3.	Methodology for estimating and evaluating a knowledge management model using structural equations	Armas et al. (2020)	The article presents a methodology for the estimation and evaluation of a knowledge management (KM) model using structural equations, which test and estimate causal relationships from statistical data	The proposed methodology includes the construction of a questionnaire. Structural Equation Models (SEM) were used to test theoretical hypotheses. Five hypotheses were formulated. The initial instrument had	The most influential variables in knowledge management for the department of systems and technological resources at Universidad Simón Bolívar are ICT, Intellectual Capital, Organizational Learning and Innovation. The ICT tools of core services define KM solutions by accessing knowledge repositories, based on the processes of

				199 items, evaluated by two experts and reduced after a pilot test with 42 IT employees, eliminating items with corrected element-total correlation of less than 0.70. The statistical programs SPSS 25, AMOS 22 and STATGRAPHICS Centurion XVI were used.	creation, organization and use. ICT tools of packaged services solve specific problems, such as customer relationship management. The designed instrument is reliable according to the results of the Cronbach's Alpha test.
4	YouTube Tutorials as a Non-Formal Learning Strategy for College Students	Rodriguez (2021)	The study discusses the didactic criteria of YouTube tutorials, noting that their relevance or pedagogical quality is not evaluated. <i>Likes</i> , <i>dislikes</i> , comments, or video length are not enough to determine its quality. Comments are essential as a feedback mechanism for users and creators, addressing technical and execution aspects.	The methodology is not explicitly detailed in the sources, but the text discusses the evaluation of YouTube tutorials as a non-formal learning strategy and mentions "our investigation", indicating the conduct of a study.	The relevance or pedagogical quality of YouTube tutorials is not evaluated. <i>Likes</i> , <i>dislikes</i> , comments, or the length of the video are not sufficient requirements to determine the quality. Comments are essential as a feedback mechanism for users and creators.
5	Influence of Knowledge Management Practices Applied to Agile Software Development	Candal et al. (2022)	The document presents a theoretical platform, method and materials applied in the research, presentation, analysis and discussion of the results, and conclusions. It addresses the relationship between	Exploratory-descriptive research with a qualitative approach with two stages: 1) literature review on the relationship between PGC and DAS; 2) application of a <i>controlled survey</i> with the Delphi	The assertions with the highest consensus include questions about <i>software</i> maintenance, staffing, knowledge sharing, agile practices, and generic DAS improvements. Assertions with less consensus address software maintenance and DAS-specific components (artifacts, ceremonies, method, and team). The model

			Knowledge Management (KM) and Agile Software Development (DAS). The Agile Manifesto is an important milestone in the DAS. The study identifies the technological profile of nurse managers. It is a quantitative, descriptive and exploratory study with 74 nurse managers who filled out a questionnaire on the use of ICT in management. Nurse managers are over 51 years old, have more than 28 years of professional practice and have more than 11 years in management, and have acquired knowledge about informatics through self-learning.	method21. A face test was performed with four experts to improve the questionnaire, which was then applied to other specialists. This is a quantitative, descriptive and exploratory study. The eligible population was nurse managers at a Hospital Center in the Northern Region (CHRN) and nurse members of the Portuguese Association of Nurse Managers and Leadership (APEGEL). A self-completed questionnaire was used. The data were treated with statistical and descriptive analysis. Descriptive approach, using the <i>survey</i> technique. A consultation instrument was applied to 10 key informants (2 health workers per hospital center) using the 13-item Likert scale. Information collection was carried out in 5 health organizations,	can enable the evolution of studies on the correlation between knowledge management and <i>software development</i> with agile methods. The most well-known technologies used by nurse managers are <i>e-mail</i> and videoconferencing. <i>Webs</i>, discussion groups and videoconferencing are known by 36.5% of the nurses. <i>E-mail</i> is the most used technology for management (4.3%), followed by <i>webs</i> (28.4%) and discussion groups (25.7%). For face-to-face training, the most mentioned are videoconferencing (63.5%), <i>e-mail</i> (60.8%) and discussion groups (50.0%). The technologies for which nurse managers would be interested in receiving training are <i>webs</i> (33.8%), discussion groups (32.4%), <i>blogs</i> (32.4%) and videoconferencing (29.7%). The results show congruence in the management of information from the hospitals consulted. The health centers have homogeneous results regarding the use of <i>web software</i>, <i>Microsoft Office</i> and <i>online</i> tools, management of social networks for service information, <i>online</i> interaction for access to services, and recording of results in the management of human talent, finance, health technologies and logistics. These
6	Use of technologies by nurse-managers in the management process	Vaz & Landeiro (2022)			
7	Knowledge management is a key element in information management in healthcare organizations	Martinez et al. (2022)	The study aims to evaluate the characteristics of information management of organizations in a knowledge <i>cluster</i> in hospitals and clinics in Ambato, Ecuador, and the impact of ICT.		

				both public and private.	homogeneous operating techniques possibly respond to a regulatory policy.
8	ECG Tutor: development and evaluation of a gamified intelligent tutor system for teaching electrocardiogram	Pereira et al. (2022)	The study aimed to explore the interest and motivation of medical students in the use of a gamified intelligent tutor system (ITS) for the study of electrocardiogram (ECG). The need to adapt to mobile devices and improve the elements of gamification and aesthetics was noted.	This is an exploratory and quantitative survey research. Graphic design prototypes of a gamified STI were conceived and evaluated by medical students from two universities. The population was 779 medical students from the fifth period onwards. Data collection was carried out through a structured questionnaire in Google Forms.	At the beginning, 53 undergraduates participated, but only 14 answered the post-interaction questionnaire.... 75.4% of the students self-rated their ECG interpretation skills as "terrible" or "bad" 100. 96.2% classified the classes on ECG as quantitatively insufficient. All students agreed that interacting with the system was clear and understandable and easy to use.
9	Applied knowledge management: digital transformation and communities of practice	Weingärtner & Romeiro (2024)	The study seeks to understand whether knowledge management (KM) practices, such as community of practice, applied in the study unit, will allow an effective improvement of processes. Process improvement is a complex and knowledge-intensive process, even more so in digital transformation projects.	Interpretative case study. The adoption of collaborative discussion through a model similar to that of communities of practice was determined. Field note records and active participation were used for observation. Document analysis included identification, collection, organization, permissions, reading, analysis and interpretation, and cross-analysis.	In the initial stages of the process methodology, only the view of the person responsible or the direct participants is considered, focusing on explicit knowledge, which neglects intangible elements and part of the history of the process. Having intentional spaces for discussion allowed the process of knowledge creation to flow in an appropriate and timely manner. The most recurrent words in the documentary corpus were: <i>learning, students, education/educational, reading/lectura, blended and teacher</i> . Information and communication technologies are undeniably important in educational scenarios. Evaluation, collaborative work, and technological mediations are the most relevant aspects in the design of <i>b-Learning experiences</i> .

10	The use of <i>design thinking</i> in solutions Innovative for information and management Knowledge in teaching hospital pharmacy	Luiz et al. (2023)	Develop innovative solutions to solve problems that are caused by the difficulty in reconciling the information recorded in the system with the physical stock in a pharmacy of a teaching hospital.	Exploratory research of qualitative nature – method adopted, case study. The sources of evidence were: interview, questionnaire, document analysis, direct observation and indirect observation with a <i>design approach thinking</i>. Three employees who work in a pharmacy of a teaching hospital, in the control of the stock of medicines (receipt, storage and distribution) were the subjects of the research.	The results show that there is a need to understand how the stock control of medications, who makes it and how it is done, in addition to identifying who used this control and their needs. In order to understand how individuals viewed this process, it was necessary to verify the occurrence of accidents, incidents and/or errors that could impair the control of the stock of medicines.
11	An Enabling Framework for the Development of Knowledge Management Practices: Perspectives from Nigeria	Pepple and Okuiomse (2023)	This study investigated the knowledge management (KM) practices of palm oil producers in Nigeria, comparing indigenous and contemporary farmers. The focus was on how information is created, stored, and disseminated, using the facilitating framework of Lee and Choi (2003).	The research adopted an interpretative posture and qualitative methodology. The structure of Lee and Choi (2003) was used to frame the interview questions. We interviewed 40 purposefully selected participants (20 indigenous farmers and 20 contemporaries) , with more than 5 years of experience in palm oil cultivation. The interviews were conducted via Zoom and lasted from 45 minutes	Indigenous farmers use traditional methods and orally transmitted information..., without documentary evidence. Contemporary farmers have formal organizations and discuss best practices in forums. Indigenous skills are learned by observation and generational transmission. There is concern about the lack of access for Nigerian producers to the relevant technology. Contemporary farmers use KM software such as "Agrisoft Systems". Both groups receive government support. Contemporary farmers use incentives and recognition (financial and non-financial) to motivate staff and foster creativity.

				to 1 hour. Thematic analysis was used, with a priori coding based on the literature.	KM contributed to increased profits and better agricultural yields for both, but contemporaries benefited more due to KM technology and practices.
12	Continuing Education in Health and Knowledge Management: Initiatives in the Regional Health Superintendence	Ribeiro and Friedrich (2023)	The study aimed to present the actions of Permanent Education in Health (PEH) and Knowledge Management (CG) carried out in a Regional Health Superintendence (SRS) of Minas Gerais, Brazil, and to reflect on the possible parallels. The results indicate formal and informal processes of training and knowledge sharing, construction and transformation of work processes, as well as fragmentation, sectorization and competitiveness based on information.	This is a qualitative and exploratory study.... Data collection took place from February to May 2021, using a remote instrument developed via Google Forms. The sample consisted of 10 health workers with complete higher education and working in management. The data were analyzed using Bardin's Thematic Content Analysis technique.	Knowledge is perceived as reflected and transformative information, which interacts with formative processes and experiences, being applied in daily work and in articulation with municipalities. There is a criticism of the lack of structure and incentive for PEH, despite its potential to favor access, exchange and integration between civil servants. KM is conceived as a tool/instrument for the daily intra-organizational work, aiming at optimizing and improving performance. There is compatibility between EPS and CG, with KM being an enabler for EPS.
13	The contribution of Learning commons practices to the knowledge management process in libraries	Pfleger and Macedo (2024)	The objective of this article is to analyze the contributions of the practices of Learning commons used in libraries for the process of managing knowledge.	Qualitative research. It used an analysis model developed in Macedo's doctoral thesis (2008) and validated in Espíndola's (2012) master's thesis. The model was adapted, using 10 KM processes identified in the literature, 21 CL	KM processes have 3 to 8 characteristics, with "partnership with other libraries" having the lowest number (3) and "sharing-dissemination-knowledge transfer" the highest number (8). The model is very useful for University Libraries and can be used for library management evaluation and action planning. The application of the model and the appreciation of the data that there is a significant relationship between Learning

			practices and characteristics inherent to KM processes applied in libraries.	commons and knowledge management, and both are relevant to the innovation of libraries.
14	Tacit Knowledge Management Strategies in Small and Medium-sized Enterprises: An Overview	Adesina and Ocholla (2024)	The study investigated tacit knowledge management (TKM) strategies in small and medium-sized enterprises (SMEs) in the province of KwaZulu-Natal (KZN), South Africa, aiming to reduce operational discontinuity and knowledge loss.	Most SMB owners are aware of the importance of tacit knowledge. The most common methods of capturing tacit knowledge are: monitoring (93.9%), hands-on sessions (92.2%), internal training programs (91.7%), and brainstorming/knowledge-sharing sessions (91.7%). Tacit knowledge is mostly shared in meetings, employee dialogues, and brainstorming sessions. Storage takes place in electronic files on computers, cloud storage, and physical files. Almost all respondents (96.1%) use information and communication technology (ICT) to manage tacit knowledge.

Source: Authors.

6 PRESENTATION AND ANALYSIS OF DATA

The systematic literature review contributed to studies focused on the problem of knowledge management. Among the authors conducting research focused on the area of study, the following stood out: Armas et al. (2020), Arango et al. (2020), Rodriguez (2021), Vaz and Landero (2022), Candal et al. (2022), Martinez et al. (2022), Pereira et al. (2022), Luiz et al. (2023), Jala et al. (2023), Pepple and Okuiomse (2023), Ribeiro and Friedrich (2023), Weingärtner and Romeiro (2024), Pflieger and Macedo (2024), Adesina and Ocholla (2024).

6.1 KNOWLEDGE MANAGEMENT IN THE ORGANIZATIONAL PROCESS OF COMPANIES

The study by Arango et al. (2020) presents contributions to discuss organizational learning strategies and the use of technologies to support knowledge management in small

and medium-sized enterprises (SMEs), specifically studying those in the Cauca Valley in Colombia.

The study by Jala et al. (2023) contributes that knowledge management within organizations that adapt to Industry 4.0 uses technological tools. For the authors, the pillars of KM are creation, sharing and use, providing strategic positioning and generating competitive advantages.

The authors adopt the definition of knowledge management based on Davenport and Prusak (2001); Koulopoulos and Frappaolo (2001); Nie, Ma and Nakamori (2009) in which it is characterized by being a set of practices and procedures, which enable organizations to: a) identify the knowledge necessary for the execution of their present and future activities; b) have this knowledge; and c) apply it appropriately to achieve the expected results (Arango et al., 2020). Among the organizational learning strategies, this study contributes to the improvement of knowledge transfer practices, in addition to the implementation of virtual platforms and the strengthening of the organization's culture to improve and qualify the knowledge management of SMEs.

The study by Martinez et al. (2022) addresses health organizations and contributes by saying that knowledge management (KM) is of great importance to manage the organization's tacit knowledge and convert it into valuable information for health centers, allowing them to respond to the demands of the environment.

The reflections and study by Ribeiro and Friedrich (2023) focused on problems in the health area, with the need to implement knowledge management and promote training and training. Knowledge management is included in activities as "the process of coordinating the flow of knowledge in an organization in a systematic and integrated manner, for the benefit of work" (Ribeiro & Friedrich, 2023).

With the authors Pepple and Okuiomse (2023) there is a facilitating framework for the development of knowledge management practices. The main points are: the definition of knowledge management, the components of its structure, the benefits and implementation.

6.2 THE EVOLUTION OF TECHNOLOGIES IN ORGANIZATIONAL KNOWLEDGE MANAGEMENT

The research by Arango et al. (2020) points to the contributions of technologies to the organizational culture of companies. For the authors, digital transformations challenge managers and companies, promoting changes in processes and organizational structure.

Thus, organizations are driven to seek new knowledge, make data-driven decisions, establish strategic partnerships, and reconfigure their operational strategies (Arango et al., 2020). Such aspects show how technological evolution directly impacts traditional models of knowledge management.

The study by Vaz and Landeiro (2022), conducted in the health sector, investigated how technologies integrated into management practices can support the work of nurses. Tools such as electronic medical record systems and management software were analyzed, which, according to the authors, enable more efficient communication, better organization of information and data, and greater agility in decision-making. The authors emphasize that digital technologies are indispensable to contemporary management, because "with the internet and constant updates and innovations, a lot of information is networked, which is vital to management" (Vaz & Landeiro, 2022). These advances reflect the growing role of technologies in strengthening KM processes.

Such studies indicate that technology has promoted significant transformations in the way knowledge is produced, managed, and disseminated. However, Vaz and Landeiro (2022) highlight that challenges still persist in the adoption of these technologies, such as resistance to change and lack of employee training. In order for the benefits of technology to be fully enjoyed, it is necessary to invest in infrastructure and continuous training of teams.

It is inferred that knowledge management and the adaptation of processes in companies are increasingly interconnected with technological resources such as artificial intelligence, digital platforms and online systems, which have proven effective in optimizing tasks, systematizing organizational knowledge and continuous learning of employees. In this sense, the research by Pereira et al. (2022) discusses innovative methodologies applied to KM, such as the use of artificial intelligence platforms and gamification in specific teaching and training contexts.

The study demonstrates the positive impacts of gamification on the learning process of medical students with difficulties in interpreting electrocardiograms (ECG). For this, intelligent tutoring systems (ITS) associated with gamification techniques were used. The results showed that the students considered the system clear, easy to use and useful, with high acceptance in terms of usability and intention of use. Despite this, aesthetic and gamification elements were not widely approved, indicating the need for adjustments in the design of these features.

In corporate environments, knowledge management is configured as the basis for strategic decisions and innovation processes. The study by Luiz et al. (2023) presents the use of *design thinking* as a tool to boost organizational learning. This approach favors the entry and circulation of knowledge through the creation of scenarios that stimulate action, innovation, and the transformation of tacit and cultural knowledge into intangible assets and social capital. The adoption of this approach highlights the growing technological sophistication in the structuring of processes aimed at KM.

In this same field of discussion, Weingärtner and Romeiro (2024) emphasize that knowledge should be treated as an essential asset for competitiveness. Digital transformations, according to the authors, directly impact management models by automating complex tasks and freeing up professionals' time for activities of greater strategic value. Thus, emerging technologies become facilitators in the process of capturing, organizing, and applying knowledge in organizations.

Finally, the study by Pflieger and Macedo (2024) contributes to the understanding of the role of digital platforms and environments in the process of knowledge management in libraries. The authors highlight the Learning Commons model as a dynamic and collaborative space, integrating individual and collective study environments, thus promoting active learning and knowledge exchange. The advancement and diffusion of these digital environments demonstrate the constant evolution of technologies applied to knowledge management.

In view of this, it is observed that the evolution of technologies has significantly impacted knowledge management models, making them more dynamic, accessible and centered on organizational innovation. The studies analyzed demonstrate that the incorporation of technological resources such as AI, gamification, digital platforms, and collaborative environments not only modernize KM processes, but also expand their effectiveness and reach, even contributing to meet normative standards such as NBR ISO 9001.

7 CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to analyze how the evolution of technologies has impacted knowledge management models in organizations, highlighting the contributions of these innovations to organizational development and, in a complementary way, to meet the normative requirements of NBR ISO 9001. From the systematic review of the literature, it was

possible to verify that knowledge management, when articulated with emerging technologies, gains a strategic dimension that goes beyond the traditional limits of stored information, becoming a central element for innovation, continuous learning and competitiveness.

Several studies analyzed reinforce this perspective, as Arango et al. (2020) and Vaz & Landeiro (2022) show that digital technologies cause transformations in organizational culture, management structures, and decision-making capacity, especially by facilitating access, organization, and use of knowledge. Resources such as collaborative platforms, artificial intelligence, electronic medical record systems, management software, and digital environments have proven effective in promoting a more dynamic, accessible, and problem-solving-oriented KM.

In addition, authors such as Pereira et al. (2022) and Luiz et al. (2023) point to the importance of active methodologies, such as the use of gamification and *design thinking*, in stimulating learning and converting tacit knowledge into explicit knowledge. These models reveal a transition movement in knowledge management, in which technologies not only support operational processes, but also reconfigure the way knowledge circulates, legitimizes itself, and is applied in organizational daily life.

On the other hand, persistent challenges were also identified, such as those pointed out by Vaz & Landeiro (2022): resistance to change, absence of a culture of sharing, lack of digital infrastructure, and gaps in team training. Such obstacles reinforce the need for structured actions by organizations to effectively integrate technologies into knowledge management, not only as instruments, but as part of the culture and business strategy.

From a theoretical point of view, the present study reinforces the relevance of classical KM models, such as those of Nonaka & Takeuchi (1997), Davenport & Prusak (1998) and Probst et al. (2002), while proposing their updating in the face of the demands of the digital age. Knowledge management, in current times, requires not only formal structuring, but also flexibility, interactivity, and integration between people, technologies, and organizational purposes.

As a path for future research, it is suggested to carry out empirical studies in Brazilian organizations of different sizes and sectors, with the purpose of understanding how technological resources are being effectively implemented and what results have been achieved. In addition, it is recommended to investigate the role of leaders in the consolidation of an organizational culture guided by knowledge management, based on data and focused on innovation. Another relevant point is to deepen the analysis of the interactions between

digital knowledge management and normative requirements, such as those of NBR ISO 9001, in different organizational contexts.

In this scope, it is also proposed the development of a practical and easily accessible tool to assist companies in the application of knowledge management concepts in accordance with the requirements of the ISO standard. Such an initiative can work as a strategy to encourage the adoption of these practices, especially by organizations that face structural limitations or lack of technical knowledge. In this way, the field of application and reflection on KM as a strategic tool for organizational development in times of digital transformation is expanded.

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**CONTEMPORARY APPROACHES IN THE DIAGNOSIS OF LE FORT
FRACTURES: A LITERATURE REVIEW**

**ABORDAGENS CONTEMPORÂNEAS NO DIAGNÓSTICO DAS FRATURAS LE
FORT: REVISÃO DE LITERATURA**

**ENFOQUES CONTEMPORÂNEOS EN EL DIAGNÓSTICO DE LAS FRACTURAS
LE FORT: REVISIÓN DE LA LITERATURA**

 <https://doi.org/10.56238/sevened2025.036-060>

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ABSTRACT

Le Fort–type fractures represent one of the most complex and challenging conditions in facial trauma due to their high clinical severity, potential functional and aesthetic impairment, and the diagnostic difficulty resulting from the anatomical complexity of the midface. Most cases are associated with high-energy trauma, such as assaults and motor vehicle accidents, predominantly affecting young men. Clinical diagnosis should be based on a thorough physical examination, including inspection, palpation, and assessment of bone mobility, as well as the identification of signs such as malocclusion, crepitus, edema, and bilateral epistaxis. However, diagnostic confirmation depends on high-precision imaging exams, such as Cone-Beam Computed Tomography (CBCT), considered the gold standard because it enables detailed three-dimensional reconstructions and precise visualization of fracture lines, overcoming limitations of conventional radiography. Waters, Caldwell, Towne, and Hirtz radiographic views may still be useful in specific cases, while complementary methods such as magnetic resonance imaging and ultrasonography assist in evaluating soft tissues and diagnosing associated injuries. Thus, it is concluded that effective diagnosis of Le Fort fractures must be grounded in a multidisciplinary approach that integrates careful clinical assessment with advanced imaging methods, ensuring greater accuracy in identifying the extent of lesions and enabling adequate surgical planning for functional and aesthetic restoration of the traumatized patient, ultimately improving their quality of life.

Keywords: Le Fort Osteotomy. Diagnostic Imaging. Clinical Diagnosis. Maxillofacial Surgery.

RESUMO

As fraturas do tipo Le Fort representam um dos quadros mais complexos e desafiadores da traumatologia facial, devido à elevada gravidade clínica e potencial de comprometimento funcional e estético, bem como à dificuldade de diagnóstico decorrente da complexidade anatômica do terço médio da face. Destaca-se que a maioria dos casos está relacionada a traumas de alta energia, como agressões e acidentes automobilísticos, acometendo principalmente homens jovens. O diagnóstico clínico deve basear-se em um exame físico

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minucioso, contemplando inspeção, palpação e avaliação de mobilidade óssea, além da identificação de sinais como má oclusão, crepitação, edema e epistaxe bilateral. No entanto a confirmação diagnóstica depende de exames de imagem de alta precisão, como a Tomografia Computadorizada de Feixe Cônico (TCFC), considerada o padrão-ouro por permitir reconstruções tridimensionais detalhadas e visualização exata das linhas de fratura, superando limitações radiográficas. As radiografias de Waters, Caldwell, Towne e Hirtz ainda podem ser úteis em casos específicos, enquanto métodos complementares, como a ressonância magnética e a ultrassonografia, auxiliam na avaliação de tecidos moles e em diagnósticos associados. Assim, conclui-se que o diagnóstico eficaz das fraturas Le Fort deve ser fundamentado em uma abordagem multidisciplinar, que associe a análise clínica criteriosa aos métodos de imagens avançados, garantindo maior precisão na identificação da extensão das lesões e um planejamento cirúrgico adequado para restauração funcional e estética do paciente traumatizado, promovendo melhora de sua qualidade de vida.

Palavras-chave: Osteotomia de Le Fort. Diagnóstico por Imagem. Diagnóstico Clínico. Cirurgia Maxilofacial.

RESUMEN

Las fracturas del tipo Le Fort representan uno de los cuadros más complejos y desafiantes de la traumatología facial debido a su elevada gravedad clínica, al potencial compromiso funcional y estético, y a la dificultad diagnóstica derivada de la complejidad anatómica del tercio medio facial. La mayoría de los casos se relaciona con traumas de alta energía, como agresiones y accidentes automovilísticos, que afectan principalmente a hombres jóvenes. El diagnóstico clínico debe basarse en un examen físico minucioso que incluya inspección, palpación y evaluación de la movilidad ósea, además de la identificación de signos como maloclusión, crepitación, edema y epistaxis bilateral. No obstante, la confirmación diagnóstica depende de pruebas de imagen de alta precisión, como la Tomografía Computadorizada de Haz Cónico (TCHC), considerada el estándar de oro por permitir reconstrucciones tridimensionales detalladas y la visualización precisa de las líneas de fractura, superando las limitaciones de la radiografía convencional. Las proyecciones radiográficas de Waters, Caldwell, Towne y Hirtz aún pueden ser útiles en casos específicos, mientras que métodos complementarios como la resonancia magnética y la ecografía contribuyen a la evaluación de tejidos blandos y al diagnóstico de lesiones asociadas. Así, se concluye que el diagnóstico eficaz de las fracturas Le Fort debe fundamentarse en un enfoque multidisciplinario que combine un análisis clínico riguroso con métodos avanzados de imagen, garantizando mayor precisión en la identificación de la extensión de las lesiones y un adecuado planeamiento quirúrgico para la restauración funcional y estética del paciente traumatizado, promoviendo la mejora de su calidad de vida.

Palabras clave: Osteotomía de Le Fort. Diagnóstico por Imagen. Diagnóstico Clínico. Cirugía Maxilofacial.

1 INTRODUCTION

Bone fractures result from the application of a mechanical load greater than the absorption capacity of the tissue, resulting in the rupture of the facial structure and the alteration of local blood flow (Araújo, Gabrielli and Medeiros, 2007). This biomechanical imbalance causes pain, edema, hemorrhage and, in more severe cases, can compromise the airways and adjacent structures, requiring immediate care and an interdisciplinary approach (Mesquita et al., 2019). As for the etiology, according to a study carried out by Zamboni and collaborators in 2017, cases of aggression are the main cause of facial trauma, followed by car and motorcycle accidents, falls, being run over, complications in sports or at work, in addition to injuries caused by firearms. These occurrences reflect social behavior and increased exposure to risk situations in certain population groups (Rao and Raghani, 2013).

Regarding epidemiology, there is a greater involvement of men between the second and third decades of life, a group more exposed to facial traumatology, especially due to associated factors such as the consumption of alcoholic beverages and illicit drugs, more frequently related to this gender (de Moura, Daltro and de Almeida, 2016). According to Almeida et al. 2023, late diagnosis and treatment are more common in this patient profile, which worsens the prognosis and increases the risk of functional and aesthetic complications.

Anatomically, facial trauma is divided into fractures of the upper third, involving frontal bone and supraorbital boundaries; middle third, which may affect, together or individually, the nasal, orbital, maxillary and zygomatic bones; and lower third, where mandibular fractures occur. Fractures in the central region of the face correspond to approximately 70% of all maxillofacial traumas (Kim and Huoh, 2010). This predominance is due to the exposed anatomical position and the relative fragility of the structures of the middle third, often associated with dentoalveolar and orbital fractures (Hupp, Ellis, and Tucker, 2015). Its intimate anatomical connection with other bones of the skull, such as the palatine, sphenoid, ethmoid and vomer, favors the occurrence of associated traumas (Kim and Huoh, 2010).

The classification of fractures involving the middle third of the face, described by René Le Fort in 1901, was based on the orientation of the bone disjunction: Le Fort I, horizontal; Le Fort II, pyramidal; and Le Fort III, cross-sectional (Bilésimo et al., 2025). While type I refers to the separation of the maxilla from the viscerocranium, from the piriform opening to the pterygomaxillary suture area, type II involves the

disengagement of the nasomaxillary complex of the skull, from the zygomatic-orbital rim area. On the other hand, Le Fort III fractures, the most severe, result from sufficiently high facial impingement vectors, capable of promoting the dissociation of the naso-orbito-ethmoid complex, zygomas, and maxilla, configuring a craniofacial separation (Hupp, Ellis, and Tucker, 2015).

The diagnosis of facial trauma, which includes Le Fort fractures, must be thorough and based on a complete detailed clinical and radiographic examination, since, when performed correctly and early, it will provide the best clinical outcome and functional recovery (Silva et al., 2025; Bohneberger et al., 2021). Therefore, the present literature review aims to highlight the methods for diagnosing Le Fort fractures, including the mechanisms performed during the physical examination, the main signs and symptoms presented by trauma patients, and the radiographic techniques that allow a better evaluation of facial bone structures and functional rehabilitation of the maxillofacial complex.

2 METHODOLOGY

This study was carried out based on searches in the PubMed and Scielo databases, using the descriptors DeCs/MeSH: Le Fort osteotomy; Diagnostic Imaging; Clinical Diagnosis; Maxillofacial surgery. Articles in both Portuguese and English were included, aiming to evaluate the recurrent patterns already described in the literature on the subject studied. The selection of studies considered publications from the last 20 years, focusing on literature reviews, case reports, and renowned books in the area that addressed diagnostic and clinical aspects related to Le Fort fractures. Studies that did not specifically address the diagnostic methods applied to fractures of the middle third of the face, including Le Fort classifications, were excluded. After screening, the data were analyzed qualitatively, seeking to identify convergences among the authors for the fabrication of the present work.

3 RESULTS/DISCUSSION

Injuries caused by facial traumatology represent an important public health problem, given that their high frequency, in addition to their significant functional and aesthetic impact, have the capacity to generate significant morbidities (Bohneberger et al., 2021). Le Fort-type lesions, in turn, are extremely complex and represent a great challenge in the scope of maxillofacial surgery, mainly because they also follow the same pattern of possible and

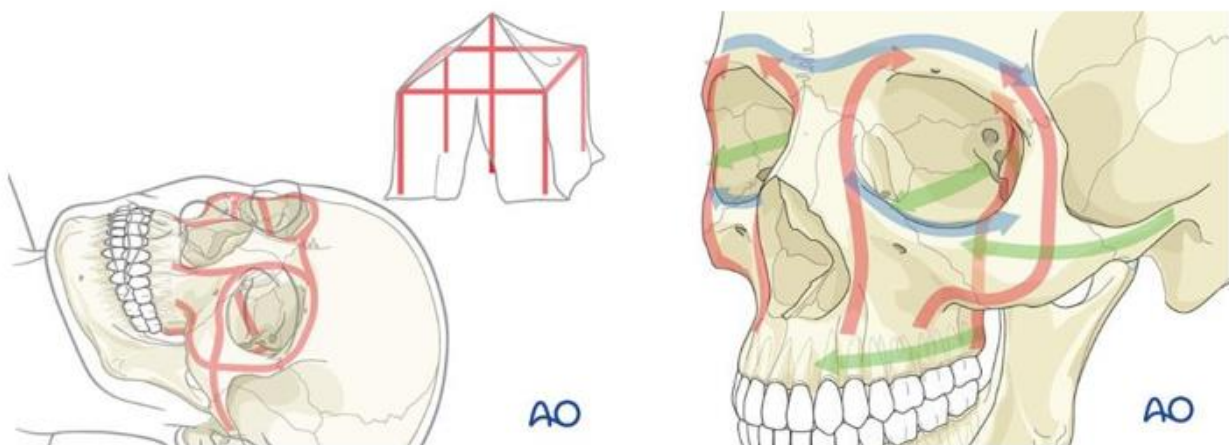
considerable complications that affect not only the functionality, but also the patient's facial aesthetics (Almeida et al., 2023).

Although not all facial fractures require surgical fixation, Le Fort fractures generally imply this need due to the impairment of the resistance pillars of the skull bone structure. The

The main ones are the nasomaxillary, the pterygomaxillary and the zygomatic-maxillary. They act in the absorption of superoinferior forces, but become susceptible to rupture when submitted to anteroposterior vectors. These structures define facial dimensions and, when compromised, result in morphological changes that give a dimorphic aspect to the face. In all Le Fort fractures, the pterygomaxillary pillar is affected, and it is the only one that does not receive surgical fixation due to the difficulty of access, as it is located in the deepest region of the middle third of the face (Hohman, Patel and Waseem, 2024).

Figure 1

Face Resistance Pillars



Source: surgeryreference.aofoundation.org

The trauma patient referred for oral and maxillofacial surgery does not always have immediate treatment of fractures, since, as a rule, the initial management is based on the pre-established protocols of SAVT (Advanced Trauma Life Support). The ABCDE of Trauma is based on the maintenance of the airways, followed by the analysis of the patient's breathing and ventilation, the control and correction of possible hemorrhages, the neurological evaluation and the subsequent total exposure of the body for examination, with the prevention of hypothermia and so that other injuries are not left unattended (Araújo, Gabrielli and Medeiros, 2007). This occurs because, in facial trauma, there is the possibility of immediate

implications in view of the involvement of the upper airways, which can be obstructed by factors such as excessive bleeding, edema, cerebrospinal fluid drainage, and teeth or fragments that may hinder ventilation (Mesquita et al., 2020). Such complications, including vision-threatening conditions, may initially be subtle, which requires two principles: the need for great suspicion on the part of the surgeon and the requirement of frequent reassessment, through secondary examinations, of this trauma patient (Rao and Raghani, 2013).

After stabilization of the patient, through the care of potentially life-threatening injuries, bone treatment should be carried out as soon as possible, within the first week after the trauma. Early intervention prevents the development of sequelae such as pseudoarthrosis, caused by inadequate consolidation of structures, which may require more complex correction surgeries later (Almeida et al., 2023). However, before any procedure, thorough and highly accurate physical and radiographic examinations are necessary, aiming to define the diagnosis in order to consequently establish a favorable prognosis for the patient (Bohneberger et al., 2021). In addition, the discussion of the case in a very clear way by the professionals involved is essential for making decisions about treatment, varying according to the energy of the trauma and the singularities of the patient involved (Mesquita et al., 2020).

3.1 PHYSICAL EXAMINATION

The patient's physical examination should include: inspection of the face in search of signs and symptoms characteristic of these lesions; palpation of bone structures, to evaluate the presence of crepitus and/or steps in the zygomatic-maxillary regions and the nasal complex, mainly; in addition to sensitivity tests to determine whether there was local nervous involvement (Silva et al., 2025). All these protocols are justified by the fact that facial traumas rarely occur in isolation, but rather in association with other injuries. Therefore, intraoral evaluation is equally essential, with attention to the presence of hematomas and dental impairment (Araújo, Gabrielli and Medeiros, 2007).

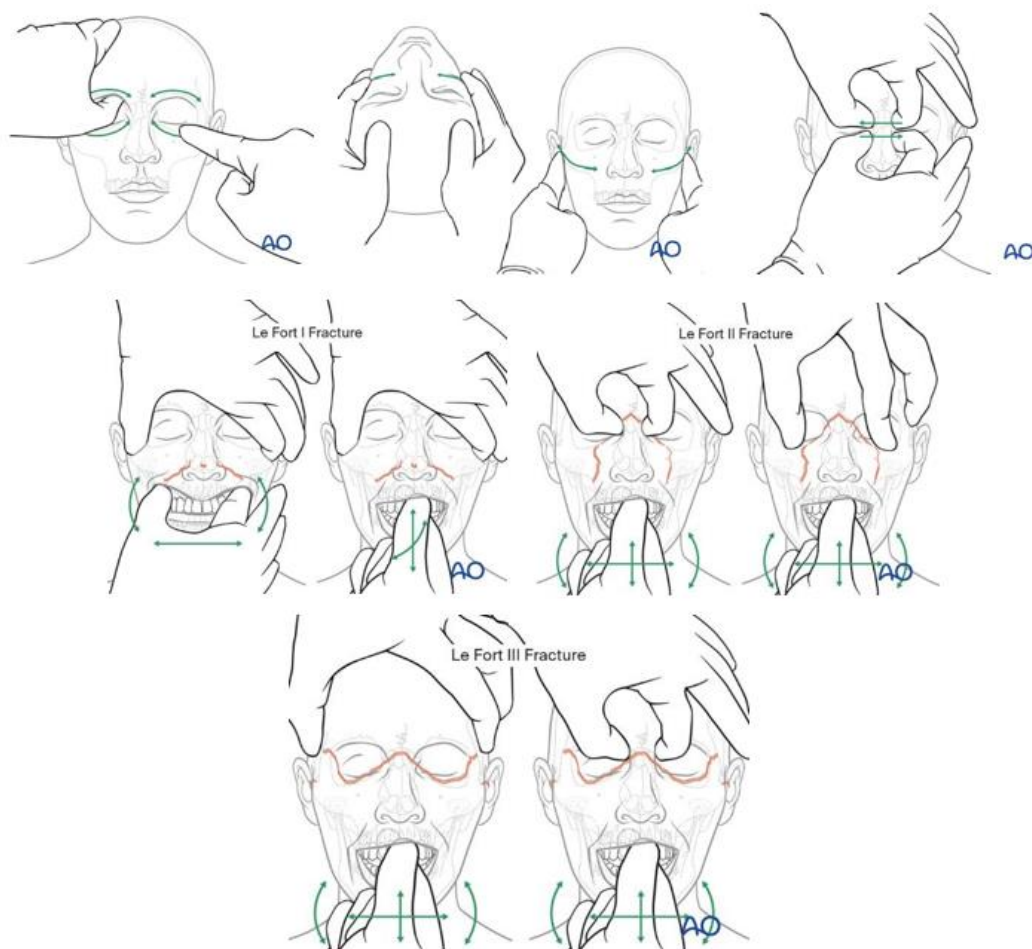
Regarding the symptomatology and profile of these traumas, common signs are: malocclusion, most commonly from the presence of an open bite; trismus; bone crepitation; anosmia (total or partial loss of olfaction); orbital and/or subconjunctival ecchymosis and edema; bilateral epistaxis; and hypoesthesia of the infraorbital nerve, which emerges in the region superior to the canine fossa in the maxilla (Almeida et al., 2023). In addition, Le Fort fractures may also be associated with increased vertical dimension of the face, septal fractures, cerebrospinal fluid fistula and, in more severe cases, significant ocular sequelae

such as diplopia, when there is a fracture of the orbital floor, for example (Araújo, Gabrielli and Medeiros, 2007).

The main palpation method for the diagnosis of Le Fort fractures consists of checking facial bone mobility, which allows the identification of the anatomical structures involved. To do this, the patient's head must be stabilized with one of the operator's hands, while the thumbs and index fingers of the other hand are positioned intraorally to assess maxillary movement through lateral and anteroposterior movements. Digital pressures must also be applied and the mobility of the other bones of the viscerocranium, periorbital ridge, and zygomatic and nasal regions, which may indicate the presence of associated fractures (Hupp, Ellis, and Tucker, 2015).

Figure 2

Steps of the Physical Examination of Le Fort Fractures



Source: surgeryreference.aofoundation.org

3.2 IMAGING EXAMS

After the initial evaluation and clinical examination of the patient, imaging tests are essential for the complete evaluation of the severity of the fracture, as well as to determine its diagnosis and plan

surgical intervention (Gonçalves et al., 2022). Cone-beam computed tomography (CBCT) is the reference method for assessing the level of the lesion and bone fragmentation, which has a three-dimensional reconstruction of the analyzed area by means of coronal, axial, and sagittal sections (Silva et al., 2025). Its proper interpretation requires deep mastery of regional anatomy on the part of the professional in charge (Gonçalves et al., 2022).

Radiography, which is two-dimensional, although not the method of first choice to obtain images of the lesion due to the high overlap of structures, has some views that are still used in these cases (Schuknecht, 2005). They are: the Fronto-naso, also called Caldwell, used mainly for the evaluation of the frontal sinus and orbital edges; the Mento-naso, or Waters, indicated for the diagnosis of fractures of the middle third of the face, allowing the visualization of the maxillary sinuses, nasal septum and ethmoidal cells; and the Fronto-occipital, or Towne, used to analyze the lateral walls of the maxilla, as well as the body and mandibular processes. There is also the Submentovertex, or Hirtz, radiograph, indicated for the examination of the regions of the foramen ovale and spinosum — from which branches of the trigeminal nerve emerge, as well as other regions such as the other sinuses, palate, and occipital bone (Silva et al., 2025).

Each Le Fort type injury has its respective technique for better observation of the fracture extent. While for Le Fort I and II the preference is given to CBCT, the incidence of Waters, always through the performance of two views, can also be used. For Le Fort type III, in addition to these two methods, the OPN test, characterized by the image of the lateral nasal complex, can be requested together (Schuknecht, 2005).

In addition to conventional CT scans and radiographs, magnetic resonance imaging and ultrasonography are alternative and associative exams. Even though they are more expensive, especially CBCT, they have the greatest benefit due to their high sensitivity in identifying fractures, almost completely reducing overlaps and distortions (Gonçalves et al., 2022).

4 CONCLUSION

Le Fort fractures are one of the greatest challenges in the field of facial traumatology, due to their high anatomical complexity, functional impairment and significant aesthetic impact. The diagnosis of these injuries requires the integration of clinical examination and highly accurate imaging methods, considering that the definition of the type and extent of the fracture is decisive for the favorable prognosis of the patient.

Thorough physical examination, which includes inspection, palpation, and evaluation of bone mobility, remains an essential step in identifying characteristic signs of these fractures. However, contemporary diagnostic approaches highlight the importance of imaging studies, especially CBCT, due to their capacity for three-dimensional reconstruction and superior anatomical detailing. These examinations allow for precise surgical planning and the reduction of diagnostic failures resulting from structural overlaps observed on conventional radiographs.

Therefore, it is concluded that the diagnosis of Le Fort fractures should be based on a multidisciplinary approach, supported by the association between detailed clinical evaluation and advanced imaging tests. This integration promotes greater diagnostic safety, favors individualized surgical planning, and contributes to the functional and aesthetic restoration of the face, directly reflecting on the improvement of the quality of life of affected patients.

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SHARED PERSPECTIVES: PARTICIPATORY PHOTOGRAPHY AND VISUAL ANTHROPOLOGY IN THE USE OF PHOTOVOICE

OLHARES COMPARTILHADOS: FOTOGRAFIAS PARTICIPANTES E ANTROPOLOGIA VISUAL NO USO DO PHOTOVOICE

MIRADAS COMPARTIDAS: FOTOGRAFÍA PARTICIPATIVA Y ANTROPOLOGÍA VISUAL EN EL USO DEL PHOTOVOICE

 <https://doi.org/10.56238/sevened2025.036-061>

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ABSTRACT

This article discusses Photovoice as a methodological practice situated within the field of visual and shared anthropology, oriented toward the collaborative production of knowledge and the understanding of life worlds shaped by intersectional identities. Drawing on an empirical experience conducted with seven participants of diverse profiles — including individuals with visual impairments — the study analyzes the process of image production, interviews, and collective meetings, examining how photography can operate simultaneously as an ethnographic artifact, an enunciative device, and a space of collective care. The methodological steps included media literacy, free image production, individual pre-selections, discussion groups, and analytical feedback sessions, with emphasis on accessibility and ethical reflexivity. The analysis of the images and narratives revealed tensions between visibility and protection, agency and vulnerability, highlighting the political and sensorial potency of the image as a space of negotiation and encounter. The work is situated within the tradition of shared anthropology and within decolonial and multisensory epistemologies, proposing a reading of photography as a gesture of sharing and an instrument of symbolic resistance.

Keywords: Intersectionality. Ethnography. Photovoice. Qualitative Methodology. Accessibility.

RESUMO

Este artigo discute o Photovoice como uma prática metodológica situada no campo da antropologia visual e compartilhada, orientada à produção colaborativa de conhecimento e à compreensão de modos de vida atravessados por identidades interseccionais. A partir de uma experiência empírica realizada com sete participantes de perfis diversos — incluindo pessoas com deficiência visual —, o estudo analisa o processo de produção de imagens, entrevistas e encontros coletivos, observando como a fotografia pode operar simultaneamente como artefato etnográfico, dispositivo de enunciação e espaço de cuidado coletivo. As etapas metodológicas compreenderam alfabetização midiática, produção livre

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de imagens, pré-seleções individuais, grupos de discussão e devolutivas analíticas, com ênfase na acessibilidade e na reflexividade ética. A análise das imagens e narrativas revelou tensões entre visibilidade e proteção, agência e vulnerabilidade, destacando a potência política e sensorial da imagem como espaço de negociação e de encontro. O trabalho inscreve-se na tradição da antropologia compartilhada e nas epistemologias decoloniais e multissensoriais, propondo uma leitura da fotografia como gesto de partilha e instrumento de resistência simbólica.

Palavras-chave: Interseccionalidade. Etnografia. Photovoice. Metodologia Qualitativa. Acessibilidade.

RESUMEN

Este artículo discute el Photovoice como una práctica metodológica situada en el campo de la antropología visual y compartida, orientada a la producción colaborativa de conocimiento y a la comprensión de modos de vida atravesados por identidades interseccionales. A partir de una experiencia empírica realizada con siete participantes de perfiles diversos — incluyendo personas con discapacidad visual—, el estudio analiza el proceso de producción de imágenes, entrevistas y encuentros colectivos, observando cómo la fotografía puede operar simultáneamente como artefacto etnográfico, dispositivo de enunciación y espacio de cuidado colectivo. Las etapas metodológicas comprendieron alfabetización mediática, producción libre de imágenes, preselecciones individuales, grupos de discusión y devoluciones analíticas, con énfasis en la accesibilidad y en la reflexividad ética. El análisis de las imágenes y narrativas reveló tensiones entre visibilidad y protección, agencia y vulnerabilidad, destacando la potencia política y sensorial de la imagen como espacio de negociación y encuentro. El trabajo se inscribe en la tradición de la antropología compartida y en las epistemologías decoloniales y multisensoriales, proponiendo una lectura de la fotografía como gesto de compartir y como instrumento de resistencia simbólica.

Palabras clave: Interseccionalidad. Etnografía. Photovoice. Metodología Cualitativa. Accesibilidad.

1 INTRODUCTION

In a world saturated with images and crossed by narrative disputes, visual production has become a privileged terrain to understand the relationships between representation, power and experience. In contemporary anthropology, photography has ceased to be a mere recording instrument to assume the status of relational language — a way of thinking and feeling the field. As Sylvia Caiuby Novaes (2017, p. 13) observes, photography "is not just a mirror of reality, but a translation that is built in the encounter", evidencing the performative and dialogical dimension of visual practices.

The Photovoice method, created by Wang and Burris (1997), is inscribed in this epistemological shift by placing the camera in the hands of the participants, redistributing the possibilities of enunciation and authorship. More than democratizing the gaze, it is a way of narrating the world from the margins — a gesture of co-authorship that gives back to the subjects the right to represent themselves. However, its application in multisensory ethnographic contexts, especially with visually impaired people, remains little explored in the anthropological literature, which reveals a theoretical and methodological gap to be addressed.

The theme of this study focuses on Photovoice as a participatory methodology situated in the field of visual anthropology, analyzing its ethical, political and sensorial power. The research problem of the study can be summarized in the following question: how can the Photovoice method, articulated with shared anthropology and decolonial and multisensory epistemologies, produce practices of co-authorship, care, and symbolic resistance among subjects crossed by intersectional markers of gender, race/color, and disabilities?

The overall objective is to understand how Photovoice can operate as a collaborative practice of knowledge production and collective care in the field of visual anthropology, especially in contexts of sensory and intersectional diversity. To this end, it seeks to: (a) analyze how the method is inserted in the tradition of the anthropology of the image in a shared posture (b) investigate the practical process of production and discussion of images among participants, observing dimensions of visibility, vulnerability and agency; (c) to examine the methodological adaptations that allowed the participation of blind and low-vision people; (d) reflect on the ethical and epistemological implications of participatory methodologies; and (e) propose a conceptual expansion of visual anthropology.

The research was developed between February and March 2024, in a process consisting of five virtual collective meetings and seven individual interviews, carried out with

the support of accessibility software and screen readers. Seven people participated, with diversity of gender, race/color, ages, modes of perception and body shapes. Among them, there were blind and low-vision participants, as well as people who declare themselves black, trans, elderly and in fat bodies; There were also reports of long-standing motor limitations. The research team was composed mostly of white people and included a blind researcher, as well as gay and fat body members. The individual breakdown was discussed in continuous consent and is aggregated here to protect privacy." The conduct of the activities was planned in an accessible way, ensuring that all stages — from the mediation of conversations to the reading of images — could occur in an inclusive and dialogical way. It is noteworthy that the description of social markers was self-reported and the level of detail negotiated with each person, applying the principle of data minimization to reduce the risk of re-identification in small samples. Consent was continuous and reviewable.

The meetings took place in a virtual environment, with time and rhythm adjusted to the needs of the group, and privileged listening, touch and imagination as legitimate forms of sensory experience. The field was conducted under principles of horizontality and co-authorship, ensuring that each person could define their own forms of expression — through photography, sound, collage, writing, or oral storytelling. This methodological choice sought not only to record the visible world, but to welcome multiple forms of perception and production of meaning.

It is based on the hypothesis that Photovoice, when articulated with principles of accessibility and reciprocity, can constitute itself as a practice of co-authorship and symbolic reparation, redistributing the power to narrate and represent. In addition, it is assumed that the inclusion of blind and low-vision participants expands the notion of visibility, demonstrating that anthropological knowledge can emerge from a multisensory field of relationships and affects.

Methodologically, it is a qualitative and exploratory study inserted in the tradition of shared anthropology (Rouch, 2003; Eckert & Rocha, 2003). The investigation was based on collective and individual meetings that combined media literacy, image production, group discussions and analytical feedback. The steps were documented through audio and video records, and field diaries, with collaborative validation of interpretations and continuous ethical consent. This approach sought to ensure accessibility, horizontality and reflexivity, transforming Photovoice into a practice of sensory and political research.

By mobilizing the contributions of shared anthropology (Rouch, 2003; Novaes, 2017) and decolonial and multisensory epistemologies (Smith, 2021; Howes, 2022), the study proposes to understand photography not only as an ethnographic artifact, but as a gesture of sharing and political practice of the sensitive. The theoretical framework articulates four interdependent axes that sustain the reading of Photovoice as an ethnographic practice of co-authorship and care: (1) visual and shared anthropology, which is based on Eckert and Rocha (2003), Novaes (2017) and Rouch (2003, 2015), emphasizing collaborative making and the return of images to the context of origin; (2) intersectionality, based on Patricia Hill Collins (2022) and Gama (2017), which allows us to understand the overlaps between gender, race, class, and body as entanglements of visibility and vulnerability; and (3) multisensory anthropology, supported by Howes (2022), MacDougall (2006), Kleege (2018) and Bolt (2021), which shifts visibility to a field of embodied and inclusive perception. It is argued, therefore, that *Photovoice*, when articulated with these references and guided by principles of accessibility and reciprocity, destabilizes visual hierarchies and produces alternative ways of seeing, hearing and existing in common

2 THEORETICAL FRAMEWORK

2.1 VISUAL ANTHROPOLOGY AND THE SHARED GESTURE

Visual anthropology has consolidated itself as a field of experimentation situated between science, art and politics. Since Jean Rouch (2003; 2015), the camera has come to be seen as a mediator of encounters and not as a simple instrument of capture. Rouch inaugurated an ethics of sharing that shifts the researcher from a place of observer to that of participant in a collective process of creation and interpretation — what he called *cinema verdade* and, later, *shared anthropology*.

In Brazil, Cornelia Eckert and Ana Luiza Carvalho da Rocha (2016) broaden this horizon by proposing the notion of "anthropology of the image", understood as a disciplinary field that seeks to understand the relationships between image, visibility, and anthropological research practices. The authors note that, historically, anthropology was a predominantly written discipline, in which images and sounds were used as illustrative appendices. However, with the advancement of audiovisual and digital technologies throughout the twentieth century, the use of the image began to be recognized as a legitimate form of knowledge production. Inspired by the contributions of Margaret Mead and Gregory Bateson, Eckert and Rocha (2016) argue that the anthropology of the image should explore the

"semantic fields" and institutional devices that integrate the visual and the sound in ethnographic production, opening space for new languages and for the dialogue between art, science and technology.

Photovoice directly inherits this principle, allowing participants to produce their own images and, with them, new meanings about their experiences. By placing the camera in the hands of those who are usually the object of research, the method becomes a device for authorship and redistribution of the gaze. However, as Liebenberg (2018) emphasizes, this delivery of the camera is not automatically emancipatory. The author proposes a critical reflection on the risks and contradictions inherent to the use of images in participatory contexts, pointing out four fundamental dimensions:

(1) the risk of exploitation and oppression, when images are used without ethical return processes and without the informed and continuous consent of the participants; (2) the subjectivity of interpretation, since the meaning of images is always situated and depends on the experiences and social contexts of those who produce and read them; (3) the limited impact on social change, when the circulation of images ignores aspects of visual literacy, cultural translation and political mobilization; and (4) the challenges in dissemination and public impact, especially when it is not planned how and to whom the results will be shared.

These criticisms reinforce that *Photovoice* requires more than the production of images: it requires an ethical and intentional commitment to the processes of co-interpretation, feedback and circulation of photographs. Without this, there is a risk of repeating the same hierarchies of power that the method seeks to question. Thus, the value of the ethnographic image lies not only in its representational capacity, but in its relational potency — as a space for care, listening, and the construction of common worlds.

2.2 INTERSECTIONALITY AND DECOLONIAL EPISTEMOLOGIES

Intersectionality, as proposed by Patricia Hill Collins and Sirma Bilge (2016), is an analytical tool that allows us to understand the complexity of human experiences in their social, political, and cultural dimensions. By recognizing that life events are shaped simultaneously by multiple factors — such as gender, race, class, and disability — the authors propose an approach that rejects one-dimensional readings of inequalities. This perspective shifts the gaze from isolated categories to the relational plots that structure oppression, revealing how different social markers intersect and reinforce each other.

More than a theoretical concept, Collins and Bilge (2016) understand intersectionality as critical praxis — a way of articulating research and transformative action. This double dimension, analytical and political, moves intersectionality away from a merely descriptive use and reinserts it in the field of collective struggles, where theory and practice co-implicate each other. The authors (Collins & Bilge, 2016) argue that knowledge is only emancipatory when it is born from a dialogical movement between bodies and territories, which brings them closer to a situated and insurgent epistemology. Thus, intersectionality is not only a methodology for analyzing inequalities, but a way of thinking and acting committed to social justice and the redistribution of the power to narrate.

In the Latin American context, intersectional reading gains density by dialoguing with authors such as Fabiene Gama (2016), who proposes an anthropology sensitive to emotions, affections, and embodied forms of expression. In his work on political demonstrations in Bangladesh, Gama demonstrates how images and emotions become devices for mobilizing and critiquing the classical dichotomies of anthropology, such as reason and emotion, body and mind, reality and fiction. Such a perspective converges with the intersectional proposal by refusing epistemological hierarchies and emphasizing the forms of knowledge that emerge from the body and lived experiences.

These articulations reveal that the challenge of intersectionality is not only to identify the overlapping of oppressions, but to reconfigure the very forms of knowledge that sustain them. By recognizing that experience is a site of theoretical production, intersectionality operates as a frontier epistemology—a practice of translation and resistance between worlds. In this sense, when applied in multisensory ethnographic contexts, such as those proposed in this study, it allows us to think of the body, gender and race not as fixed markers, but as relational dimensions that cross the ways of seeing, feeling and representing the world.

2.3 MULTISENSORIALITY AND ACCESSIBILITY AS EPISTEMOLOGY

The anthropology of the senses, as proposed by David Howes (2022), invites us to understand knowledge as an embodied and situated experience, in which each culture organizes and values the senses in its own ways. Perceptual hierarchies—the predominance of vision in Western societies, for example—are not universal, but cultural constructs. Howes argues that multisensory studies should comparatively investigate these sensory ecologies, recognizing that feeling is always collective and relational. Such a perspective also implies an epistemological openness to embrace non-Western paradigms of perception, in which

seeing, hearing, touching, and imagining are intertwined in forms of knowledge that challenge the separation between body and mind.

This approach is echoed in the visual and filmic anthropology of David MacDougall (2006), who conceives the image as a way of thinking with the body. In *The Corporeal Image*, the author argues that sensory ethnography is not limited to observation, but emerges from contact—from physical presence, ambient sound, gesture, and breathing. The camera, in this context, becomes a perceptive extension of the researcher and the participants, establishing a field of sensory exchanges that mobilizes all the senses. MacDougall proposes an *expanded visibility*, in which knowledge is not only represented, but lived.

By integrating people with different forms of perception, the *Photovoice project* revealed that seeing is also listening, imagining and touching. The collective exercise of translating experiences through photography, narration and sound made visible the plurality of ways of perceiving the world. From Georgina Kleege (2018), it is understood that blindness — or any perceptual variation — is not absence, but another form of presence. The images produced by participants with little or no vision expanded the concept of photography, transforming it into tactile, auditory and imaginative gesture. In this sense, the right to image is expanded: it is also the right to perception and sensory expression in its multiple languages.

The thought of David Bolt (2019) offers a critical basis for this expansion. Its tripartite model — between normative positivisms, non-normative negativisms, and non-normative positivisms — allows us to understand how certain forms of perception are marginalized while others are elevated to the norm. Bolt advocates a pedagogy that recognizes these differences not as failures, but as sources of insight. The "cryptaemologies", in their formulation, challenge the privilege of the dominant epistemes and propose a liberating education, based on dialogue and collaboration between different ways of existing and knowing.

Thus, accessibility is understood here not only as a technical adaptation, but as an epistemological and political principle. Researching and creating in an accessible way means recognizing that knowledge is born from the relationship between bodies, sounds, images and affections. Photovoice becomes, in this horizon, an expanded and liberating sensory method — a practice of co-authorship in which perceptual difference is cognitive and ethical power. By relating different experiences of the sensible, the study reaffirms that every form of knowing is, above all, a way of sharing the world.

3 METHODOLOGY

3.1 METHODOLOGICAL DESIGN

The methodological design was conceived as a report of ethnographic experience, developed from a collective process of visual creation and reflection. The study had seven participants, intentionally selected in order to ensure diversity of gender, age group, race/ethnicity, disability and social class.

Among them, there were people with low vision and total blindness, which allowed them to explore multisensory dimensions of image production, both among the researchers and among the participants. This plural composition reflects the conception of Patricia Hill Collins (2022), according to which intersectionalities should be understood as networks of relationships that configure positions and experiences, and not as a simple sum of inequalities.

3.2 RESEARCH STAGES

Data collection was organized in five main stages, articulating training meetings, visual productions, individual interviews and moments of collective feedback. All phases were planned based on principles of accessibility, horizontality and ethical reflexivity.

a) Initial meeting — Collective construction and media literacy

The first meeting had an introductory and formative character. The objectives of the research were presented, ethical aspects were discussed and the set of generating questions that would guide the production of images was collectively elaborated. This session included a media literacy workshop, focused on reflection on framing, consent and visual narrative.

b) Production of images (10 days)

For ten days, the participants produced images from the collectively elaborated questions, using cell phones, digital cameras or alternative resources, such as sound recordings, collages and textual descriptions. This plurality was fundamental to ensure inclusion and expressive freedom, especially in the case of people with visual impairments.

(c) Individual pre-meetings – Selection and negotiation of consents

Each participant held an individual meeting with the researchers, presenting the set of materials produced, performing a pre-selection and discussing issues of anonymity, exposure and circulation of images. These moments functioned as spaces for listening and ethical negotiation, in which consent was treated as a continuous process, as argued by Liebenberg (2018) and Catalani & Minkler (2010).

d) Collective meeting — Presentation and discussion of the images

In a group, each participant chose three images to share. After each exhibition, the collective produced a "force-word" that synthesized the symbolic or affective meaning of the photograph. This exercise promoted a space for co-interpretation and sharing, transforming the group into a community of analysis and care.

e) Analytical feedback

The process ended with a final feedback meeting, in which the researchers presented preliminary readings of the images and narratives. The interpretations were submitted to the group's review, ensuring traceability, transparency and co-authorship in the construction of the results.

3.3 ETHICS AND TRACEABILITY

Ethics was understood as a situated and continuous practice, not restricted to a formal stage of approval. Consent was renegotiated throughout the process, and participants had the autonomy to remove materials, modify authorizations or decide on the public destination of the images. Concrete counterparts were offered, such as the printing of photographs, the holding of a community exhibition and the writing of a collective manifesto-text.

As Hikiji (2018) argues, the ethnographic image only acquires full meaning when it returns to the field and is re-inscribed in the exchanges and affections that originated it. From this perspective, ethics is not limited to avoiding harm, but implies promoting reciprocity, recognition, and mutual care.

In this way, all meetings were recorded in audio and video, with formal authorization. The researchers prepared individual field diaries and a collective notebook with observations and reflections. The analysis of the corpus was based on methodological triangulation — between images, speeches and field notes — and on collaborative validation strategies, during feedback and collective reviews.

3.4 ACCESSIBILITY AND MULTISENSORY ANTHROPOLOGY

The participation of blind and low-vision people required methodological adaptations that became a constitutive part of the project's epistemology.

Standardized sound descriptions were created for all images, audio versions of the instructions, and the use of software compatible with screen readers. During the meetings,

the images were described aloud and commented collectively, promoting an environment of sensory listening and shared interpretation.

These practices materialized what Fabiene Gama (2016) calls multisensory ethnography, in which knowledge emerges from bodily and affective interactions, and not only from visual observation. Thus, Photovoice was re-signified as an expanded sensory practice, capable of including and valuing different modes of perception and presence in the ethnographic field.

4 RESULTS AND DISCUSSION

The analysis of the material produced and the collective interactions revealed dimensions that go beyond the simple application of *Photovoice* as a participatory technique. The process proved to be a field of sensory and political learning, in which the boundaries between researcher and participant, between image and word, between seeing and feeling, were constantly negotiated.

4.1 THE IMAGE AS A RELATIONAL DEVICE

The delivery of the camera and other expressive means to the participants not only democratized visual production, but reconfigured the very idea of authorship. The images emerged as relational events, crossed by affection, memory and imagination.

Figure 1

The Diary of a Magician



Photograph produced by a participant during the Photovoice stage, in response to the question: "What has changed and what has changed in me? What phases and mutations have I gone through that have passed me by?" Source: Photovoice research collection (2024). Publication authorized by the participants.

As Novaes (2017) points out, ethnographic photography is always an encounter. In collective meetings, everyday objects — canes, windows, shadows — have become symbolic operators of belonging and transformation. The group not only analyzed images, but produced bonds, sharing experiences of the body and resistance.

4.2 INTERSECTIONALITY IN IMAGE: BETWEEN VISIBILITY AND VULNERABILITY

The diversity of the group brought different regimes of visibility. Black participants, LGBTQIA+ participants, and blind or low-vision participants exposed tensions between showing up and protecting themselves. This ambiguity confirms Smith's (2021) warning: the risk of participatory practices becoming new forms of symbolic extraction. For this reason, Photovoice proved to be a space for continuous negotiation — each image was also an ethical decision about what to display and what to silence.

During the discussions, recurrent tensions emerged: the desire to show oneself and the fear of exposure; the desire to represent oneself and the awareness of the risk of stigmatization. These ambiguities echo Linda Tuhiwai Smith's (2021) concerns about the danger of transforming participatory practices into new mechanisms of symbolic extraction. Thus, decisions about circulation, subtitles and public uses became a constitutive part of the analytical and ethical process.

Figure 2

Coat



Source: Photograph produced by a participant during the Photovoice survey, in response to the question: "Where is the discomfort — mine and others'? Where and how do I need to adapt?" Source: Photovoice research collection (2024). Publication authorized by the participants.

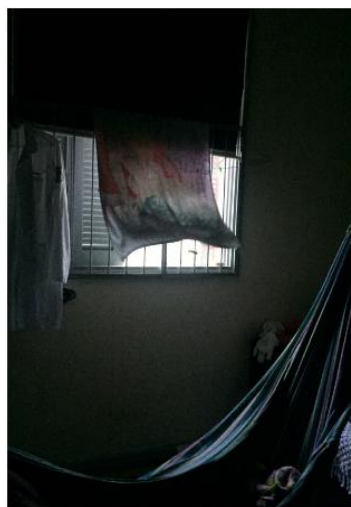
Each photograph, read together with their narratives, revealed a space for negotiation between *saying* and *being silent*. The interpretations did not seek consensus, but multiplicity. This polysemy is consistent with what Gama (2017) calls the "emotional density of images", in which each gaze contains layers of memory, desire, and care. *Photovoice*, in this context, proved to be not only a research method, but a space for symbolic elaboration — a field of care, in which the act of showing can be, at the same time, vulnerable and reparative.

4.3 ACCESS, SENSORIALITY AND EPISTEMOLOGICAL DISPLACEMENTS

The inclusion of blind people has redefined the very idea of visibility. The images were also sounds and descriptions. This experience confirmed MacDougall's (2006) proposal that the body is the first instrument of observation. Photovoice, in this context, has become a laboratory of sensoriality and imagination, reaffirming that the perceptual difference is a source of knowledge. The participation of blind people, both among the surveyed and among the researchers, destabilized conventional conceptions of "visibility". The dynamics of description and collective listening showed that the image is also sound, texture, rhythm. What is produced, in this sense, is a multisensory anthropology, where the gaze is replaced by the sensitive presence.

Figure 3

The dark and the wind



Source: Photograph produced by a participant during the Photovoice stage, in response to the question: "Who is the author? Where and who am I?" Source: Photovoice research collection (2024). Publication authorized by the participants.

For David MacDougall (2006), the body is the first instrument of anthropological observation. This proposition found practical resonance in the project: by welcoming other forms of perception, the group expanded the field of the visible and opened paths for what Bolt (2021) calls *cultural studies of disability*, in which sensory difference becomes epistemological power.

This displacement requires visual anthropology to rethink its own denomination. If the image is an event, and if the event involves multiple senses, then the field is not limited to the "visual", but to relational and embodied experience. *Photovoice*, in this case, not only documents, but also transforms — the way of seeing, hearing and understanding the other.

5 CONCLUSIONS

The study confirmed that Photovoice, when articulated with shared anthropology and epistemologies of the sensible, is more than participatory methodology: it is an ethical and political practice of co-authorship. The images and narratives produced revealed that photography can operate as a gesture of care and symbolic resistance. Specifically, regarding the inclusion of blind participants, it showed that visibility is a form of relationship, and not an attribute of the gaze.

Visual anthropology, therefore, expands into a multisensory anthropology — capable of recognizing in sensory differences the power of encounter and collective creation. The experience with blind participants introduced decisive shifts: by requiring methodological and communicative adaptations, the group became a laboratory of sensoriality and imagination. This learning showed that visibility is not an attribute of the gaze, but a form of relationship. Thus, visual anthropology, by embracing practices of listening, touch, and imagination, is transformed into multisensory anthropology, capable of recognizing the power of perceptual differences as an epistemological engine.

From an ethical and political point of view, the research reaffirmed that there is no shared anthropology without protocols of reciprocity and dynamic consent. Co-authorship must translate into real decisions about circulation, anonymity, credit, and return of results, ensuring that the image is not appropriated, but shared. This requires recognizing Photovoice as a practice of symbolic reparation — a way of giving people back the right to represent themselves, and to participate in decisions about the fate of their narratives.

Analytically, the results show that intersectional identities do not add up in a linear way: they become entangled in situated experiences that challenge the conventional categories of

social research. The method revealed the power of these intersections by allowing multiple layers of subjectivity to emerge in images and words, configuring a plural and sensitive ethnography.

As Eckert and Rocha (2003) state, the image is always negotiation; as Novaes (2017) reminds us, its meaning is born from the encounter; and, according to Paulo Freire (2022), every shared process must serve freedom and collective transformation. Photovoice, in this sense, proved to be a pedagogical and political space, in which the act of looking is also the act of freeing oneself from the imposed narratives.

In dialogue with the initial objectives, this study sought to understand how *Photovoice*, articulated with shared anthropology and multisensory epistemologies, can become a method of co-authorship, care and symbolic resistance. The methodological path confirmed the hypotheses that guided the work: the perceptual difference is cognitive power; accessibility is an epistemological principle; and photography, when shared, becomes the political language of the sensitive. Thus, the lived field reaffirmed that knowledge is not produced about others, but with others — in processes of listening, reciprocity and collective imagination

The research, in the end, produced a double movement: methodological and existential. For the participants, the process represented an opportunity to express themselves and to reconfigure their relationship with their own bodies and with the world. For the researchers, it implied ethical and sensory learning, a re-education of looking and listening. This circularity confirms that shared anthropology is less a method than an ethic of presence—a way of doing science that recognizes otherness as a principle and encounter as a purpose.

In summary, the project demonstrated that the camera, when placed in the hands of the participants, can become an instrument of recognition, listening and resistance. Visual anthropology, in this context, becomes a field of creation and care — a practice that intertwines aesthetics, ethics, and politics in the collective production of knowledge. By returning the gaze, the right to exist and narrate oneself in one's own time is also returned.

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THE PHILOSOPHY AND THE MARKET: BETWEEN HOMO FABER AND HOMO SAPIENS

A ONTOLOGIA DA SERVIDÃO VOLUNTÁRIA: ENTRE O HOMO FABER E O HOMO SAPIENS

LA ONTOLOGÍA DE LA SERVIDUMBRE VOLUNTARIA: ENTRE EL HOMO FABER Y EL HOMO SAPIENS

 <https://doi.org/10.56238/sevened2025.036-062>

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ABSTRACT

Since Antiquity, social life has established a hierarchy between *vita activa* and *vita contemplativa*. This hierarchy gave rise to the concepts of *homo faber* and *homo sapiens*. Beginning in modernity, with the scientific revolution, *homo faber* rose to the top of the hierarchy, assuming various characteristics as the centuries progressed. However, it is in contemporaneity that this split becomes radical, and the market poses the question: What is Philosophy for? Thus, the culture industry promotes a new mode of *Dasein*: an ontology of voluntary servitude. In light of this, the present article intends to serve as a response to those who seek to instrumentalize the human condition.

Keywords: Phenomenology. Alienation. Technique. Instrumental Rationality. Ontology.

RESUMO

Desde a Antiguidade, a vida social estabeleceu uma hierarquia entre *vita activa* e *vita contemplativa*. A hierarquia promoveu e fundou os conceitos de *homo faber* e *homo sapiens*. A partir da modernidade, com a revolução científica, o *homo faber* assumiu o topo da hierarquia, assumindo diversos aspectos conforme os séculos. Contudo, na contemporaneidade é que esta cisão se torna radical e o mercado questiona: para quê serve a Filosofia? Assim, a indústria cultural promove um novo modo do *Dasein*: uma ontologia da servidão voluntária. Diante disso, o presente artigo pretende-se uma resposta àqueles que pretendem instrumentalizar a condição humana.

Palavras-chave: Fenomenologia. Alienação. Técnica. Racionalidade Instrumental. Ontologia.

RESUMEN

Desde la antigüedad, la vida social ha establecido una jerarquía entre la vida activa y la vida contemplativa. Esta jerarquía fomentó y fundó los conceptos de *homo faber* y *homo sapiens*. A partir de la modernidad, con la revolución científica, el *homo faber* asumió la cúspide de la jerarquía, adoptando diversas facetas a lo largo de los siglos. Sin embargo, es en la época contemporánea que esta división se radicaliza, y el mercado se pregunta: ¿cuál es el propósito de la filosofía? Así, la industria cultural promueve una nueva forma de *Dasein*: una

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ontología de la servidumbre voluntaria. Ante esto, este artículo pretende dar respuesta a quienes buscan instrumentalizar la condición humana.

Palabras clave: Fenomenología. Alienación. Tecnología. Racionalidad Instrumental. Ontología.

1 INTRODUCTION

The tradition of Western thought developed from the establishment of a dichotomy between *homo faber* and *homo sapiens*. Work and contemplation, work and philosophical activity were seen as antagonistic activities, where there was a primacy of the contemplative life. This posture disintegrated man into his human condition. It divided nobles from slaves.

To work meant to be enslaved by necessity, and this enslavement was inherent in the conditions of human life. Because men were dominated by the necessities of life, they could only gain freedom by dominating others whom they forcibly subjected to necessity. The degradation of the slave was a stroke of fate and a fate worse than death, as it implied the metamorphosis of man into something similar to a domestic animal (ARENDT, 2011, p. 103).

In Greco-Roman Antiquity, the enslavement of man was justified by the alienation of the necessities of his life (eating, maintaining the home, maintaining his family and a certain level of comfort). With the rise of Christianity, slavery took on new contours. If before the slave was a slave because his needs were alienated, now the slave is a slave because his condition of birth requires it. Being a slave, being the "last among men", the slave attains the Kingdom of Heaven:

And since the text is so clear and literal that it admits of no doubt, let us listen to the comment of St. Thomas, Archbishop of Valencia: *Aethiopes non abiicit virgo decora, sed amplectitur ut parvulos, diligit ut filios. Sciunt ergo ipsam matrem etenim quia Altissimi mater est, Aethiopis matrem nominari non dedignatur*. The Prophet put the Ethiopians and the Blacks in the last place; for this is the place which the world gives them, and the low esteem in which they are treated of other men, children of Adam like themselves. But the Virgin Lady, being Mother of the Most High, does not despise them, nor does she despise herself to have them as her children; rather, because she is the Mother of the Most High, for this very reason she is also proud to be his Mother: *Etenim quia Altissimi mater est, Aethiopis matrem nominari non dedignatur*. Let the Blacks know, then, and do not doubt that the same Mother of God is their Mother: *Sciunt ergo ipsam matrem*: and know that being such a sovereign Lady, she is such a loving Mother, that as small as they are, she loves them and has them as children: *Amplectitur ut parvulos, diligit ut filios* (VIEIRA, 2013).

The rhetoric used by Father Antônio Vieira in Sermon XIV of the Rosary is a very clear example of the way consciences were domesticated through the use of religion. There is no real theology behind the speech, but pure and simple rhetoric. Although the centuries have passed, the domination of consciences is still present. But now the contemplative way of life is no longer privileged, but now mechanical work, specialization and focus on the delivery of

value are privileged. The fetishization of the commodity, already detected by Marx's sociological analysis, caused a shift in the "hierarchy" of human activities. With promises of quick profits, enrichment and economic stability, post-contemporary man lives as in the Myth of Sisyphus: an existence whose life or death implies no difference.

2 METHODOLOGY

The methodology used in this study was based on the researcher's practical market experience, on the observation of social (administrative) phenomena and on the exploratory search for bibliographic references that could explain the collaborator's way of being subservient. This new way of being, in which existence coincides with utility, raised the hypothesis of an ontology of voluntary servitude. However, the will here, not endowed with freedom of thought, but founded on an unovercome Oedipus complex, causing a dependence on a tutor to think, judge and act. The complex network that is formed around this new ontology requires an observation that goes beyond the limits of a merely descriptive phenomenology, and must be explained from a philosophical, historical and psychoanalytic multidisciplinary.

Therefore, the methodology starts not only from mere description and reflection, but from the real experience of this ontology and its most serious consequences, especially from the birth of a possible totalitarianism, the dissemination of prejudices and the trivialization of a social evil seen as beneficial. The methodology is also based on a practical activity, originating from the phenomenology workshops, part of the curricular component of the Bachelor's Degree in Philosophy at the Claretian University Center (Curricular Extension Project). All participants had their identities and data preserved, according to the Free and Informed Consent Forms, submitted to the University Center and the Ethics Committee. Thus, the methodology adopted does not aim to test theories, but to understand the ontological meaning of the phenomenon of voluntary subservience as it manifests itself in lived experience and in the contemporary social structure.

3 RESULTS

In a phenomenology workshop conducted on October 25, 2025, an experiment was carried out with the workshop participants. The activities of the workshops aim to unveil the being in its existentiality, that is, in time. From Husserl and Heidegger he proposed the understanding of authentic existence and inauthentic existence. In "Being and Time",

Heidegger describes how the individual judges, acts and thinks in the impersonal. These questions, further refined by Nietzsche's nihilism, may have generated some discomfort. Although it seems like a supposed failure, the workshop has achieved its success, which is to awaken critical consciences, subjects with the ability to carry out a *social epoché* and understand the world, the other and oneself as an existential possibility.

The reflection focused on the validity of aesthetic assumptions and how the cultural industry is a mechanism of social scale of the impersonal. The subject is emptied of himself, forced and educated to "like" certain aesthetic standards since childhood, creating a cycle of exclusion and social marginalization. The dynamics made was with a thought experiment in which we asked each person to describe a person's standard of beauty without judgment. The descriptions, although divergent on certain points, most were coincidental, such as body structure: body type, height and expected behavior. This fact led the participants to realize that the aesthetic standard is not a real value, but heteronymic and that, by force of society, it was judged as true.

The thought experiment carried out with the participants demonstrated, therefore, that truths are historically constructed and deconstructed, representing a crucial turning point in the understanding of phenomenology: phenomenological praxis is the attitude of placing oneself in front of reality, not as a skeptic, but as one who questions the validity of the judgments constructed about a phenomenon. Notwithstanding this, from an existential point of view, he demonstrated that the inauthenticity of existence is the tool that feeds the cultural industry, as non-thinking beings are needed to be domesticated.

In summary, the hypothesis raised at the beginning of the research was not only validated through exploratory bibliographic research, but was demonstrated in its reality. The ontology of voluntary servitude is a reality, not only daily, but psychic: it comes from child development, when the child is taught to value productivism and to despise contemplation. There, the expropriation of man of his capacity to think and of his ethical and political freedom is born. However, it is worth noting that the discussions about the workshops, both from a methodological point of view and in the discussions, will remain confidential. The experiences described were treated in a phenomenological way, fully preserving the privacy of the participants according to ethical and legal requirements.

4 THE QUARREL BETWEEN THE HUMAN SCIENCES AND THE NATURAL SCIENCES

The scientific advance of modernity has brought an enchantment with scientific principles. All human knowledge, to be valid, had to pass through the sieve of scientific methods. The development of Kant's *Critique of Pure Reason* was an attempt to save the sciences from Hume's bitter skeptical doubt. In fact, Humean skepticism would not allow the development of valid scientific knowledge. For such an enterprise, Kant shifted the foundation of science from the object to the subject, operating the so-called Copernican Revolution.

However, the dispute was not resolved there. It was in the nineteenth century that positivism tried to apply the same method to the human sciences as the natural sciences. However, this reduction is problematic, because, according to Habermas, the human sciences cannot be objectified and subsumed in general laws, without losing the humanity that is proper to each science and must be apprehended through its own hermeneutics:

They do not arise, as positivism supposes, from flawed or obscure methodological presuppositions; nor can the most complex approaches be reduced without prejudice to the platform of a general science of behavior. It is only at first glance that it is a confusion that could be resolved by means of finer distinctions. The competing approaches, formed in the social sciences, are much more found in a context that is negatively produced through the fact that the apparatus of general theories of society does not adapt as easily as the objectified natural processes (HABERMAS, 2011, p.10).

In short, a "science of culture cannot exhaust its interest in the research of empirical regularity" (HABERMAS, 2011, p. 23). Human phenomena are therefore endowed with meaning, that is, actions are intentional. Intentionality, already explored in Husserl, allows us to understand that each movement of a subject is not just a coldly calculated movement, as the followers of the positivist stance claim. But it has a meaning that must be understood. This meaning occurs absolutely, in what the Phenomenology has called the "world of life":

The world is for me in no way anything other than the world apprehended by consciousness, existing and valid for me in such a cogito. The world has all its universal and special meaning and its validity-of-being exclusively from my *cogitationes*. [...] I cannot live, experience, think, value and act within any other world than the one that has meaning and validity in me and from myself. [...] The fundamental phenomenological method, that of the transcendental *Epoche*, insofar as it directs back to it, is therefore called transcendental-phenomenological reduction (HUSSERL, 2019, p. 49).

In other words, the valuation of the world and the meaning that is given to each object of experience takes place from the subject itself. Not of the Kantian subject, but of the intentional subject, who opens up to the object and builds an "*I-thou*" relationship with it. We are, therefore, faced with a reality that cannot be measured, but which must be apprehended from a hermeneutic methodology.

5 THE TURNING POINT OF THE CONTEMPORARY WORLD

Following in the footsteps of the old quarrel, contemporaneity has accentuated the dichotomy between contemplation and human praxis, but now in a different way: pragmatism is privileged in such a way that it can be said that the current world lives under a dictatorship of utilitarianism. In 2024, on the Meu Valor Digital website, an article was published entitled "The 10 colleges that are least worth it and should be avoided". Among the courses listed are Philosophy, Sociology, Archaeology, History, Music, Anthropology, among others. Thus, the author writes about Philosophy:

Philosophy, while rich in critical thinking, faces challenges in translating directly into job opportunities. In an era where science dominates many fields, directing studies to more practical areas can be advantageous. Those interested in philosophy may consider supplementing their studies with other disciplines or opt for alternative careers that value analytical thinking ability (FREITAS, 2024).

At first glance, the statement seems pragmatic; however, it reveals a deep and mistaken dichotomy: the separation between *homo sapiens* and *homo faber*, as if thought and action were antagonistic realities. Now, all scientific activity is born from an act of questioning and questioning is the first gesture of Philosophy. The scientist's way of proceeding is, first of all, the philosopher's way of proceeding. All human praxis presupposes a rationality:

If we had to rely only on the so-called practical instincts of men, there would never have been any technology worthy of note; and, although the technical inventions that exist today bring with them a certain impetus that will probably generate improvements to a certain extent, it is unlikely that our world conditioned to technique could survive, let alone continue to develop, if we could convince ourselves that man is, above all, a practical being (ARENDT, 2020, p. 359).

In suggesting this division, Freitas fell into an old error: the ancient hierarchy between the *vita activa* and the *vita contemplativa*. However, modernity inverted this hierarchy,

privileging action to the detriment of contemplative (philosophical-rational) activity, but at the cost of reducing active life to mere production and consumption. As Hannah Arendt observes:

The modern inversion of the traditional hierarchy between the *vita activa* and the contemplative does not restore the lost dignity of action, but transforms the entire *vita activa* into a mere activity of production and consumption (ARENDT, 2011, p. 348).

Also according to the philosopher, the inversion that began at the beginning of modernity (seventeenth century) and deepened in our days has altered, from the epistemological and ontological point of view, the human questioning:

The shift from "why" and "what" to "how" implies that the true objects of knowledge cannot be eternal things or motions, but processes, and that, therefore, the object of science is no longer nature or the universe, but history—the story of how nature came to be. life or the universe (ARENDT, 2011, p. 367).

The introduction of the concept of process did not only represent a hierarchical inversion, but a radical and complete break with the contemplative life. The *vita activa* now occupies the place that previously belonged to political, intellectual and creative activity (ARENDT, 2011, p. 373). Thus, this radical rupture reaches all dimensions of human life, reifying the individual to the point that he identifies with his profession, that is, the person is no longer his being, but his profession (doctor, nurse, programmer, teacher). The individual loses his identity and becomes standardized within an organization.

Arendt's critique is very current: education and thought are constantly subordinated to the logic of utility, to the imperative of productivity. In this context, philosophical thought becomes suspect, disposable, "unproductive". However, the author is wrong to deny human beings something inherent to their condition: the ability to think. The problem we highlight here is not whether we should first think and then act or act without thinking, whether we should turn to a praxis or an existential reflection, but it is the established hierarchy itself. The contemplative life without action is a phantom that eliminates all possibility of human experience. On the other hand, a pragmatic life without contemplation is like a corpse, it dissolves human existence into an impersonality, that is, an inauthentic existence, a totally manipulable mass.

Finally, we can raise the question: what is the purpose of such alienation? When we follow child development, we commonly see children entertaining themselves with toys that simulate instruments, machines and others related to the producer market.

Let us return to this: have you ever seen a child play, you have seen how he already populates the technical social machines with his desiring machines, O sexuality! – and which father and mother, from whom the child draws, if necessary, parts and gears, are in the background, as emitting, receiving or intercepting agents, benevolent agents of production or suspicious agents of anti-production? (DELEUZE; GUATTARI, 2024, p. 393).

The proposal here of Deleuze and Guattari is that the fetishization and mechanization of life comes from a *social pathos* that is already found within the family. "The identity of desire and work is not a myth, but above all an active utopia par excellence that designates the limit to be crossed by capitalism in desiring production" (DELEUZE; GUATTARI, 2024, p. 399). In short, the thought presented by Freitas in the magazine "Meu Valor Digital" is nothing but a split of the self itself, a division at the psychoanalytic and ontological level of the subject itself; Ultimately, it consists in the annihilation of an important aspect of the human condition nourished by the capitalist utopia.

6 CONSEQUENCES

Given the above considerations, we can draw some very serious consequences in various aspects of human life. Freitas' thought is only the externalization of the contemporary pragmatic spirit. From it, we can establish the effects of the culture industry, which provides "bread and circuses" in exchange for human domestication. Secondly, it promotes a silent totalitarianism: once the individual abdicates his ability to think, he loses political freedom and freedom of expression. As a consequence of this, we have an ontological crisis where human existence dissolves into the impersonal: one thinks as the impersonal, one acts as the impersonal. Its characteristics and possibilities of existence are voluntarily reaped. Finally, an ethical crisis. Once this thinking is normalized in a heteronymic way, without critical capacity, space is opened for the banality of evil. Violence, prejudice and the death of so-called "useless" people are no longer a problem. It even becomes a social "benefit".

In short, the ethics of the disposable treats what it considers useless with a *social pathos* and marginalizes it. In the history of psychiatry, it is common to perceive this behavior: the madman, in fact, is the one who does not bring benefit to society, who does not fit into

the pre-established "standard" and the "truths" produced. In short, the serious consequences drawn from the divorce between the *vita activa* and the *vita contemplativa* can become ways for the spread of evil, like Auschwitz.

6.1 THE CULTURAL INDUSTRY

Once the rupture with the *contemplative vita* is made, the subject becomes the target of the cultural industry. Aesthetic taste and production are no longer guided by Kantian schematism, but by what is defined as an aesthetic standard, even if it is empty of meaning. The focus of production, of course, is no longer the improvement of human conditions, but the accumulation of capital.

In their leisure, people must orient themselves by this unity that characterizes production. The function that Kantian schematism still attributed to the subject, namely, to refer in advance to the sensible multiplicity of fundamental concepts, is taken from the subject by industry. Schematism is the first service provided by it to the client (ADORNO; HORKHEIMER, 2006, p. 103).

Applying the concept of Adorno and Horkheimer to the criticism raised by Freitas of the courses of Human Sciences, it is perceived that the *author's pathos* is nothing more than the elite of the cultural industry that validates what is useful or useless and decides, from early childhood, what the subject should or should not study. It is noted that, in a veiled and silent way, the concept of slavery is still fed by the cultural industry that promotes the domestication of consciences. Now, not through violence, but through the promise of professional success. From this we can see the second consequence: the fertile ground for totalitarian policies

6.2 TOTALITARIANISM

Now I would like to understand how it is possible that so many men, so many towns, so many cities, so many nations sometimes support a single tyrant, who only has the power that is granted to him; that he has no power to offend them, but that they have the power to bear it; that he would not know how to do them any harm, but that they prefer to contradict him (LA BOÉTIE, 2009, p. 34).

La Boétie in the fourteenth century deftly noted that the tyrant exists only to the extent that there are people who serve him. To the extent that man, deprived of his rational capacity,

reified and alienated from the world, becomes fertile ground for totalitarian ideas. As much as, at first, they do not carry an obvious evil, abdicating critical consciousness means abdicating freedom and political consciousness, allowing oneself to be used as an object. In the corporate world, it can be said that the famous cliché "is to become a number". An employee is a mere enrollment and their satisfaction and well-being are measured in climate surveys; their intellectual capacity is reduced to mere "doing". In fact, "barbarism begins when thought submits itself to calculation" (BENJAMIN, 2012, p. 98). Benjamin does not propose a war on the analytical aspects that promoted the advancement of the sciences, but, like Arendt, he denounces that the elimination of one of the aspects of human life leads to the enslavement of man and to barbarism.

However, the question may be raised: "why not get rid of this dominant power? Why are people, like Freitas, accepted as "cases" of success?" The answer is quite simple: we can take up again with Foucault, in the work *Discipline and Punish: birth of the prison* the concept of "docile bodies". Power has its greatest merit when it is not traceable, its origin and its end are not known. Only a network of tensions with the objective of training bodies is enough for ideas like these to be internalized. And this process begins in childhood: the school-age child undergoes "exams". According to the French author:

The examination combines the techniques of the hierarchy that monitors and those of the sanction that normalizes. It is a normalizing control, a surveillance that allows qualifying, classifying and punishing. It establishes a visibility over individuals through which they are differentiated and sanctioned. That is why, in all discipline devices, the exam is highly ritualized (FOUCAULT, 2014, p. 181).

Through these discipline devices, with a view to the "docility of bodies", society classifies who should dominate, who should be dominated, who should work, who cannot have a job, who should be marginalized and forgotten and who are the enemies of society. Failure to accept this training leads to serious consequences: the individual can be treated as a criminal or as a "madman". Here come other methods of combat and punishment: prison systems or medicalization. Thus, through these means:

The human body enters a machinery of power that scrutinizes it, disarticulates it, and recomposes it. A political anatomy, which is also also a mechanic of power, is being born; it defines how one can have dominion over the bodies of others, not simply so that they do what one wants, but so that they operate as one wants, with techniques, according to the speed and effectiveness that one determines. Discipline thus

manufactures submissive and exercised bodies, docile bodies (FOUCAULT, 2014, p. 135).

In this sense, "isolation is the essence of totalitarianism, the impotence to act is its most common condition" (ARENDT, 2012, p. 478). Kant, in his pamphlet "Answer to the question what is enlightenment" writes in a very different way that man in this stage of minority needs to be tutored by another (KANT, 1985, p. 100-101). This inability to think for itself comes from the aforementioned training since childhood pointed out by Deleuze and Guattari.

Submissive behavior in need of a tutor clearly reveals castration in the period of child development. The Oedipus complex not overcome by sexual intimidation (threat of castration) provides dependent personalities: on the one hand, a submissive subject, in need of a tutor. On the other hand, a totalitarian personality, willing to dominate consciences at all costs (FREUD, 2024, p. 254).

Here arises the greatest danger of this ideological propaganda for the domination of consciences: once power is no longer external, it does not use violence and torture for punishment, propaganda becomes its most powerful vehicle of indoctrination. Under discourses of "cleaning up a city" one can simply "eliminate" people in street conditions to the applause of the masses. When writing about totalitarian movements (Nazism), Arendt wrote:

They did not need to resort to terror to support their propaganda, nor did they do so. When they liquidated most Polish intellectuals, they did not do so because of their opposition, but because, according to Nazi doctrine, Poles had no intellect; and, when they planned to take the blue-eyed, blond-haired children to Germany, they did not intend to terrorize the population, but only to save "the Germanic blood" (ARENDT, 2012, p. 475).

Obviously, Freitas' proposal, as well as that of the entire ideology of which he is a part, is not to dominate through terror. But, through propaganda, the classification that occurs from childhood, thus defining who should have access to education, comfort, employment and quality of life and who should not. Therefore, it is important to emphasize and reinforce that it is not just a "council", but a totalitarian ideology that develops over the centuries, sometimes manifesting itself through terror, sometimes through the seduction of power.

6.3 EXISTENTIAL AND ONTOLOGICAL IMPLICATIONS: THE ONTOLOGY OF VOLUNTARY SERVITUDE

Men also segregate inhumanity. In certain moments of lucidity, the mechanical aspect of their gestures, their pantomime devoid of meaning, makes everything around them stupid. A man talks on the phone through a glass partition; You don't hear what he says, but we see the meaningless mime: we wonder why he lives. This uneasiness in the face of man's own inhumanity, this incalculable fall in the face of the image of what we are, this "nausea", as an author of our days says, is also the absurd (CAMUS, 2025, p.29).

The Myth of Sisyphus is not just a story printed in works of mythology. It is an allegory of contemporary existence: man, massified, indoctrinated and dominated by the culture industry, reduces his mundane existence to a mere repeater of actions. It is the process that replaces life, the meaningless aesthetic standard that replaces individuality. Under the aegis of a supposed inclusion, large corporations standardize behaviors and determine what should or should not be consumed. It is a true abdication of the capacity of judgment. In fact, only a refined spirit and a free mind is capable of grasping the uniqueness of human existence:

The more our feelings are refined, the more apt they become to distinguish individuals. The highest sense would be the highest receptivity to peculiar nature. To it would correspond the talent for affixing the individual, whose dexterity and energy are relative. When the will is expressed in reference to this sense, then passions for or against individuality are born: love and hate. The mastery in the performance of one's own role is due to the orientation of this sense towards oneself under the domination of reason (NOVALIS, 2021, p. 62).

When we carry out a deep analysis of the way of being, presence (*Da-sein*) manifests itself in temporality. This same temporality is the being of historicity:

The being of presence has its meaning in temporality. This, in turn, is also the condition of the possibility of historicity as a temporal mode of being of presence itself, even abstracting from the question of whether and how presence is an "entity" in time. The determination of historicity is offered before what is called history (an event belonging to universal history). [...] In its factual being, presence is always as and "what" it once was. Explicitly or not, presence is always its past and not only in the sense of the past that always drags itself "behind" itself and, in this way, has as simply given properties, the past experiences that sometimes act and influence the way of its being, which means, roughly speaking, that it always "happens" from its future (HEIDEGGER, 2024, pp. 57 - 58).

This Heideggerian proposal is profoundly important for understanding a fundamental error presented by Freitas: by promoting an eidetic rupture between thinking and acting, Freitas intends to reduce existence to an ahistorical dimension, that is, the *Da-sein* loses its essential sense of being as constructed in temporality. Consequently, by manifesting itself as ahistorical (alienated from history), the *Da-sein* loses the ability to question itself. Autonomous questioning is the principle of freedom of thought and political freedom. In fact, for Heidegger (2024, p. 58):

Presence is assumed in the way of being of questioning and researching historiographical facts. Factual history (Historie) or, more precisely, historiographical factuality (Historizität) is only possible as a mode of being of the presence that questions because, at the foundation of its being, presence is determined and constituted by historicity. If historicity is hidden from presence and as long as it remains so, it is also denied the possibility of questioning and factually discovering history. The lack of factual history (Historie) is not a proof against the historicity of presence, but a proof in its favor, as a deficient mode of this constitution of being. An era can only be devoid of historical facts because it is historical (HEIDEGGER, 2024, p. 58).

In this sense, *Da-sein* can only be understood in history, insofar as it exists in time. And from this temporality, he "is" "being", that is, he is always projecting himself into the future; it is about the past of your future. This gives us an important key to reading Freitas' proposal in his article: to the extent that *the Da-sein* is deprived of the understanding of itself as being in history, its existence, which was previously open to possibilities, is now regulated by the market and by the imposition of the cultural industry. As demonstrated in the phenomenology workshops, discussed in the results of this article, the participants demonstrated that they were totally dominated by aesthetic and pragmatic ideals arising from the very alienation of their existence. What the article by the CEO of the magazine "Meu Valor Digital" represents is not only advice with a view to quick success, but it is a reflection of an inauthentic existence, where life, which should be lived to its fullest potential, becomes a market product, a stock on the shelf of Human Resources.

The fact that *Da-sein* fails to question its elementary historicity also brings a profound problem to the selection processes. If human existence is determined by the future (we are the past of the future), under what argument are the current selection processes that require heavy years of experience sustained? In fact, it is undeniable that the lived experiences of a human being influence his way of thinking and acting, but he does not delimit his possibility of being. In other words, as historical beings, we project ourselves into the future, having the

creative possibility of learning, creating values and building ourselves. The mistake of selection processes is to remain in a medieval essentialist posture, in which they seek an essential that delimits the entity that is being interviewed.

Now, contemporary social structures (corporations, the cultural industry, Human Resources processes and even religion) constitute in the ultimate sense the Heideggerian *Gestell*, that is, the servile and functional way in which the world reveals itself. *Gestell* is not a machine, but the metaphysical essence of the technique that frames the being and transforms it into a means to achieve ends (most of the time profit). *Gestell*'s idea spreads through all human structures: from the family, school, companies and even the State. Ultimately, *Gestell* is the reification of being, its framing in a decadent essentialism. In this way, *Gestell* can be defined as a way of being in the technical era. This mode of being is no longer *Da-sein* (existence as possibilities), but existence as a stock (*Bestand*). Voluntary servitude emerges as a form of subjectivation corresponding to this unveiling. Now, voluntary servitude moves from the political field, as La Boétie proposed, to be reinterpreted as an affective need, whether from the sociological point of view or from the psychoanalytic point of view. The subject who, before being a possibility, commits suicide philosophically in the name of his social admission to the impersonal, becoming a disguised and dangerous theatrical game.

Nietzsche, in his work *On Truth and Lies in the Extramoral Sense*, had already denounced the errors of essentialism, proposing a pedagogy of "becoming what you are". Truth and lies are allegories, metaphors and illusions created to try to equate the non-equal in an arbitrary way:

What is truth, then? A mobile battalion of metaphors, metonymies, anthropomorphisms, in short, a sum of human relations, which have been poetically and rhetorically emphasized, transposed, embellished, and which, after long use, seems to a people solid, canonical and obligatory: truths are illusions, which have forgotten what they are, metaphors that have become worn out and without sensible force, coins that have lost their effigy and now only come into consideration as metal, no longer as coins (NIETZSCHE, 1974, p. 56).

Freitas' market study is nothing more than a "truth", a utilitarian and technicist morality that was learned since childhood. This same morality, admitted as a convention, constitutes the morality of the herd. The ontology of voluntary servitude unfolds here in a slave-owning and antiquated morality, founded on metaphysical illusions.

The phenomenological analysis of contemporary alienation, anchored in the critique of the reification of the human being and the domination of instrumental reason, inevitably leads us to a reflection on man's way of being in the world. The problem that is evident is not only social or economic, but ontological. Modern man finds himself removed from the original experience of being-in-the-world, reduced to the condition of a functional entity within the technical machinery that he himself created. The result of this split is the forgetfulness of being, as diagnosed by Heidegger. In this sense, one can understand the essential point of convergence between the culture industry, criticized by Adorno and Horkheimer, and the inauthenticity of existence, dealt with by Heidegger in "Being and Time": the culture industry is the means by which inauthenticity is consolidated and reproduced on a social scale. Therefore, the article published by Freitas is only an expression of this same inauthenticity of existence that produces a cycle of domination of consciousness: first, the individual is emptied of his existence as a possibility and all his critical capacity is taken from him. Then, this process is reinforced through promises of satisfaction of basic needs, of immediate wealth. These ideals are "validated" by the great influencers, which affect from aesthetic and behavioral aspects. So, heteronomic laws are assumed by the subject as his *ethos* that are transmitted within the family. The children, then, grow up in an environment of productivist fetishism, learning to despise their critical conscience. Thus, what we can call the "cycle of manipulation of consciences" takes place.

The alienation that manifests itself in the realm of productive life, and that begins already in the early stages of human formation — as pointed out by Deleuze and Guattari — is the expression of the forgetfulness of the existential dimension of Dasein, the being that is understood from its opening to the world. Heidegger (2015, p. 86) states:

The oblivion of being is the very destiny of the West. For modern man, fascinated by beings, objectivity and technical mastery, forgets to ask about being. In this way, he not only ignores the fundamental question of philosophy, but loses the possibility of understanding himself in his most proper existence.

The reduction of man to a functional piece, whether in the productive system or in the bureaucratic structures of organizations, translates into an inauthentic form of existence (*Uneigentlichkeit*). It is the loss of the ability to assume one's own being, replaced by obedience to the patterns of behavior dictated by the "if" (das Man). In the corporate context, the "if" manifests itself in the form of the homogenizing organizational culture, in the

standardization of desires and in the domestication of subjectivity. The subject no longer acts from an authentic project, but according to the expectations of performance, goals and metrics that imprison him to the horizon of the useful. One can dare to say that his project of existence is no longer constructed by him, but is imposed on him as a social obligation. Failure to adhere to this project implies its exclusion from social circles and its pathologization. Let's take as an example the male aesthetic standard adopted in 2025. Men who do not conform to this standard are less valued, whether in the labor market or in social relationships. In the same way as the way of dressing, speaking, thinking, society imposes on the individual the production of truths:

Basically, we have to produce the truth as we have to produce wealth. On the other hand, we are also subject to truth in the sense that it is law and produces the true discourse that decides, transmits and reproduces, at least in part, effects of power. After all, we are judged, condemned, classified, forced to perform tasks, and destined to a certain way of living or dying according to the true discourses that bring with them effects of power (FOUCAULT, 2021, p. 279).

What Foucault intends to demonstrate is that, in the cycle of manipulation of consciousnesses, the production of "truths" and "true discourses" bring power at their origin. Every human relationship, in fact, is guided by power. However, when this relationship becomes neurotic, the way is opened for discourses of the emptying of the subject, for his limitation. Returning to the aesthetic example: the body that would previously have countless possibilities, the main one being man's way of being in the world, becomes only an object of immediate delight. The dissolution of existence in the "impersonal" is pointed out as one of the most worrying issues for Heidegger in "Being and Time":

This coexistence entirely dissolves one's own presence [Da-sein] in the way of being of the "others", and this in such a way that the others disappear even more in their possibility of difference and expression. The impersonal develops its own dictatorship in this lack of surprise and possibility of verification. Thus we amuse and entertain ourselves as impersonally it is done; we read, see and judge about literature and art as we impersonally see and judge ourselves; we also withdraw from the great crowds as one impersonally withdraws; we find "revolting" what the impersonal considers revolting (HEIDEGGER, 2024, p. 184).

Heidegger was precise in his critique of the "impersonal". The article published by the CEO of the magazine "Meu Valor Digital" represents the impersonal. This same impersonal that annihilates all possibility of existence of being. The judgment he makes about the Human

Sciences is not just an isolated fact, but an opinion of the impersonal in which the individuality of each subject is dissolved. In short, the subject is no longer master of himself, but is only a manipulable piece of the cultural industry that aims at profit. In his Zollikon Seminars, Heidegger demonstrates that:

[...] Human existence in its essential foundation is never just an object simply present in any place, and it is certainly not an object enclosed in itself. On the contrary, this existence consists of "mere" possibilities of apprehension that point to what it lacks and finds it and cannot be apprehended by sight or touch. All objectifying encapsulated representations of a psyche, a subject, a person, an I, a consciousness, used to this day in Psychology and Psychopathology, must disappear in the Daseinsanalytic view in favor of a completely different understanding (2001, p. 33).

Thus, Freitas' proposal in his article is nothing more than an inhumanity that takes away man's contemplative dimension and inserts him into a servile essentialist dynamic. Behind an apparently advising discourse, there is a slave tendency that hinders man's existence as possibilities. Now, if there are no possibilities, we fall into Camus' absurdity and are led to question "whether or not life is worth living" (CAMUS, 2025, p. 17) and suicide becomes the central theme of the discussion. Submission to the impersonal is, therefore, a form of existential servitude. Contemporary man, by identifying himself with his social and professional role, abdicates his own ontological freedom. It does not "is", but "works". Its existence is governed by external, measurable and comparable parameters. The sense of being, once rooted in the experience of the world of life (*Lebenswelt*), is converted into performance and productivity. The consequence is the ontological emptying of the subject, who, by losing the link with being, also loses the possibility of meaning.

This reduction of man to functionality is the reflection of what Heidegger called the age of technology (*das Gestell*), that is, the way of unveiling the being characteristic of modernity, in which everything (including man himself) is placed as a resource, as something to be calculated and manipulated. Man ceases to be the shepherd of being and becomes the administrator of beings. In "The Question of Technique", Heidegger (2012, p. 23) insists on this point:

The way in which the real is unveiled in the technical age is not something that man masters. He himself is swept away by that way of unveiling which impels him to regard all that is as a reserve fund. The danger does not lie in technique, but in the fact that man finds himself imprisoned in this way of thinking and acting, without perceiving the event that is taking place in him.

Modern administrative logic, by claiming efficiency and total control, mirrors exactly this *Gestell*: man becomes the guardian of a system that surpasses him, and whose rationality absorbs him. Work ceases to be an expression of being and becomes a form of self-forgetfulness. In this condition, *Dasein* no longer inhabits the world poetically, but operationally.

It follows from what has been stated that the author commits yet another error: an error of method and an error of object. By intending to affirm the primacy of practical activities, the author, as an administrator, does not take into account the fact that there are factors that cannot be measured. But the fact that they are not measured does not imply their non-existence.

Ontological phenomena are not perceptible sensorially, they have always shown themselves, necessarily before for perceptible phenomena. To be able to perceive a table as the table that it is, it is necessary to have already perceived before that there is such a thing as a presence. Ontological phenomena are, therefore, hierarchically the first, but, in order to be thought and seen, they are later. [...]. In relation to what is taken as real and being: only that which can be subordinated to uninterrupted causal connections of psychological forces is real and true, in Freud's opinion. And the world-renowned modern physicist Max Planck said, verbatim, a few years ago: "only what can be measured is real". One can rightly contest this: why would there not be realities that are impossible to measure exactly? A sadness, for example (HEIDEGGER, 2001, p. 35-36).

Following the guiding thread of Heidegger's thought, we can question it: "under what premises can we apply the method of the natural sciences to the study of the human condition as *homo faber* and dispense completely? What is really paramount?" This question is not merely rhetorical, but seeks to understand under what premises the annihilation of an essential aspect of the human condition can be carried out.

Kant was the first to explicitly express the character of nature represented in a scientific-natural way. For this reason, he was also the first to say what a law is in a natural-scientific sense. The fact that the true spokesperson of the natural sciences was a philosopher indicates that reflecting on where the natural sciences are headed is not a matter of the natural sciences, but of philosophy, without scientists generally knowing it explicitly (HEIDEGGER, 2001, p. 52).

Heidegger's critique in Zollikon's Seminars is extremely difficult for us to understand the fragility of Freitas' argument: his intention is to direct society towards a political and pedagogical project based on technicality: a doctor, for example, can understand man

technically, the functioning of his organs as the old *L'Homme-Machine* project by Julien Offray de La Mettrie (1748). However, this posture is limited, because it does not understand man as a man-being, only an entity in nature:

Natural science can only observe man as something simply present in nature. The question arises: would it be possible to reach the human being in this way? Within this natural-scientific project we can only see it as natural, that is, we have the pretension of determining the being-man by means of a method that was absolutely not designed in relation to its peculiar essence (HEIDEGGER, 2001, p. 53).

Now, if the method of the practical sciences is not adequate to the understanding of the human being, we can extend this criticism to the administrative sciences. By arrogating to themselves the right to try to measure what is immeasurable, namely human existence, Freitas and so many other authors corroborate the flourishing of a dehumanized and disposable culture. The very etymology of the term "resource" (from which the area and practice of "human resources" management comes) denotes the reification of man: derived from the junction of two Latin words "*re*" (undo) and "*cursus*" (path; career) demonstrates the emptying of being-man for his identification with his career. In other words, it is a matter of getting rid of oneself, getting rid of one's primordial characteristic as a being-there, open to possibilities to remake oneself, to mold oneself in such a way that it becomes a "piece in a stock". Freitas' regrettable position in his publication is a symptom of a structure that intends to turn *Dasein* into *Rekursus*. In his latest Encyclical, Pope Francis writes:

In the age of artificial intelligence, we cannot forget that poetry and love are necessary to save the human. What no algorithm will be able to encompass is, for example, that moment of childhood that is fondly remembered and that continues to happen in all corners of the planet, even as the years go by (2024, p. 16).

The ontological crisis also reveals to us an ethical crisis. It is a heteronymic behavior that, due to the cultural industry, becomes autonomous. If the validity of something is conditioned to its usefulness, consequently there is a tendency to trivialize evil through prejudice against the elderly, homeless people, people with disabilities and other marginalized people in society. The serious consequences of this led Nazi-fascism to rise in Europe in the 1930s and these same prejudices are still fed in a banal way: the woman who is refused in a selection process because of her feminine condition (she can get pregnant and cause damage), the disabled person who is rejected because it may generate costs with

adaptability or the homosexual who is seen with looks of concern due to his sexuality. Now, it can be seen here that the way of being "voluntarily servile", this "ontology of voluntary servitude" has social, political, ethical and economic scalability. The classification and training of man, the power internalized in a biopsychic way, is translated into the cultural industry: it is a way of being that, instead of freedom of conscience, abdicates it and evil is seen as a benefit of society. Therefore, the homeless person is not seen as human, but as a despicable object, who deserves social disdain and is removed from society, sometimes treated as crazy and medicated.

Ontology allows us to understand in a broad way how the immense network of power and training of bodies relate to and determine the way of human existence. The man who is a mere possibility becomes dominated and, as in Plato's Republic, begins to have his social role strictly defined. The determinism that hides behind Freitas' statements reveals an antiquated form of discipline, sensation and punishment.

7 FINAL CONSIDERATIONS

The reflections developed throughout this work allow us to understand that the predominance of utilitarian logic, by converting human experience into a mere productive function, does not only represent a change in values, but a profound ontological reconfiguration. The transformation of the human being into a resource occurs silently, sustained by a pedagogy of submission that naturalizes efficiency as the only criterion of meaning. In this context, homo *faber* becomes not only dominant, but totalizing, redefining life from the paradigm of utility and producing a form of voluntary servitude in which subjects not only obey, but wish to obey. It is precisely this spontaneous adherence to productivism that configures the core of contemporary alienation: a process of internalization of calculation that inhibits phenomenological openness and reduces presence to performance. The loss of *the contemplative vita* is not a side problem, but the most evident symptom of the colonization of existence by technique, because where there is only time to do, the time to be disappears.

This study sought to show that technicality, when elevated to the condition of the ultimate measure of reality, does not present itself as a neutral instrument, but as a way of revealing and shaping the world. Its norms operate as ontological principles, establishing what is perceived as real, valuable, and true. In this way, management goes beyond the organizational field and becomes a universal grammar, imposing itself as a filter of experience and as a structure of subjectivation. The criticism of the pedagogical discourse that reduces

education to adaptation and utility, exemplified in the article analyzed, highlights the way in which instrumental rationality invades spaces originally intended for the expansion of freedom. Education ceases to form subjects to form products, and thought, reduced to the function of solving problems, loses its original dimension of openness to being. When thought is instrumentalized, not only is intelligence impoverished, but a new form of totalitarianism is produced without the need for explicit violence, since control is effective through consensus and the naturalization of effectiveness.

Now, the phenomenology workshops, developed in ten meetings in the city of Mogi das Cruzes (whose data and reports will not be presented for ethical and legal reasons) clearly demonstrated the capillarity of the power of the cultural industry. It is not a question of power by coercion, but of a power acquired and naturalized throughout the process of human development. This same power defines aesthetic values, judgments, prejudices, who should or should not have access to opportunities in the labor market. Foucault's "docile bodies" is Heidegger's inauthentic way of existing. This constitutes the substantial soil on which the concept of the "ontology of voluntary servitude" is erected: it is not a question of servitude through violence, but an imposition through discipline, repetition and propaganda. Contemporary totalitarianism differs radically from twentieth-century totalitarianism because it is not traceable. It is not possible to recognize its origin, how it acts and where it ends. We can only distinguish its effects: a massified, uncritical population subject to accepting the mentality of its owners as true.

Therefore, the proposal of the concept of the ontology of voluntary servitude is to demonstrate that the abdication of man of his own capacity to think and become a *Bestand* is to show that this biopsychic condition moves from the political and psychoanalytic axis to the question of the foundation of one's own being. In short, it is not only a structural and political critique, nor a psychoanalytic one, but an ontological one. It is the emptying of the being-there, as a possibility, to become a body trained in a power structure. Phenomenology, in this sense, as ontology, according to *Being and time*, is an act of rebellion, because it unmasks the created structures that keep *Dasein* attached "to the cave contemplating only shadows".

To conclude here means to affirm that there is no resistance possible without the rescue of the contemplative life and philosophy as a radical experience of unveiling. Thinking becomes a political act when it breaks the automatism of demands and restores to existence the possibility of signifying beyond utility. Philosophy is not opposed to technique, but to its

absolutization; it does not reject action, but action without foundation, moved only by the logic of results. Only through phenomenological suspension, which deactivates the domain of the impersonal, can the subject rediscover the dimension of meaning that the market and management try to subsume. The *epoché* is, in this horizon, more than method: it is ontological disobedience. Therefore, the task of thought is not to reform the system from within, but to expose its ontological poverty and reopen the space of the possible.

Between *homo faber* and *homo sapiens*, the decision remains open. As long as we persist in confusing value with productivity and autonomy with performance, we will continue to accept the mutilation of experience as the price of belonging. But where there is still room for contemplation and questioning, the administered world will find its limit. Resistance is not only in explicit refusal, but in the preservation of the interior space that no device can control. To think is to resist and to resist is to remember that the being is not exhausted in the function. Philosophy remains, therefore, as a gesture of care for the human and as the only way capable of bringing life back to its proper density. If technology organizes the world as a machine, it is up to thought to remember that before being useful, life must be true.

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**THE INTRODUCTORY CONTENTS OF ORGANIC CHEMISTRY IN A
TEXTBOOK: THE METHODOLOGICAL APPROACH FROM THE PERSPECTIVE
OF THE PNLD 2021 AND THE BNCC**

**OS CONTEÚDOS INTRODUTÓRIOS DA QUÍMICA ORGÂNICA EM UM LIVRO
DIDÁTICO: A ABORDAGEM METODOLÓGICA SOB A ÓTICA DO PNLD 2021 E
A BNCC**

**EL CONTENIDO INTRODUCTORIO DE LA QUÍMICA ORGÁNICA EN UN LIBRO
DE TEXTO: UNA APROXIMACIÓN METODOLÓGICA DESDE LA PERSPECTIVA
DEL PNLD 2021 Y LA BNCC**

 <https://doi.org/10.56238/sevened2025.036-063>

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ABSTRACT

The BNCC and PNLD are currently the main guidelines to be observed in the development of didactic material intended for Brazilian students, which demands constant evaluations of the textbooks adopted in schools. From this perspective, the work presented here describes an analysis of the pedagogical approach to the 'Fundamentals of Organic Compounds' present in a textbook from the 'Moderna Plus: Natural Sciences and their Technologies' collection, comparing it with the guidelines of the BNCC and PNLD 2021. Qualitative and descriptive in nature, the research was developed from a documentary analysis with the objective of investigating the conformity of the approach to the introductory content of Organic Chemistry, presented in this chapter, with the documentary guidelines, focusing on its potential in promoting a civic, critical, and contextualized education. The results revealed that, although the chapter partially addresses skills such as the construction of chemical representations and the application of knowledge in everyday contexts, its pedagogical approach remains traditional, content-based, and poorly connected to social, environmental, and cultural issues. The absence of experimental proposals, the superficiality in the interdisciplinary treatment, and the weak stimulus to critical reflection compromise the formative function of the chapter. Therefore, teacher mediation is essential to transform the content into an emancipatory tool, capable of going beyond memorization and contributing to a critical understanding of reality.

Keywords: Organic Chemistry. Textbook. High School. BNCC. Civic Education. PNLD 2021. Critical Education.

RESUMO

A BNCC e o PNLD constituem hoje as principais diretrizes a serem observadas na elaboração do material didático destinado ao estudante brasileiro, o que demanda a realização de avaliações constantes dos livros adotados nas escolas. Sob esse olhar, o

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trabalho aqui apresentado descreve uma análise da abordagem pedagógica dos Fundamentos dos Compostos Orgânicos presente em um livro da coleção didática ‘Moderna Plus: Ciências da Natureza e suas Tecnologias’, confrontando-a com as orientações da BNCC e do PNLD 2021. De caráter qualitativo e descritivo, a pesquisa se desenvolveu a partir de uma análise documental com o objetivo de investigar a conformidade da abordagem dos conteúdos introdutórios de Química Orgânica, apresentada nesse capítulo, com as diretrizes documentais, focando o seu potencial na promoção de uma formação cidadã, crítica e contextualizada. Os resultados revelaram que, embora o capítulo contemple parcialmente habilidades como a construção de representações químicas e a aplicação de conhecimentos em contextos cotidianos, sua abordagem pedagógica permanece tradicionalista, conteudista e pouco conectada às questões sociais, ambientais e culturais. A ausência de propostas experimentais, a superficialidade no tratamento interdisciplinar e o fraco estímulo à reflexão crítica comprometem a função formativa do capítulo. Diante disso, a mediação docente é essencial para transformar o conteúdo em uma ferramenta emancipadora, capaz de ultrapassar a memorização e contribuir para uma leitura crítica da realidade.

Palavras-chave: Química Orgânica. Livro Didático. Ensino Médio. BNCC. Formação Cidadã. PNLD 2021. Educação Crítica.

RESUMEN

El BNCC (Currículo Básico Común Nacional) y el PNLD (Programa Nacional de Libros de Texto) son actualmente las principales directrices que deben observarse en el desarrollo de materiales didácticos para estudiantes brasileños, lo que exige una evaluación constante de los libros adoptados en las escuelas. Desde esta perspectiva, este trabajo describe un análisis del enfoque pedagógico de los Fundamentos de Compuestos Orgánicos presente en un libro de la colección didáctica ‘Moderna Plus: Ciencias Naturales y sus Tecnologías’, comparándolo con las directrices del BNCC y el PNLD 2021. De naturaleza cualitativa y descriptiva, la investigación se desarrolló a partir de un análisis documental con el objetivo de investigar la conformidad del enfoque del contenido introductorio de Química Orgánica, presentado en este capítulo, con las directrices documentales, centrándose en su potencial para promover una educación cívica, crítica y contextualizada. Los resultados revelaron que, si bien el capítulo aborda parcialmente habilidades como la construcción de representaciones químicas y la aplicación del conocimiento en contextos cotidianos, su enfoque pedagógico sigue siendo tradicionalista, centrado en el contenido y poco conectado con cuestiones sociales, ambientales y culturales. La ausencia de propuestas experimentales, la superficialidad del tratamiento interdisciplinario y el escaso fomento de la reflexión crítica comprometen la función formativa del capítulo. Por lo tanto, la mediación docente es esencial para transformar el contenido en una herramienta emancipadora, capaz de ir más allá de la memorización y contribuir a una lectura crítica de la realidad.

Palabras clave: Química Orgánica. Libro de Texto. Enseñanza Secundaria. BNCC (Currículo Nacional Brasileño). Educación para la Ciudadanía. PNLD 2021 (Programa Nacional de Libros de Texto). Educación Crítica.

1 INTRODUCTION

Guided by guidelines such as the National Common Curricular Base (BNCC), textbooks are challenged to present their content in a contextualized and interdisciplinary way (Vilanova, 2015; Brazil, 2017). This document also ratifies the organization of disciplines in the area of Natural Sciences and their Technologies in order to integrate Chemistry, Physics and Biology, focusing on the development of competencies and skills applicable to real situations of the student's daily life (Alves; Martins; Andrade, 2021).

However, these guidelines often come up against technicist approaches that prioritize memorization and contribute little to the construction of meaningful knowledge, especially in the case of Organic Chemistry, often treated as a sequence of naming rules and formulas detached from the social reality of the learner (Maciel; Leão, 2022; Shah; Ibiapina, 2023).

The challenge becomes even more evident in public schools, where the reduced workload of the subject, the precariousness of the infrastructure and the socioeconomic reality of the students aggravate the difficulties in working with the contents in a critical way and aimed at the exercise of citizenship (Gramowski; Delizoicov; Maestrelli, 2017).

Organic Chemistry, a branch of Chemistry that studies carbon compounds, including molecules that are fundamental to life, such as DNA, proteins, and vitamins, plays a strategic role not only in understanding the composition of matter and its transformations, but also in the changes that occur in society. From the fall of the Theory of Vitalism, in the first half of the nineteenth century, to contemporary innovations, with the emergence of RNA vaccines and smart tissues, the evolution of Organic Chemistry directly reflects on the scientific and technological advances that shape human daily life (Solomons; Fryhle; Snyder, 2023).

Thus, the articulation between the Teaching of Organic Chemistry and the major contemporary themes, such as the environment, health and technology, becomes fundamental to ensure a more relevant learning and connected to the students' experiences. In this context, the mastery of its basic concepts must go beyond the memorization of rules of nomenclature and classifications: it must constitute an exercise in critical thinking and reading of the world (Nelson; Cox, 2022).

However, what is observed in Brazilian schools, especially in the public network, is a teaching of Organic Chemistry marked by reductionist and decontextualized approaches. The contents are still often worked on in a fragmented way, with a focus on the fixation of formulas and mechanical repetitions, neglecting the connections of the subjects with social reality and contemporary themes (Paixão, 2019; Adam; Xavier; Maciel, 2009).

This perspective discourages the interest of students and compromises their comprehensive education, as it fails to establish bridges between scientific knowledge and the challenges of daily life, precisely what the BNCC proposes to overcome (Brasil, 2017). By sanctioning this document, the National Book and Didactic Material Program (PNLD) emerges as an essential regulatory tool in the process of choosing the textbook to be adopted in Basic Education schools across the country (Brasil, 2021).

Therefore, the present research collaborated in the search for answers to the following questions: are the contents of Organic Chemistry, present in the textbooks approved by the PNLD 2021, in fact committed to the guidelines of the BNCC (Brasil, 2017)? Are these materials capable of really promoting critical and reflective learning? Do they really contribute to citizenship education?

In view of the above, this research aimed to analyze the alignment of the approach of the Fundamentals of Organic Compounds presented by chapter 10 of the book 'Scientific Knowledge', of the didactic collection 'Moderna Plus: Natural Sciences and their Technologies', with the guidelines of the BNCC, especially with regard to the promotion of critical, reflective learning aimed at citizenship formation.

2 METHODOLOGY

To achieve the proposed objective, this investigation was developed under a qualitative approach, and can be classified as descriptive as to its objectives, since it seeks to analyze the relationships between sets of ideas. As the research data were obtained from sources consisting of texts, it can be considered as being of the documentary type, since its main focus was to answer questions that require the analysis and discussion of written records (Malheiros, 2011).

The choice of chapter 10, of the book 'Scientific Knowledge', is justified by the fact that the content covered in it is responsible for introducing the study of Organic Chemistry in High School, exploring the essential conceptual basis for deepening in topics studied later.

In addition, the collection to which it belongs, 'Moderna Plus: Natural Sciences and their Technologies', is part of the teaching materials recommended by the PNLD 2021 (Brasil, 2021). Because it has an expressive national representation in the public educational scenario, it is being widely adopted in public schools in the city of Crateús-CE.

The intention of the analysis, therefore, was to verify, with special attention focused on citizenship education, to what extent the contents presented in the chapter dialogue with the

competencies and skills proposed by the National Common Curricular Base (BNCC) (Brazil, 2017), listed below:

(EM13CNT104) Evaluate the benefits and risks to health and the environment, considering the composition, toxicity and reactivity of different materials and products, as well as the level of exposure to them, taking a critical position and proposing individual and/or collective solutions for their responsible use and disposal.

(EM13CNT207) Identify, analyze and discuss vulnerabilities linked to the contemporary experiences and challenges to which young people are exposed, considering the physical, psycho-emotional and social aspects, in order to develop and disseminate actions.

(EM13CNT301) Construct questions, elaborate hypotheses, forecasts and estimates, employ measurement instruments and represent and interpret explanatory models, data and/or experimental results to construct, evaluate and justify conclusions in facing problem situations from a scientific perspective.

(EM13CNT302) Communicate, to varied audiences, in different contexts, results of analyses, research and/or experiments, elaborating and/or interpreting texts, graphs, tables, symbols, codes, classification systems and equations, through different languages, media, digital information and communication technologies (DICT), in order to participate and/or promote debates around scientific and/or technological topics of sociocultural and environmental relevance.

(EM13CNT303) Interpret texts of scientific dissemination that deal with themes of the Natural Sciences, available in different media, considering the presentation of data, both in the form of texts and in equations, graphs and/or tables, the consistency of the arguments and the coherence of the conclusions, aiming to build strategies for the selection of reliable sources of information.

(EM13CNT306) Evaluate the risks involved in daily activities, applying knowledge from the Natural Sciences, to justify the use of equipment and resources, as well as safety behaviors, aiming at physical, individual and collective, and socio-environmental integrity, being able to make use of digital devices and applications that enable the structuring of simulations of such risks.

(EM13CHS304) Analyze the socio-environmental impacts resulting from the practices of government institutions, companies and individuals, discussing the origins of these practices, selecting, incorporating and promoting those that favor socio-environmental awareness and ethics and responsible consumption (BRASIL, 2017, p. 555-560; 575).

The analysis procedure was developed in four main stages. The first consisted of the survey and selection of the material to be examined, with the choice falling on the corpus of the research already described. The second stage involved exploratory recognition,

comprising an initial reading of the chapter to familiarize with the content and preliminary identification of the structure and organization of the theme.

The third stage included the analysis itself, conducted through systematic reading with a focus on the identification and registration of elements related to the skills of the BNCC (Brasil, 2017), and on the critical appreciation of the pedagogical approaches and contextualizations presented by the chapter. The fourth and final stage, carried out from the data collected in the light of the theoretical foundation, comprised the interpretation and synthesis of the articulation between the findings and the guidelines of the BNCC (Brasil, 2017), culminating in the construction of inferences about the formative potential of the material analyzed.

The entire analytical process was performed manually, with the systematic recording of the skills identified, the pedagogical approaches used and the contextualization elements present in the material. This procedure allowed to raise evidence about the alignment (or not) of the content presented in the chapter with the BNCC guidelines, contributing to a critical reflection on the role of the textbook in the construction of a more meaningful Chemistry Teaching focused on citizenship formation (Brasil, 2017).

3 RESULTS AND DISCUSSION

In this section, the results of the analysis of chapter 10, entitled 'Fundamentals of Organic Compounds' of the book 'Scientific Knowledge' (volume 1), are presented, having as its core the alignment of the approach of the content and the suggested activities with the guidelines contained in the BNCC and citizen education (Brasil, 2017).

3.1 A TOPICAL ANALYSIS

The chapter begins on page 115, connecting science and everyday life through an illustration containing acarajé dumplings, a typical dish of Afro-Brazilian culture (Figure 1), aiming to relate its ingredients to chemical substances (organic compounds) important for nutrition, such as methionine and lysine. This approach has the potential to stimulate reflections on cultural diversity, food, health, and history, aligning with the EM13CNT104 ability of the BNCC (Brasil, 2017).

Figure 1

Initial illustration of Chapter 10 showing acarajé associated with some organic compounds. Page 115 of the book analyzed



Source: Amabis *et al.* (2021, p. 115).

The text located just below this illustration brings a brief history of Organic Chemistry, differentiating organic from inorganic compounds through everyday examples, which can contribute to encourage a critical analysis of how science is communicated to the public. Interdisciplinarity appears when relating chemistry to nutrition, history and geography, opening space for ethical and social debates on food production and consumption. There is also mention of the artificial production of organic compounds, a useful topic for discussions addressing Science, Technology, Society and Environment (CTSA), although it has been treated in an irrelevant way.

The content of this text also raises questions about the symbology in molecular representations, which could be a starting point to develop the students' investigative and argumentative thinking, as long as it is well explored by the teacher. By encouraging students to observe and question molecular representations, highlighting, for example, the absence of the carbon symbol and the meaning of zigzag strokes, its last paragraph explores EM13CNT301, EM13CNT302 and EM13CNT303 skills.

In Topic 1, located on page 116, the concepts related to structural formulas are revisited, but the approach does not stimulate the exercise of full critical reasoning, although it presents the model of spheres and rods to facilitate spatial understanding.

On page 117, in the sections 'Dialoguing with the text' and 'Group activity' (Figure 2), students are asked to compare molecular models and research compounds such as anethole and estragole. This performance could be further enriched with sensory experiences (smell, touch, sight), since these are substances contained in simple materials, such as fennel and basil, and which can be easily manipulated with due care.

Figure 2

Presentation of the sections 'Dialoguing with the Text' and 'Group Activity'. Chapter 10, page 117 of the book analyzed

Dialogando com o texto

Compare cada um dos modelos moleculares ao lado com as respectivas fórmulas estruturais e verifique a correspondência entre as representações. Como parte da interpretação, deduza quais são as esferas usadas para representar os átomos de cada elemento químico, no modelo molecular.

Atividade em grupo

A substância **anetol** é responsável pelo aroma da erva-doce, bastante usada no Brasil para fazer chás e doces.

Já a substância **estragol** está presente em algumas variedades de manjerição, contribuindo para seu aroma.

Pesquisem na internet a fórmula estrutural desses dois compostos e analisem-nas. Qual é a diferença entre as moléculas de ambas?

Deduzam a fórmula molecular das duas substâncias e comparem-nas. A fórmula molecular, isoladamente, é suficiente para designar de modo inequívoco essas substâncias? Argumentem para justificar.

Source: Amabis *et al.* (2021, p. 117).

Activities of this nature can promote the visualization of molecules from different perspectives, and encourage the formulation of hypotheses about their properties, such as color and odor. By interpreting different molecular representations, students develop skills to communicate results and select reliable sources, preparing for reasoned scientific debates.

In the section 'Applying knowledge', also located on page 117, students are led to identify and interpret different types of formulas (molecular, structural, condensed and with lines), exercising the process of structural deduction. However, the contextualization of theobromine and theophylline is superficial, not allowing the content to be deepened (Skill EM13CNT207).

Although these sections seek to stimulate reasoning, they are less critical and more formal, seeming to meet curricular requirements, without worrying about promoting an in-depth understanding. Practical activities, such as building molecular models with simple materials, could enrich learning by connecting theory and practice, and encourage the formation of critical thinking.

Despite this, the proposed questions seem to present adequate complexity to the level of knowledge explored, stimulating the logical thinking of students when they challenge them to compare carbon and hydrogen atoms in different molecules, reinforcing the learning of the content related to structural analysis.

Topic 2, 'Carbon chain' (page 118), explores the identification of carbon chains in molecules such as limonene and methyl anthranilate. Using subtitles, the authors relate molecular structure to compounds present in everyday life, such as BHT, a preservative and antioxidant. It also addresses the concepts of heteroatoms and the classification of carbons (primary to quaternary).

This favors the understanding of the applicability of the knowledge of Organic Chemistry (EM13CNT306), and consolidates the learning of basic terminology (EM13CNT301). However, the methodological approach is characterized as transmissive, without stimulating teamwork, the development of critical thinking or practical application.

In Topic 3, 'Benzene ring' (page 119), the concept of resonance is briefly presented without going into depth. However, the description of benzene toxicity stimulates reflection on health and safety risks (EM13CNT104). The group activity on this same page proposes research and discussion on amino acids containing benzene rings in their molecules, which can promote the construction of scientific argumentation and knowable communication (EM13CNT302).

The text of Topic 4, 'Attributes of carbon chains' (page 120), presents the appropriate terminology to recognize carbon chains and their classifications (saturated, unsaturated, branched, for example), and also promotes a minimal construction of critical thinking, without delving into the real importance of scientific communication in ethical and environmental

issues. The suggested group activity on the synthetic production of indigo relates structural formula, organic synthesis and green chemistry, encouraging research, the development of critical analysis and the discussion on Science and Sustainability (EM13CNT302).

Topic 5, 'Stereochemistry of saturated carbon' (page 121), addresses essential concepts related to the theme discussed in this part, but does not stimulate the development of critical thinking or contextualize the relevance of stereochemistry in areas such as pharmacology and biomedicine. The lack of suggestions to stimulate dialogue and group activities limits the aspect related to citizenship formation. A richer proposal could include collaborative research on chiral molecules, interdisciplinary connections, and ethical debates.

Despite this, Topic 5 stands out for offering images of the three-dimensional molecular structure of methane (page 121), which can help in understanding the concept of molecular geometry. However, this section prioritizes technical and mechanical learning, focused on assessments, without encouraging ethical reflection or interdisciplinarity.

The questions suggested at the end of this topic, in the section 'Applying knowledge' (page 122), ask the reader to make inferences and argue about the structure-property relationship, using examples such as the molecules of lysine, cadaverine and threonine. This practice is capable of stimulating the development of critical textual and graphic analysis to consolidate learning.

Topic 6, 'Polymers' (page 123), addresses natural and synthetic macromolecules, highlighting ethical and environmental issues related to the production and disposal of plastics. The explanation of the polymerization reaction and the structure of starch connects the molecular structure to the properties of polymers, contributing to the development of EM13CNT306 ability.

In the 'Group activity' section, it is suggested to prepare a video for scientific dissemination, stimulating argumentation, systematization of knowledge and accessible communication (EM13CNT301 and EM13CNT302). This topic also highlights, through an illustration and a short text, the scientist Stephanie Kwolek, inventor of Kevlar, illustrating the practical application of polymers.

The section that closes the chapter, 'Final Activities' (page 124), presents external evidence questions that require interpretation and analysis of molecular structures. It is worth noting that one of them alludes to the degradation process of glyphosate, awakening the student to the optimization of the understanding of environmental problems.

However, many of these questions are inexpressive and practically make the content disconnected from the student's daily life, that is, they do not adequately explore the ability EM13CHS304. It would be necessary, therefore, for these activities to truly contribute to fostering debates on ethics and socio-environmental impacts.

3.2 A GENERALIZED ANALYSIS

Chapter 10, 'Fundamentals of Organic Compounds', of the book 'Scientific Knowledge', addresses fundamental contents of Organic Chemistry with some attempts at contextualization, however it remains stuck in a traditionalist and contentist approach. Although it brings examples from everyday life and group activities, there is a lack of depth in the ethical, socio-environmental, and interdisciplinary discussion, essential elements, according to the LDB (Brazil, 2023) and the BNCC (Brazil, 2017), to form critical and conscious citizens.

Activities often focus on memorization and preparation for assessments, failing to explore the potential to promote relevant critical debates on sustainability, social impact, and scientific responsibility (EM13CNT306). There is a lack of incentive for the development of simple and low-cost experimental activities, limiting the practical and investigative application of knowledge, which is fundamental for citizenship education. Thus, the chapter leaves something to be desired by integrating theory, practice and socio-environmental awareness, essential in preparing students for the challenges of the contemporary world.

In order for the chapter to fully achieve the objectives of the BNCC (Brasil, 2017), the active mediation of the teacher and the school is indispensable. Therefore, it is necessary for these actors to transform the content into opportunities for dialogue, critical reflection and interdisciplinarity, connecting Chemistry to themes related to ethics, the environment, biology, history and society. In addition, encouraging simple experimental activities and the use of digital technologies can contribute to student engagement, making learning more practical, investigative, and aligned with the socio-emotional and scientific competencies provided for in the curriculum guidelines.

Without this mediation, the didactic material runs the risk of being just a repository of technical information, disconnected from reality and contemporary educational demands. The critical and integrative performance of the teacher is essential to transform the content into living knowledge, capable of fostering citizenship education, socio-environmental responsibility and the potential of students to apply science in a conscious and innovative

way in their daily lives. In this way, teaching ceases to be a mere transmission to become an active process of construction and transformation.

The chapter is right to use acarajé as a bridge between Organic Chemistry and everyday life, highlighting the African origin of this dish. However, this success is restricted to the small text that accompanies the illustration of the dumplings, since the entire text of the chapter's introduction is dominated by traditionalism. There are no reflections on the ethnic-racial issues associated with the dish, nor even a discussion of religious syncretism, the role of black women in the Bahian tradition or the impact of colonization on the formation of Brazilian food culture.

It is worth noting that the LDB determines the mandatory teaching of Afro-Brazilian history and culture (Brazil, 2023), and the BNCC (Brazil, 2017) reinforces the appreciation of diversity and the fight against inequalities. Ignoring this deepening reinforces historical invisibilities, treating Afro culture only as a 'curiosity' and not as an essential part of the construction of national identity. The chapter thus wastes a potent trigger for the promotion of interdisciplinary debates on cultural heritage, resistance and belonging.

Despite exhibiting different ways of representing molecules (structural, rod, sphere, and rod formulas, among others) as tools for understanding the structure of compounds, the analyzed material lacks a critical and historical approach that can answer questions such as: Why do these representations exist? How did they come about? What limitations do they present?

Without this perspective, the opportunity to develop epistemological thinking, the look at science as a social construction, is lost. In addition, there are no experimental activities that allow students to build physical or digital models, which would make learning more concrete and accessible. The BNCC advocates the use of different languages and media to promote scientific understanding, which requires practical actions, and not just passive visual reading (Brasil, 2017). The absence of these practices makes the content abstract and exclusionary, hindering meaningful learning and the democratization of scientific knowledge.

The text of the chapter mentions the toxicity of benzene and refers to the National Health Surveillance Agency (ANVISA), but in a decontextualized way and without delving into the practical and political implications of these issues (Brasil, 1999). There is a lack of discussions about how inspections occur, what regulatory criteria are used or what are the legal limits for exposure to hazardous materials. In addition, the role of regulatory standards,

such as NR-15 (unhealthy activities), which are crucial for occupational safety, is completely ignored (Brasil, 2022).

This gap is serious, as it prevents students from understanding Chemistry beyond the classroom and as part of their lives; as a tool to assess risks, demand rights and propose solutions (EM13CNT306). The BNCC also encourages students to critically evaluate the impacts of materials and processes on the environment and public health. By not discussing safe or sustainable alternatives and by ignoring the debate on the use and disposal of chemical substances, the chapter fails in the process of forming critical and conscious citizens (Brasil, 2017).

4 FINAL CONSIDERATIONS

Chapter 10 of the book 'Scientific Knowledge', from the collection 'Moderna Plus: Natural Sciences and their Technologies', offers an introductory approach to Organic Chemistry distributed in six topics and some activities, including molecular representations, carbon chains, the benzene ring, the stereochemistry of saturated carbon and polymers.

In his presentation, specific attempts to connect the content to the student's daily life are highlighted, such as the association of some chemical compounds present in acarajé to the Afro-Brazilian culture, which demonstrates the potential to stimulate cultural and nutritional reflections, in addition to promoting the ability to critically evaluate the benefits and risks that some chemical substances can offer (EM13CNT104).

The pedagogical approach adopted by the chapter, however, remains marked by a traditionalist and content-based bias, with an emphasis on memorization and with little openness to the development of investigative practices, critical reflections or meaningful interdisciplinary connections. In other words, the chapter studied disappoints by not fully exploring the transformative potential of teaching the discipline of Chemistry.

Nevertheless, it is possible to say that it does not fulfill the function of satisfactorily introducing the fundamentals of Organic Chemistry in High School, since it contemplates only some of the skills provided by the BNCC, such as the construction and interpretation of chemical representations (EM13CNT301, EM13CNT302 and EM13CNT303) and the application of knowledge in real contexts (EM13CNT306).

Although there is potential to transit in a process of citizenship education, especially in topics such as chemical safety, cultural diversity and environmental impacts, this potential is underutilized. The superficiality with which the authors deal with ethnic-racial themes, the

absence of accessible experimental activities and the omission of discussions about regulations and the world of work, reveal limitations that compromise the emancipatory role of science education. The material lacks a broader formative intentionality, which goes beyond technical preparation and is capable of promoting a critical reading of the world, as recommended by the BNCC and the LDB.

The sections 'Dialoguing with the Text' and 'Applying Knowledge' offer questions and activities aimed at the development of technical knowledge and logical reasoning, but fail to promote in-depth critical discussion, interdisciplinarity and active engagement of students. Group activities are limited and underexplored in terms of collaborative and investigative development. Although research and discussions are proposed, there is a lack of stimuli for students to build practical or sensorial experiences, such as the manipulation of molecular models, which could strengthen their understanding and interest in the subject.

With regard to interdisciplinarity and socio-environmental awareness, the chapter approaches relevant topics, such as the use of polymers and their environmental impacts, but without deepening discussions on ethics, sustainability and responsible consumption (EM13CHS304).

The questions that end the chapter seem to be mainly focused on the preparation of students for school evaluations and external tests, since they focus on memorization and mechanical problem solving, leaving aside the stimulus to critical reflection and the contextualization of contents. All these characteristics observed in the chapter limit the formative potential of the material, reducing the scope of the competencies associated with citizenship-oriented education.

In view of these findings, teacher mediation becomes essential. It is the teacher's role to reinterpret the book, transforming it into a tool for dialogue, reflection and student protagonism. This requires planning, creativity, and commitment to transformative education.

From another perspective, it is necessary that the publishers and bodies responsible for the PNLD consider, in future editions, the insertion of pedagogical proposals capable of promoting the appreciation of cultural diversity and the development of scientific thinking, expanding the social reach of Chemistry Teaching. This means more contextualizing, interdisciplinary, critical approaches that value experimentation. Only in this way will it be possible to bring the learning of Organic Chemistry closer to the lives of students and, above all, to show them the importance of this knowledge for the exercise of citizenship.

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**CLIMATE DISINFORMATION AND DIGITAL MOBILIZATION: HEATWAVES IN
BRAZIL AND SOCIO-ENVIRONMENTAL JUSTICE**

**DESINFORMAÇÃO CLIMÁTICA E MOBILIZAÇÃO DIGITAL: ONDAS DE
CALOR NO BRASIL E JUSTIÇA SOCIOAMBIENTAL**

**DESINFORMACIÓN CLIMÁTICA Y MOVILIZACIÓN DIGITAL: OLAS DE CALOR
EN BRASIL Y JUSTICIA SOCIOAMBIENTAL**

 <https://doi.org/10.56238/sevened2025.036-064>

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ABSTRACT

The year 2024 was the hottest ever recorded in Brazil, with an average temperature of 25.02°C, revealing the intensification of the climate crisis. Paradoxically, climate risk denial almost doubled, rising from 5% to 9% of the population, according to Datafolha. This contradiction reveals an epistemic and communicational crisis that undermines public understanding of global warming. This study aims to analyze how climate disinformation circulates in Brazil, compromising adaptation and mitigation policies. To this end, a qualitative and documentary approach was adopted, grounded in Luciano Floridi's concept of the infosphere and supported by INMET data, UN reports, and recent scientific literature. Findings indicate that the contamination of the infosphere by false narratives—amplified by social media and political groups—functions as an active environmental risk vector, turning disinformation into an instrument of symbolic and economic power. The results demonstrate that confronting the climate crisis also requires protecting the informational environment. It is concluded that future sustainability depends on an epistemic governance capable of integrating science, technology, and cognitive justice, ensuring that climate information remains a public good guided by truth and the preservation of life.

Keywords: Infosphere. Climate Disinformation. Climate Denial. Extreme Events. Scientific Communication.

RESUMO

O ano de 2024 foi o mais quente já registrado no Brasil, com temperatura média de 25,02°C, revelando o agravamento da crise climática. Paradoxalmente, a negação dos riscos ambientais quase dobrou, passando de 5% para 9% da população, segundo o Datafolha. Tal contradição evidencia uma crise epistêmica e comunicacional que afeta a percepção pública sobre o aquecimento global. Objetiva-se analisar como a desinformação climática se propaga no país, comprometendo políticas de adaptação e mitigação. Para tanto, procedeu-se a uma abordagem qualitativa e documental, fundamentada no conceito de infoesfera, proposto por Luciano Floridi, e apoiada em dados do INMET, relatórios da ONU e literatura científica recente. Observa-se que a contaminação da infoesfera por narrativas falsas —

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amplificadas por redes sociais e grupos políticos — atua como vetor ativo de risco ambiental, transformando a desinformação em instrumento de poder simbólico e econômico. Os resultados indicam que o enfrentamento da crise climática requer também a proteção do ambiente informacional. Conclui-se que a sustentabilidade futura depende de uma governança epistêmica, capaz de articular ciência, tecnologia e justiça cognitiva, garantindo que a informação climática seja um bem público orientado pela verdade e pela preservação da vida.

Palavras-chave: Infoesfera. Desinformação Climática. Negação Climática. Eventos Extremos. Comunicação Científica.

RESUMEN

El año 2024 fue el más caluroso jamás registrado en Brasil, con una temperatura media de 25,02°C, lo que revela la profundización de la crisis climática. Paradójicamente, la negación de los riesgos ambientales casi se duplicó, pasando del 5% al 9% de la población, según datos de Datafolha. Esta contradicción expresa una crisis epistémica y comunicacional que afecta la comprensión pública del calentamiento global. El objetivo de este estudio es analizar cómo la desinformación climática se propaga en el país, debilitando las políticas de adaptación y mitigación. Para ello, se adopta un enfoque cualitativo y documental, basado en el concepto de infosfera propuesto por Luciano Floridi, con apoyo en datos del INMET, informes de la ONU y literatura científica reciente. Se observa que la contaminación de la infosfera por narrativas falsas —amplificadas por redes sociales y grupos políticos— actúa como vector activo de riesgo ambiental, transformando la desinformación en instrumento de poder simbólico y económico. Los resultados muestran que enfrentar la crisis climática requiere también proteger el entorno informacional. Se concluye que la sostenibilidad futura depende de una gobernanza epistémica capaz de articular ciencia, tecnología y justicia cognitiva, garantizando que la información climática sea un bien público orientado por la verdad y la preservación de la vida.

Palabras clave: Infosfera. Desinformación Climática. Negación Climática. Eventos Extremos. Comunicación Científica.

1 INTRODUCTION

This article discusses a recent and complex phenomenon that affects not only Brazilian society, but several others around the world, namely, climate disinformation, which transcends digital borders and directly impacts public opinion around the world about the climate and environmental crisis. The year 2024 was marked, in Brazil, by intense temperatures that exceeded all previous records, reaching an average of 25.02°C — almost one degree above historical normality. Something that corroborates what INMET already warned, which pointed to the last decade as the warmest. (National Institute of Meteorology, 2022). Despite this situation, there are still many people and government leaders who minimize or deny - deniers - the seriousness of climate change.

The term "public opinion" is treated in the manner of Gabriel Tarde (2005), as a psychosociological concept. This means that the public in question is not subdivided into a merely political public (left, right or center) that defines the legal rules and shapes the political institutions that, in turn, would form a dominant political opinion; and on the other hand, the mass of consumers of tastes, ideas, fads of all kinds. On the contrary, the term "public opinion" refers to a shared opinion in which elements of tradition, politics, customs, reason, and social networks are conflictually shaped in a given time and space.

In this way, the disinformation shared and updated in posts and face-to-face does not act in isolation. It is connected to power structures, inequalities and exclusion that cross Brazilian society, mainly affecting populations that already live in conditions of socio-environmental vulnerability — residents of urban peripheries, indigenous peoples and traditional communities.

As Torres *et al* (2020) observe, these groups have the least access to digital education, reliable information, and institutional protection structures, since they are located on the margins of the flows of communication and power that structure environmental risk management, and are often made invisible in public policies and scientific information networks, which amplifies the impact of climate catastrophes on these groups, limiting their collective response capacity.

This process of marginalization, which makes environmental costs unfeasible for a portion of the population, is what Henri Acselrad (2010) calls environmental racism. It is a perverse logic in which the costs of ecological degradation fall disproportionately on the shoulders of the victims, most of whom are racialized and discriminated groups. These victims inhabit territories with a history of absence of territorialized public policies of the

State, more exposed to the risks of large development projects, such as mining and hydroelectric projects.

Consequently, unraveling the flows of disinformation is to understand the very power dynamics that perpetuate environmental inequality. On the other side of the spectrum, community collectives and social movements occupy the infosphere to counter hegemonic narratives, announce possible alternatives, and strengthen practices of socio-environmental justice (Porto, 2012).

Understanding these informational flows is, therefore, a fundamental step towards the realization of socio-environmental justice. This concept, widely discussed by several authors, is related to the need to ensure that all social groups — especially the most vulnerable — have equitable access to natural resources and the decisions that affect their use:

This is understood as the set of principles that ensure that no group of people, whether ethnic, racial or class groups, bears a disproportionate share of the negative environmental consequences of federal, state and local economic operations, policies and programs, as well as those resulting from the absence or omission of such policies. (Herculano, 2002)

A survey by the United Nations (UN, 2025) pointed to the occurrence of 10 extreme weather events in Brazil throughout 2024. Among these, we can mention three that were classified as unprecedented in their breadth and impact: the devastating floods in Rio Grande do Sul, the severe drought in the Amazon and the prolonged heat waves in the Midwest region.

In the hottest year in Brazil's history, surprisingly more Brazilians have come to deny that climate change is dangerous. A Datafolha survey showed that this number rose from 5% to 9% between 2024 and 2025 (Datafolha, 2025). How is this possible? How can people deny something they are feeling on their skin?

To understand this paradox, we use the concept of infosphere created by the Italian philosopher Luciano Floridi (2015). He explains that we no longer live only in the physical world or only in the digital world - we live in a mixture of the two, which he calls the infosphere:

A new type of conviviality, connected and unlimited, extended in spatiality and not only in physical personal relationships, "face to face", but characterized by connective forms that, through their translation into bits, continuously transform people, streets, squares, houses, things, into data networks, creating an unprecedented and hybrid condition, defined by Luciano Floridi (2015) "on-life. (Schlemmer; Di Felice; Serra,

2020, p. 4).

This is like the air we breathe, but made of information rather than oxygen. Just as polluted air is bad for our lungs, false information is bad for our ability to understand reality and make good decisions.

2 THE ECOSYSTEM OF THE INFOSPHERE

2.1 THE FIVE VECTORS OF CONTAMINATION IN THE BRAZILIAN CLIMATE INFOSPHERE

During the year 2024, the Brazilian infosphere composed of social networks, digital platforms, media channels, and messaging apps was flooded with five main types of false information about the climate, which function as vectors of cognitive pollution (Floridi, 2015).

In that same year, the circulation of false information about the climate in Brazil took on unprecedented dimensions because it coincided with a convergence of critical factors: the worsening of extreme events, especially heat waves and fires in the Amazon and the Pantanal, the intensification of political disputes around the energy transition, and the increase in digital engagement on platforms with low informational control.

We can identify five main vectors of this cognitive pollution (Floridi, 2015), which help to understand how disinformation spreads and affects the collective perception of the climate crisis. The first vector refers to the systematic denial of scientific data produced by consolidated institutions, such as INMET (National Institute of Meteorology). Even in the face of records of extreme heat, discourses that discredited global warming circulated widely on social networks, accusing science of ideological manipulation (Aguiar; Martin; Batista, 2022). This type of disinformation is based on strategies of delegitimization of scientific knowledge and intentional confusion between fact and opinion.

The second vector is manifested by the attempt to naturalize or trivialize extreme weather events. The floods in Rio Grande do Sul or the prolonged drought in the Amazon were often treated as phenomena of "nature", in the face of which man would have almost nothing to do, except to reconstruct the shards left by the phenomenon.

The third vector, which has a political nature, refers to ideological polarization, which transforms the environmental debate into a field of partisan dispute between the extreme left and the extreme right. Throughout 2024, but not only, because this scenario remains in 2025,

climate policies were treated as "communist threats" or part of a "globalist agenda", reducing scientific questions about global warming to ideological debates (Evangelista; Garcia, 2024).

The fourth vector refers to a process of commodification of sustainability, very close to the idea of an ecological modernization, which centers its merely discursive action on campaigns and business discourses that appropriate the environmental vocabulary to only sell products and reputations. In this process, the collective sense of sustainability is diluted in individual and consumerist practices, diverting the focus from the structural causes of the crisis and rewarding individualistic actions as redemptive.

Finally, the fifth element acts in a treacherous way, stifling the reports and experiences of the people most impacted by the climate crisis. Thus, the opinions of native peoples, residents of the banks of rivers and remaining quilombo communities are constantly silenced or misrepresented. Such omission intensifies what Acseirad (2010) calls environmental discrimination, an injustice that brings together the lack of balance in nature and the contempt for traditional knowledge. To understand, therefore, the paths of disinformation is also to understand the debates about knowledge that builds the idea of the climate crisis in Brazil.

2.2 DIFFERENTIATED VULNERABILITIES AND EPISTEMIC RESISTANCES IN THE INFOSPHERE

Informational contamination does not affect everyone in the same way. It is possible to see that populations from the urban peripheries, indigenous peoples, and traditional communities in Brazil experience this process in a more accentuated way, as they face not only the physical impacts of climate change, but also barriers to access to knowledge and public protection policies (Torres *et al* 2020). During the 2024 heat waves, these previously mentioned groups felt the effects in a concrete way. There was, among them, an increase in cardiovascular diseases and difficulties in water supply and food production.

Among the most striking reports are those of Amazonian riverside dwellers, who describe the intensification of the "heat" and noticeable changes in the cycles of flood and drought of the rivers. However, the empirical knowledge of these populations — so rich and situated — rarely finds dialogue with the scientific information that circulates in institutional environments. This distance between what is lived and what is explained deepens what we are calling epistemic and climatic injustice, in which historically marginalized groups bear the double burden: they suffer more from the effects of the crisis and are less able to face it based on accessible and contextualized data.

This observation reinforces the thought of Enrique Leff (2001), for whom the environmental crisis is also a crisis of knowledge. The author argues that the current ecological collapse reflects the limitation of a rationality that separated man from nature and reduced knowledge to the logic of production.

As Vieira (2001, p. 9), the socio-environmental crisis that was once treated as if it were something punctual and surmountable, has become an inevitable reality of our times:

Almost three decades after the Stockholm Conference was held in 1972, it would not be an exaggeration to say that we continue to deal with the socio-environmental crisis as if it represented only an untimely disturbance, a kind of background noise to be dealt with in a reactive and fragmented way, without implying the transgression of the profound logic that conditions the organization of contemporary societies.

In fact, climate disinformation is not just an isolated fact, but an expression of a dominant rationality that reduces reality to *fake news* and knowledge to capitalist utility. The infosphere contaminated by disinformation is, in this sense, the digital mirror of instrumental rationality that Leff (2006) criticizes, by transforming information into a manipulative commodity and truth into an algorithmic performance. The aforementioned author defends an environmental rationality as a means to overcome this totalitarian rationality, based on Marx's thought, Bookchin's anarchist naturalism, Baudrillard's postmodern thought, the ideas of Georgescu-Roegen, Prigogine, Morin, Habermas and Heidegger's ontology:

The construction of a new productive paradigm based on principles and bases of environmental rationality implies a strategy of deconstruction of economic rationality through social actors capable of mobilizing political processes that lead to productive and knowledge transformations to achieve the purposes of sustainability, rather than through norms that can be imposed on capital and consumers to reform the economy. In addition to the capitalization of nature through a formal economic-ecological rationalization, sustainability is debated in the emerging field of political ecology, where the perceptions and interests of the majority groups of society, Third World populations and indigenous peoples come into play, who resist being globalized, reduced to the condition of producers and consumers of a greenish market system. (Leff, 2006, p. 232)

This vision moves the interaction between science and society to the field of the ecology of knowledge, where different ways of understanding – scientific, popular, ancestral – can communicate in a reciprocal way. In this sense, significant movements of epistemic resistance emerged in the Brazilian infosphere, promoted by peripheral and traditional

communities. By flooding the infosphere with their own stories about global warming, sustainability, and the environmental crisis, they generate anti-hegemony discourses that break the prevailing monopoly of truth and reestablish the territory as a legitimate source of knowledge and sustainable practices that can be the solution to the challenge imposed by climate change that has been experienced more intensely in recent decades.

Thus, the infosphere becomes a terrain of confrontation between the unique rationality of technoscience and the various rationalities of the ecology of knowledges. Socio-environmental activism and community movements of collective struggle tactically appropriate digital platforms to combat misinformation and develop mitigation and adaptation policies.

Indigenous leaders such as Txai Suruí and quilombola activists use Instagram, Facebook, and other digital social networks to promote climate advocacy and occupy the digital space with critical and creative educational content (Evangelista; Garcia, 2024).

2.3 COLONIALITY OF KNOWLEDGE AND THE EPISTEMIC CRISIS

The climate crisis, which is currently characterized by the increase in extreme events and the spread of online disinformation, is also a crisis of knowledge. We are living, more than an ecological collapse, a global epistemic crisis, the result of the domination of modern rationality and the coloniality of knowledge, a concept elaborated by Aníbal Quijano (2005) to refer to the way in which the European positivist project of modernity structured the world based on the hierarchization between different forms of knowledge. Colonization not only exploited bodies and lands, but also imposed a single rationality — scientific, Eurocentric, instrumental — as the standard of universal truth.

Boaventura de Sousa Santos (2007, p. 71) argues that:

Modern Western thought is abyssal thinking. It consists of a system of visible and invisible distinctions, the latter of which underlie the former. Invisible distinctions are established through radical lines that divide social reality into two distinct universes: "on this side of the line" and "on the other side of the line"

This line defines what is considered science and what is relegated to ignorance — silencing the culture of the original peoples, the peasant folk wisdom and the epistemologies of the basal urban peripheries. To break this separation, the author proposes an *ecology of knowledges*, understood as "post-abyssal thinking is premised on the idea of the

inexhaustible epistemological diversity of the world, the recognition of the existence of a plurality of forms of knowledge beyond scientific knowledge. This implies renouncing any general epistemology" (Santos, 2007, p. 85-86)

These formulations converge on a point that seems inescapable, namely, climate disinformation in the Brazilian infosphere is not, in short, an isolated phenomenon, much less restricted to the technological field. It is, rather, a hasty incarnation of our known forms of epistemic coloniality, contained in the world-system as Immanuel Wallerstein called it. The infosphere, conceived as an ecosystem of hybrids of life and information, reproduces and amplifies the asymmetries of power between the various social groups when it itself concentrates cognitive power in the corporations and knowledge-producing institutions of the global North, relegating other forms of knowledge to the condition of noise, curiosity or folklore.

In a land and a time like contemporary Brazil, cognitive inequality takes on very particular contours. It manifests itself in phenomena such as the digital divide and the epistemic invisibility of the populations that, as already mentioned, most directly experience climate change: indigenous peoples, quilombola communities, riverside populations, among others.

By finding circulation channels for their own readings of the climate crisis, these organizations build what Santos (2018) would call intercultural translations: dialogues between knowledges that are not subject to hierarchy, but are strengthened in reciprocity.

These examples demonstrate that epistemic climate governance, in order to be democratic, needs to adopt strategies for the recognition and integration of traditional and territorial knowledge as a legitimate part of the production of environmental knowledge. Climate information should not be treated only as technical data, but as a shared cultural heritage, whose effectiveness depends on the diversity of voices that build it. The ethical and political challenge is to ensure that public policies for communication and climate education consider local knowledge not as cultural ornaments, but as active epistemologies in the formulation of solutions.

Ecological epistemic governance must be based on the reappropriation of the knowledge of traditional peoples, in which the quality of information and the diversity of knowledge are considered interdependent dimensions of sustainability. Therefore, addressing climate disinformation goes beyond preserving the informational environment; It is about restoring the connection between knowledge and cultural diversity, between the

digital and the physical, between the global and the local (glocal). From the perspective of the Epistemologies of the South, epistemic governance takes on a decolonial trait: it aims to decentralize the power of knowledge, sharing the right to name, interpret, and propose remedies for the climate crisis.

By adopting the Epistemologies of the South, with all their diversity and potentiality, the State has the opportunity to propose an epistemic governance with a decolonial character. In other words, this governance model seeks to decentralize colonizing power, redistributing the right to name, interpret, and propose solutions to the climate crisis. In other words, it is a matter of transforming the *infosphere* — today contaminated by mercantile interests and hegemonic narratives — into an ecosystem of plural knowledge, where knowledge becomes a common good and an instrument of emancipation.

In this sense, climate justice cannot be dissociated from cultural, economic, social and epistemic justice. Climate epistemic governance, in the light of the epistemologies of the South, is not limited to the technical management of information, but configures a civilizing project, aimed at reconfiguring humanity's way of thinking, feeling, and communicating about its relationship with the Earth

2.4 EPISTEMIC GOVERNANCE AND PUBLIC POLICIES

Brazilian epistemic governance is shaped by the recognition that climate disinformation is structurally favored by the algorithmic logic of digital platforms. During the aforementioned year 2024, recommendation algorithms on YouTube, Facebook, and TikTok, for example, were identified as multipliers of denialist content, favoring controversial and emotionally charged narratives. This dynamic reveals that the protection of information requires the regulation of information infrastructures, as argued by Floridi (2015).

In response to this active vector of environmental risk, the Brazilian government established in 2025 the Network of Partners for the Integrity of Climate Information. The network is part of the "Brazilian Chapter" of the Global Initiative for the Integrity of Information on Climate Change, which was launched globally in partnership with the UN and UNESCO. This initiative is the result of a collaboration between the Secretariat of Social Communication of the Presidency of the Republic (Secom PR), through the Secretariat of Digital Policies (SPDigi), the Ministry of Foreign Affairs (MRE) and the Ministry of Environment and Climate

Change (MMA).³

This initiative seeks to integrate environmental protection and informational quality, articulating scientific institutions (INMET, INPE), government agencies, civil society and digital platforms. The Network's actions include the creation of information quality indicators, the development of rapid response protocols to disinformation during extreme events, and the strengthening of digital climate education.

Experience has shown that traditional scholarly communication is insufficient, requiring the development of strategies that combine scientific rigor with narrative competence to compete for audience engagement. Proposed initiatives involve the creation of specialized scientific influencers and the adaptation of communication formats (such as *stories* and *reels*) for different platforms.

The contamination of the infosphere raises ethical issues governed by the principle of distributed responsibility (Floridi, 2015). This responsibility is shared among digital platforms, which must ensure the integrity of the algorithms; digital influencers, who must prioritize the quality and veracity of the content they produce; scientific institutions, which must make their communications accessible and understandable to the public; and citizens, who must exercise careful verification of the information they consume. The ultimate goal is to promote scientific accuracy and social justice through an ethics of climate information.

3 METHODOLOGY

To this end, a qualitative and documentary approach is carried out, based on the concept of infosphere, proposed by Luciano Floridi, and supported by data from INMET, UN reports and recent scientific literature. It is observed that the contamination of the infosphere by false narratives — amplified by social networks and political groups — acts as an active vector of environmental risk, transforming disinformation into an instrument of symbolic and economic power.

4 RESULTS AND DISCUSSIONS

The year 2024 was the year in which the increasing frequency of extreme weather events was met with the denial of these risks by the population.

³ Brazil. Presidency of the Republic. Secretariat of Social Communication. Available at: <https://www.gov.br/secom/pt-br/assuntos/noticias/2025/03/governo-apresenta-rede-que-une-sociedade-civil-e-orgaos-internacionais-para-proteger-o-debate-climatico> Accessed on: 05 nov. 2025.

According to the assessment of the Brazilian infosphere, climate disinformation is an active vector of environmental risk because it amplifies socio-environmental vulnerabilities, which makes it even more difficult to implement climate change adaptation and mitigation policies that are indispensable to address the climate crisis.

The five vectors of cognitive pollution identified - scientific denialism, naturalization of extreme events, ideological polarization, invisibility of vulnerable populations, and commodification of sustainability - revealed how the algorithmic architecture of digital platforms can be instrumentalized to fragment public debate and weaken scientific consensus. The Brazilian experience demonstrates that protecting the climate necessarily requires protecting the quality of information, ensuring the effectiveness of epistemic governance that is as crucial as traditional environmental governance.

The creation of the Network of Partners for the Integrity of Climate Information represents a significant advance in the development of public policies that integrate environmental protection and informational quality. This pioneering initiative sets an important precedent for other countries to address similar challenges, demonstrating that future sustainability will depend on algorithms and narratives that prioritize scientific evidence over polarizing ideologies. However, as evidenced by studies on environmental governance in Brazil, structural challenges still persist that require articulation between multiple levels of government and sectors of organized civil society to ensure the effectiveness of these policies.

The analysis of differentiated vulnerabilities in the infosphere pointed out that epistemic climate injustice intensifies already existing socio-environmental inequities. The marginalized populations in history – indigenous peoples, quilombola communities, riverside communities – are the ones who suffer the most simultaneously from the effects of climate change and the ones who least access duly confirmed scientific information. On the other hand, epistemic resistance movements indicate the transformative power of the critical appropriation of digital technologies by socio-environmental entities.

As the country will hold COP 30 in Belém, the Brazilian context becomes particularly relevant, as Brazil will be at the epicenter of climate governance and global Amazon preservation narratives. Therefore, it is necessary to take advantage of the historic opportunity that this global event offers Brazil to debate its role in combating climate change, strengthening national capacities in confronting climate disinformation and fostering epistemically based narratives.

Future studies should investigate the effectiveness of different scholarly communication strategies that take into account the regional and cultural contexts of Brazil. This includes the integration of traditional and scientific knowledge, the development of analyses to assess the quality of climate information, and the creation of rapid response protocols to disinformation about specific extreme weather events. It will also be necessary to deepen the analysis of the impact of artificial intelligence and recommendation algorithms on climate information flows, advancing ethical *frameworks* to guide the design of digital technologies that promote scientific accuracy and social justice in every field.

Therefore, the construction of an ethics of climate information constitutes an interdisciplinary challenge to the traditional division between the natural and social sciences and technology. As Floridi (2015) alludes to, as everything is related, the environment is no longer exclusively the responsibility of those who deal directly with the land, the rural world or the oceans. Acting in solidarity, the natural, social, and technological sciences must converge in a common project of informational sustainability, capable of articulating the production of knowledge, digital regulation, and socio-environmental justice in the same ethical horizon.

5 FINAL CONSIDERATIONS

Projections for future climate change scenarios in Brazil indicate the intensification of extreme events and the increase in socio-environmental vulnerability in several regions (National Institute of Meteorology, 2024). In this context, the ability to maintain complete information becomes even more crucial for the effective implementation of adaptation policies and for building social resilience. Brazilian sustainability in the twenty-first century will depend not only on the protection of its physical ecosystems, but also on the preservation of an informational environment that facilitates decision-making based on scientific evidence and promotes the inclusion of all social groups in the climate debate.

We conclude that addressing the Brazilian climate crisis requires an integrated approach that recognizes the interdependence between environmental protection and informational quality. The experience of 2024 has shown that it is not enough to produce scientific knowledge: it is necessary to ensure that this knowledge circulates in an accessible, understandable, and culturally relevant way in the infosphere. Epistemic governance thus emerges as an essential component of climate governance, requiring institutional, technological, and educational innovations that place scientific precision and socio-

environmental justice at the center of Brazilian public policies. The future of the sustainability of Brazil's natural assets and intangible wealth will depend on our collective ability to build an infosphere that serves life, not the interests that threaten.

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ARTIFICIAL INTELLIGENCE: AN OVERVIEW OF PUBLICATIONS ON THE SCIELO PLATFORM

INTELIGÊNCIA ARTIFICIAL: PANORAMA GERAL DAS PUBLICAÇÕES NA PLATAFORMA SCIELO

INTELENCIA ARTIFICIAL: PANORAMA GENERAL DE LAS PUBLICACIONES EN LA PLATAFORMA SCIELO

 <https://doi.org/10.56238/sevened2025.036-065>

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ABSTRACT

This study allowed us to have a broad view of the publications on Artificial Intelligence on the Scielo platform, in which it pointed out a historical, methodological analysis and thematic fields. He improved his knowledge on the subject by synthesizing and structuring the information in the articles, to determine the general scenario of the works. The impact consists of novelty, considering that no other study was found in the literature that presented the same scope and perspective. It deals with a topic in vogue, relevant and that deserves to be investigated to know general trends and scope. To this end, the research strategy adopted was bibliographic research based on the methods of bibliometric study and systematic review of the literature. Scielo publications on AI were scarce until 2019. Starting in 2020, research on AI has increased. Articles on AI in health and bioethics were the most published in Scielo in the period analyzed, followed by publications, respectively in the following order, in the field of education; related to law, legislation and ethics; critical analysis of AI; Business Management and Markets; communication; agrarian and computer science.

Keywords: Bibliometric Study. Systematic Review of the Literature. Artificial intelligence.

RESUMO

Este estudo permitiu ter uma visão ampla das publicações sobre a Inteligência Artificial na plataforma Scielo em que apontou uma análise histórica, metodológica e os campos temáticos. Aprimorou o conhecimento sobre o assunto ao sintetizar e estruturar as informações dos artigos, de forma a determinar o cenário geral das obras. O impacto consiste no ineditismo, tendo em vista que não foi encontrado na literatura outro estudo que apresentasse a mesma abrangência e perspectiva. Trata de um tema em voga, relevante e

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que merece ser investigado com vistas a se conhecer tendências gerais e abrangência. Para tanto, a estratégia de pesquisa adotada foi a pesquisa bibliográfica a partir dos métodos do estudo bibliométrico e revisão sistemática da literatura. As publicações no Scielo sobre IA foram escassos até 2019. A partir de 2020, as pesquisas sobre IA se intensificaram. Os artigos sobre a IA na saúde e bioética foram os mais publicados no Scielo no período analisado, seguido por publicações, respectivamente na seguinte ordem, no campo da educação; relacionadas ao direito, legislação e ética; análise crítica à IA; Gestão Empresarial e Mercados; comunicação; agrárias e; ciência da computação.

Palavras-chave: Estudo Bibliométrico. Revisão Sistemática de Literatura. Inteligência Artificial.

RESUMEN

Este estudio permitió obtener una visión amplia de las publicaciones sobre Inteligencia Artificial en la plataforma Scielo, presentando un análisis histórico, metodológico y de los campos temáticos. Mejoró el conocimiento sobre el tema al sintetizar y estructurar la información de los artículos, con el fin de determinar el panorama general de las obras. Su impacto radica en su carácter inédito, dado que no se encontró en la literatura otro estudio con la misma amplitud y perspectiva. Aborda un tema en auge, relevante y que merece ser investigado para conocer las tendencias generales y su alcance. Para ello, la estrategia de investigación adoptada fue un estudio bibliográfico basado en métodos bibliométricos y en la revisión sistemática de la literatura. Las publicaciones sobre IA en Scielo fueron escasas hasta 2019. A partir de 2020, las investigaciones sobre IA se intensificaron. Los artículos sobre IA en la salud y bioética fueron los más publicados en Scielo en el período analizado, seguidos respectivamente por publicaciones en el área de educación; derecho, legislación y ética; análisis crítico de la IA; gestión empresarial y mercados; comunicación; ciencias agrarias; y ciencias de la computación.

Palabras clave: Estudio Bibliométrico. Revisión Sistemática de la Literatura. Inteligencia Artificial.

1 INTRODUCTION

The central theme of this work is Artificial Intelligence (AI), which has been gaining more notoriety. Commissioned by *Microsoft*, a study conducted by *PricewaterhouseCoopers* stated that AI will be able to contribute more than US\$15.7 trillion to the global economy by 2030 (MICROSOFT, 2019). According to Naudé (2021), the growing interest in AI has brought expectations and uncertainties. Regarding expectations, it is expected that AI will improve productivity, growth prospects, and even leverage progress towards a technological utopia, which would be achieved when it advances to the point of becoming a superintelligence. With regard to uncertainties, there is a fear that AI will negatively affect the labor market, creating employment inequality, or even that it will become an existential threat to everyone. Santos, Schaal, and Goulart (2024) state that understanding the effects of AI has been the focus of studies and public policies in various parts of the world. These studies include the possible impacts of AI on economic growth, employment, income distribution, productivity, industrial organization, innovation, inequality, and economic policy.

Several fields of knowledge carry out research involving the use of AI, such as the fields of education, health, law and ethics, business management, communication, agricultural sciences, in addition to research that discusses, in general, the capacity of AI, its benefits and the risks of its use. Kaufman (2018) claims that AI is also a subject of research in areas such as computing, linguistics, philosophy, mathematics, neuroscience, among many others.

Based on the above, this study consisted of conducting a systematic analysis of AI based on peer-reviewed scientific articles, specifically, those published by the *Scielo - Scientific Electronic Library On-line* database. The Scielo platform is a program to support the communication infrastructure of open access research, created in 1997 and launched in March 1998, adopted in 16 countries that form the Scielo Network of national collections of quality journals. Its *raison d'être* and the relevance of the Scielo Program lie in the recognition, promotion and improvement of journals edited by universities, scientific societies and professional associations. It has nationally edited journals that communicate basic and applied research, of national and foreign authorship, multilingual, of various disciplines, from different countries and regions within them, with the inclusion of themes of priority or regional and local interest. The 28th Scielo Program contributes to providing science in the countries where it operates with the infrastructure and capacity to progressively carry out the complete cycle of research in the *modus operandi* of Open Science (SCIELO, 2024).

The following guiding question arises: how has AI been treated in the literature? Which field of study conducts the most research involving AI? Thus, this research is justified as it allows us to understand how AI has been approached in scientific works, from the first article published in *Scielo* to the present day. It also allows to improve knowledge in the elaboration of a systematic literature review, synthesizing, structuring and analyzing the data provided by the articles, in order to determine the general scenario of the works under analysis. It is also noteworthy that this is a topic in vogue at the present time, which makes this work relevant to the academic environment, since no broad study was found in the literature that indicated the paths addressed about publications related to AI, giving originality to the present work.

2 THEORETICAL FRAMEWORK

Two scholars in this field, Stuart Russell and Peter Norvig, define AI as the study of intelligent agents that receive perceptions from the environment and perform actions, in which each agent implements a function that maps sequences of perceptions into actions. For them, AI ranges from general-purpose applications (such as learning and perception) to specific tasks (such as playing chess, demonstrating mathematical theorems, creating poetry, and diagnosing diseases), systematizing and automating intellectual tasks that are relevant to various spheres of human activity, being a field that tries not only to understand, but also to construct intelligent entities (RUSSELL; NORVIG, 2004).

Another definition is that AI is the ability to create machines capable of replicating human intelligence, allowing them to do what was typically done by humans (KAUFMAN, 2018; PEIXOTO, 2020; SAINTS; SCHAAL; GOULART, 2024; TEIXEIRA, 1990). Santos, Schaal, and Goulart (2024) add that machines, or intelligent systems, are capable of performing tasks autonomously, based on stored information and their own experiences, by cross-referencing and interconnecting thousands of data. For them, AI has the potential for widespread application in society and production, which amplifies and deepens the changes brought about by it. Taulli (2020) states that AI is not only associated with computer science and mathematics, there have also been important contributions from other fields, such as economics, neuroscience, psychology, linguistics, electrical engineering, and philosophy.

According to Taulli (2020), philosopher John Searle, writer of the article "*Minds, Brains and Programs*", which, in Portuguese, means "Minds, Brains, and Programs", believed that there were two forms of AI: strong AI and weak AI. For him, strong AI refers to when a machine actually understands what is going on, and can even demonstrate emotions and

creativity; as an example, he mentions that it can be found in companies such as *Google's Deep Mind*. Coppin (2012) believed that, having a computer with adequate processing capacity and giving it sufficient intelligence, it would be possible to create a computer capable of thinking and being conscious, just as a human is conscious. But he recognizes that, for the time, this idea was considered absurd and even unfounded.

Searle believed that weak AI refers to a machine's ability to match patterns by typically focusing on specific tasks, such as *Apple's Siri* and *Amazon's Alexa* (TAULLI, 2020). For Coppin (2012), unlike strong AI, weak AI is about replicating intelligence through commands given to a computer to solve complex problems. Thus, the fact that a computer acts intelligently does not mean that it is really intelligent, like a human.

3 METHODOLOGY

Regarding the approach, the present study is characterized as a bibliographic research, in which the bibliometric study and systematic review of the literature were adopted to characterize works present in the *Scielo database*, on the theme "Artificial Intelligence". The bibliometric study involved the analysis of the temporal evolution of the works, classification of the journals, methodologies and objects investigated in these articles. And the systematic literature review approach was applied as a method, with the objective of creating categories of analysis of the contents present in the analyzed works. The present work is also characterized as descriptive research and exploratory study.

In this sense, this study describes, based on a previously elaborated research protocol, the characteristics present in scientific articles on AI published in journals and made available on the *Scielo Platform*. This description aimed to discuss the general characteristics of the publications and the contents involved in what was published in relation to this theme, and the exploratory perspective was due to the fact that the theme is in vogue and still in scientific and epistemological construction.

The present study was structured on the collection of secondary data, more specifically on articles published in journals that have been submitted to peer review. The platform chosen for the research was *Scielo* (Online Digital Scientific Library). Data collection was carried out from May 15 to July 16, 2024 and to ensure a more complete result, it was decided to use search terms (descriptors/keywords) in both Portuguese and English, namely: Artificial Intelligence and *Artificial Intelligence*. In the research protocol created, citable articles, characterized as being in Portuguese, that contained the terms "Artificial Intelligence" or

"Artificial Intelligence" in the "Title" and "Abstract" fields, published on the platform until July 16, 2024, were selected, resulting in a total of 127 works. The next step was to *download* these articles to start the analysis.

Articles that did not contain the term "artificial intelligence" in the title and abstract (review of the protocol applied) were excluded; articles in which the topic was not related to AI; any works that were not articles from journals/magazines (including TCC, dissertation, thesis, specialization monograph, event articles and books); repeated articles and articles with incomplete text/incomplete availability. All 127 works selected after the inclusion parameters had the term "artificial intelligence" in the title and abstract, contained a theme related to AI, and were articles from journals/magazines. However, there were 60 repeated works and one work with incomplete availability, which resulted in 66 articles selected to compose the systematic literature review carried out, which were ordered in Table 1.

Table 1

Selected articles

No.	Title	Quote
1	Artificial intelligence in the improvement of ecology essays: a study in a Brazilian high school	Silva Neto e Leite (2024)
2	Health literacy in ChatGPT: exploring the potential of using artificial intelligence for the preparation of academic texts	Peres (2024)
3	Artificial intelligence for predicting bed bath time in Intensive Care Units	Toledo, Bhering and Ercole (2024)
4	Lexical density in texts generated by ChatGPT: implications of artificial intelligence for writing in additional languages	Silva and Rottava (2024)
5	Diagnosis of diabetic retinopathy by artificial intelligence through <i>smartphone</i>	Oliveira <i>et al.</i> (2024)
6	Application of artificial intelligence techniques to classify evasion of the theme in essays	Pinho, Gaspar and Sassi (2024)
7	Artificial intelligence applied to evaluate the perception of the quality of <i>E-commerce logistics</i> : the case of Rio de Janeiro	Sucena and Cury (2024)
8	Generative artificial intelligence (AI) and information competence: informational skills necessary for the use of generative AI tools in informational demands of an academic-scientific nature	Trindade and Oliveira (2024)
9	Behind Artificial Intelligence: An Analysis of the Epistemological Underpinnings of Machine Learning	Aaron (2024)
10	Artificial intelligence in tourism studies and research in Brazil	Santos <i>et al.</i> (2024)
11	New challenges for education in the age of artificial intelligence	Azambuja e Silva (2024)
12	Bioethics and artificial intelligence: a current panorama of literature	Ships (2024)
13	Artificial intelligence-assisted judicial decision and the Victor System of the Federal Supreme Court	Valle, Gasó and Ajus (2023)
14	Artificial Intelligence and ethics: a dialogue with Lima Vaz	Broached (2023)
15	Dimensions of the use of technology and artificial intelligence (AI) in recruitment and selection (R&S): benefits, trends and resistances	Blumen and Cepellos (2023)
16	The use of artificial intelligence in judicial decision-making	Toledo and Pessoa (2023)
17	Artificial intelligence in the analysis of the emotions of nursing students submitted to clinical simulation	Leon <i>et al.</i> (2023)

18	Use of artificial intelligence to predict the risk of flexible post-ureteroscopy sepsis: a systematic review	Alves <i>et al.</i> (2023)
19	Multimodal Information Architecture: contributions to the development of artificial intelligence	Kuroki Junior and Gottschalg-Duque (2023)
20	Innovations in Surgical Training: Exploring the Role of Artificial Intelligence and Large Language Models (LLM)	Varas <i>et al.</i> (2023)
21	Artificial intelligence in education: the challenges of ChatGPT	Rodrigues and Rodrigues (2023)
22	The Ultimate Robot: Artificial Intelligence, Empowerment, and Control	Kirtschig and Olsen (2023)
23	Artificial intelligence in health and bioethical implications: a systematic review	Elias <i>et al.</i> (2023)
24	Story More Than Human: Describing the Future as Repeating Upgrade of Artificial Intelligence	Bonaldo (2023)
25	Artificial intelligence in the constitutional bodies of control of accounts of the Brazilian public administration	Ball and Martins (2023)
26	Artificial intelligence and chemistry teaching: a propaedeutic analysis of ChatGPT in the definition of chemical concepts	Milk (2023)
27	Artificial intelligence and prediction of death from Covid-19 in Brazil: a comparative analysis between <i>the Logistic Regression, Decision Tree, and Random Forest algorithms</i>	Silva and Silva Neto (2022)
28	Criminal procedure and artificial intelligence: towards a maximum security (procedural) criminal law?	Santos (2022)
29	Artificial intelligence and legal personality: perspectives in Brazilian corporate law	Chaves and Colombi (2022)
30	Bioethical challenges of using artificial intelligence in hospitals	Nunes Guimarães and Dadalto (2022)
31	Correlation of glucose dosage by glucometer, laboratory dosage, and artificial intelligence equipment	Oliveira Barcelos and Siqueira (2022)
32	Barriers and benefits in the adoption of artificial intelligence and IoT in operation management	Rock and Kissimoto (2022)
33	Artificial Intelligence and Real Existential Risks: An Analysis of Human Limitations of Control	Candiotto and Karasinski (2022)
34	The political economy of artificial intelligence: the case of Germany	Mendes (2022)
35	Ethical limits for the use of artificial intelligence in the Brazilian Justice System, according to Law 13.709 of 2018 (LGPD) and Resolutions 331 and 332 of the National Council of Justice	Gomes, Vaz and Dias (2021)
36	The challenge of artificial intelligence technologies in education: teachers' perception and evaluation	Grapevine Lehmann and Oliveira (2021)
37	Validation of an artificial intelligence algorithm for the diagnostic prediction of coronary heart disease: comparison with a traditional statistical model	Correia <i>et al.</i> (2021)
38	The (Brazilian) Shop Floor of Artificial Intelligence: Data Production and the Role of Communication Between <i>Appen</i> and <i>Lionbridge</i> Workers	Grohmann and Araújo (2021)
39	Diagnostic performance of FFR by coronary CT angiography by <i>software</i> based on artificial intelligence	Morais <i>et al.</i> (2021)
40	National vaccination plan against COVID-19: use of spatial artificial intelligence to overcome challenges	Rocha <i>et al.</i> (2021)
41	On the artificial intelligence channel - New season of disheveled and perky	Cozman (2021)
42	Artificial Intelligence and Machine Learning: Current State and Trends	Ludermir (2021)
43	Artificial intelligence and the challenges of Digital Forensics in the 21st century	Padilha <i>et al.</i> (2021)
44	Influences of artificial intelligence technologies on teaching	Vicari (2021)
45	Prescription of physical exercises by artificial intelligence: will physical education end?	Oliveira e Fraga (2021)
46	Artificial Intelligence and Damaged Training: Deep Learning and Shallow Ethics Between Teachers and Students	Zuin (2021)
47	Artificial intelligence that predicts mortality in an intensive care unit and comparison with a logistic regression system	Nistal-Nuño (2021)
48	Artificial intelligence as a subject of law: construction and critical theorization about personhood and subjectivation	Divine (2021)

49	Impact of artificial intelligence on the choice of radiology as a medical specialty by medical students in the city of São Paulo	Brandes <i>et al.</i> (2020)
50	Artificial intelligence in public relations? No thanks. Perceptions of European communication and public relations professionals	Sebastian (2020)
51	Semi-training and artificial intelligence in teaching	Campos and Lastória (2020)
52	Implementation of an artificial intelligence algorithm for sepsis detection	Gonçalves <i>et al.</i> (2020)
53	<i>Legal tech: analytics</i> , artificial intelligence and the new perspectives for the practice of private law	Andrade, Rosa and Pinto (2020)
54	The Playful Fallacy of the Three Laws: An Essay on Artificial Intelligence, Society, and the Difficult Problem of Consciousness	Lent (2020)
55	The Digital Technological System: artificial intelligence, cloud computing and <i>Big Data</i>	Silva Neto, Bonacelli and Pacheco (2020)
56	The metaphysical dimension of artificial intelligence	Braga and Chaves (2019)
57	The use of artificial intelligence in the application of public law: the special case of the collection of tax credits - a study aimed at the Brazilian and Portuguese cases	Abraham and Catarino (2019)
58	Artificial intelligence and medicine	Wolf (2017)
59	Communication and artificial intelligence: new challenges and opportunities for communication research	Gunkel, Trento and Gonçalves (2017)
60	Estimation of the tapering of the Araucaria Stem using artificial intelligence techniques	Martins <i>et al.</i> (2017)
61	Artificial intelligence applied to animal science	Costa (2009)
62	Artificial intelligence: an application in a continuous process industry	Sellitto (2002)
63	Diagnosis of cerebellopontine angle tumors with the aid of artificial intelligence techniques	Leitão <i>et al.</i> (2000)
64	Biological intelligence <i>versus</i> artificial intelligence: a critical approach	Sanvito (1995)
65	An approach to artificial intelligence and simulation, with an application in national beef cattle	Costa (1992)
66	Artificial intelligence and problem-solving theory	Teixeira and Gonzales (1983)

Source: The authors, 2025.

After selecting the articles, a content analysis of all selected articles was carried out, followed by a thematic categorization based on the main focus of each work. To agglutinate the works into the categories created, the keywords and the content of the abstract of each article were specifically analyzed. In all, eight categories of analysis were created: Health and Bioethics; Education; Law, Legislation and Ethics; Critical Analysis of AI; Business Management and Markets; Communication; Agricultural; Computer Science.

4 RESULTS AND DISCUSSION

Over the years, there has been a significant increase in publications about AI. The first article on AI, present on the *Scielo Platform*, dates from 1983. There was a 9-year gap until the publication of the second article, in 1992. Until 2009, there were six articles about AI on the platform, representing 9.09% of the articles analyzed. From 2010 to 2016, no article on this topic was published in *Scielo*. The year 2017 brought the contribution of three articles, which represent 4.55% of the articles analyzed, followed by two articles in 2019 (3.03%).

In 2020, seven articles were published. From this moment on, publications about AI took off. In 2021, 14 articles were published, followed by eight publications in 2022 and 14 in 2023. In 2024, until July 16 (the final date of collection of this research), 12 articles were published. In other words, the interval of the last four years represented 83.33% of the publications present in this study, which proves the growing interest in this area of research in recent years.

4.1 QUALIS CAPES CLASSIFICATION OF JOURNALS

In total, the 66 articles were published in 49 journals. Of these, the one that was most repeated was the Advanced Studies, with a Qualis Capes A1 classification, with four publications. Then, with three publications in each journal, the Journal of Constitutional Investigations (A1), the Brazilian Journal of Nursing (A4) and the Journal of Bioethics (B1) were presented.

Two articles were published in eight different journals, namely: *Ciência & Saúde Coletiva* (A1), *Texto Livre* (A1), *Trans/Form/Ação* (A1), *Filosofia Unisinos* (A1), *CONSINTER International Journal of Law* (A3), *Journal of the Brazilian College of Surgeons* (B1), *Brazilian Archives of Cardiology* (B1) and *Archives of Neuro-Psychiatry* (B2). Finally, 35 journals presented only one article published in each one and their Qualis Capes classifications ranged from A1 to B3.

It should be noted that the predominant Qualis Capes classification is A1, representing 40.91% of the publications. The B1 classification appears in second place, representing 18.18%. Then there is the A4 classification, with 13.64%; A2, with 12.12%; A3, with 7.58%; and B2, with 6.06%. Finally, there is the B3 classification, representing 1.51% of the publications. The quality of the articles analyzed in this study is highlighted, since 74.25% of them are classified as quality indicator A, and most of them are A1, which is the best possible classification.

4.2 METHODOLOGIES AND OBJECTS/FIELDS OF STUDY INVESTIGATED

This analysis sought to determine which methods were most used for the construction of the articles, also outlining the objects (when concrete) or fields (when abstract) investigated. In all, 25 research classifications were observed, and in some cases, a single article presented more than one type of research. Theoretical articles were the research classification of 33.33% of the articles, which was the most used. Qualitative research

appeared in second place, representing 18.18% of the articles, followed by exploratory research, which was used in 16.67% of the articles, this being the third most used classification.

As for the objects/fields of study, they were classified as being primary-based, secondary-based, or with a theoretical/conceptual approach. The primary base objects/fields of study were those that worked with data collected directly by the authors themselves and represented 27.27% of the articles. The secondary base objects/fields of study were those that worked with existing data, such as databases or published literature, totaling 34.85% of the articles. The objects/fields of study with a theoretical/conceptual approach were those that analyzed or discussed concepts and theories, without necessarily relying on collected data, and represented 22.73% of the articles. There were also articles that did not present a defined object/field of study, totaling 15.15% of the studies analyzed.

The most recurrent object/field of study was linked to the area of education, being ChatGPT, which was the specific object of four articles. The articles that specified places to carry out their research were mostly carried out in Brazil. However, there were three articles that presented objects/fields of study with international bases: experts from Germany, specifically from the Rhine-Main metropolitan region (Frankfurt and Darmstadt), and from the cities of Stuttgart and Bonn; perceptions of European communication and public relations professionals, in particular, those working in Portugal; article that analyzed the use of AI in Law in Brazil and also in Portugal.

4.3 CATEGORIES OF THEMATIC ANALYSIS OF ARTICLES

When analyzing each article, it was possible to observe that some contained a similar research focus, which allowed them to be grouped into categories of analysis. In all, the 66 articles were allocated by the authors into eight categories, which included articles that related FI to the fields of study described in Table 2.

Table 2

Categories of thematic analysis of the articles

Analysis Category	Articles (absolute value)	Articles (relative value - %)
Health and Bioethics	19	28,8
Education	13	19,7
Law, Legislation and Ethics	12	18,2
AI Critical Analysis	8	12,1
Business Management and Markets	6	9,1
Communication	3	4,5
Agricultural	3	4,5

Computer Science	2	3,0
Total	66	100

Source: The authors, 2025.

The articles analyzed in this study date from 1983 to 2024 and, over the course of these 41 years, subjects from different categories stood out. Table 3 shows how the studies in each category have advanced over the years.

Table 3

Time advance of the categories

CATEGORY	YEAR													TOTAL
	1983	1992	1995	2000	2002	2009	2017	2019	2020	2021	2022	2023	2024	
Health and Bioethics				1			1		2	5	3	4	3	19
Education									1	3		2	7	13
Law, Legislation and Ethics								1	1	2	2	6		12
AI Critical Analysis	1		1					1	1	2	1		1	8
Management Business and Markets					1					1	2	1	1	6
Communication							1		1	1				3
Agricultural		1				1	1							3
Computer Science									1			1		2
TOTAL	1	1	1	1	1	1	3	2	7	14	8	14	12	66

Source: The authors, 2025.

The first published article is a critical analysis of AI, a theme that has remained stable, presenting one article in the years 1983, 1995, 2019, 2020, 2022 and 2024, and two articles in 2021. The category of agrarian women appeared next, with three scattered publications, the first in 1992, the second in 2009 and the third in 2017. Articles on health and bioethics began to be published only in 2000, with a long interval until the second publication on the subject, in 2017. From 2020 onwards, this topic began to gain prominence, with two articles published this year, five in 2021, three in 2022, four in 2023, and three in 2024, which made this the category with the most publications in this study. In 2002, there was an article on business management and markets, a subject that was only addressed again in 2021 with one publication, followed by two in 2022, one in 2023 and one in 2024. The communication category was centralised over a four-year period, with one publication in 2017, one in 2020 and one in 2021.

The categories of education and law, legislation and ethics have been the focus of research only in recent years, but even so, they represented, respectively, the second and third largest categories in this study. The first article on law, legislation and ethics was published in 2019, followed by one more in 2020, two in 2021, two in 2022 and six in 2023.

Publications on education began in 2020 with one article, followed by three in 2021, none in 2022, two in 2023, and seven in 2024. Finally, there is the computer science category with one article in 2020 and another in 2023. Table 4 presents the articles that made up each category.

Table 4

Articles by category

Analysis Category	Articles
Health and Bioethics	Naves (2024); Elias <i>et al.</i> (2023); Nunes, Guimarães and Dadalto (2022); Toledo, Bhering and Ercole (2024); Oliveira <i>et al.</i> (2024); Leon <i>et al.</i> (2023); Alves <i>et al.</i> (2023); Varas <i>et al.</i> (2023); Silva and Silva Neto (2022); Oliveira, Barcelos and Siqueira (2022); Correia <i>et al.</i> (2021); Moraes <i>et al.</i> (2021); Rocha <i>et al.</i> (2021); Nistal-Nuño (2021); Oliveira and Fraga (2021); Brandes <i>et al.</i> (2020); Gates <i>et al.</i> (2020); Lobo (2017); Leitão <i>et al.</i> (2000).
Education	Silva Neto and Leite (2024); Peres (2024); Silva and Rottava (2024); Pinho, Gaspar and Sassi (2024); Trindade and Oliveira (2024); Santos <i>et al.</i> (2024); Azambuja and Silva (2024); Rodrigues and Rodrigues (2023); Milk (2023); Parreira, Lehmann and Oliveira (2021); Vicari (2021); Zuin (2021); Fields and Lastória (2020).
Law, Legislation and Ethics	Valle, Gasó and Ajus (2023); Toledo and Pessoa (2023); Bitencourt and Martins (2023); Andrade, Rosa and Pinto (2020); Abraham and Catarino (2019); Kirtschig and Olsen (2023); Chaves and Colombi (2022); Divino (2021); Broached (2023); Bonaldo (2023); Santos (2022); Gomes, Vaz and Dias (2021).
AI Critical Analysis	Arão (2024); Candiottto and Karasinski (2022); Cozman (2021); Ludermir (2021); Quaresma (2020); Braga and Chaves (2019); Sanvito (1995); Teixeira and Gonzales (1983).
Business Management and Markets	Sucena and Cury (2024); Blumen and Cepellos (2023); Rocha and Kissimoto (2022); Mendes (2022); Grohmann and Araújo (2021); Sellitto (2002).
Communication	Padilha <i>et al.</i> (2021); Sebastião (2020); Gunkel, Trento and Gonçalves (2017).
Agricultural	Martins <i>et al.</i> (2017); Costa (2009); Costa (1992).
Computer Science	Kuroki Júnior and Gottschalg-Duque (2023); Silva Neto, Bonacelli and Pacheco (2020).

Source: The authors, 2025.

In all, 19 of the 66 articles analyzed were associated with the **Health and Bioethics Category**. Of these, three referred specifically to ethics in the field of health, called bioethics. Naves (2024) concluded that AI and robotics require prior implementation of ethical operating standards that ensure safety and applicability in the field of health and that the relatively unstable state of AI and its potential liability provide an opportunity to develop a new model, which accommodates medical progress and instructs stakeholders on how best to respond to this disruptive innovation. Elias *et al.* (2023) concluded that transparency is the main basis of AI in health and that regulations need to evolve, both in the definition of responsibilities and in the understanding and trust about the autonomy of decisions generated by AI. Nunes, Guimarães, and Dadalto (2022) believe that, in the hospital phase, when AI is implemented in the care unit, it is essential to monitor the bioethics committee, making sure of the integrity of the technology, the data from the research that preceded it, and its management, in

addition to making the role of the State in regulating AI and ensuring compliance with the legislation essential.

Other articles in this category analyzed the use of AI in various medical situations. In some cases, the authors tested different AI algorithms in order to determine which one was best to achieve the goal they proposed. In other cases, the authors developed the AI algorithm themselves, and there have been papers that have discussed how AI is affecting medicine and its fields.

In **the Education Category**, all articles that have education as the focus of study were allocated, totaling 13 works. The most explored subject in this category was the ChatGPT Generative AI model, which appears as a tool with great potential to facilitate the academic field, but which brings many uncertainties and concerns. Another theme analyzed by the articles in this category was the impact of AI on the teaching-learning process, both from positive and negative perspectives.

Silva Neto and Leite (2024) concluded that *chatbots* were able to facilitate the application of content and make assessments more engaging and productive. Peres (2024) concluded that, even for a topic that is still emerging in the reference literature in the Portuguese language (health literacy), the AI tool was able to generate coherent and structured texts. The results of Silva and Rottava (2024) revealed that ChatGPT does not follow the instructions of the tasks regarding the number of words requested, thus impacting the calculation of lexical density, nor does it produce texts that show significant differences in lexical density between additional languages and proficiency levels. Pinho, Gaspar and Sassi (2024) concluded that the solution validated by the research contributes to positively impact the work of teachers and educational institutions, by reducing the time and costs associated with the essay evaluation process.

Trindade and Oliveira (2024) stated that, in order to use generative AI tools effectively and strategically, people need to analyze the need for information, analyze the tool, plan search strategies/elaborate commands, analyze synthesized content, use synthesized content, and apply the 18 informational skills related to these steps. Santos *et al.* (2024) pointed to the need to have legal regulations regarding the ethical and responsible use of AI, highlighting the use of AI tools for spelling correction and proper formatting of texts as an advantage. Azambuja and Silva (2024) came to the conclusion that it is necessary to enhance AI systems inside and outside the classroom and suggested that teachers focus more on developing students' interpersonal and critical skills.

Rodrigues and Rodrigues (2023) pointed out that AI does not guarantee objectivity and neutrality just because it is processed by machines and supposedly protected against human error, a factor observed in the use of the ChatGPT tool, whose searches and contributions are not free from errors. Leite (2023) concluded that ChatGPT has excellent linguistic capacity, but it is limited in logic, abstraction, high-level reasoning, and is not able to maintain a coherent and high-level discussion, which can be carried out through teacher-student and student-student interaction. Parreira, Lehmann and Oliveira (2021) stated that teachers realize that flexibility and adaptability are the basis for responding to the challenges they will soon face and that transversal skills are the essence of this flexibility and adaptive capacity.

Vicari (2021) came to the conclusion that, when it comes to technology, breaking paradigms and disruption can change the trend at any time. He said that, if changes in education are necessary, the way of evaluating education also needs to change. Zuin (2021) concluded that the attitudes of teachers, who assume their conditions as human beings subject to failures and successes, will most likely lead to a type of empathy among students, which will make both groups use digital technologies to understand the causes of educational phenomena and become ethically sensitized to change their own practices inside and outside schools. Campos and Lastória (2020) reflected on audiovisual technologies, digital platforms, and AI *software* aimed at personalizing teaching and stated that it is up to the critical teacher, in the face of the technological modernization of education, to teach students exercises that make them capable of carrying out experiences that expand sensitivity and the capacity for conceptual abstraction.

The **Law, Legislation and Ethics Category** was composed of 12 works, in which AI appears as a tool capable of streamlining and facilitating work in different sectors of the field of law, but which needs a defined legislation so that it does not go against the ethical precepts of society. Valle, Gasó, and Ajus (2023) presented the historical context from the creation of AI to its insertion in the world of Law and, in more detail, the problem of *biases* and artificial hypernormalization, reporting state measures that aim to remedy this type of problem. Toledo and Pessoa (2023) concluded that there are several advantages brought by computerization and the current implementation of AI in the Brazilian Judiciary, however, due to the risks observed, the authors stated that AI should not be used for judicial decision-making. Bitencourt and Martins (2023) concluded that AI is present in several Brazilian Courts of Auditors, performing predictive functions, aiding and qualifying human decision-making.

Andrade, Rosa, and Pinto (2020) found that AI mechanisms based on *analytics* platforms tend to provide greater predictability for private law, mainly because they allow a better understanding of the patterns of behavior present in trials.

Abraham and Catarino (2019) believe that AI, using increasingly complex and sophisticated means, will help to solve the biggest bottleneck present in the Judiciary, which would be the collection of tax credits through tax enforcement action. As for ethical issues, they highlighted the need to guarantee justice in the decisions and interactions of public authorities with citizens, the freedom of choice of *learning* machines and, finally, the great concern about the need for regulation in this field. Kirtschig and Olsen (2023) concluded that it is necessary for state bodies of political representation to be transparent about the content and mode of operation of AI tools, so that they can regulate, monitor, and control their use, to verify their compatibility with the objectives set out in the Constitution and to determine any course correction. For Chaves and Colombi (2022) there is no legal impediment to the adoption of *Bayern's thesis* to Brazilian corporate law, which makes it possible for a limited liability company to be created and, subsequently, to be left without partners, creating the legal receptacle of AI. Divino (2021) concluded that the process of subjectivation and attribution of personality depends on the participation of AI to claim the rights to which it is inherent, and it is not up to the human being to choose and attribute them. Brochado (2023) starts from the work of Lima Vaz to present some ethical questions about the experiences lived today in the horizon of a highly technicized culture. Bonaldo (2023) made an interdisciplinary discussion covering the sociology of algorithms, informational ethics, and the philosophy of mind to, based on the theory of history, assess how the ubiquity of automation adds new dimensions to the study of the contemporary historical condition. Santos (2022) stated that the digital dictatorship of AI will stretch the boundaries between what is allowed and what is prohibited, between what is legal and what is illegal, between what is constitutional and what is unconstitutional, between man and machine, and thus will usher in a new era of iniquity that only divine providence can put an end to. Gomes, Vaz and Dias (2021) concluded that human supervision is necessary in judicial decisions that use AI in compliance with the right to explanation and review.

Eight articles made up the **Critical Analysis of AI Category** and presented, in a critical way, the authors' view of the potential and risks of AI. They talked about its use, styles, challenges, capacity, relationship with the human and philosophical relevance. Aaron (2024) concluded that the most AI can do is recognize patterns and repeat, not being a source of

absolute truth, but rather a human construction that involves mathematics, induction, subjectivity, and work. In the end, he stated that many people are criticized for lack of originality, precisely because they seem to copy someone else's work and style, while admiring the machine for doing so. Candiotta and Karasinski (2022) concluded that, in the hypothesis of internal causes, in which the self-modifications originate from the system itself, with a lack of understanding about the functioning of AI, the existential risk would remain the same, since the human brain would have many difficulties in perceiving the flaw and, even realizing it, in making decisions that contradict the suggestion of AI.

Cozman (2021) came to the conclusion that the community involved in the development of AI, for the most part, continues to seek to improve the productivity and quality of human life by building artifacts that can intelligently assist human beings. Ludermit (2021) concluded that machines are far from learning to master many human aspects, although the success of AI is undeniable and is impacting the world. Quaresma (2020) based his article on Isaac Asimov's "three laws of robotics" and exposed how these laws relate to AI. He came to the conclusion that the "three laws of robotics" are incapable of understanding AI and considers them fictitious. Braga and Chaves (2019) believe that humans are still capable of living without machines, but that machines depend on humans to exist and that humans have the ability to demonstrate qualities that computers do not yet possess and may never possess. Sanvito (1995) sought to understand the brain/mind complex and related it to AI. He determined that the great challenge of the cognitive sciences is to seek knowledge itself and not just to reproduce a simple logical-mathematical formalization of knowledge. Teixeira and Gonzales (1983) sought to show the relevance of AI to Philosophy, especially to the Philosophy of Mind and the Theory of Knowledge. They concluded that AI research intersects with philosophical research, insofar as building programs often means inquiring into the conditions of possibility of certain cognitive performances present in natural language, perception, among others.

The **Business Management and Markets Category** was composed of six articles. The subjects covered by these leftovers are, respectively, *e-commerce*, AI in the recruitment and selection process, AI in operations management, AI in the German market, working on global AI platforms, and AI in a continuous process industry.

Sucena and Cury (2024) sought to develop a mathematical model using an AI technique called *Fuzzy Logic*, capable of evaluating the quality of *e-commerce* logistics, interpreting qualitative expressions captured through a questionnaire submitted to the end

customer, transforming them into quantitative values that form partial indices and the IQLE (E-commerce Logistics Quality Index). Blumen and Cepellos (2023) cited the role of technology and AI in reducing bureaucracy in the Human Resources (HR) area, in order to make its focus more strategic and consultative, as it reduces time and cost in screening resumes and selecting candidates.

Rocha and Kissimoto (2022) found that the main barriers found in the literature for the adoption of new technologies are the difficulty of working with data and the feelings of vulnerability and insecurity in the use of these technologies by users. Mendes (2022) carried out an analysis of how AI was progressively stimulated by the German government, having chosen Germany because it is one of the centers of origin of Industry 4.0, which adopted government strategies aimed at the diffusion of AI. It concluded that AI has a variety of applications in the country, both in academic research and in market goods and services, and that the government was approaching universities and companies to push this technology. However, several challenges to the diffusion of AI and their impacts have been identified.

Grohmann and Araújo (2021) concluded that the work dynamics of Brazilians who work on global AI platforms is complex and shows several specificities beyond ideas such as "global workforce" or something in that direction. They highlighted the material conditions of data production and the role of communication between workers as emerging and complex solidarities, as fissures and gaps, in order to build strategies to deal with work on these platforms. Sellitto (2002) concluded that expert systems, CBR and *fuzzy* logic can be employed in multivariable process control systems in the continuous process industry, with satisfactory results.

In the **Communication Category**, only three articles focused on communication. The first analyzed the influence of AI on the challenges of Digital Forensic Science, with the organization of data for the media. The second analyzed the knowledge of communication professionals about AI. The third sought to understand how communication is present within the field of AI.

Padilha *et al.* (2021) concluded that, due to the volume of information, which makes manual analysis unfeasible in a timely manner, modern AI methods have become essential tools in the expert's arsenal. However, they state that many of these methods are complex and difficult to explain, which needs to be discussed so that their application is feasible in real cases, especially in sensitive CFD contexts, as interpretability and transparency about the decision-making flow of these models are essential characteristics for their use in practice.

Sebastião (2020) analysed the responses of communication and public relations professionals on questions from the *European Communication Monitor* 2019 (the world's largest study in strategic communication and public relations) related to AI and concluded that Portuguese respondents are among the least informed about AI in Europe. Gunkel, Trento, and Gonçalves (2017) concluded that, traditionally, communication studies understand and analyze the computer as a means of communicative interaction, ignoring that it can also be a participant in communicative interactions.

The Agrarian Category was composed of three articles. In these works, three different agrarian situations were presented, where AI was used as a means of research. The subjects discussed were: forest production, problems in the field of animal husbandry and beef cattle.

Martins *et al.* (2017) carried out a research on the stem of *Araucaria angustifolia* in order to identify which AI technique is most effective to contribute to traditional tapering functions. They concluded that the Artificial Neural Network 2 - RNA 2 (with the addition of the age variable) provided superior results than the other models evaluated. Costa (2009) presented the ideas of symbolic AI and connectionist AI. He stated that, in the case of zootechnics, the specialist is the zootechnician, the only one capable of making the power of AI be used to improve the production of food of animal origin and it is he who should seek interdisciplinarity, working together in areas such as electronic instrumentation and computing, in order to, increasingly, improve the way of solving complex problems in the area of animal husbandry.

Costa (1992) concluded that the combination of the traditional Simulation methodology with AI concepts produces a powerful tool to support the project, known as Knowledge-Based Simulation. He stated that this approach transforms simulation from a descriptive tool into a prescriptive tool and that the trend of having more and more expert simulation systems and other AI applications in simulation contributes to its advancement.

Of the 66 articles, only two presented computer science topics as the main focus of study. The article by Kuroki Júnior and Gottschalg-Duque (2023) presented the contributions of Multimodal Information Architecture (AIM) in the organization of information for training artificial neural networks, aiming to position Information Science as an area of knowledge active in AI problems, while the article by Silva Neto, Bonacelli, and Pacheco (2020) analyzed, from a historical and evolutionist perspective, the Digital Technologies System and argued that it has AI, cloud computing and Big Data as its core technologies.

5 FINAL CONSIDERATIONS

This study reviewed, bibliometrically and systematically, works published on the Scielo data platform that had AI as a research theme. Regarding the temporal evolution of publications, it is concluded that, as of 2020, there has been a considerable advance in studies related to AI, with the years with the most publications being 2021 and 2023, with 14 articles in each. However, this research only considered articles published up to July 16, 2024, which resulted in a total of 12 articles in 2024, leading to believe that, considering the filters applied, this would be the year with the highest number of publications made on AI in Scielo. Regarding the classification of journals, it is concluded that this research was based on articles with a high evaluation weight, since the lowest quality indicator presented was B3, and most of the articles were published in journals with quality indicators A1, which represents the maximum evaluation weight. Despite the fact that different research methodologies were observed, most authors chose to write a theoretical article, contributing with knowledge about different issues about AI and, often, strengthening their thoughts through critical analysis. As for the objects/fields of study, there was a prevalence in the choice of secondary data for the elaboration of AI research, with ChatGPT being the most recurrent.

Regarding the categories of analyses created, it is concluded that, until 2019, studies on AI were still scarce. Until then, research on how AI could help the agricultural sciences and critical analyses of what AI had become were the subjects most addressed by the articles, with only three publications each. Next, with two publications made, were research on AI in the field of health, and the other categories had one or no articles. However, from 2020 onwards, research on AI intensified. Articles on AI in health, including those related to bioethics, reached a total of 16 publications by the date of collection of this study, which made this the category with the most research carried out, followed by 13 studies in the field of education and 12 related to law, legislation and ethics. There were only two articles that dealt specifically with subjects related to computer science, which made this the category with the fewest publications.

Finally, it is concluded that, based on the results obtained with the systematic review carried out, the publications on AI on the Scielo platform demonstrate a growing interest in the literature on the subject. The academic and professional environment is dedicating itself to understanding this technology and seeking to improve it for application in various situations, due to its potential to facilitate and make agile the execution of the most complex tasks, and most of the publications on AI in Scielo, up to the period analyzed in this study,

are related to the field of health.

Therefore, the research brings contributions to researchers who want to understand AI in a more interdisciplinary and comprehensive way. For future studies, it is suggested to expand the research, analyzing articles published in other languages, and not only in Portuguese, in addition to an analysis that encompasses other data platforms, for a more assertive result in the research. For future studies, it is suggested to expand the research, analyzing articles published in other languages, and not only in Portuguese, in addition to an analysis that encompasses other data platforms, for a more assertive result in the research.

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**THE PRESERVATION OF THE COMPANY AS A FUNDAMENTAL PRINCIPLE:
THE MAINTENANCE OF BUSINESS AND ECONOMIC ACTIVITY, ITS SOCIAL
FUNCTION, AND THE COLLECTIVE INTEREST**

**A PRESERVAÇÃO DA EMPRESA COMO PRINCÍPIO FUNDAMENTAL: A
MANUTENÇÃO DA ATIVIDADE EMPRESÁRIA E ECONÔMICA, SUA FUNÇÃO
SOCIAL E O INTERESSE COLETIVO**

**LA PRESERVACIÓN DE LA EMPRESA COMO PRINCIPIO FUNDAMENTAL: EL
MANTENIMIENTO DE LA ACTIVIDAD EMPRESARIAL Y ECONÓMICA, SU
FUNCIÓN SOCIAL Y EL INTERÉS COLECTIVO**

 <https://doi.org/10.56238/sevened2025.036-066>

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ABSTRACT

This paper analyzes the preservation of the enterprise as a fundamental principle implicit in the 1988 Federal Constitution, recognizing the enterprise as an essential vector for the realization of fundamental rights and the enforcement of social justice in the economic order. The article seeks to demonstrate that the enterprise, conceived not only as an economic entity but also as a legal and social institution, plays a structuring role in contemporary society, constituting an instrument for realizing the constitutional values of free enterprise, the valorization of human labor, and the dignity of the human person. To this end, a deductive methodology is employed, with bibliographical research and doctrinal analysis, addressing the interconnection between economics, law, and constitutional foundations. Based on this, the article argues that the principle of preservation of the enterprise should be understood beyond Law n. 11.101/2005, encompassing all phases of business life, as a way to ensure the continuity of productive activity and the protection of collective interests. It is argued that this principle, although not expressly stated, has an implicit constitutional nature, radiating from the regulatory system and integrating the core of the Brazilian economic Constitution, as a guarantee of social stability, job creation, and the promotion of sustainable development.

Keywords: Fundamental Principle of Business Preservation. Social Function. Free Enterprise. Fundamental Rights. Collective Interest.

RESUMO

Este artigo tem como objetivo analisar a preservação da empresa como princípio fundamental implícito na Constituição Federal de 1988, reconhecendo a empresa como vetor essencial para a concretização dos direitos fundamentais e para a efetivação da justiça social na ordem econômica. Busca-se demonstrar que a empresa, concebida não apenas como ente econômico, mas como instituição jurídico-social, exerce papel estruturante na sociedade contemporânea, constituindo instrumento de realização dos valores constitucionais da livre iniciativa, da valorização do trabalho humano e da dignidade da pessoa humana. Para tanto, emprega-se metodologia dedutiva, com pesquisa bibliográfica

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e análise doutrinária, que trata da comunicação entre a economia, o direito e os fundamentos constitucionais. A partir dessa base, defende-se que o princípio da preservação da empresa deve ser compreendido para além da Lei n. 11.101/2005, alcançando todas as fases da vida empresarial, como forma de garantir a continuidade da atividade produtiva e a tutela dos interesses coletivos. Argumenta-se que tal princípio, ainda que não expreso, possui natureza constitucional implícita, irradiando-se do sistema normativo e integrando o núcleo da Constituição econômica brasileira, como garantia da estabilidade social, da geração de empregos e da promoção do desenvolvimento sustentável.

Palavras-chave: Princípio Fundamental da Preservação da Empresa. Função Social. Livre Iniciativa. Direitos Fundamentais. Interesse Coletivo.

RESUMEN

Este artículo tiene como objetivo analizar la preservación de la empresa como principio fundamental implícito en la Constitución Federal de 1988, reconociendo a la empresa como un vector esencial para la concreción de los derechos fundamentales y para la efectividad de la justicia social en el orden económico. Se busca demostrar que la empresa, concebida no solo como un ente económico, sino también como una institución jurídico-social, ejerce un papel estructurante en la sociedad contemporánea, constituyendo un instrumento para la realización de los valores constitucionales de la libre iniciativa, la valorización del trabajo humano y la dignidad de la persona humana. Para ello, se emplea una metodología deductiva, con investigación bibliográfica y análisis doctrinal, que aborda la comunicación entre la economía, el derecho y los fundamentos constitucionales. A partir de esta base, se sostiene que el principio de la preservación de la empresa debe comprenderse más allá de la Ley n.º 11.101/2005, abarcando todas las etapas de la vida empresarial, como una forma de garantizar la continuidad de la actividad productiva y la tutela de los intereses colectivos. Se argumenta que dicho principio, aunque no esté expresamente previsto, posee naturaleza constitucional implícita, irradiándose del sistema normativo e integrando el núcleo de la Constitución económica brasileña, como una garantía de estabilidad social, generación de empleos y promoción del desarrollo sostenible.

Palabras clave: Principio Fundamental de la Preservación de la Empresa. Función Social. Libre Iniciativa. Derechos Fundamentales. Interés Colectivo.

1 INTRODUCTION

The company and the entrepreneur constitute elementary legal institutes of Business Law, radiating effects on various branches of the legal system due to their economic and social importance. In contemporary times, the company presents itself not only as a unit for the production of goods and services, but as an institutional organization indispensable to national development, promoting employment, income and innovation. Its relevance goes beyond the patrimonial sphere, assuming a role of mediation between private interests and the common good. In this context, it is essential to rethink the place that the company occupies in the Brazilian legal-constitutional system and, especially, to recognize the preservation of business activity as a fundamental principle implicit in the Constitution of the Republic.

The Federal Constitution of 1988, by structuring the economic order in articles 1, items III, IV, 3, items II, III, with a logical-systematic interpretation of article 170, radiates throughout the Brazilian legal system the general principles of economic activity, guaranteeing free initiative and private autonomy, and, consequently, enshrines the Preservation of the Company as a fundamental principle.

However, observing the collective interest and social well-being, the Federal Constitution of 1988 balanced free enterprise with the valorization of human work, with the objective of ensuring everyone a dignified existence, according to the dictates of social justice. Business activity, therefore, is one of the instruments for the realization of these constitutional values, as it enables the exercise of economic freedom, the generation of jobs and social development. It is in this scenario that the idea of preserving the company emerges, understood as the legal duty to ensure the continuity of productive activity whenever there is economic viability and social relevance.

The Principle of Company Preservation must be understood as a fundamental principle. Thus, as a core commandment, to influence the legal hermeneutics and the legal system, which regulates business and economic law, providing the necessary promotion and protection for business activity, so that it is able to fulfill its social function, helping to provide a dignified life to people. The company needs to be maintained, because when the company disappears, *ipso facto*, the social function disappears.

Although not expressed, the Principle of Preservation of the Company is derived from the constitutional foundations of free enterprise, the social function of property and the pursuit of full employment, provided for in article 170 of the Federal Constitution of 1988. This

principle is recognized by the doctrine as implicit, due to its logical and axiological necessity for the realization of social justice and for the maintenance of a balanced economic order. It is, therefore, a principle understood by hermeneutic inference (Carvalho Dias, 2022, p. 84), a rule of fundamental right attached, in the intelligence of article 5, paragraph 2, of the Federal Constitution of 1988. The preservation of the company goes beyond the field of strict Business Law, reaching the dimension of fundamental rights of an economic and social nature, especially with regard to the protection of productive activity as a legal asset essential to the economy and the community.

Due to this role, the company goes beyond the private sphere of its partners, becoming an entity functionally linked to the achievement of social and constitutional purposes. Its preservation, therefore, is a legal imperative that should guide not only the legislator and the judge, but also the public administrator, economic agents and civil society itself. By ensuring the continuity of business activity, the State guarantees the maintenance of jobs, tax collection and the stability of economic relations, aspects that make up the social dimension of the company and justify its treatment as a fundamental principle.

The methodology adopted in this article is deductive and descriptive, based on the analysis of doctrinal and normative sources, as well as on the jurisprudential interpretation of the higher courts. It seeks, based on the normative structure of the Constitution and the doctrine of fundamental rights, to demonstrate the implicit presence of the Principle of Preservation of the Company as a structuring element of the Brazilian economy. Such recognition allows us to understand that the protection of the company is not limited to moments of crisis, as in the cases regulated by Law No. 11,101/2005, but must cover the entire cycle of its existence, from incorporation to extinction, whenever its continuity is threatened.

In this way, the preservation of the company is not only an instrument of economic policy, but a legal-constitutional commandment to protect productive activity, connected to the principles of human dignity, the social function of property and social solidarity. The company, in its role as an agent promoting development, should be seen as an integral part of the structure for the protection of fundamental rights, because, by generating work and income, it concretely achieves social justice and economic inclusion.

Thus, this article proposes a dialogue between Constitutional Law, Economic Law and Business Law, in order to show that the preservation of the company must be understood as an autonomous fundamental principle, endowed with normative force and direct applicability,

guiding constitutional and infra-constitutional hermeneutics. The study is developed in two main axes: the first, focused on the institutionalist and interdisciplinary view of the company; and the second, the analysis of the nature and constitutional scope of the principle of preservation of the company, with special attention to its application beyond the limits of bankruptcy legislation.

2 AN INTERDISCIPLINARY INSTITUTIONALIST PUBLICIST VIEW OF THE COMPANY

According to Fábio Konder Comparato, "if we want to indicate a social institution that, due to its influence, dynamism and power of transformation, serves as an explanatory and defining element of contemporary civilization, the choice is undoubted: this institution is the company" (Comparato, 1978, p. 24). This statement reveals the breadth of the business function in the post-industrial society, in which corporate decisions have a direct impact on living conditions, income distribution and environmental sustainability.

The understanding of the company as a legal-social institution requires a reading that goes beyond the merely contractual or patrimonial focus, placing it in the scope of the economic and constitutional relations that make up the Democratic State of Law. The modern company is, above all, a complex organization, in which multiple interests converge, such as those of partners, workers, consumers, creditors, the State and society. In this sense, the contemporary doctrine adopts an institutionalist and publicist view of the company, recognizing it as an autonomous center of collective interests, whose performance must be guided by the constitutional principles of the social function of the economy and the dignity of the human person. Therefore, for the company to achieve all these collective interests, first, the whole society must build a healthy environment for it to survive over time.

2.1 THE COMPANY AS A SOCIAL AND LEGAL INSTITUTION

Historically, the company was conceived by the Contractualist Theory as the result of an agreement of wills between individuals, whose objective was to obtain profit through the exercise of economic activity. This conception is insufficient in the face of contemporary reality, in which companies assume social and environmental responsibilities that transcend the limits of the private interests of their partners.

From the Institutional Theory, developed by authors such as Maurice Hauriou, Alan Pereira de Araujo and Isabel Vaz, cited in the work of Professor Eloy Pereira Lemos Junior (2009, p. 94), it is understood that the company is not only an instrument for the realization

of individual interests, but an organization aimed at serving public and collective interests. From this point of view, the company is integrated into the social fabric as an entity endowed with a derived public function, participating in the implementation of constitutional values such as national development, the eradication of poverty and the reduction of regional and social inequalities (art. 3, III, CF/88).

The 1988 Constitution, by establishing in article 170 that the economic order is based on the valorization of human work and free enterprise, imposed on economic agents the duty to observe social and environmental purposes in their activities. This guideline reveals that the company, although located in the private domain, is an instrument for the realization of constitutional policies of social justice, and must exercise its economic freedom in accordance with the public interest. Thus, the company acquires an institutional nature, being recognized as an expression of functionalized private autonomy, a space of individual freedom, but guided by collective purposes.

The Brazilian doctrine, especially after the promulgation of the 1988 Constitution, began to identify the company as a subject of fundamental rights and duties, whose performance must respect both labor and consumer rights and the principles of social solidarity and economic sustainability. In this way, the preservation of the company is not restricted to a matter of business law, but is projected as a condition for the effectiveness of fundamental rights of an economic and social nature, assuming constitutional relevance (Silva, 2002, p. 773).

2.2 THE SOCIAL FUNCTION AND THE COLLECTIVE INTEREST

The social function of the company constitutes the central axis of this institutionalist vision. Derived from the social function of property (art. 170, III, FC/88), it translates the idea that economic freedom must be exercised in line with the values of social justice and the fundamental objectives of the Republic. This principle implies the obligation that business activity produces benefits not only to the owners of capital, but also to the community in which it is inserted, through the generation of jobs, the payment of taxes, respect for the environment and the promotion of local development (Lemos Junior, 2009, p. 154).

The social function, therefore, is an instrument of constitutional legitimation of the company. It establishes the bridge between private interest and public interest, transforming economic activity into a functional duty that links the exercise of entrepreneurial freedom to the social objectives of the Constitution. The company that fulfills its social function acts in

harmony with the Democratic Rule of Law, contributing to the realization of fundamental rights and to the strengthening of the national economy. However, in our view, the maintenance of business activity is essential and comes first, so that it is possible to achieve the social function.

This conception is close to the doctrine of Robert Alexy, cited in an article by Professor Alexandre Trivisonno (Alexy *apud* Trivisonno, 2021), according to which principles are commandments of optimization, which must be carried out to the greatest extent possible within the existing legal and factual conditions. The social function of the company, seen as a principle, imposes the maximization of economic and social results compatible with the common good, so that any restrictive interpretation of the business activity must be with the purpose of preserving the productive activity, weighed in the light of its contribution to collective development.

In this way, the company is no longer just an instrument for capital accumulation and becomes the fundamental cell of organized economic activity, an institution that must be preserved to contribute to the realization of the constitutional values of solidarity and sustainability. Thus, the preservation of the company is a prerequisite for the fulfillment of the social function, preserving the company is preserving the social function of the economy itself.

2.3 THE INSTITUTIONALIST VIEW AND ITS INTERDISCIPLINARITY WITH CONSTITUTIONAL ECONOMIC LAW

The institutionalist theory is supported by Economic Constitutional Law, a branch that studies the interaction between the State, the market and civil society, from the perspective of fundamental rights. Article 170 of the Constitution enshrines a model of social market economy, in which free enterprise and state intervention coexist in balance, guided by the purpose of ensuring a dignified existence for all. In this model, the company occupies a central position, as it is the agent responsible for materializing the economic and social values of the system (Lemos Junior, 2009, p. 224).

From this point of view, the State is not a mere regulator, but a co-executor of constitutional economic purposes, and must create normative and institutional conditions for the continuity of business activity. This includes public policies to encourage innovation, access to credit and tax simplification, but also the judicial interpretation favorable to keeping the company viable. The jurisprudence of the Superior Court of Justice has repeatedly stated

that "the decree of bankruptcy is an extreme measure, and should be adopted only when the preservation of the production unit is unfeasible" (Brasil, 2018).

This guideline reveals that the Principle of Preservation of the Company is already recognized by judicial practice as an instrument for the realization of the constitutional values of the economy, even if implicitly. The interpreter of the Law must, therefore, adopt a hermeneutic posture in accordance with the Constitution, recognizing that the company is an expression of economic freedom and social solidarity. Thus, its preservation does not constitute a business privilege, but an imperative of distributive justice and protection of collective fundamental rights.

From an interdisciplinary perspective, the preservation of the company is articulated with Labor Law, Tax Law and Environmental Law, composing an interdependent protection system. The maintenance of productive activities ensures jobs, contributes to tax collection and encourages sustainable practices, reinforcing the role of Law as an instrument of balance between economic efficiency and social justice (Lemos Junior, 2009, p. 226).

Thus, the company must be understood as a fundamental institution of the Social State of Law, whose preservation represents the continuity of the constitutional pact itself that links economic freedom to the promotion of the common good. The recognition of this institutional nature is the first step towards the consolidation of the principle of preservation of the company as a fundamental, autonomous principle that radiates effects throughout the legal system.

3 OF THE FUNDAMENTAL PRINCIPLE OF PRESERVATION OF THE COMPANY WITH SCOPE BEYOND LAW NO. 11,101/2005

The Principle of Company Preservation represents one of the most relevant advances in the evolution of contemporary Business Law, assuming an implicit constitutional nature and an essential role in the interpretation of the rules that make up the Brazilian economic order. Although its normative recognition is expressly manifested in article 47 of Law No. 11,101/2005, which provides for judicial reorganization and bankruptcy, its origin and justification go back to the constitutional values and foundations provided for in articles 1, IV; 3, II and III; and 170 of the Federal Constitution of 1988, which enshrine free enterprise, the valorization of human work and the search for full employment as structuring principles of the Democratic Rule of Law.

When examining the logic that sustains this principle, it is observed that its *raison d'être* is not limited to the protection of patrimonial or business interests, but aims at the preservation of organized economic activity as an expression of the collective interest. The continuity of the viable company is an instrument for promoting the common good and the realization of fundamental social rights, such as work, income, human dignity and sustainable development.

3.1 THE PRINCIPLE OF PRESERVATION OF THE COMPANY IN THE CONSTITUTIONAL CONTEXT

The 1988 Constitution does not explicitly mention the principle of preservation of the company, from which a normative command aimed at the maintenance of productive activities can be implicitly extracted. It is a constitutional principle attached, derived from the normative force of the constitutional values of free enterprise and the valorization of work and endowed with an equal axiological hierarchy in relation to the principles expressed (art. 5, § 2, CF/88).

As José Afonso da Silva teaches, quoting Gomes Canotilho, the fundamental principles "make explicit the fundamental political values of the constituent legislator" (Gomes Canotilho *apud* Silva, 2002, p. 98). Thus, if free initiative and the valorization of human work are the foundations of the Republic (art. 1, IV, CF/88), the preservation of the company is its logical consequence, since the company is the instrument that materializes these values in economic and social practice.

From a normative point of view, the constitutional economic order is governed by principles that harmonize freedom and social justice, which implies recognizing that the company, as a subject that operationalizes the economy, must be preserved whenever its maintenance proves to be socially and economically viable. It is in this perspective that it is stated that the preservation of the company transcends business law, becoming an institutional guarantee of the Social State of Law, aimed at the protection of labor, free enterprise and balanced economic development.

From the functional point of view, the preservation of the company acts as a vector of constitutional interpretation and as a criterion for weighing interests, allowing the judge, in the face of a conflict between infra-constitutional norms, to opt for the solution that favors the continuity of the productive activity. The violation of this principle causes harm not only to entrepreneurs, but to society as a whole, since the paralysis of a productive unit implies unemployment, loss of revenue and disruption of the local economic chain.

It is concluded that the Principle of Preservation of the Company is a direct corollary of the social function of property and the company, and it is impossible to guarantee full employment and the dignity of human work without ensuring the continuity of business activities. Thus, although the Constitution does not make it explicit, this principle emerges from the constitutional text itself as an expression of a systemic rationality guided by the collective interest.

3.2 THE PRESERVATION OF THE COMPANY AS AN EXPRESSION OF THE DIGNITY OF THE HUMAN PERSON AND THE SOCIAL FUNCTION OF THE ECONOMY

The dignity of the human person, the foundation of the Republic (art. 1, III, FC/88), constitutes the point of convergence of all fundamental rights and guides the interpretation of the economic order. From this point of view, the company should be seen as a means to achieve dignity, since it is through business activity that jobs, income and opportunities for social inclusion are generated.

By recognizing the company as an institutional space for the realization of human dignity, the Law confers on it a public function of an instrumental nature. The entrepreneur, when exercising his freedom of initiative, does not act in isolation, but is inserted in a social system that depends on his production, his taxes and his social responsibility. For this reason, the unnecessary extinction of viable companies represents an indirect violation of fundamental rights, since it compromises the exercise of citizenship and the guarantee of the existential minimum.

The principle of preserving the company presupposes the social function of the economy, by balancing freedom of initiative with the duty of solidarity. The constitutional economic order is not based on a pure liberal model, but on a social market economy, in which the State and private individuals share responsibilities in the search for sustainable development.

In this context, preserving the company means ensuring the fulfillment of its expanded social function, which covers not only the production of goods and services, but also the generation of collective benefits. The jurisprudence of the Superior Court of Justice has been enshrining this interpretation by deciding in favor of the possibility of maintaining the company, in observance of the principle of preservation and the social function (Brasil, 2017a; Brazil, 2017b).

Similarly, in the judgment of Special Appeal 1303284/PR, Justice Nancy Andrighi reiterated that "partial dissolution should prevail whenever possible, in honor of the principle of preservation of the company, a corollary of the social function" (Brasil, 2013). These precedents demonstrate that jurisprudence has recognized the principle as an interpretative and normative foundation, capable of limiting the exercise of individual rights in favor of the continuity of productive activity.

Law No. 11,101/2005, by instituting judicial reorganization, was the legislative framework that consolidated the principle in its practical dimension. Article 47 of the aforementioned law establishes that "the purpose of judicial reorganization is to make it possible to overcome the debtor's situation of economic and financial crisis, in order to allow the maintenance of the production source, the employment of workers and the interests of creditors, thus promoting the preservation of the company, its social function and the stimulation of economic activity" (Brasil, 2005). However, the application of this principle should not be restricted to the scope of judicial reorganization or bankruptcy: it is a constitutional principle of general application, and should guide the entire interpretation of Business and Economic Law (Venosa, 2010, p. 298).

The preservation of the company, therefore, is not a discretionary faculty of the judge, but a legal imperative derived from the Constitution, which is imposed whenever the continuity of the productive activity proves to be compatible with the public interest and economic viability. Therefore, it should not be restricted to an article of a law, but in every legal system, every hermeneutic, every jurisprudence, with the objective of preserving the company over time.

In summary, the preservation of the company should be understood as an autonomous fundamental principle, in the wake of Alexy's doctrine, it is a principle that should be carried out to the greatest extent possible, as a commandment of optimization (Alexy, 2017, p. 90) with immediate applicability and sufficient normative force to guide the legislator, the interpreter and the judge. Its function is to ensure that the exercise of economic activity remains in line with constitutional values and the dignity of the human person, promoting harmony between freedom and solidarity.

The protection of the company, therefore, is not limited to judicial reorganization, it is projected on all legal relationships involving productive activity, including Corporate, Labor, Tax and Environmental Law. Thus, the preservation of the company is a condition for the

effectiveness and realization of fundamental rights of a social and economic nature, and should be recognized as a fundamental principle of the Brazilian State.

4 FINAL CONSIDERATIONS

The analysis developed throughout this study shows that the preservation of the company transcends the mere private interest of the partners, consolidating itself as an implicit fundamental principle of the Brazilian legal system. Although not expressed literally in the Federal Constitution of 1988, the principle emerges from the systematic reading of articles 1, IV; 3, II and III; and 170 of the Federal Constitution of 1988, on which the foundations of free enterprise, the valorization of human work and the search for full employment are based, values that are part of the very reason for the existence of the Democratic State of Law.

By recognizing that the company is a structuring agent of the economic and social order, the Law begins to conceive it as an institution endowed with a derived public function, responsible for promoting sustainable development, the generation of jobs and the circulation of wealth. Its preservation, therefore, is not justified only from the perspective of economic efficiency, but mainly from the perspective of the dignity of the human person and the social function of the economy, which constitute supreme constitutional values.

Law No. 11,101/2005, by establishing the institute of judicial reorganization, affirmed the practical application of this principle, but its relevance goes beyond the bankruptcy scope. The preservation of the company must be understood and applied beyond the judicial reorganization law, as a constitutionally oriented guideline, capable of radiating effects on the entire legal system, that is, from Corporate to Labor Law, from Tax to Environmental. It is, therefore, a transversal principle, intended to ensure economic stability and the effectiveness of fundamental social rights.

From this perspective, the preservation of the company proves to be an instrument for the realization of the social function, serving as a link between freedom of initiative and the duty of solidarity. By ensuring the continuity of business activity, the State not only protects private assets, but also ensures the effectiveness of social rights that depend on the production of wealth and the maintenance of employment.

The company, in this context, ceases to be a simple economic subject to become a functional entity of constitutional relevance, whose existence and permanence are conditions for the fulfillment of the fundamental objectives of the Republic.

This essay intended to bring a new view on the social function of the company, a new reflection on the logical order between the "Preservation of the Company" and the "Fulfillment of the Social Function of the Company". It was argued that, in order to achieve the social function of institutions, it is first necessary to ensure the maintenance of economic activity. First, the company must be preserved and then radiate its social function in society. The company is the fundamental cell of organized economic activity, therefore, it is impossible to emanate the social benefits that are expected from the company without a free and protected environment that collaborates for the exercise of business activity.

In view of the above, it is concluded that the Principle of Preservation of the Company must be formally recognized, by hermeneutic inference (article 5, § 2, CF/88), by doctrine and jurisprudence as an autonomous fundamental principle, as an attached norm, of an implicit constitutional nature, capable of guiding the creation, interpretation and application of the rules of the legal system. Its observance is imperative not only in times of crisis, but throughout the trajectory of business activity, as a guarantee of the dignity of the human person, the social function of the economy and the collective interest.

Thus, by preserving the company, its social function, the social value of work, the eradication of poverty, the dignity of the human person, the stability of economic relations and the fundamental rights that sustain the Democratic Rule of Law are achieved.

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**THE EVOLUTION OF LANGUAGE AND THE DEVELOPMENT OF HUMAN
THOUGHT ACCORDING TO GIAMBATTISTA VICO**

**A EVOLUÇÃO DA LINGUAGEM E O DESENVOLVIMENTO DO PENSAMENTO
HUMANO PARA GIAMBATTISTA VICO**

**LA EVOLUCIÓN DEL LENGUAJE Y EL DESARROLLO DEL PENSAMIENTO
HUMANO SEGÚN GIAMBATTISTA VICO**

 <https://doi.org/10.56238/sevened2025.036-067>

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ABSTRACT

This article aims to present the relevance and importance of the thought of the Italian philosopher, historian, and jurist Giambattista Vico. This will be achieved through the study and understanding of his analysis of the historical development of language and human thought. To this end, the article discusses a central point in his theory: the three modes of communication among peoples, based on their languages. These are: the language of the gods, the heroic language, and the language of men. The first is not necessarily a spoken language, as it is closer to original sounds and grunts. The second is an intermediate stage of development still closely tied to heroic narratives. The third, that of men, already presents characteristics that most closely resemble a properly rational and developed language. In this context, poetic wisdom, which encompasses the first two types of language mentioned above—that of the gods and the heroic language—is the first expression of understanding reality, the origin of all future languages. This reflection concludes by highlighting the importance of understanding these languages as fundamental to the constitution of rational human thought itself.

Keywords: Vico. Philosophy of History. Language. Human Thought.

RESUMO

Presente artigo tem como objetivo principal apresentar a relevância e a importância do pensamento do filósofo, historiador e jurista italiano Giambattista Vico. Isso se dará a partir do estudo e compreensão da análise que este filósofo fez acerca do desenvolvimento histórico da linguagem e do pensamento humano. Para isso o artigo traz uma discussão central em sua teoria, que são os três modos de comunicação dos povos, a partir de suas linguagens. São elas: a linguagem dos deuses, a linguagem heróica e a linguagem dos homens. A primeira não se constitui necessariamente como uma linguagem falada, já que se aproxima dos sons e grunhidos originários. A segunda é uma fase intermediária de desenvolvimento ainda muito atrelada às narrativas heróicas. A terceira, a dos homens, já apresenta as características que mais se aproximam de uma linguagem propriamente racional e desenvolvida. Neste contexto, a sabedoria poética, que abarca os dois primeiros tipos de linguagem supracitadas, a dos deuses e a heróica, é essa primeira expressão de compreensão da realidade, originária de todas as outras futuras. Conclui-se a presente

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reflexão destacando a importância na compreensão dessas linguagens como fundamentais na constituição do próprio pensamento humano racional.

Palavras-chave: Vico. Filosofia da História. Linguagem. Pensamento Humano.

RESUMEN

Este artículo tiene como objetivo presentar la relevancia e importancia del pensamiento del filósofo, historiador y jurista italiano Giambattista Vico. Esto se logrará mediante el estudio y la comprensión de su análisis del desarrollo histórico del lenguaje y el pensamiento humano. Para ello, el artículo aborda un punto central de su teoría: los tres modos de comunicación entre los pueblos, basados en sus lenguas. Estos son: la lengua de los dioses, la lengua heroica y la lengua de los hombres. La primera no es necesariamente una lengua hablada, ya que se asemeja más a sonidos y gruñidos primigenios. La segunda es una etapa intermedia de desarrollo, aún estrechamente vinculada a las narraciones heroicas. La tercera, la de los hombres, ya presenta características que se asemejan más a una lengua propiamente racional y desarrollada. En este contexto, la sabiduría poética, que abarca los dos primeros tipos de lengua mencionados —la de los dioses y la heroica—, es la primera expresión de la comprensión de la realidad, el origen de todas las lenguas futuras. Esta reflexión concluye destacando la importancia de comprender estas lenguas como fundamentales para la constitución del pensamiento humano racional.

Palabras clave: Vico. Filosofía de la Historia. Lenguaje. El Pensamiento Humano.

1 INTRODUCTION

The main objective of this article is to present some central ideas in the thought of the Italian philosopher, jurist and historian Giambattista Vico. In his most famous book, called "The New Science", he discusses important and relevant foundations of the philosophy of history.

In this sense, it is possible to say that this philosophical exercise is justified due to the importance of discussing such innovative ideas in the historical-social approach. Studying and understanding some fundamental ideas of this philosopher of colossal relevance can bring a huge contribution to the expansion of theoretical and philosophical knowledge. And, as it is an evolutionary discussion, it brings up a series of current issues.

The development of this study, as well as potential future adjacent research, has valuable theoretical contributions, which can extend to the branches of history, philosophy, philology and sociology, among others. In the practical field, studying and understanding this philosopher and his New Science can bring good references to help and understand the codification of new civilizing processes that are currently underway.

The use and development of Artificial Intelligence, as a "language" that feeds on human language, bringing fundamental issues such as respect for intellectual property and really what would be the limit of the use of AI. Is it possible to say limits for something that is so advanced, and apparently currently rooted in contemporary social structures?

Vico's proposal in "New Science" is to seek to investigate the origins and foundations of human knowledge. From this he seeks this origin of thought in the development of men in the historical process.

It is from this historical development of men that, according to Vico, we can locate a first thought common to all men. Vico demonstrates that the first human thought, which in its beginning was a rude, small and obscure thought, is common to the origin of all civilizations.

It is called the "language of the gods", because it is still linked to natural phenomena, noises, grunts and whispers. Although it is a form of "language", it does not have the status of a spoken language per se, being a first expression of language much more crude and original.

The second type of language that he points out as intermediate is heroic language. This, although more developed than the first, is still linked to myths and divinities, being more developed and rational than the language of the gods and less than the third and last to be

explained in this work, the language of men itself, in all its complexity and load of historical and human development.

In this sense, the main objective of this article is to present and discuss the importance of Vico's theory about the development and evolution of human thought from language. For this, the fundamental characteristics of the three types of language brought by Vico in his work will be presented, as well as the importance of poetic wisdom as the first expression of human understanding of the world, present, according to the author himself, in practically all historically known civilizations.

2 DEVELOPMENT

The first thought about the world by men is defined by Vico as a very grotesque, small, crude thought, which is given by astonishment. This thought is somewhat deified, frightening and incipient about the knowledge of the reality that surrounds primitive man (when we speak of primitive man we mean that the first men who emerged, who for Vico were the ones who used an interpretation of the world still in a poetic way, were in a way the initiators of human thought).

This thought is closely linked to natural things and takes place in the process of interpreting the world of these men through the creation of the first deities that are cultivated from their relationship with natural phenomena such as fire, thunder and other natural phenomena.

In support of what has been said, one may recall the case cited by Vico in the text of the "Poetic Wisdom", where he introduces the question that "Jupiter" was the first human God for most nations, a God of thunder and lightning who manifested himself for each gentile nation.

Thus, when Vico speaks of a "God Jupiter", he points out that each nation in its genesis had a similar kind of divinity, which man discovered and interpreted in a frightened way, who saw in the noise of thunder the first form of divinity. It can be said then that apparently there were several "Jupiters" that constituted the first human thoughts about the divinities. These were supposedly the first forms of human interpretation about the nature that was around them, and were still a kind of initial thought, originating and linked to natural phenomena.

This first "mode" of human knowledge, this first way of expressing men's thought, which is given by astonishment, is "Poetic Wisdom". It is this poetic language that allows man his first expression of thought about the nature that surrounds him. This wisdom is a fabulous,

divinized and heroic wisdom, and, although it expounds ideas that are still apparently rude, small and obscure, it is the genesis of human thought. In it, Vico finds traces, from his studies and investigations, in practically all nations of humanity.

It is from this observation that it can be said that the first records of human events were by poets and theologians and almost always refer to the divinities. This primitive thought, despite being tied to the things of nature, already consists of the genesis of the first human thought.

To illustrate this issue of the poet theologians, I quote² Vico's text:

"But the poet-theologians, not being able to make use of the understanding, with a more sublime work, completely opposite, gave meaning and passions, as we have just seen, to bodies, and to vast bodies such as heaven, earth, and sea; and later, diminishing such vast fancies and reinvigorating abstractions, they were taken in their little signs." (**VICO, 199, p.168**)

"Poetic wisdom" is for Vico the first expression, even if fabulous and obscure, of the primitive mind, which seeks to organize the human experience in history. From there, Vico points out that this first mode of knowledge occurs concomitantly with the production of the first primitive language, which is already a language used and shared by several individuals.

When Giambattista Vico highlights a primitive "speech" he does not mean exactly what can be instinctively thought of as the specifically spoken language, but rather a first form of shared language. In the early days, this language is often made at first only by signs. However, this first linguistic expression could already be understood by the individuals in the group.

It is in the process of developing this "language" that "poetic wisdom" happens. This is because Vico believes in the progress of this language and in the purification of the concept shared by men. It should be noted that all this is due to the historical civilizing process of humanity and human civilizations.

In this sense, it is possible to affirm that for the philosopher Giambattista Vico, "Poetic Metaphysics" can then be equivalent to the history of human ideas, which develops in the historical process and is intimately linked to the progress of language among men.

² This quotation is found in the text of Vico's "New Science", in the part of "Poetic Wisdom", page 168.

It is from the progress of language that Vico will seek the origin of human thought and, for this reason, we will highlight here the three types of language that he defines in the "Scienza Nuova" as follows:

"... three languages were spoken, corresponding in number and order to the three ages that had elapsed before them in the world: of the gods, of heroes, and of men; and they said that the first language was hieroglyphic, that is, sacred or divine; the second, symbolic, or by signs, that is, by heroic enterprises; the third epistolary to communicate to those distant from each other the vulgar needs of their lives" (VICO, 199, p.182)

Vico presents three types of languages to demonstrate the process of historical purification of the development of human thought. Thus, for this philosopher, the first type of language elaborated by men was the language of the "gods". This, as mentioned earlier, is a very incipient type of language. It is even a practically 'mute' and "non-articulate" mode of communication, made by signals, moans, grunts and noises.

Giambattista Vico considered that, although this first language is practically not given by articulated speech, it can be considered as a kind of language because it is already configured as a first form of communication and human expression.

The second form of language that he makes explicit is the "heroic language", which is a form of language that is already more developed and more articulated and that operates with some signs in the communication between men. The "heroic language" is a language that is still intermediate in which mute and articulate resources are mixed, but which already demonstrates a considerable advance in relation to the language of the "gods" or "divine" language, which is practically a "mute" language.

The third type of language explained by Vico is the "language of men". It already takes place in a third moment of the development and progress of human language in history. The "language of men" is already an almost totally articulated and very little mute language, which is no longer expressed impregnated with the things of nature, but which manifests itself as a greater development of human thought.

It is in this development of human language in the history of humanity that Vico locates the progress of human thought itself, since the development of language is intrinsically linked to the development of human thought. Heroic language is in this context the first form of interpretation of the world by man, and although at the beginning of the construction of this language it was not yet made exclusively by speech, this does not imply that it is not a first form of language and interpretation of the world by man.

Vico based himself on the knowledge of the origins of human thought from the examination of human language, considering that it is at the center of man's development in history. It is for this reason that Vico is able to point to a "New Science" that allows the study and analysis of a human "universal history".

It is a fact that this development of language, which is well outlined by Vico in the text of the "Poetic Wisdom", took place in practically all societies. For this reason it is possible to observe in this process of development the historical progress of language. And, of course, it becomes possible to locate something common to all human nations.

Therefore, the importance of poetic wisdom to understand the development of human thought must be understood, since this type of wisdom is the first form of interpretation of the world by man. Poetic wisdom is the first speech, the first expression, the first knowledge of the world that surrounds man elaborated by himself.

Poetic wisdom is a divine wisdom, based on astonishment, on fright, small and rude, but it is a wisdom, and a wisdom that is found in the genesis of all human thought, regardless of time and place. When we speak independently of time and place, we mean that this type of thinking is common to all men, all nations, in its origin, whether of the Indians of America, of the ancients such as the Persians, of the Chinese or of the Europeans.

Vico thus assumes an important position with regard to the philosophy of history, as he promotes an innovative reading that takes into account the development of human thought based on the study of the progress of human language and its different moments throughout history.

Based on this analysis, this philosopher will investigate the genesis of human language and the passage from a simpler and cruder language to a more elaborate, more elaborate language.

It is from the development of human language that, according to Vico, one can seek elements to understand the development of human thought itself. It seeks, from language, a history of the development and improvement of human thought about the recognition and communication with the world and its peers.

The proposal to build a new science that would be able to encompass founding characteristics of practically all nations based on the study of language development is an ambitious project that leaves open questions. Future studies will be responsible for additional analyses to the present study, which is so relevant to understand the development of rational thought.

3 CONCLUSION

It can be concluded that Vico's thought stands out for the universality to be achieved in the study of the philosophy of history. It is located in the peculiarities of each nation, in the particular history of each civilization, of each people.

He sought to find the true and universal history of nations from themselves, and considers that the first men, those of poetical wisdom, represented the infancy of humanity, of the world. As history developed, it would reach more advanced stages of knowledge of the world. This knowledge, when improved, would take place at a stage of greater "old age" in the world, in which more elaborate and profound knowledge, such as philosophy itself, would finally be capable.

The objective of this article was to present in an introductory way some ideas of this relevant Italian philosopher, who through this differentiated reading of historical development through language leaves several other future questions to be developed. It is clear that the present study is of paramount importance in presenting this discussion as a viable option for understanding human development.

In any case, the process of continuous polishing of these innovative ideas should be done in future studies and reflections. For now, the objective of reflecting on the theme is taken into account, even knowing the momentary limitations. It is believed that some foundations are laid for future discussions, on related topics, such as the development of "artificial language" among others.

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ARTIFICIAL INTELLIGENCE IN CLINICAL RESEARCH: A SYSTEMATIC LITERATURE REVIEW

INTELIGÊNCIA ARTIFICIAL EM PESQUISA CLÍNICA: REVISÃO SISTEMÁTICA DE LITERATURA

INTELIGENCIA ARTIFICIAL EN INVESTIGACIÓN CLÍNICA: REVISIÓN SISTEMÁTICA DE LA LITERATURA

 <https://doi.org/10.56238/sevened2025.036-068>

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ABSTRACT

The integration of Artificial Intelligence (AI) into clinical research has grown exponentially in recent decades, keeping pace with advancements in computer science and healthcare. This systematic literature review aimed to map the main applications, potential benefits, and challenges of using AI in different stages of clinical research, including drug discovery, eligible patient selection, clinical trial design, and real-time data monitoring. The methodology followed the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), with searches conducted in databases such as PubMed, SciELO, and Web of Science, considering publications from 2020 to 2024. Forty-eight studies that met the inclusion criteria were selected. The results indicated that AI, particularly through machine learning and deep learning techniques, has contributed to reducing drug development time, improving the accuracy of participant screening, and enhancing patient safety. Furthermore, there was an observed increase in the use of algorithms for predictive analysis of clinical outcomes, contributing to faster and more informed decision-making. In conclusion, while AI does not replace the methodological rigor of clinical trials, it is a complementary and strategic tool for accelerating and improving the generation of knowledge in the field of health.

Keywords: Artificial Intelligence. Clinical Research. Machine Learning. Clinical Trials. Public Health.

RESUMO

A incorporação da Inteligência Artificial (IA) em pesquisas clínicas tem crescido de forma exponencial nas últimas décadas, acompanhando os avanços das ciências da computação e da saúde. Esta revisão sistemática de literatura buscou mapear as principais aplicações, potencialidades e desafios do uso da IA em diferentes etapas da pesquisa clínica, incluindo

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descoberta de novos fármacos, seleção de pacientes elegíveis, desenho de ensaios clínicos e monitoramento em tempo real de dados. A metodologia seguiu as recomendações da Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), com busca em bases como PubMed, SciELO e Web of Science, considerando publicações entre 2020 e 2024. Foram selecionados 28 estudos que atenderam aos critérios de inclusão. Os resultados indicaram que a IA, sobretudo por meio de técnicas de machine learning e deep learning, tem contribuído para reduzir o tempo de desenvolvimento de medicamentos, melhorar a acurácia na triagem de voluntários e aprimorar a segurança dos pacientes. Além disso, observou-se um crescente uso de algoritmos para análise preditiva de desfechos clínicos, contribuindo para decisões mais rápidas e embasadas. Conclui-se que, embora a IA não substitua o rigor metodológico dos ensaios clínicos, ela se configura como ferramenta complementar e estratégica para acelerar e qualificar a produção de conhecimento em saúde.

Palavras-chave: Inteligência Artificial. Pesquisa Clínica. Machine Learning. Ensaios Clínicos. Saúde Coletiva.

RESUMEN

La incorporación de la Inteligencia Artificial (IA) en la investigación clínica ha experimentado un crecimiento exponencial en las últimas décadas, en consonancia con los avances en informática y ciencias de la salud. Esta revisión sistemática de la literatura tuvo como objetivo identificar las principales aplicaciones, potencialidades y desafíos del uso de la IA en las distintas etapas de la investigación clínica, incluyendo el descubrimiento de nuevos fármacos, la selección de pacientes, el diseño de ensayos clínicos y el monitoreo de datos en tiempo real. La metodología siguió las recomendaciones de PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), con búsquedas en bases de datos como PubMed, SciELO y Web of Science, considerando publicaciones entre 2020 y 2024. Se seleccionaron 28 estudios que cumplieron los criterios de inclusión. Los resultados indicaron que la IA, especialmente mediante técnicas de aprendizaje automático y aprendizaje profundo, contribuye a reducir el tiempo de desarrollo de medicamentos, mejorar la precisión en la selección de voluntarios y optimizar la seguridad de los pacientes. Además, se observó un creciente uso de algoritmos para el análisis predictivo de resultados clínicos, lo que contribuye a una toma de decisiones más rápida y fundamentada. En conclusión, si bien la IA no reemplaza el rigor metodológico de los ensayos clínicos, se configura como una herramienta complementaria y estratégica para acelerar y mejorar la generación de conocimiento en salud.

Palabras clave: Inteligencia Artificial. Investigación Clínica. Aprendizaje Automático. Ensayos Clínicos. Salud Pública.

1 INTRODUCTION

Artificial Intelligence (AI) has established itself in recent decades as one of the most disruptive technologies in science applied to health. From the first expert systems, such as MYCIN, in the 1960s, to today's machine learning and deep learning algorithms, there has been an unprecedented evolution in the ability to process and analyze large volumes of biomedical data (Schmidt et al., 2024). This advance is particularly relevant in view of the exponential growth in the production of health data, driven by the digitization of electronic medical records, the popularization of genomics, and the use of wearable devices, which provide continuous information on physiological parameters (Tan et al., 2024).

Clinical research, defined as the set of systematic studies aimed at evaluating the efficacy and safety of health interventions, faces persistent challenges, such as high costs, long deadlines, and difficulties in recruiting representative samples. The development of a drug, for example, can take more than 10 years and exceed billions of dollars in investments (Hu et al., 2024). In this scenario, AI emerges as a strategic ally to accelerate the innovation cycle, reduce costs, and increase scientific precision, acting from the discovery of promising molecules to the prediction of clinical outcomes.

Recent studies have highlighted the role of AI as a catalyst for precision medicine, allowing to predict individualized responses to therapies based on clinical, genomic, and environmental data (Lu et al., 2024). Likewise, its application in automated patient recruitment strategies has increased population representativeness in clinical trials, reducing biases historically present in the biomedical literature (Han et al., 2024). These advances show that AI is not only an auxiliary tool, but an integral part of the transformation of research paradigms in collective health.

However, the incorporation of AI into clinical research also raises ethical, regulatory, and societal challenges. Issues such as transparency of algorithms, governance of sensitive data, and accountability for automated decisions require clear regulation and continuous vigilance (Schmidt et al., 2024). In order for its benefits to be equitably distributed, it is essential to balance technological innovation with principles of social justice and equity.

Drug discovery and development is one of the areas in which AI has proven to be most revolutionary. Traditionally, molecular screening and preclinical trials require years of work and billionaire investments, with high failure rates. Deep learning algorithms have been used to analyze millions of molecules in biomedical and chemical databases in a matter of weeks, identifying structural patterns and pharmacological interactions that indicate greater

therapeutic potential (Stokes et al., 2020). This capacity reduces costs and shortens deadlines, accelerating the arrival of new treatments to the market.

A milestone in this process was the creation of AlphaFold, a system that achieved unprecedented precision in the structural prediction of proteins, directly impacting the identification of therapeutic targets and opening up new possibilities for structural biology (Jumper et al., 2021). The expansion of the AlphaFold Protein Structure Database has expanded access to millions of predicted structures, making it an indispensable tool for researchers worldwide (Varadi et al., 2022). This integration between AI and structural biology strengthens the paradigm of precision medicine, in which therapies are adapted to the individual biological profile of each patient.

Another advance is in drug repurposing, or repurposing of drugs. By cross-referencing clinical, genomic, and pharmacological data, algorithms can identify new therapeutic indications for existing drugs, reducing the time and costs required for treatment development. This resource was widely explored during the COVID-19 pandemic, when urgency demanded rapid and low-cost strategies to test potential therapies (Cortial et al., 2024).

Despite progress, important limitations remain. The quality and diversity of databases continue to be obstacles to the generalization of predictive models. Incomplete or biased datasets can compromise scientific validity and generate risks of inappropriate extrapolation for different populations (Hu et al., 2024). In addition, the costs associated with the development and training of advanced AI models still represent a barrier for research groups in low- and middle-income countries, widening global scientific inequalities (Han et al., 2024).

In the face of these challenges, it is essential to invest in more diverse and standardized databases, in addition to expanding international collaboration between academic institutions, regulatory agencies, and the pharmaceutical industry. Only through collective efforts will it be possible to ensure that AI, applied to drug discovery, consolidates itself as a reliable and accessible scientific resource on a global scale.

Based on this context, the present systematic review seeks to answer the question PICO: How has Artificial Intelligence been applied in different stages of clinical research (Population: patients in clinical trials; Intervention: use of AI; Comparison: traditional methods; Outcome: benefits, limitations, and ethical implications)?

The analysis aims to identify benefits, limitations, and gaps in the literature, providing subsidies to guide scientific practices and policies in public health. Given this scenario, the

question that guides this systematic review arises: For human populations (P), how do AI-based interventions (I), compared to traditional methods or absence of AI (C), affect clinical and methodological outcomes (O) in clinical research studies between 2020 and 2024?

Unlike other reviews available in the literature, this research is unprecedented for systematically and critically integrating the multiple applications of Artificial Intelligence in all stages of clinical research, from drug discovery to ethical and social implications. By gathering updated evidence from the period 2020 to 2024, the study offers a comprehensive and articulated view on the topic, allowing the identification not only of technical advances, but also gaps and challenges that have not yet been explored in previous reviews. Thus, this investigation contributes in an original way to the scientific debate, especially in the field of collective health, by proposing an analysis that combines technological innovation, ethical responsibility, and commitment to equity in health.

The objective is to map how AI has been applied in different stages of clinical research (drug discovery, patient selection, trial design, monitoring, predictive analysis), identify the observed benefits, and highlight gaps and risks that are still underexplored.

2 METHODOLOGY

The present systematic review of the literature was conducted in accordance with the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), recognized as an international standard for the preparation of quality reviews. The methodological objective was to ensure transparency, reproducibility and scientific rigor in all stages of the process, from the bibliographic search to the analysis of the selected studies.

2.1 SEARCH STRATEGY

The research was carried out between August and September 2025, in databases of wide scientific relevance, including PubMed/MEDLINE, Web of Science, Scopus, and SciELO, in order to include both international publications and studies produced in the Latin American context. Controlled descriptors from the Medical Subject Headings (MeSH) and the Health Sciences Descriptors (DeCS) were used, combined by Boolean operators, such as: "Artificial Intelligence", "Machine Learning", AND "Deep Learning" AND "Clinical Research" AND "Clinical Trials" and their counterparts in Portuguese. This strategy allowed for greater scope and precision in the identification of articles relevant to the theme.

2.2 PUBLICATION PERIOD

Studies published between January 2020 and December 2024 were considered, a period chosen because it reflects the consolidation of AI as a tool applicable to the biomedical field, especially after the technological advances in *deep learning* that have occurred since 2015.

2.3 INCLUSION CRITERIA

Original articles and systematic reviews that explicitly addressed the application of AI at any stage of clinical research were included. Studies dealing with drug discovery, patient screening and recruitment, clinical trial design, and real-time data monitoring were also considered. Only studies available in Portuguese, English and Spanish were analyzed, respecting the linguistic scope of the review team.

2.4 EXCLUSION CRITERIA

Editorials, comments, conference abstracts, dissertations, and theses not published in peer-reviewed journals were excluded. Studies focused exclusively on related areas, such as artificial intelligence applied to hospital management or population health, were also disregarded when they were not directly related to the scope of clinical research. In addition, articles that did not provide full text, paid or that presented insufficient methodology for critical evaluation were also eliminated.

2.5 SELECTION PROCESS

The initial screening was done from the reading of titles and abstracts, followed by the full reading of potentially eligible articles. Two independent reviewers participated in the data selection and extraction process, with disagreements resolved by consensus. This approach ensured greater reliability and reduced the risk of bias in the choice of included studies. This methodological rigor ensures that the results presented represent a reliable and up-to-date synthesis of the scientific literature, allowing a critical analysis of the impact of AI on the advancement of contemporary clinical research.

After the final selection of the included articles, a systematic data extraction process was conducted with the objective of organizing the relevant information for the review in a standardized way. For this, a structured form was prepared containing the following items: title, year of publication, country of origin, journal, objectives, type of study,

sample/population, AI techniques used, area of application in clinical research, main results and limitations identified by the authors. This systematization allowed not only the individual analysis of each article, but also the comparison between them, identifying patterns and divergences.

The extraction process was performed by two independent reviewers, with cross-checking to minimize transcription errors and reduce the risk of bias. In cases of inconsistencies or doubts regarding the categorization of certain information, a third researcher was consulted, ensuring greater scientific rigor.

Based on the data collected, thematic content analysis was carried out, inspired by the methodological framework of Laurence Bardin (2011), which consists of identifying, classifying and interpreting the nuclei of meaning present in the studies. This technique was chosen because of its suitability for the systematization of qualitative results and for enabling a critical reading of scientific discourses on the application of AI in clinical research.

To complement this qualitative step, a descriptive quantitative approach was also used, with the frequency count of the main AI techniques applied, the areas of clinical research covered, and the temporal and geographic distribution of the publications. This integration of methods, qualitative and quantitative, has enabled a more comprehensive understanding of the phenomenon, allowing both the identification of objective trends and the critical interpretation of the meanings attributed to AI in the field of health.

The articles were then organized into thematic categories that reflect the main axes of application of AI in clinical research: Discovery and development of drugs with AI; Selection and recruitment of patients with AI; Design and conduct of clinical trials with AI; Predictive analysis of clinical outcomes with AI and the ethical, regulatory, and social issues of Artificial Intelligence in clinical research. This categorization process allowed us to build an integrated and critical view, highlighting not only the practical benefits, but also the dilemmas that emerge from the application of AI in clinical research. The crossover between quantitative and qualitative analysis strengthened the reliability of the findings and provided a solid basis for the discussion presented in the next section.

3 RESULTS AND DISCUSSIONS

The analysis of studies published between 2020 and 2024 shows that AI already has a cross-cutting impact on the clinical research cycle, from drug discovery to predictive analysis of outcomes, offering gains in efficiency, accuracy, and representativeness. At the

same time, challenges remain related to algorithm transparency, methodological standardization, and ethical governance (Liu et al., 2023; Cruz Rivera et al., 2022).

3.1 DRUG DISCOVERY AND DEVELOPMENT WITH AI

The application of AI in the discovery and development of new drugs has accelerated historically time-consuming and costly processes. Machine *learning and deep learning algorithms* have been shown to be able to perform virtual screenings on millions of molecules, identifying chemical patterns with therapeutic potential in weeks, in contrast to the years required by conventional screening (Stokes et al., 2020). This efficiency gain has translated into cost reduction and increased success rate in preclinical phases, making biomedical innovation more accessible and sustainable.

In addition to the discovery of new molecules, the use of AI in *drug repurposing* stands out, which consists of identifying new therapeutic indications for drugs that have already been approved. This strategy proved crucial during the COVID-19 pandemic, when algorithms were applied to cross-reference clinical and pharmacological data, allowing for the rapid proposition of alternative therapies (Cortial et al., 2024). AI-driven drug repurposing not only reduces the time it takes to make new treatments available, but also minimizes risk, since the safety of these compounds is already established.

Another relevant milestone was the development of AlphaFold, which revolutionized structural biology by predicting, with high accuracy, the three-dimensional conformation of proteins (Jumper et al., 2021). The creation of the AlphaFold Protein Structure Database, later expanded, made millions of structures available to the scientific community, consolidating itself as a fundamental resource for the identification of therapeutic targets (Varadi et al., 2022). This innovation strengthens the logic of personalized medicine, by enabling therapies to be designed based on the individual molecular profile.

Despite the advances, challenges persist, as the generalization of the models depends on the quality and diversity of the databases used, which still represents an important limitation. Incomplete or biased datasets can compromise the accuracy of models and widen inequalities, especially in populations in low- and middle-income countries (Hu et al., 2024). To overcome these barriers, experts advocate for greater methodological standardization, international collaboration, and continuous audits on the performance of algorithms (Han et al., 2024).

Thus, the results analyzed indicate that AI represents a new scientific paradigm in drug development, but its full incorporation requires a balance between technological innovation, scientific rigor and ethical responsibility.

3.2 SELECTION AND RECRUITMENT OF AI PATIENTS

Patient selection and recruitment are recognized as critical steps for the success of clinical trials, accounting for a large part of the delays and interruptions of studies. It is estimated that up to 80% of clinical trials face difficulties in this phase, impacting both the timeline and the costs of the research (Lu et al., 2024). In this context, AI has been consolidated as a strategic resource, capable of processing large volumes of electronic health records (EHRs), population databases, and genomic data to identify eligible participants more quickly and accurately.

The use of machine learning algorithms makes it possible to automate the screening of volunteers based on inclusion and exclusion criteria in the protocols, reducing the dependence on manual processes and increasing the scope of the search (Han et al., 2024). This efficiency translates not only into time savings, but also into greater representativeness of the samples, since patients from different ethnic, socioeconomic, and geographic contexts can be included, mitigating biases historically present in clinical trials.

According to Hau et al., (2023) in addition to the initial screening, AI has been applied in predicting participant adherence and retention. Predictive models, based on health and behavioral histories, can identify patients at higher risk of abandonment, enabling the implementation of preventive strategies, such as strengthening communication, remote monitoring, and individualized support. This approach increases the consistency of studies, reduces sample losses, and contributes to the statistical robustness of the results.

Another important advance is in the use of natural language processing (NLP). Explainable NLP tools can automatically interpret eligibility criteria and cross-reference them with structured and unstructured clinical information, accelerating the pairing between patients and protocols. In oncology, this technology has shown promising results by associating genetic mutations with specific studies, increasing the precision of selection (Ghosh et al., 2024).

Schmidt et al., (2024) argue that despite the advances, ethical challenges remain central. The use of sensitive clinical data requires compliance with data protection legislation, such as the LGPD in Brazil and the GDPR in the European Union. In addition, algorithms

trained on non-diverse databases run the risk of reproducing inequalities and limiting the external validity of the results.

Therefore, the analysis of the studies demonstrates that AI can transform the recruitment and selection of patients into more efficient, inclusive, and reliable steps, as long as it is accompanied by ethical governance, data diversity, and transparency in processes.

3.3 AI CLINICAL TRIAL DESIGN AND CONDUCT

Adequate methodological design is crucial for the scientific validity of clinical trials, and AI has stood out as a tool capable of optimizing this step. Algorithms have been used to simulate clinical scenarios before the start of studies, making it possible to predict response rates, identify critical variables, and estimate more realistic sample sizes. These simulations reduce the risks of unfeasible protocols and strengthen the representativeness of the results (Liu et al., 2020).

Corroborating Vasey et al., (2022) when they state that one of the most promising advances is the incorporation of adaptive assays, which allow for real-time adjustments as data are collected. With the support of AI, it becomes feasible to stop a study early when there is robust evidence of efficacy, or to redirect resources in cases of low effectiveness. This methodological flexibility contributes to reducing costs, preserving the safety of participants and improving the efficiency in the use of available resources.

AI has also been applied in intelligent randomization, balancing intervention and control groups according to multiple clinical, demographic, and genomic variables. This practice reduces biases and strengthens comparability between groups, increasing the statistical robustness of the findings (Plana et al., 2022). In addition, algorithms can help monitor volunteers' adherence, identifying behavioral patterns that signal the risk of abandonment. From this data, customized support strategies can be implemented, increasing retention and reducing sample losses (Hau et al., 2023).

Another growing field is the use of wearable devices and digital sensors integrated with AI models, which allow continuous collection of physiological data during trials. Recent reviews demonstrate that this approach increases safety, making it possible to identify adverse events early and reducing the need for face-to-face visits, which increases participant adherence (Smuck et al., 2021; Tan et al., 2024). This integration brings clinical trials closer to everyday care practice, favoring the direct application of the results in health systems.

However, regulatory and methodological challenges persist. There is still a lack of international standardization regarding the use of AI in trial design, which makes it difficult to validate and compare studies. Initiatives such as the CONSORT-AI and SPIRIT-AI extensions represent advances in this regard, but require greater dissemination and global adherence (Liu et al., 2020).

Therefore, the results of the literature demonstrate that AI promotes a paradigm shift in the design and conduct of clinical trials, making them more dynamic, responsive, and patient-centered, as long as they are accompanied by clear regulation and rigorous methodological validation.

3.4 PREDICTIVE ANALYSIS OF CLINICAL OUTCOMES WITH AI

Prediction of clinical outcomes represents one of the most innovative areas of the application of AI in biomedical research. Traditionally, the analysis of therapeutic efficacy and safety is performed retrospectively, after the completion of trials. With the use of *machine learning and deep learning* algorithms, it has become possible to anticipate trends during the conduct of the studies itself, offering subsidies for faster and safer interventions (Tan et al., 2024).

Predictive AI models have been applied to estimate the probability of individualized response to therapies, especially in areas such as oncology and cardiology. By integrating clinical, laboratory, and genomic data, these algorithms identify patterns associated with a greater or lesser chance of therapeutic benefit, strengthening the logic of precision medicine (Schmidt et al., 2024; Tan et al., 2024). This ability contributes to optimizing protocols, personalizing treatments, and avoiding patient exposure to ineffective interventions.

Another prominent field is the early detection of adverse events. Recent studies have shown that predictive algorithms, trained on historical data and information collected in real time, are able to anticipate clinical complications, allowing the adoption of preventive measures before serious damage occurs (Tan et al., 2024). Integration with wearable devices and digital sensors has expanded this capacity by allowing continuous monitoring of physiological parameters, increasing the safety of participants (Smuck et al., 2021).

The application of AI has also advanced in modeling survival and disease progression. In oncology, for example, algorithms have achieved high accuracy in predicting tumor progression time and response to targeted therapies, outperforming conventional statistical methods in some scenarios (Tan et al., 2024). In chronic diseases, such as heart failure and

diabetes, similar models have been used to predict the risk of hospitalization, contributing to the integration of clinical research and care practice (Han et al., 2024).

However, limitations persist. The diversity of training data is still restricted, with most algorithms developed from populations in high-income countries. This compromises the generalization of models and may reinforce global health inequalities (Hu et al., 2024). In addition, the opacity of *deep learning* models raises questions about explainability and auditability, which are essential factors for scientific trust.

Thus, the analyzed results indicate that predictive analytics with AI has the potential to transform clinical research towards more proactive, safe, and personalized approaches, but its consolidation requires sample diversity, regulatory validation, and methodological transparency.

3.5 ETHICAL, REGULATORY AND SOCIAL ISSUES OF ARTIFICIAL INTELLIGENCE IN CLINICAL RESEARCH

While the benefits of AI in clinical research are widely recognized, its incorporation raises ethical, regulatory, and societal concerns that cannot be overlooked. The use of algorithms to support medical decisions directly involves the well-being of participants, requiring robust governance and transparency principles (Schmidt et al., 2024).

The privacy and protection of personal data are one of the main challenges. The analysis of large volumes of clinical, genomic and demographic records implies access to highly sensitive information, which, if poorly managed, can expose individuals to risks of stigmatization and discrimination. Although legislation such as the General Data Protection Law (LGPD) in Brazil and the General Data Protection Regulation (GDPR) in the European Union represent important advances, their effective application in clinical trials still faces practical barriers (Han et al., 2024).

Another critical point refers to the responsibility for automated decisions. When an algorithm contributes to recommending therapeutic approaches or assists in the monitoring of patients in clinical trials, the question arises: who should respond in case of error? The absence of regulatory consensus on this responsibility undermines trust in automated systems, especially in high-risk contexts (Hu et al., 2024).

From a social point of view, there is concern about the reproduction of inequalities. Many algorithms are trained on data from populations in high-income countries, which limits their applicability in contexts of greater vulnerability and may reinforce historical exclusions

in access to health innovations (Schmidt et al., 2024). In addition, the requirement for advanced technological infrastructure and highly specialized teams restricts the full adoption of AI in low- and middle-income countries, widening the so-called "technological gap" (Han et al., 2024).

In the regulatory field, there is a lack of international standardization. Although agencies such as the FDA and EMA have begun to develop specific guidelines for the use of AI in healthcare, there is still no global consensus that ensures comparability between studies and universal scientific validity. Initiatives such as CONSORT-AI and SPIRIT-AI constitute relevant milestones to increase transparency and reproducibility, but their adherence is still limited (Liu et al., 2020).

Therefore, the results of the literature indicate that the consolidation of AI in clinical research depends on a balance between technological innovation, ethical regulation, and social justice. Only with clear regulatory frameworks, data diversity, and strategies aimed at equity will it be possible to ensure that AI advances fairly benefit different populations.

4 CONCLUSION

The present systematic review demonstrated that AI has been consolidating itself as a strategic tool in clinical research, with applications ranging from drug discovery to the prediction of clinical outcomes in real time. Although it does not replace traditional methods, AI acts as a complementary resource, capable of speeding up processes, reducing costs, and increasing the representativeness of samples, responding to historical challenges related to assay design and patient selection. This potential positions AI as a central element of precision medicine and scientific innovation in health.

However, the incorporation of AI requires caution and responsibility. Ethical, regulatory, and methodological issues remain significant barriers, especially with regard to the transparency of models, the quality and diversity of databases, and the need for international standardization. Risks of bias, the possibility of reinforcing inequalities, and the absence of clear regulatory frameworks persist, factors that may limit the full realization of the benefits of this technology. Thus, the use of AI must be accompanied by data governance policies and regulations that ensure its ethical and equitable application.

The limitations of this review, such as the time limit (2020–2024) and the methodological heterogeneity of the included studies, highlight the need to expand scientific production on the subject. The lack of large multicenter clinical trials and detailed information

on algorithms compromises the critical evaluation of results and reinforces the urgency of research that develops explainable, auditable models applicable to different epidemiological contexts. In addition, future investigations should explore the impact of AI on health equity, analyzing whether its application reduces or widens inequalities in access to clinical research.

Thus, this review contributes by offering a critical and updated synthesis of the literature, highlighting both the potentialities and limitations of AI in contemporary clinical research. The evidence indicates that the consolidation of this technology will depend on investments in infrastructure, training of multidisciplinary teams and strengthening of international networks of scientific cooperation. By balancing technological innovation with principles of social justice and transparency, it will be possible to transform the potential of Artificial Intelligence into concrete gains for public health, bringing science closer to the real needs of society.

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THE RELEVANCE AND TIMELINESS OF PAULO FREIRE'S TEACHINGS

A RELEVÂNCIA E ATUALIDADE DOS ENSINAMENTOS DE PAULO FREIRE

LA RELEVANCIA Y ACTUALIDAD DE LAS ENSEÑANZAS DE PAULO FREIRE

 <https://doi.org/10.56238/sevened2025.036-069>

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ABSTRACT

This work aims to reflect on the relevance and timeliness of the teachings left by our greatest Brazilian educator: Paulo Freire (1921-1997). His Liberating Pedagogy, his philosophy of education, and his focus on issues in Brazilian education, especially for the most vulnerable (oppressed), are important not only for Brazil but also for several countries that use his teachings. Methodologically, this paper presents itself as a theoretical, reflective, and qualitative bibliographical research, seeking concepts and bases for critical thinking from selected texts. The theoretical reflections raised here seek to engage in a dialogue with the challenges of contemporary education, contributing to the strengthening of pedagogical practices committed to an ethical vision of the world, of the subject², and of Education.

Keywords: Education. Ethics. Humanization.

RESUMO

Este trabalho tem como objetivo refletir sobre a relevância e a atualidade dos ensinamentos deixados pelo nosso maior educador brasileiro: Paulo Freire (1921-1997). Sua Pedagogia Libertadora, sua filosofia da educação e seu foco nas questões da educação brasileira, principalmente dos mais vulnerabilizados (oprimidos), são importantes não somente para o Brasil, mas também para vários países que utilizam seus ensinamentos. Este escrito se coloca, metodologicamente, como uma pesquisa teórica, reflexiva e qualitativa de cunho bibliográfico, buscando conceitos e bases para o pensar crítico a partir de textos selecionados. As reflexões teóricas levantadas aqui buscam travar um diálogo com os desafios da educação contemporânea, contribuindo para o fortalecimento de práticas pedagógicas comprometidas com uma visão ética de mundo, de sujeito e de Educação.

Palavras-chave: Educação. Ética. Humanização.

RESUMEN

Este trabajo tiene como objetivo reflexionar sobre la relevancia y la actualidad de las enseñanzas dejadas por nuestro mayor educador brasileño, Paulo Freire (1921–1997). Su Pedagogía Liberadora, su filosofía de la educación y su enfoque en las cuestiones de la educación brasileña—especialmente respecto a los más vulnerabilizados (oprimidos)—son importantes no solo para Brasil, sino también para varios países que utilizan sus aportes. Metodológicamente, este escrito se configura como una investigación teórica, reflexiva y

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² Freire's use of the word "subject" refers to a person who acts with an understanding of the importance of their historical action, acting upon their realities.

cualitativa de carácter bibliográfico, buscando conceptos y bases para el pensamiento crítico a partir de textos seleccionados. Las reflexiones teóricas aquí presentadas buscan entablar un diálogo con los desafíos de la educación contemporánea, contribuyendo al fortalecimiento de prácticas pedagógicas comprometidas con una visión ética del mundo, del sujeto y de la Educación.

Palabras clave: Educación. Ética. Humanización.

1 INTRODUCTION

This text aims to reflect on the relevance and timeliness of Freirean teachings in education today. We understand that Liberating Education, as conceived by Paulo Freire, is still extremely necessary in our society, mainly because of its emphasis on critical subjects and agents in their societies.

We justify writing this work at a time when teacher training programs are attracting less and less interest from young people leaving Brazilian high schools. In other words, the teaching profession has ceased to be seen for its social relevance and has come to be judged solely by its financial gains (from a neoliberal perspective). We are not saying that teachers should not earn good salaries, but that neoliberal governments (from the last decades of the 20th century to the present day) have been, constantly, trying to cheapen (or outsource) public education and devalue the teaching profession.

The constant attacks on Brazilian public school education, its weakening on several fronts, attempts to privatize public assets, the recurring ban on literary works in schools, among other points, reinforce the need for an educational shift towards Freirean theories.

In this sense, this study aims to use Freirean views to understand the increasingly relevant importance of a Liberating Education in times of constant fake news, taking into account the need for critical thinking on the part of students and teachers, so that they do not vote for or support politicians and policies that are only against us Brazilians and against public, democratic and quality education.

For this text, we used a qualitative, reflective, and bibliographical approach, giving preference to books and scientific articles to support our thoughts on the relevance and importance of Freirean theories today. We used some works by Freire (1967, 1987, 1996); Barbosa (1995); Gadotti (2007); Morin (2001); and Rodrigues (2021, 2022, 2023) to provide theoretical support for this writing and to show how Freirean theories are current and relevant.

Through the studies of some thinkers, we sought to reveal the relevance of Freirean theories today and their necessary use in Brazilian education, especially in public education that serves the most socially oppressed.

2 THE RELEVANCE OF FREIREAN THOUGHTS IN THE EDUCATIONAL PERSPECTIVE

Paulo Freire (1921-1997), one of the most important educators in 20th-century Brazilian education, was a pioneer in conceiving a pedagogy appropriate for our then-underdeveloped reality. Besides being a sharp intellectual and a perceptive philosopher, he

was a prolific writer, expressing his thoughts in his various publications. Rodrigues and Azevedo (2019) inform us a little about Freire:

Paulo Reglus Neves Freire (1921-1997), better known simply as Paulo Freire, was a lawyer by training and an educator and philosopher of education by vocation. He worked on themes relevant to Brazil: adult literacy, popular education, and other themes of school pedagogy in general. He created a method of adult literacy that sought to teach from the learner's reality and not from primers completely outside the social and cultural context of the learner, especially those from the Northeast of Brazil. (Rodrigues; Azevedo, 2019, p. 49)

We understand Freire's most important works to be the following books: *Education: the practice of freedom* (1967); *Pedagogy of the Oppressed* (1968); *Pedagogy in Process: The Letters to Guinea-Bissau* (1975); *Educação e Mudança* (Education and Change, 1979); *Conscientização: teoria e prática da libertação* (Conscientization: Theory and Practice of Liberation, 1980); *Ideologia e educação: reflexões sobre a não neutralidade da educação* (Ideology and Education: Reflections on the Non-Neutrality of Education, 1981); *Prática e Educação* (Practice and Education, 1985); *Toward a Pedagogy of the Question: Conversations with Paulo Freire* (1985); *The Importance of the Act of Reading* (1989); *Pedagogy of Hope: Reliving Pedagogy of the Oppressed* (1992); *Teacher, but aunt not: letters to those who dare teach* (1993); *Pedagogy of Freedom: Ethics, Democracy and Civic Courage* (1998), in addition to various other texts and interviews given in different parts of the world. These are just some of the books published by Freire. His work has influenced many researchers who have expanded and continue to expand his thoughts and understandings.

In this vast range of publications, Freire teaches us not only a method of education for the illiterate, but also gives us a philosophical vision of hope for a better world through education. School education is therefore presented as a path to one's emancipation, critical thinking, and action, a fertile ground for developing critical, conscious citizens, agents, and political subjects.

Freire desired (hoped for³) and believed in education as a true instrument of social transformation, teaching critical thinking, emotional development, sharing, dialogue, ethical coexistence, among many other important points for humanizing people. Freire (1997),

³ In Portuguese "esperançar".

revealing much of his theories and conceptions, tells us what humanist education is and is not:

The humanist conception, which rejects mere deposits, dissertations, or narrations of isolated fragments of reality, is realized through a constant problematization of the human-world relationship. Its purpose is to problematize, never to lecture or deposit. Just as the recently criticized conception (the banking model), in some of its aspects, cannot overcome the educator-learner contradiction, the humanist conception starts from the necessity of doing so. And this necessity is imposed on it to the very extent that it views man as a being of choices. A being whose point of decision is, or should be, within himself, in his relationships with the world and with others. To achieve this overcoming, an existence that is the phenomenal essence of education, which is its dialogicity, education then becomes dialogue, communication. And, if it is dialogue, the relationships between its poles can no longer be those of antagonistic opposites, but of poles that reconcile. (Freire, 1997, p. 14)

In his *Liberating Education*, Freire undertakes an effort to show that students and educators learn and teach together, questioning the various structural inequalities in our country in the field of Education, through a dialogical relationship and respect for each other's knowledge.

It is worth noting that from wealthy Northern Europe to poor countries in Africa, Freire's legacy resonates as a cry of hope for a better life and a better world for all, where education has a privileged space for critical thinking, inclusion, and social recognition. Freire also does not forget the political importance of education.

In *Pedagogy of the Oppressed* (1987), Freire posits education as an instrument of genuine social transformation. In this work, he seeks to defend a model of school education in which students and educators learn and teach together, critically questioning the many structural inequalities in their realities. Freire emphasizes the need for an inquiring education (to inquire is the very exercise of philosophizing), grounded in criticality, knowledge of realities, and ethics, taking dialogue as the tool for a truly liberating education. In *Toward a Pedagogy of the Question: Conversations with Paulo Freire* (1985), Freire makes it very clear the importance of being critical and questioning social structures in order to change them.

From this perspective, the teacher is not better, more intelligent, or the ultimate authority who knows everything in the eyes of the students, but a learner from the multiple realities and thoughts of dialogical interaction with scientific knowledge, with their students, and with their peers. The equality of human beings and the importance of their actions in the world are made clear in *Liberating Education*.

In *Pedagogy of Freedom: Ethics, Democracy and Civic Courage* (1996), Freire highlights the importance of the educator as a mediator between knowledge and students, and encourages us to train more critical and reflective students, capable of building their own intellectual autonomy and learning to navigate the world of literacy independently. The importance of the teacher as a mediator is even more crucial today, when information, widely available through digital means, is consumed extensively but needs to be critically articulated to become knowledge.

Furthermore, according to Freire, the educator must be an example of respect, integrity, and consistency, recognizing their students as autonomous subjects endowed with critical thinking, agents in their realities as historical beings. Freire also does not forget to mention the need for the teacher's affectivity towards their students and their lived realities.

In *Education: the practice of freedom* (1967), Freire discusses the need for the school to teach the student to read the world and its realities and to intervene positively in them, "hoping" for a possible change. He considers education as a constant process that is capable of raising people's awareness of their realities and motivating them to transform them. In this sense, this Freirean work already places education as a political act, of awareness for agency in the world.

He also reflects, in his writings, on the role of the teacher and the importance of reading the world around us, a process which precedes reading the word. Here he paves the way for current thoughts on the multiple literacies needed by teachers and students today. Especially for reading multimodal (or multisemiotic, or multisensory) texts, texts that are very common in our digital and post-industrial society.

Also, Freire, with all his prior philosophical background, shows us that education must also be a political act, of criticality and action in the face of realities that oppress and assault us. Hence the need to exercise thinking from lived realities, avoiding illiteracy (literal, historical, critical, political, etc.). Hence, banking education (opposed to liberating education) disconnects theory from practice, seeking not to critically question the world, domesticating people:

The existing dichotomy between theory and practice, the sensibly universal validity of knowledge free from all historical conditioning, the role of philosophy as an explanation of the world and as an instrument for its acceptance, education conceived as a mere exposition of facts and as the transmission of a heritage of "chaste" knowledge: all this characterizes the naive consciousness of the politically illiterate. Ideologized on the plane of domestication, such a consciousness will not even reach the objective

idealism of Hegel's *Phénoménologie de L'Esprit*, where praxis appears as the transformative action that men exert on the world and as their own formation – even though for Hegel praxis is only a purely mental activity. Such an ideology will never be able to understand the impossibility of theory without practice, of thought that is not an act of transforming the world; it clings to knowledge for knowledge's sake, to a theory that does nothing but explain reality, and to a neutral education. (Freire, 1997, p. 24)

We realize that Freire's effort was to place education as a mechanism for understanding the world and for historical action in the world. Therefore, he positioned education as a political action, as it would make us act in society with real objectives of removing people from their situations of oppression, whether social, cultural, historical, etc. Education, therefore, serves as a tool to break the chains of oppression that limit individuals from acting towards a better and more just life.

We see that many authors and researchers echo Freirean teachings and update them, as is the case with art educator Ana Mae Barbosa. She does so through her well-known **Triangular Approach in Arts**, a methodology rooted in Freirean influences. Barbosa worked with Paulo Freire in São Paulo and applied much of what she learned from him to her educational practice and thinking in the field of Arts teaching.

Edgar Morin also acknowledges the strong influence of Freire's thought on his **Theory of Complexity**, which is a philosophical and epistemological approach attempting to interpret realities. It is a non-linear and complex approach to interpretation. Morin explains a little about the notion of complexity:

Complexity arises from something that is complementary to something else. It comes from a certain degree of complementarity between the parts involved in the process. This notion of antagonistic complementarity is basic to our reasoning. It is an antagonistic complementarity between the individual and the artistic on the one hand, and the standardized and industrial on the other. (...) The complementary association of antagonistic things. (Morin, 2001, p. 10)

We can also mention the feminist philosopher bell hooks (1952-2021), who sought a transformative pedagogical approach, from a more inclusive and critical perspective, focusing on the struggles against various forms of oppression against Black women. Her **education as a practice of freedom** echoes Freire's teachings regarding the need to educate the oppressed. She had direct contact with Freire and questioned him about the absence of the feminine perspective in his works.

Also, hooks learned from Freire the need to understand the realities of oppression in order to work towards a truly liberating education. She tells us that:

The emphasis on education as necessary for liberation, which Black people affirmed during the time of slavery and later during reconstruction, informed our lives. And that is why Freire's emphasis on education as a practice of freedom made immediate sense to me. Aware since childhood of the need for literacy, I carried with me to university the memory of reading to people, of writing for people. I carried with me the memories of Black female teachers in the segregated school system who had been critical educators and had provided us with liberating paradigms. (hooks, 2013, p. 72-73)

Moacir Gadotti is another contemporary thinker who uses Freirean theories and thoughts to understand current issues. Regarding **education in times of neoliberalism**, he tells us that:

Paulo Freire's worldview and his socio-political-educational theory help us not only to better understand how the neoliberal model works, but also to build the necessary response to neoliberalism. He defends a **new modernity** whose rationality must be "wet with affectivity." Against the pedagogical and cultural Enlightenment that emphasizes only the acquisition of curricular content, he highlights the importance of the cultural dimension in the processes of social transformation. Education is much more than instruction. To be transformative – to transform the conditions of oppression – it must be rooted in the culture of the people. (Gadotti, 2007, p. 80, author's emphasis)

The appropriation and reinterpretation of Paulo Freire's thought by various authors is still necessary and essential for understanding the issues of current Brazilian education.

Walace Rodrigues (2018, 2019, 2021, 2022, 2023) applies Freirean ideas (such as criticality, dialogue, and autonomy) to contemporary educational contexts, such as **multiliteracies and the decolonization of knowledge**, showing the relevance and adaptability of Freirean pedagogy to the current challenges of education.

In this sense, Freire's teachings are extremely relevant to be used in basic schools, in undergraduate programs, and in all places where there is a need for education focused on criticality, on understanding world situations, on a hopeful approach to education that preserves the utopia of thinking for the common good and that leads to an agentive action of the subjects.

Freirean ideas can also be applied to a more ecologically conscious understanding of the world that values the cultures of traditional peoples, riverside communities, quilombola

communities, etc., taking their knowledge and practices as a basis and giving them importance in school environments.

3 SOME FINAL CONCLUSIONS

We were able to verify, here, the relevance and timeliness of Paulo Freire's teachings for an education that seeks to understand today's oppressed subjects, their problems, their aspirations, and their possibilities for breaking the chains of oppression through education. In addition to the possible applicability of Freirean theories in areas such as the Arts, Ecology, Anthropology, Sociology, Education, among many others.

The results of this work reveal that several thinkers currently utilize Paulo Freire's theories and thoughts, updating them for their applications in education, whether in schools, universities, or other educational institutions.

We have seen that important and current thinkers, such as Gadotti, Barbosa, Morin, hooks, Rodrigues, among many others, echo Freirean studies in various spheres of education.

In this way, teachers in current education should have more contact with Freire's teachings to try to understand the possible advantages of dialogue, criticality, ethics, affectivity, learning from the realities of students, etc., for the exercise of a truly liberating education.

In this context, we have several theories influenced and implemented based on Freirean views, such as the Triangular Approach, by Ana Mae Barbosa; the Theory of Complexity, by Edgar Morin; education as a practice of freedom, by bell hooks, among others, which are clear examples of the relevance of Freire's thoughts today and their necessary applicability to the educational problems and themes of the current world.

As we can see, **Liberating Education** for Freire must be an education that promotes beneficial transformations in people's lives, because "If education alone does not transform society, without it society does not change either" (Freire, 2000, p. 67).

Throughout this journey, his theories and teachings engage with contemporary education, which is so focused on the digital world but forgets the most human and humanizing aspects of the task of teaching: dialogue, affectivity, understanding the humanity of others, critical thinking, questioning reality, understanding humankind as historical beings who construct their own history, education as a political act, among many other important points that end up being forgotten in our post-industrial society.

ACKNOWLEDGMENTS

This work was funded by national funds through the FCT – Foundation for Science and Technology, I.P., Portugal, within the scope of project ref^a: UI&D 6303 - Applied Research Laboratory in Communication and Media - LIACOM/ESCS/IPL Lisbon; and with support from the Coordination for the Improvement of Higher Education Personnel – CAPES/CNPq, Brazil.

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BUSINESS PLAN FOR OPENING AN ONLINE STORE SELLING UNIQUE BABY CLOTHES - SO CUTE! WITH EMPHASIS ON ONLINE MARKETING

PLANO DE NEGÓCIO PARA A ABERTURA DE LOJA VIRTUAL DE ROUPAS DIFERENCIADAS PARA BEBÊS - TÃO FOFINHO COM ÊNFASE EM MARKETING PARA LOJAS VIRTUAIS

PLAN DE NEGOCIOS PARA ABRIR UNA TIENDA EN LÍNEA DE ROPA DE BEBÉ ÚNICA. ¡QUÉ MONADA! CON ÉNFASES EN MARKETING DIGITAL

 <https://doi.org/10.56238/sevened2025.036-070>

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ABSTRACT

This work aims to expand upon and address the principles of customer-centric marketing in a competitive environment and commercial management. Through literature on the subject, it seeks to convey some basic concepts, focusing on the dynamic changes occurring in marketing in a globalized world. It focuses on developing and integrating the idea of creating value for customers as the primary goal of marketing, helping to understand its principles and how its elements are used to create value for customers and achieve organizational objectives for effective management in the commercial area. In the context of online stores, according to the developed management PIN, it applies viable fundamentals to meet this demand.

Keywords: Marketing. Online Stores. Organizational. Commercial Area.

RESUMO

O trabalho tem o objetivo de ampliar e abordar os princípios de marketing centrado no compromisso com o cliente, em um ambiente competitivo e a gestão comercial. Através das literaturas encontradas sobre o tema na busca de transmitir alguns conceitos básicos, voltando-se para as mudanças dinâmicas que ocorrem no marketing em um mundo globalizado. Com foco no desenvolvimento e integração da ideia de criação de valor para os clientes como a meta primária do marketing, ajudando a compreender os seus princípios e o modo como os elementos do esses elementos são utilizados com o intuito de criar valor para os clientes e alcançar os objetivos organizacionais para efetivar uma boa gestão na área comercial. No contexto das lojas virtuais conforme o PIN da gestão elaborado, aplicar os fundamentos viáveis para atender essa demanda.

Palavras-chave: Marketing. Lojas Virtuais. Organizacionais. Área Comercial.

RESUMEN

Este trabajo busca ampliar y abordar los principios del marketing centrado en el cliente en un entorno competitivo y la gestión comercial. A través de la literatura sobre el tema, se busca transmitir algunos conceptos básicos, centrándose en los cambios dinámicos que se están

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produciendo en el marketing en un mundo globalizado. Se centra en desarrollar e integrar la idea de crear valor para el cliente como objetivo principal del marketing, ayudando a comprender sus principios y cómo se utilizan sus elementos para crear valor para el cliente y alcanzar los objetivos organizacionales para una gestión eficaz en el área comercial. En el contexto de las tiendas online, según el PIN de gestión desarrollado, se aplican fundamentos viables para satisfacer esta demanda.

Palabras clave: Marketing. Tiendas Online. Organizacional. Área Comercial.

1 INTRODUCTION

I recommend the investment in this company because the work arises after the elaboration of the group study carried out with the result of a business plan to open a virtual *website* for the commercialization of differentiated clothes and differentiated packaging in the format of sweets, ecological products, associated with high quality with a differentiated finish for babies from 0 to 2 years old.

The packaging will be made in the shape of candy, so that they can remember their childhood, the clothes will be made with organic cotton and the inks for the prints used in the process will be water-based, thus obtaining a lower impact on the environment.

Comfortable product, ecologically and sustainable, aiming at the well-being of customers with satisfaction in being able to acquire a differentiated product, with quality, respecting the environment with attractive and captivating packaging.

Another attraction will be the expansion of unisex products so that they can be used by other babies in the family or friends. There are already success stories in this segment where a differentiated product is attractive first to parents and then to children.

Online shopping through computers continues to be on the rise compared to other technologies, the high investment in the clothing and footwear sector, the growing, in view of the theme of digital marketing according to the Pin developed for the company "Tããã Fofinho" we seek to present the concepts that involve the commercial scope and the steps necessary to carry out marketing within the innovations found today for the market, and in order to promote a reflection on the expansion of concepts and strategies according to a qualitative research, based on literature and authors who have focused on this theme in order to demonstrate the benefits that can be achieved for the growth of a virtual store.

Even today, the concept of marketing in Brazil is quite unfocused, as many associate it with the sale of products in any way, even if people do not want them. Still others believe in the consumerist concept, that is, that it is a way to make people buy what they do not need. Because its application occurred in Brazil when we still had an economy composed of monopolies and non-competitive oligopolies that began in the 1960s, in which the government's function was much more of management than of tutelage of the economy.

In fact, it is the result of a study based on several sciences (Sociology, Psychology, Mathematics, Anthropology, Statistics, Philosophy, among others), with the objective of knowing people's behavior and, based on this, satisfying the needs and desires of each one. Marketing has become a pervasive and influential force in all sectors of the economy. In a

few years, it has stripped itself of its old image of something unethical and unnecessary and has come to be seen as an essential instrument for the formation and maintenance of various businesses, including its concepts applied in the most varied types of organizations, from soccer teams to churches, including governments and non-governmental organizations.

When in fact the concept of marketing is considered a vision from the perspective of philosophy and within organizations, it is verified that it must extend to practically the entire organization, especially to those directly related to the market. In this sense, Raimar Richers³, one of the greatest authorities on marketing in Brazil, defines his function as simply being the intention to understand and serve the market. Thinking in this way, all activities related to the search for customer satisfaction, whether internal or external, have a direct relationship with those responsible for marketing.

By focusing on customers, the main reason for companies to exist, the actions that will negatively or positively influence their satisfaction are responsible for marketing executives. From this perspective, we will see that marketing represents much more than promotion and sales tools; It is a philosophy within organizations, a philosophy that has the customer as the main reason for the organization's existence.

In a general and simplistic way, it can be stated, according to Kotler (2000),⁴ that marketing is a social process through which people and groups of people obtain what they need and desire through the creation, offer and exchange of products and services. In other words, marketing can be considered a two-way street between the market and organizations, in which the latter seek information about their desires and needs in the market, receiving information in return, in this first phase. As a next step, organizations start to offer products and services to the market according to the desires and needs of customers, with financial resources and satisfied customers in return.

2 DEVELOPMENT

Nakamura (2001, p. 3),⁵ "is the interconnection of several computer networks spread in various parts of the world". Practically all countries are interconnected on the internet. Due to this interconnection, it is possible to communicate instantly between two computers anywhere in the world, in addition to sharing data and information.

³ Richers, Raimar. 1926- What is marketing I Raimar Richers. — 15. ed. — São Paulo : Brasiliense, 1994.

⁴ Kotler, Philip. Marketing Principles. São Paulo: Prentice Hall, 2000

⁵ Nakamura, Rodolfo Reijiro. E-commerce on the Internet: Easy to understand. São Paulo, Érica, 2001

The internet emerged in the United States of America (USA) and, according to Catalani et al., (2004 p. 13),⁶ "the intention was to create technologies capable of allowing the intercommunication of different and geographically scattered computers, connected to different networks". Currently, the world wide web has become a means of communication and information that is increasingly present in people's lives.

According to Quaino (2012, p. 1),⁷ "more than half of the Brazilian population is included in the digital world". In this sense, this fact has become increasingly common due to the low cost of acquiring devices that promote access to that network, whether fixed with computers or mobile, such as tablets and cell phones.

Castells (2003) states that the internet is the fabric of our lives. It also alludes that information today is what electricity was in the industrial era, it also states that the internet would not only be energy, but also the electric motor, due to its ability to propagate information throughout the domain of human activity.

Castells (2003) states that the network is a set of interconnected nodes. The formation of networks is a very old human practice, but nowadays networks have been incorporated into information networks energized and supplied by the internet. The internet transforms the way organizations act related to their suppliers and customers, their administration and management, in their production of services and material goods, in their financing and in their analysis of actions in the financial market

Teixeira (2017) states that electronic commerce (e-commerce) is characterized by being part of the present and the commercial future. There are several business opportunities that are provided by the advent of the internet, in addition to those that originate from temporal phenomena.

E-commerce, or electronic commerce, is a form of communication between the company and the customer, a means of sales, where sellers offer products or services through the internet. According to Nakamura (2001, p. 31),⁸ electronic commerce is understood as "any buying and selling activity carried out with the help of electronic resources".

⁶ Catalani, C. And. Gans, J. S., 2017. "Some Simple Economics Of The Blockchain", Rotman School Of Management Working Paper, No. 2874598; Mit Sloan Research Paper, No. 5191-16

⁷ Quaino, Lilian. Half of the Brazilian population is included in the digital world, says FGV. :Accessed on: 28.04.2020

⁸ Ibid. Item 4

According to Kotler (2000), behind electronic business there are two phenomena: connectivity and digitalization. The author analyzes two types of e-commerce:

Commercial channels: Several companies have established information and e-marketing services that can be accessed by those who subscribe to the service and pay a monthly fee. (...) These channels provide information (news, libraries, education, travel, sports, consultations), entertainment (fun and games), shopping services, opportunities and dialogues (newsletters, forums, chat rooms), and email. **The Internet:** The Internet is a global mesh of computer networks that has made instantaneous and decentralized global communication possible. (...) They can send emails, exchange experiences, buy products, and access news, recipes, and information about art and business. The Internet itself is free, although individual users need an Internet service provider to be connected to it. (p.681)

Teixeira (2017) says that in Brazil, currently, about 45.6% of the population has access to the internet (corresponding to 90 million people). Making a comparison between the years 2000 and 2012, a significant growth is identified, equivalent to 1,500% in the number of internet users in Brazil. The great leverage of the internet in recent years has been essential for the rise of e-commerce in Brazil and in the world.

Nascimento (2011) says that in relation to the correspondent in cash that is moved with e-commerce in the United States (approximately 173 billion dollars or approximately 294 billion reais²), it can be highlighted that it is higher than that found in Brazil (which is close to 14 billion reais in 2010, according to data from the Webshopper Report). The trend in the United States, as well as in Brazil, is for growth. The estimate, according to Forecast Research (2010) is that this number will double in four years.

Lessa et al. (2020) In a scenario in which technology is increasingly present in the daily lives of people and organizations, the term "digitalization" is being incorporated, exposing the evolution of physical media to the digital world. Even with this evolution that occurred a few decades ago, new ways of selling are identified, constantly adding ascension, such as marketplaces and applications available on cell phones, adding, and in some cases, replacing sales sites.

E-commerce, commonly known as e-commerce, is implemented in organizations, accounting for a large portion of their revenues. And this is due to the high convenience and satisfaction attributed to consumers by this means of acquisition.

According to Turchi (2004), the potential found in the internet has allowed organizations to analyze and act in a more comprehensive way and to encompass their

planning and marketing and e-business strategies, a broad concept that is related to a complex fusion of internal processes, business applications and organizational structures, with the use of technology (hardware and software), aiming to develop a high-performance business model.

The advantages of e-commerce are the immediate insertion in the market, the analysis of the competitive and consumer market, the service and support twenty-four hours a day, and seven days a week, with very low operating costs. With caveats to its weaknesses to external factors, such as the dangers found in the network.

Hoffman and Novak (1995)⁹ describe that this relationship between customers and companies has undergone changes over time, mainly due to marketing efforts that have demonstrated innovations in the search to expand their penetration in strategic segments to reach a greater number of customers. Companies aim to influence sales, but without disregarding quality and good service. Brondmo (2001)¹⁰ adds that the customer-company relationship is going through a predictable cycle that has four stages, consent, attention, loyalty and involvement.

The same author defines that in order to obtain the customer's attention, there is a need to promote liquidation actions and advantages that should follow the organization's marketing planning and with the criteria that one wishes to influence the customer (BRONDMO, 2001).¹¹

Godin (2001)¹² mentions that the internet facilitates this approximation between customer and company, highlights that it also plays an important role in holding the consumer's attention. Since on the web it is the customer who makes his choice and opts for a website, and this consists of keeping the products attached in your virtual store in a strategic way so that in the midst of so many options he chooses to stay on your website. TURBAN, 2000¹³ also emphasizes that the content must be attractive with relevant information.

⁹ Hoffman, Donna L. and Thomas P. Novak (1995), "Panning for Business Models in a Digital Gold Rush, HotWired, (Intelligent Agent section).

¹⁰ Brondmo, H. P. Fidelização: como conquistar e manter clientes na era da internet. São Paulo: Futura, 2001

¹¹ Ibid., item 9

¹² Godin, Seth. The new marketing idea Virus. Hsm Management, May/June. 2001.

¹³ Turban, E.; Gehrke, D. Determinants Of Successful Website Design: Relative Importance And Recommendations For Effectiveness. In: 32nd Hawaii International Conference On System Sciences, 1999, Hawaii. *Proceedings...* Hawaii, 1999.

Brondmo (2001) ¹⁴argues that the company, when reaching the customer's attention, must be equipped with tools that enable this communication. In order to effect the company's relationship with the customer and the interest of the public it serves.

Turban (et al., 2000)¹⁵ recalls that at this stage, a commercial contact initiative with the customer must be formed by the company, after his consent that the company can send him its content, promotions and others.

Another means of service, through technologies, is e-mail, which can be used to forward advertisements, offers, promotions and publicity, once, as a way to carry out marketing advertising, addressing issues of interest to the customer through their authorization to receive the content. These principles ensure greater consideration and confidence on the part of the consumer, who will be able to choose whether or not to receive certain advertisements, valuing the company's profile. (HOFFMAN; BATESON, 1999).¹⁶

Reedy et al., (2001), ¹⁷define that during the process of customer involvement with the company, in the midst of the wide variety of information available about the product, it is the differences in details and specifications that can make the purchase since people do not buy on impulse or emotion on the internet. The author also points out that for this to be effective, the customer must be convinced of the real usefulness of the product offered in order to make the purchase. What should be proposed is that the greater the content with information, offer, samples and promotions of the product, the greater the chance of influencing the customer in the purchase.

Generally most customers, at the time of choice are influenced by value, and they are aligned by quality, convenience and price especially. (RUST et al., 2001).¹⁸

From the moment a potential customer makes their first purchase, they leave the position of listener and become a de facto customer. At this stage, the basis of a relationship must be prepared, through the offer of information, promotions and entertainment, which are aligned with the customer's interest. It is through this relationship that involvement arises (BRONDMO, 2001).¹⁹

¹⁴ Ibid., item 9

¹⁵ Ibid., item 11

¹⁶ Hoffman, D.; Bateson, J. E. G. *Essentials Of Services Marketing*. London: International Thomson Publishing, 1999

¹⁷ Reedy, J.; Schullo, S.; Zimmerman, K. *Electronic Marketing: Integrating Electronic Resources Into The Marketing Process*. Cincinnati: South-Western, 2001.

¹⁸ Rust, R. T., Zeithaml, V. A., & Lemon, K. N. (2001). *Customer value: the model that is reshaping corporate strategy*. Porto Alegre: Bookman

¹⁹ Ibid., item 9

Brondmo (2001),²⁰ From the moment a customer's potential is identified in their first purchase, they actually become a customer. At this point, it is essential to prepare a basis to create a relationship with the consumer that is made by acquiring the largest amount of information about the customer, their interests, and thus promote approximation and involvement so that this relationship develops with new offers that meet their profile.

Through the rate for the conversion of visitors into customers is a fundamental factor for building a level in the relationships of a website and its users. That is, to understand the reason that leads consumers to use the internet, whether for the most diverse reasons as we will see in the following literature.

Moe and Fader, (2001),²¹ through analyses, identified two antagonistic behaviors on the internet: for an objective or exploratory research. TURBAN et al. 2000,²² named these behaviors hedonistic or utilitarian. WOLFINBARGER AND GILLY, 2001²³ describe the behavior that aimed at parameters in experiments. In any case, there are these two types of profiles and they should be evaluated on the website to measure these differences and score their changes.

Bellman et al., (1999),²⁴ through research on lifestyle and purchase profile, defined that there is a group of associated and connected indicators (wired) where users are able to evaluate preferences and willingness to buy online.

According to the authors, it is not the demographic indicators that will define the conception of the purchase on the website. Because on the internet, the highest index that indicates the tendency to buy is defined by sites that contain content with details and specifications about the products. In this research, the authors found that the biggest buyers on the internet have similar peculiarities in their way of life and are called the Wired Style.

Kim et al., (2000),²⁵ deepened the concept of willingness to buy *online*, addressing the risk and benefit presented in the purchase as fundamental factors in a transaction. According to Bellman et al. (1999),²⁶ according to the perception that consumers with an internet-

²⁰ Ibid., item 9

²¹ Moe, W. W.; Fader, P. S. *Modeling Online Store Visit Patterns As A Measure Of Customer Satisfaction*. 2001.

²² Ibid. item 12

²³ Wolfenbarger, M., & Gilly, M. C. (2001). Shopping Online For Freedom, Control, And Fun. *California Management Review*, 43(2), 34-55.

²⁴ Bellman, S.; Lohse, G. L.; Johnson, E. J. Predictors Of Online Buying Behavior. *Communications of ACM*, v. 42. n. 12, p. 32-38, Dec. 1999.

²⁵ Kim, D. J.; Cho, B.; Rao, H. R. *Effects of consumer lifestyles on purchasing behavior on the internet: a conceptual framework and empirical validation*. In: Twenty First International Conference On Information Systems, 2000, Brisbane, Australia. *Proceedings...* Brisbane, Australia, 2000. p. 688-695.

²⁶ Ibid., item 23

oriented style (*wired*) identify greater benefits in an *online purchase*. Moe and Fader (2001),²⁷ Wolfinbarger and Gilly (2001)²⁸ and Turban et al. (2000)²⁹ recall that consumers with greater time orientation adopt online purchases of goods and services as a benefit, confirming the utilitarian-hedonistic behavior mentioned above.

Las Casas (2007)³⁰ in his studies states that marketing in Brazil originated in 1954. Approaching the concept, we can see that it describes marketing as a primary means to create means to provide services that can retain the quality of advertising, advertising and products, and discusses in other areas offers, negotiations and a high degree of influence between the parties, due to the connection that favors the consumer to the company or social network and this leads to good results. (LAS CASAS, 2007³¹; MESQUITA, 2015³²).

Gabriel (2010);³³ Souza (2011),³⁴ associates that since technology has grown the , marketing has evolved, improving its theories, innovations and methodologies according to digital media and content production, known as digital marketing and the Influencer Marketing trend, influencers and content production processes directly interconnected to a brand or label, whose main role is to sharpen creativity, the emotional, stimulating consumers to acquire this content, especially those presented by images (MESQUITA, 2015).³⁵

And its influencers, who in the procedures of producing content linked to a certain label or brand, have the fundamental role of instigating, through their influenced or followers, the realization of purchases by digital means through their image (MESQUITA, 2015).³⁶

One of the main differences between traditional and digital marketing is based on information tools and the power of persuasion. In digital marketing it is done through websites, social media including: Twitter, Facebook, Instagram, YouTube and in its connection it is possible to find explanatory content, which is determined as a set of actions and activities that a company or person performs through the internet and globally and brings the proposal

²⁷ Ibidem item 20

²⁸ Ibid., item 22

²⁹ Ibid. item 12

³⁰ LAS CASAS, A. M. Marketing de serviços. 5th Ed. Atlas Publisher; São Paulo, 2007.

³¹ Ibid., item 29

³² MESQUITA, R. What is marketing: everything you need to know about it. Brazil, 2015. Available at: <http://marketingdeconteudo.com/o-que-e-marketing/>. Accessed on: 09.23.202

³³ GABRIEL, Martha. Marketing in the Digital Age. São Paulo: Novatec, 2010

³⁴ OKADA, Sionaraloco, SOUZA, Eliane Moreira Sá de. Digital Marketing Strategies in the Age of Search. Revista Brasileira de Marketing, São Paulo, v. 10, n. 1, p 46-72, jan./apr. 2011. Accessed on: 09.23.2020

³⁵ Ibid., item 30

³⁶ Ibid., item 30

to attract through news in trends, business, relationships and that adds value in your advertisements.

What caused a solid effect on changes in the traditional marketing previously exercised, the creation of Digital Marketing and the growth of the internet and the use of technology resulting in a high volume of Internet users, led institutions to remodel their services through digital means, realizing the scope of the network and better results in what makes up advertising and dissemination, which generated new direct and indirect competitors and heated up innovations in this scenario in the production of more creative, strategic content in order to remain in the Advertising market and stand out among the others in the scope of the internet, which is broad.

According to Santos (2020), the way of doing marketing through the internet and other digital platforms is named by the visualization of different terms, among them: online marketing, internet marketing, webmarketing, electronic marketing, digital marketing, e-marketing. The term digital marketing was the one that spread the most and has been most used by researchers and professionals in the area to address the theme.

So we can define digital marketing as a set of new strategies in constant change that are applied through the internet and that must be attentive to the browser (consumer) their customs, searches, in order to promote effective approaches to constitute this relationship between consumption and company, internet user and content, and that their actions become positive and successful.

Torres (2010, p.7),³⁷ defines digital marketing as a means of presenting your business to customers and achieving trust in what you publish, bringing the consumer to decide to buy or share your content. The author also points out that it is a communication used in the digital environment to develop strategies and practices, such as email marketing, content marketing, digital media and even links sponsored by Google through information and content relevant to the consumer.

As verified, the conception of digital marketing through the frequent competition contained in this area, led institutions and organizations to generate their image through strategies differentiated from others, forming new alternatives and ways to establish content marketing. With marketing criteria focused on distributing, creating and promoting valuable content, with consistent, relevant products, services and trends that attract and retain the

³⁷ TORRES, Claudio, Practical Guide to Internet Marketing for Small Businesses, 2010. Accessed September 2020.

customer's audience, leading to profitable and effective actions. (CONTENT MARKETING INSTITUTE, 2012, p.15). ³⁸

Mesquita (2015)³⁹ adds that content marketing is defined as an instrument with the ability to improve and that enables the construction and creation of specific content, with the power to attract its audience and constituted by values, creativity, advantages, innovation, which leads those involved in these campaigns to obtain positive results in sales, profit, campaign propagation, styles, behaviors that are fundamental to position yourself in this market.

Torres (2018) states that the expansion of the digital field is immensely richer and more complex, and all technological tools are complementary, occupying their prominent position in the daily lives and in the use of consumers. The big divergence is that before the internet was a simpler organism, and currently it has become more complex.

Previously it was understood that the internet analyzed consumer behavior, and then digital marketing was elaborated, but currently with the evolution of strategies and the greater complexity of digital technology, we also have to expand the model and for this we must consider several aspects that not only clarify digital marketing, but also the profile of consumers.

According to Kotler (2000) ⁴⁰, the result is that effective marketing can take many forms. There will always be a tension between the professionalized stage of marketing and its most creative manifestation. It is easier to learn the professional approach, which will be dealt with in most of these books." Marketing is generally seen as a sector responsible for developing, creating, and disseminating content about products, services, and ideals, also covering events, experiences, people, places, properties, organizations, and information.

Okada, De Souza (2011) corroborates by stating that digital marketing can be transformed into a process of continuous learning and interaction between customers and the market, and, in this way, disseminate a more efficient communicative connection.

Gabriel (2009) characterizes search marketing as a sphere of strategies that seek to reach the potential customer when he searches for a product, service or information on the Internet. According to Cintra (2010), digital marketing strategies have proven to be efficient

³⁸ CONTENT ROCK (2017) Inbound Marketing 2.0: The future of Marketing is here. [Internet] available on [Consult. 23.09.2020]

³⁹ Ibid., item 30

⁴⁰ Ibid., item 30

in several businesses, impacting those that are entirely online, such as those that use auxiliary platforms, interconnecting the physical with the virtual.

It is also noteworthy that marketing professionals are increasingly looking for online services focusing on the new era of relationship marketing, linking relationships from one to another, and from one to several, providing the so-called word-of-mouth advertising.

Current technologies, accessible to all, allow organizations of the most diverse sizes to more effectively control their points of connection between consumers and suppliers using digital marketing correctly, in addition to understanding the target audience, also providing them with easy, cheap and immediate benefits.

Richers (1986) says that "marketing is the set of activities that aims to concentrate exchange relations. This exchange occurs between the company's products and services with the consumer's purchasing power." Marketing is constantly updating and renewing itself with new attributions.

According to Kotler and Armstrong, 1998 Apud Santana, relationship marketing focuses on favoring the satisfaction of the company's consumers in the long term, through the elaboration and maintenance of solid relationships.

Marketing is constantly changing and should be seen as a changing science, so it is essential that companies implement strategies to highlight actions and marketing efficiently, such as redirecting actions with low effectiveness.

It is emphasized that marketing has fundamental characteristics, relating the elaborative processes and value identification, in which the concept of Relationship Marketing is related, therefore, the essentiality of an excellent high-performance commercial service brings the reformulation of the company/consumer relationship.

Relationship Marketing encompasses the characterization of values and the sharing of benefits caused by a partnership, it is the demanding consumer who has determined the success of the company, not the service/product.

3 APPLICATION

Addressing the means of digital marketing and what permeates its application in a virtual store, the object of our study, we will point out some researched strategies that can help us implement this tool effectively, aiming to collaborate to stimulate sales and new possibilities to expand the business without the need for high investments for this process.

In view of the growth of technology worldwide and with repercussions in our country, we can see that the search for shopping on the internet has become a trend among Internet users who used to only use entertainment sites, adhering to the habit of making their choices through computers, smartphones, tablets and others. And that has become a safe, fast, and convenient way to make your purchases from your homes. This has generated an increase in consumers with this profile, however, some criteria must be considered by shopkeepers to achieve success in their business. Among them, being attentive to the profile and behavior of consumers, as well as structure to promptly serve the interlocutor to be competitive with the numerous existing and continuously growing sales sites and websites in the market.

Another aspect to be highlighted is that the company adopts a strategy to be able to sell its products and services. The strategic orientation will guide all the company's business and its way of acting in front of the market and its customers. And success lies in diversity, innovation and agility in service.

Hanson (2000) ⁴¹ points out that it is a fundamental principle to generate trust in the virtual market. Which are identified through consumer searches on the web that cover trends, customs and behaviors. Another essential point is that the supplier has all relevant information in a clear and objective way, since the lack of these causes insecurity and determines one of the causes of certain people not making online purchases.

To the extent that the internet creates buying habits in which customers and sellers are spatially and temporarily separated, the parties involved remain anonymous during a transaction. As sellers and customers need to evaluate the integrity and respectability of the other party, trust is a very important factor in electronic commerce (SMITH et al., 1999).⁴²

Once the consumer purchases an item in a physical store, this transaction is usually done simultaneously: he pays for the merchandise and receives it immediately. While in virtual stores, in its vast majority, it denotes a time difference between the closing of the order, payment and delivery of the product. Consequently, the consumer will hardly be in direct contact with any employee of the company (REEDY et al., 2001).⁴³ In this process, which takes place without the physical presence and anonymity pertinent to the virtual process,

⁴¹ Hanson, W. *Principles Of Internet Marketing*. Cincinnati: South-Western College Publishing, 2000.

⁴² Smith, Rob.; Speaker, Mark.; Thompson, Mark. *The most complete guide on eCommerce* 1. ed. São Paulo: Futura, 2000.

⁴³ Ibid., item 16

which are also identified by the customer and their perception of the company, a primary factor for business done over the internet. (LOEBBECKE; HORNIG, 2001).⁴⁴

Hoffman et al. (1998)⁴⁵ and Jarvenpaa et al. (2000)⁴⁶ point out that among so many challenges contained in commercial relations in the digital environment, some aspects are evident that guarantee continuity, competitiveness and trust on the part of consumers in the website. As well as, the idiosyncratic characteristics are measured by the customers, that is, the way and conception attributed to the company in the digital market.

To fully establish the operation of a Marketing Plan, it is essential that it has a common structure and information system. Which will be used by the manager and the marketing area so that the actions take place based on the reality of the market. Using this information system is directly interconnected with market analysis.

Kotler (2000)⁴⁷ adds that a Marketing Information System is composed of people, equipment and procedures to collect, select, analyze and evaluate and later distribute this information when necessary.

Another relevant factor is the design of the product, its descriptions, usefulness, the maximum specification ensures greater credibility and consumer adherence. Product-oriented companies consider that customers will give preference to products that offer better quality, performance, and benefits. In this case, the company seeks to produce products that have these innovative attributes or characteristics. Usually this guidance is followed by companies that idolize their products and in no way intend to change it, even if their customers demand a different product.

As an example, we can cite typewriter manufacturers in the past who were slow to assimilate the idea that their customers wanted computers. They imagined that they would prefer their machines, because they were simpler to handle. In fact, people were more susceptible to the facilities that computers offered, even if they had to learn how to handle them.

Marketing-oriented companies are guided by the following way of acting and thinking: they seek to find out what their customers want and offer exactly what they want. They do this before their competitors and in such a way that their products become different and

⁴⁴ Loebbecke, C.; Hornig, V. Increasing trust in e-commerce: concepts and examples of insurance solutions. In: 14TH Bled Electronic Commerce Conference, 2001, Bled, Slovenia. *Proceedings...* Bled, Slovenia, 2001.

⁴⁵ Ibid., item 8

⁴⁶ Jarvenpaa, S. L.; Tractinsky, N.; Vitale, M. Consumer trust in an internet store. *Information Technology & Management*, v. 1, n. 1, p. 45-71, 2000.

⁴⁷ Ibid., item 2

attractive to customers. Thus, they will have satisfied customers and, having satisfied customers, they will have loyal customers.

According to Kotler (2000),⁴⁸ marketing-oriented companies are constantly concerned with customer desires. When these desires change, companies seek to evolve, guided by what customers want, looking for ways that can serve them.

Due to the existence of an increasingly competitive market in Brazil, it is necessary to remember that **loyal customers** are those who are satisfied. And satisfied consumers are those who see their expectations and requests met. Therefore, no matter the concept of loyalty adopted by companies, the ways to build customer loyalty will still be the same, which determines being ahead in the competition with other companies.

An example that we can mention is the pizza delivery segment, today we have numerous pizzerias with the same service, which can be differentiated in the provision of this service in addition to the quality of the product, the delivery must be the fastest, the pizza must arrive hot, these are challenges that these companies face to be pioneers and ensure the preference of their customers

Information is defined as a raw material for marketing, and a Marketing Information System is a continuous process, where data and information are collected, processed, and stored to be Marketing, that is, with the function of understanding and serving the market in a targeted way. Due to its great importance, information must be developed through the company's Internal Records, or Marketing Intelligence methods, Marketing Research and analysis of Support Systems for new implementations or changes in the company.

We will present below the Components of a Marketing Information System:

- Internal Record System: with reports on orders, sales, pricing, inventory levels, accounts receivable, accounts payable, and more
- Marketing Intelligence System: through a set of procedures and sources used by administrators and which requires daily information on sales, developments to apply in the marketing plan. And it also denotes the need for managers to expand research in market literature, newspapers, trends, and innovations to feed and keep the market warm.
- . Marketing Research System: Through data collection, statistics, and new paths that can be taken to expand the service with relevant concepts in the company's daily life.

⁴⁸ Ibidem item 2.

We can mention quantitative marketing research, through primary research in order to analyze the relationships between the number of people and the preferences that the market presents so that they can articulate more effective strategies to increase sales and better acceptance by the public in question.

- Marketing Decision Support System: formed by coordinated data with the use of technological tools and techniques to provide support to the commercial area where it contains all the data cataloged and organized for consultation and use of the area, in prospecting, the seasonality of greater results to add promotions and new ways to promote sales.

Understanding the behavior of your consumers can make all the difference when it comes to putting your business strategies into practice. For this, it is essential to understand **how they relate to products, services, brands and, above all, how they make their choices**. All of us, as consumers, are influenced by a series of factors that lead us to decide what to buy. According to KOTLER, 2000, there are four main factors, commented below:

- Culture:** people end up acquiring a set of values, perceptions, preferences, and behaviors through life in society (social groups), which interfere with their consumption habits.
- Subculture:** the subculture is composed of a set of cultural particularities of a smaller group, differing from the standard of the larger society, however, without disconnection from the current culture. Examples of subculture are the values that differentiate religions, racial groups, geographic regions, etc.
- Social class:** composed of a group of people who are framed in a common social stratum. It consists of orderly, relatively homogeneous and lasting divisions of a society. Its members have similar values, interests, and behaviors.

Many companies advocate the idea of promoting only one benefit to the target market. Each brand must choose an attribute and promote itself as number one in that attribute. Buyers tend to remember message number one, especially in a society of excessive communication. What are some of the number one positions to promote? The main ones are better quality, better service, lower price, higher value, and more advanced technology. If a company takes one of these positions and sticks to them convincingly, it will likely be best known and remembered for its strength.

Marketing mix denominated as marketing compound which is the set of marketing tools that the company uses to pursue its marketing objectives in the target market. These tools are classified into four broad groups, called the 4Ps of marketing: product, price, place or point of sale. In the promotion of the English language product, price, place and promotion.

The figure below presents a mix with the company's conceptions in products, services and prices.

Figure 1



saiadolugar



rockcontent

Source: rock contente

- Product: the product must be the product desired by the customer, within their expectations and that meets their needs.

- Price: The customer will look for a fair price, which should not be too high so that the customer considers it not worth buying. Not so low that it leads you to think that there is something wrong with the product, to the point of refusing it.
- Place (Point or Distribution): the desired product with a fair price must be accessible to the customer, that is, in a place where he can buy it at the time he wants.
- Promotion: There is a popular proverb that says: . Advertising is the soul of the business, and in fact, he is absolutely right, because if we do not disclose the product to customers, they will not know about its existence and will not be able to purchase it.

Production-oriented companies have the vision that customers will give preference to products that are found anywhere and at a low price. Thus, the company seeks to produce more and more, aiming to lower its prices and place its products or services in as many points of sale as possible, so that customers can find them easily. They don't consider the individual needs and wants of their customers and the fact that the cheapest product won't always satisfy everyone.

As an example, some doctors believe that the simple fact of offering their services to clients at an affordable price (via Public Service) will make them satisfied with the services and be willing to wait until they can be seen. In reality, customers, in general, are completely dissatisfied and, at the first opportunity they can afford a health plan or a private consultation, they will look for a competitor. It is possible to see that there is not, in this approach, a greater concern with customers, their desires and their needs.

3.1 PRODUCT ORIENTATION

Holding that consumers prefer products that offer superior quality and performance or that have innovative features, managers in organizations that follow these lines focus on making quality products and improving them over time.

3.2 SALES ORIENTATION

Sales-oriented companies adopt the thinking that customers don't decide to buy on their own. In this way, the company needs to induce them to make the decision, otherwise there will be no purchase. Several companies adopt this orientation, and with success. What happens is that they are not concerned with satisfying the needs of customers, but with

satisfying their own needs. Often, the customers to whom the product was sold did not want it and only purchased it due to the so-called Pressure Selling, which can inevitably generate an unsatisfied customer.

According to several marketing authors, an unsatisfied customer is a potential enemy. For example, some companies that sell encyclopedias look for their customers at home, usually at night, and insistently try to convince them to purchase the product. Often customers are not in need of the product, but are convinced to buy it. These people will not be satisfied with the purchase made and, later, they will become negative propagandists of the company and the product.

3.3 MARKETING ORIENTATION

Reference groups: groups of people who influence consumer feelings, thoughts, and even behaviors. For this reason, they are also known as opinion-forming groups.

They can be divided into informal groups, consisting of those with greater affinity or formal groups.

Family: the most influential reference group. They can be family members such as parents or consumer children.

Social roles and positions: throughout life, people participate in groups and assume certain social roles. This makes them choose products that represent their status in society.

Personal age: people's needs and desires change throughout life and, consequently, so does their consumption.

Occupation: The profession exercised also directly influences consumption patterns.

Economic condition: composed of equity, savings, disposable income, and credit conditions that directly affect consumer purchasing choices.

Lifestyle: activities, interests, and opinions that are associated with specific products and services can lead the consumer to buy according to the brand's positioning in the market.

Personality: Each person has a distinct personality, which will influence their buying behavior. It is an important element that can establish strong correlations between certain personality types and consumer choices.

Motivation: the desire that drives the consumer to the action of satisfying their specific needs and desires through consumer choices.

Perception: the process in which the individual selects, structures and deciphers the information received. Perception depends not only on physical stimuli, but also on the relationship of these stimuli with the needs at that moment.

Learning: knowledge acquired by the consumer due to their previous experiences can cause changes in behavior.

Beliefs and attitudes: the psychological positioning, negative or positive, of the consumer in the face of consumption choices.

It is necessary to keep in mind that consumption is one of the multiple actions that permeate the daily life of human beings. People have infinite motivations to pursue ambitions, to conquer spaces and for personal fulfillment. Therefore, evaluate in detail all the factors that can influence your customers' behavior and take advantage of the insights learned from this exercise to compose your marketing strategies.

An important factor to consider is the diversity present in society, which goes against thinking and how it influences the choices of products or services in relation to their style, age group, gender, group to which they belong.

Known as Market Segment to a part of the market with similar characteristics or not. Where in two groups are found variables that can be used to segment consumer markets. Consumer characteristics and behavior are usually analyzed. Through these characteristics of consumers and their Variables, the performance of marketing for Segmentation of Consumer Markets is consolidated:

- Geographic: proposes to divide the market into different geographic units, such as countries, states, regions, cities, or neighborhoods.
- Demographic: occurs when the market is divided into groups based on demographic variables, such as age, family size, family life cycle, gender, income, occupation, educational background, religion, race, generation, nationality or social class;
- Psychographic: occurs when buyers are divided into different groups, based on lifestyle under personality. Marketing is much more than a promotion and sales tool, it denotes a customer-centric philosophy
- Consumer behavior presents the following variables for Segmentation of Consumer Markets:
- Occasions: Consumers can be differentiated according to the occasions when they feel a need, buy or use a product such as when they are traveling what they consume.

- Benefits: Buyers can be classified according to the different benefits they seek in a product as it serves the customer from a different angle or situation.
- User status: Users can be segmented into groups of non-users, former users, potential users, new users, and regular users of a good that can be re-consumed.
- Usage rate: they can be segmented into small, medium, or large users of a product or service.
- Loyalty status: the market can be segmented by consumer loyalty patterns such as those loyal to the brand, such as Coca-Cola or McDonald.s.

A business should look to identify specific ways to differentiate its products in order to gain competitive advantages. Differentiation develops a set of significant characteristics to distinguish your product from the competing market.

How, exactly, can a company differentiate its market offering from its competitors. A company can be differentiated in five dimensions: product, services, channel, and image.

- Product differentiation: the main product differentiations are the characteristics, performance, compliance, durability, reliability, ease of repair, style and design we can exemplify furniture companies and their brand.
- Service differentiation: the main differentiators of services are ease of ordering, delivery, installation, consumer training, consumer consulting, maintenance and repair, among others such as internet sales.
- People differentiation: This is about gaining competitive advantages by hiring and training people who are better qualified than your competitors. Basically there are six characteristics: competence, courtesy, credibility, reliability, responsiveness and communication
- Differentiation through the distribution channel: it is about obtaining differentiation by the way in which its distribution channels are developed, especially in terms of coverage, experience and performance such as Natura, Avon, Demillus and others.
- Differentiation through image: buyers may respond differently to the image of the company or brand. The image basically involves four aspects: symbol, audiovisual and written media, atmosphere and events.

As for positioning, each company will want to develop differences that will more strongly appeal to its target market. She will develop a focused positioning strategy, the

company's offer and image, so that they occupy a distinct and valued place in the minds. We call this simply positioning, and we define it as follows: it is the act of developing target consumers.

Being a resource with great power to influence organizations, information plays a prominent role in the management of companies, regardless of their size or area of activity.

However, we must distinguish two basic concepts that make up information, the concept of data and information itself. According to Oliveira (2002, p. 36),⁴⁹ we can verify: data is any element identified in its raw form that, by itself, does not lead to an understanding of a certain fact or situation. Information is the data worked on that allows the executive to make decisions. For data to be transformed into information, it is necessary to process it, that is, the data receives a treatment that gives it meaning, functioning as a system where data are the inputs and information is the results of this process or outputs

In the era of sharing and digital technological generation, e-commerce is promising in Brazil. According to a report from the Brazilian Micro and Small Business Support Service (Sebrae), "the market for baby items, in the age group from zero to six months, is the most promising. It is part of the family budget to permanently buy baby items, because at each stage of life of the baby and the child, it requires different products". (BRAZILIAN MICRO AND SMALL BUSINESS SUPPORT SERVICE, 2016).⁵⁰

E-commerce represents part of the present and future of commerce. There are several business opportunities spread across the internet, in addition to many that are created all the time. It is very likely that a price search on the internet will bring not only the lowest price, but also the best options for goods. And, despite the bottleneck represented by the "digital illiteracy" of a large portion of the population, e-commerce is already emerging with a generation that was born with the computer "in their lap" or "in their hands". The growth in the number of Internet users in the last decade is astounding. (TEIXEIRA, 2015, p. 19).⁵¹

The demanding market values the details and quality of the products, which can generate differential at the time of purchase. The arrival of a child causes changes in the family environment. Before the baby is born, it is necessary to prepare the layette, decorate the baby's corner and other details.

⁴⁹ OLIVEIRA, Djalma de Pinho Rebouças. Systems, organization & methods: managerial approach. 9. ed. São Paulo: Atlas, 1995, p. 85 - 97.

⁵⁰ BRAZILIAN SUPPORT SERVICE FOR MICRO AND SMALL ENTERPRISES. How to set up a baby supply store.. Accessed on: 09.23.2020

⁵¹ TEIXEIRA, Tarcisio. Electronic commerce: according to the Civil Rights Framework for the Internet and the regulation of e-commerce in Brazil. São Paulo: Saraiva, 2015.

Future parents are going through a unique experience and want to purchase products that meet these needs, however, it is important to have a company that complies with the law. In this sense, the potential of the market is observed, because, "It is increasingly common to find families where both parents work, which means a more significant income to be spent on the children". (BRAZILIAN MICRO AND SMALL BUSINESS SUPPORT SERVICE, 2016).⁵²

It is interesting to note that "the consumer, in the search for authenticity, has sought to relate to their brands as a way of getting to know them and analyzing whether to put them in their life or not". (VAZ, 2016, p. 169). For the author, credibility is a fundamental point, regardless of the type of business, because "credibility goes through the consumer's perception of ethical behavior on the part of companies". (VAZ, 2016, p. 169).

The author adds: You only allow someone to become your friend if you trust them. Something similar happens with brands nowadays. Credibility is everything. No matter your business, you have to generate credibility in your consumer so that he buys from you and not from your competitor. (VAZ, 2016, p. 169).

Therefore, the ethical posture is essential for building a solid brand in the competitive market, because with the establishment of attitudes that a differential can be made. It cannot be forgotten that we live in an era in which transparency is a fundamental point for digital marketing intelligence. As Conrado Adolpho Vaz (2016, p. 168) shows,⁵³ "being ethical is more than telling the truth and being transparent in your attitudes. To be ethical is to reveal the secrets of your institution to the consumer as a way of asking for their consent."

And yet, according to how to proceed in an e-commerce, the author adds: It is to allocate time to your customer to explain why your company is doing this or that. To be ethical is to give back to society what it has given it in the form of profits. A movement that started a few years ago and that has only increased its influence, the search for ethics in relationships, has changed the market. (VAZ, 2016, p. 168).⁵⁴

In a virtual world in which geographical and temporal barriers are broken, in the understanding of Tarcísio Teixeira (2015, p. 27), with the use of the internet there is a need for attention to the consumer. With the support of computers, merchants now have a greater

⁵² Ibid. item 36

⁵³ VAZ, Conrado Adolpho. The 8 P's of digital marketing: your digital marketing strategic guide. 7. Reimp. São Paulo: Novatec, 2016.

⁵⁴ Ibid. item 38

radius of reach, considering that with the internet there are practically no geographical barriers for business; at least as far as the disclosure of goods is concerned, as there are still some obstacles regarding the difference between legal systems and the borders between countries, especially when a physical delivery of the product or an on-site service is required.

E-commerce requires a series of planning, obligations, and monthly expenses that must be thought out, focused, and planned. The strategies, whether they are marketing, customer care from purchase to delivery and a possible exchange, as provided for in the legislation, the right of repentance, must be in perfect harmony at all times for the good performance of the product, the brand and the store in a market that grows more and more every day.

According to Fábio Ulhoa Coelho (2016, p. 80) ⁵⁵"currently, with the diffusion of e-commerce, the parallel is no longer significant. The internet is seen, today, no longer as a virtual establishment, but as a specific business channel [...] ". The changes that have occurred in the behavior of society in the information age, "the law faces new challenges and needs to adapt in order to guarantee social peace, disciplining relations and imposing new norms of conduct consistent with the virtual environment". (MARTINS, 2015, p. 09)⁵⁶element. For this, it is important to know the legislation on e-commerce, such as the Civil Rights Framework for the Internet, the Civil Code and the Consumer Protection Code to seek the correction of the e-commerce site of the First Steps Baby Store so as not to generate distrust to customers.

The Civil Rights Framework for the Internet brought specific civil regulation for cases related to the use of the Internet in Brazil. The lack of a specific law made many consumers suspicious of the type of commerce carried out through a virtual environment. Insecurity stems from issues related to rights, whether administrative or judicial. For negotiations via the internet in Brazil, the Civil Code and the Consumer Protection Code apply. Also mentioned are Decree No. 7,962, of March 15, 2013,⁵⁷ on contracting in e-commerce, regulating the Consumer Protection Code, and also the validity of Law No. 12,965, of April 23, 2014, the Civil Rights Framework for the Internet, which brings rules and principles for the security of internet users.

⁵⁵ COELHO, Fábio Ulhoa. Manual de direito comercial. 28. ed. ver. current. eampl. São Paulo: Revista dos Tribunais, 2016.

⁵⁶ MARTINS, Vanessa do Sul. Electronic law. Palhoça: UnisulVirtual, 2015.

⁵⁷ BRAZIL. Decree No. 7,962, of March 15, 2013. Regulates Law No. 8,078, of September 11, 1990, to provide for contracting in electronic commerce. Accessed on: 09.23.2020

As Tarcísio Teixeira (2014) explains,⁵⁸ "when analyzing the Marco Civil, one may have the initial impression that the rule does not clearly deal with electronic commerce in the strict sense (regarding the purchase and sale of products and provision of services), but only with other operations carried out in electronic commerce in a broad sense (such as issues involving the protection of privacy and the prohibition of the improper capture of data and its commercialization). However, its rules and principles have a direct implication in everything that occurs on the internet in Brazil, including e-commerce, as operations involving the production and circulation of goods and services."

João Paulo de Mello Filippin (2016, p. 6),⁵⁹ corroborates the analysis above that "with regard to electronic commerce, the aforementioned law practically does not provide anything. In fact, in the justification of the law itself, it was said that the Civil Rights Framework for the Internet would not deal with e-commerce." However, the same author points out that "[...] This law imposed a limitation on the collection of information from users' personal data.

It assured that it is their right to 'express consent to the collection, use, storage and processing of personal data, which must occur separately from the other contractual clauses (BRASIL, Law No. 12,965/2014)⁶⁰'. In this sense, there are implications in electronic marketing, consequently in e-commerce. (FILIPPIN, 2016, p. 7)⁶¹element. The Civil Rights Framework for the Internet makes clear, in the case of e-commerce, the obstacle in carrying out remarketing, and it is "necessary to include in the contract entered into with the buyer (whether consumer or not) the information of what will be carried out, as well as to ask for his authorization to carry out promotions or offers". (FILIPPIN, 2016, p. 7).⁶² The more consumers talk (well) about your brand on the internet, the greater the credibility it will enjoy and the greater the number of buyers per hundred visits.

When I say "buyers" I mean people who reach the site's goal. This goal can be an email contact, a registration, a request for a quote, or a purchase, in fact, if your site is an e-commerce site. The conversion rate will give you the direct measure of your brand's credibility and the degree of sellability of your website. In order for you to have good credibility on the internet, your website must use and abuse testimonials on and off the site and do intense

⁵⁸ Ibid. item 36

⁵⁹ FILIPPIN, João Paulo de Mello. Legislation. Article written for UA E-commerce. Instructional design: Marina Melhado Gomes da Silva. Spelling review: Diane Dal Mago. Graphic design: Noêmia Mesquita. Palhoça: UnisulVirtual, 2016.

⁶⁰ BRAZIL. Civil Rights Framework for the Internet. Law No. 12,965, of April 23, 2014. Establishes principles, guarantees, rights and duties for the use of the Internet in Brazil. Accessed on: 09.23.2020

⁶¹ Ibid., item 44

⁶² Ibid., item 44

work on social networks so that the consumer's opinion of you on the web is positive and viral. (VAZ, 2016, p. 172-173).⁶³

Also in this area, it is important to warn that the Civil Rights Framework for the Internet establishes access to the Internet as an essential part of the exercise of citizenship and the user. To this end, some rights are ensured: (I) inviolability of intimacy and private life, their protection and compensation for material or moral damage resulting from their violation; (II) inviolability and secrecy of the flow of its communications over the internet, except by court order, in accordance with the law; and (III) inviolability and secrecy of your stored private communications, except by court order.

It is worth noting that one of the main achievements of the Civil Rights Framework for the Internet was the recognition, in article 7, XIII, of the need to "apply consumer protection and defense rules in consumer relations carried out on the Internet". In addition, the law provides soon after, in its article 8, the guarantee of the right to privacy and freedom of expression in communications as a condition for the full exercise of the right to access the internet. It is, as can be seen, an attempt to create security in a complex scenario, bringing the possibility of future and beneficial reflections on consumer relations carried out via the internet. (URNAUER; BARRETO, 2014, p. 281).⁶⁴

Legal certainty is a key factor in the times of the Internet, with attention to principles, guarantees and the good use of digital media in Brazil. For Suellem Aparecida Urnauer and Ricardo de Macedo Menna Barreto (2014, p. 284),⁶⁵ "the Marco Civil then proceeds to normatively redefine the complex consumer relations that occur in cyberspace, revealing itself as an important logical principle to face issues involving not only traditional electronic commerce, but also electronic social commerce". Therefore, it is interesting to understand the laws that govern e-commerce in Brazil, as legal certainty is a primary factor in a commercial context.

The objective of this study is to investigate the strategic management of information in the application of relationship marketing in retail. As a research method, exploratory research was chosen. According to the objectives, according to Gil (2002, p. 41) ⁶⁶"exploratory

⁶³ Ibid. item 38

⁶⁴ URNAUER, Suellem Aparecida; BARRETO, Ricardo de Macedo Menna. Legal security in the consumer cyberculture: reflections in the light of Law No. 12,965/2014 (Civil Rights Framework for the Internet). In: Journal of the Master's Degree in Law of the Catholic University of Brasília, v. 8, nº 2, p. 263-287, jul-dez, 2014

⁶⁵ Ibidem item 49

⁶⁶ GIL, Antonio C. Classifying research IN: How to develop research projects. 3 ed. São Paulo: Atlas, 1996. (p. 86 - 101).

research aims to provide greater familiarity with the problem, with a view to making it more explicit or to constitute hypotheses. [...] improvement of ideas or the discovery of intuition". For Marconi and Lakatos (2003, p. 124), ⁶⁷exploratory research:

It is the first step of all scientific work. The purposes of an exploratory research, especially when bibliographic, are to provide more information on a given subject; facilitate the delimitation of a work theme; define the objectives or formulate the hypotheses of a research or discover a new type of approach for the work that is in mind.

The present work also assumes a descriptive research character, since it seeks to establish a relationship with the information necessary to subsidize relationship marketing with the data collected from customers. According to Gil (2002, p.42), ⁶⁸it is characterized as:

[...] the description of the characteristics of a given population or phenomenon or, alternatively, the establishment of relationships between variables. [...] Included in this group are surveys that aim to survey the opinions, attitudes and beliefs of a population.

As for the design or the means, it is a matter of defining its conceptual and operational model, that is, the design of a research "refers to its planning in its broadest dimension, which involves both the layout and the prediction of analysis and interpretation of data collection." (GIL, 2002, p. 43). Thus, the definition of the research is important for the process of data collection and analysis.

In view of this, the present research in relation to the means or delineations is of the survey type, which is characterized by the direct interrogation of the people whose behavior is desired to be known through quantitative analysis, obtaining the conclusions corresponding to the collected data (GIL, 2002, p. 50).⁶⁹

Like all research, bibliographic analysis is also an integral part of this study, given the need for theoretical foundation focused on the object of study and data analysis. According

⁶⁷ MARCONI, Maria de Andrade; LAKATOS, Eva Maria. Fundamentals of Scientific Methodology. São Paulo: Atlas, 2003, p. 195 – 202; 223 – 224

⁶⁸ GIL, Antonio C. Classifying research IN: How to develop research projects. 3 ed. São Paulo: Atlas, 1996. (p. 86 - 101).

⁶⁹ Ibid. item 65

to Gil (2002, p. 45)⁷⁰ "bibliographic research is developed based on material already prepared, consisting of books and scientific articles".

To complete the theoretical foundation of this work, it was also used internal documents of the company, characterized as a documentary research. Highlighting that every new posture or attitude taken by an organization brings many changes with relationship marketing, this is no different.

In order for the company to put it into practice, it is necessary to promote changes in the culture of its managers, employees and shareholders, where the sense of establishing relationship marketing is a factor in generating competitive differential, and that it is understood by all that information has a main role in this new scenario.

4 CONCLUSION

The present work in accordance with the PIN developed about such a cuddly baby clothes manufacturing company brings an analysis of the importance of financial management in companies as a result of success and profits, through a set of actions and procedures aimed at digital marketing and e-commerce sales, such as planning, analysis and control of financial activities. It was understood that the financial function in a company requires care, planning and a lot of responsibility in managing finances.

We understand through the literature review that the currently predominant concepts are the result of the accumulation of knowledge and previous experiences. It was highlighted by the history that the evolution of the financial function is not finished. Studies are underway and new points of view are being explored.

In view of the literature that supports the steps and procedures to be followed for the constitution with expansion of marketing in the digital world, it was possible to verify that every process, even if online, requires management, and needs interventions from different areas such as purchases, accounts payable and receivable, production and inventory control, logistics. And to institute this concept, there must be a systemic connection between these sectors, there are two important tools that the financial manager needs to master, such as: cash flow and income statement. Every financial manager needs to be up to date to manage finances with the capacity and awareness to lead the company to success and growth.

Marketing is going through the greatest moment of sensitivity in history with its consumer. More than ever, strategies prove to be the main element in the market. Knowing

⁷⁰ Ibid. item 65

how to win in a trade as treacherous as today's is not easy, but strategic planning has been able to reinvent itself with the internet, which presents the challenge of being in constant change. Finally, it is worth noting that digital marketing revolutionizes the market by bringing an unprecedented interaction between consumer and brand, allowing for greater precision in communication. The market has become more challenging with digital marketing, however the possibilities that came along with this tool have no limits.

ACKNOWLEDGMENTS

To my friends and family who supported me for the creation, development and completion of this project. I thank all the professors at Fundação Getúlio Vargas who made their days available and shared their professional experiences. In particular, to our advisor and professor Luís Eduardo Machado for the explanations and guidance in all steps until the conclusion of this project, the Business Plan.

DEDICATION

I respectfully dedicate this project to friends and family who understood with affection all the time spent and effort made so that in the end we could conclude our work well.

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WIRELESS COMPUTING TOOL WITH RFID AND ESP32 IN SUPPORT OF LITERACY: A QUALITATIVE CASE STUDY

FERRAMENTA COMPUTACIONAL SEM FIO COM RFID E ESP32 NO APOIO À ALFABETIZAÇÃO: UM ESTUDO DE CASO QUALITATIVO

HERRAMIENTA INFORMÁTICA INALÁMBRICA CON RFID Y ESP32 PARA APOYAR LA ALFABETIZACIÓN: UN ESTUDIO DE CASO CUALITATIVO

 <https://doi.org/10.56238/sevened2025.036-071>

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ABSTRACT

The objective of this study was to evaluate the application of a tangible, wireless educational technology, based on ESP32 and RFID, to support the literacy process of children with writing difficulties. The research was conducted in a public school, involving ten third- and fourth-grade students and a literacy teacher. Over ten workshops, the technology mediated reading, writing, and phonological awareness activities. The children were assisted in tasks such as reading, writing words, and recognizing letter sounds. The results demonstrated that the technology proved to be a highly effective resource in the literacy process. Data collection included observations of the participants, analysis of written productions, records of correct and incorrect answers, and evaluation of student progress by the literacy teacher. Content analysis was used, which indicated significant advances in phonological awareness, self-correction, autonomy, and engagement of the children. Among the most relevant occurrences was the advancement in understanding the grapheme-phoneme relationship. The tangible interface, combined with instant auditory feedback, promoted greater participation and focus, allowing for longer work periods with less need for researcher intervention. The teacher evaluated the tool as easy to use, requiring low infrastructure, and applicable to different school contexts. The study thus highlights the potential of tangible educational technologies as cognitive mediators in the initial literacy process of children with learning difficulties, while also emphasizing the importance of continuous teacher training.

Keywords: Literacy. Tangible Educational Technologies. Learning Difficulties. ESP32 and RFID. Phonological Awareness.

RESUMO

O objetivo deste trabalho foi avaliar a aplicação de uma tecnologia educacional tangível e sem fio, baseada em ESP32 e RFID, como suporte ao processo de alfabetização de crianças com dificuldades de escrita. A pesquisa foi conduzida em uma instituição pública de ensino, envolvendo dez alunos do terceiro e quarto ano e uma professora alfabetizadora. Ao longo de dez oficinas, a tecnologia mediou atividades de leitura, escrita e consciência fonológica.

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As crianças foram assistidas em tarefas como leitura, escrita de palavras e reconhecimento dos sons das letras. Os resultados demonstraram que a tecnologia se revelou um recurso altamente eficaz no processo de alfabetização. A coleta de dados incluiu observações dos participantes, análise das produções escritas, registros de acertos e erros, além da avaliação do progresso dos alunos pela professora alfabetizadora. Utilizou-se a técnica de análise de conteúdo, que apontou avanços significativos na consciência fonológica, na autocorreção, na autonomia e no engajamento das crianças. Entre as ocorrências mais relevantes destacou-se o avanço na compreensão da relação grafema-fonema. A interface tangível, aliada ao feedback sonoro instantâneo, promoveu maior participação e foco, permitindo períodos de trabalho mais prolongados e com menor necessidade de intervenção do pesquisador. A professora avaliou a ferramenta como de fácil uso, de baixa demanda de infraestrutura e aplicável a diferentes contextos escolares. O estudo evidencia, assim, o potencial das tecnologias educacionais tangíveis como mediadoras cognitivas no processo inicial de alfabetização de crianças com dificuldades de aprendizagem, ao mesmo tempo em que ressalta a importância do treinamento contínuo dos professores.

Palavras-chave: Alfabetização. Tecnologias Educacionais Tangíveis. Dificuldades de Aprendizagem. ESP32 e RFID. Consciência Fonológica.

RESUMEN

El objetivo de este estudio fue evaluar la aplicación de una tecnología educativa tangible e inalámbrica, basada en ESP32 y RFID, para apoyar el proceso de lectoescritura de niños con dificultades de escritura. La investigación se llevó a cabo en una escuela pública, con la participación de diez estudiantes de tercero y cuarto grado y un docente de lectoescritura. A lo largo de diez talleres, la tecnología facilitó actividades de lectura, escritura y conciencia fonológica. Los niños recibieron asistencia en tareas como leer, escribir palabras y reconocer los sonidos de las letras. Los resultados demostraron que la tecnología resultó ser un recurso altamente efectivo en el proceso de lectoescritura. La recopilación de datos incluyó observaciones de los participantes, análisis de producciones escritas, registro de respuestas correctas e incorrectas, y evaluación del progreso estudiantil por parte del docente de lectoescritura. Se utilizó el análisis de contenido, el cual indicó avances significativos en la conciencia fonológica, la autocorrección, la autonomía y la participación de los niños. Entre los avances más relevantes se encuentra el avance en la comprensión de la relación grafema-fonema. La interfaz tangible, combinada con la retroalimentación auditiva instantánea, promovió una mayor participación y concentración, permitiendo períodos de trabajo más largos con menor necesidad de intervención del investigador. El docente evaluó la herramienta como fácil de usar, con baja infraestructura y aplicable a diferentes contextos escolares. Por lo tanto, el estudio destaca el potencial de las tecnologías educativas tangibles como mediadores cognitivos en el proceso de alfabetización inicial de niños con dificultades de aprendizaje, a la vez que enfatiza la importancia de la formación docente continua.

Palabras clave: Alfabetización. Tecnologías Educativas Tangibles. Dificultades de Aprendizaje. ESP32 y RFID. Conciencia Fonológica.

1 INTRODUCTION

Educational inclusion is a principle that ensures all students, regardless of their particularities, such as disabilities or specific educational demands, the same access to regular education. Although there are legal frameworks that guarantee the presence of people with disabilities in schools, Silva *et al.* (2025b) highlight that simply inserting these people in learning environments is not equivalent to promoting genuine inclusion. To achieve true inclusion, it is necessary to confront and overcome the various obstacles that still exist in our education system (Araújo *et al.*, 2025).

Among these barriers, the pedagogical one stands out, which concerns the lack of adaptation of teaching techniques to the varied educational demands of students. This can include the lack of methods that take into account and respect the various forms of learning, rhythms and styles of each student. A considerable challenge that affects the effectiveness of the teaching-learning process is the difficulty in adjusting the content, tasks and assessments to the particularities of students with specific needs. Cardoso, Santos, Mendonça Neto (2025) and Furtado, Almeida, Kohls-Santos (2025) address the way in which technologies, especially robotics, can provide multidisciplinary resources and curricular flexibility, benefiting varied strategies to access content and assessments. Silva *et al.* (2025c) suggest that collaborative and flexible methodologies are solutions to overcome these challenges. The absence of truly inclusive education for all students not only diminishes learning opportunities, but can also generate a negative environment in which these students feel excluded or unmotivated.

Another aspect to be considered is literacy, which plays a fundamental role in the school trajectory of any child. The literature on education shows that many students have difficulties at this time of learning and this is even clearer for those who have specific needs (Matos; Santos, 2021; Lyre; Silva; Silva Neto, 2024; Cardoso, 2022; Viana; Amorim; Amorim, 2023). Literacy involves not only the decoding of words, but also the comprehension of texts and written production, being a milestone for the academic and social development of students. Therefore, pedagogical intervention is essential in this scenario. According to Martins, Giraffa, and Raabe (2021), pedagogical practices that use innovative technologies, such as robotics, favor the development of reading and writing skills, in addition to transforming the environment into a place conducive to experimentation and creativity. In the same sense, Cardoso, Santos, Mendonça Neto (2025) and Furtado, Almeida, Kohls-Santos

(2025) point out that technological resources help to minimize barriers by stimulating student participation.

In addition, Oliveira, Senff and Silva (2024) say that the training of teachers and educators is a key point to make education truly inclusive. In order for education professionals to be able to meet the various needs of their students, they need to have access to the right training that helps them see and deal with differences (Dias *et al.*, 2024). This not only involves theoretical knowledge but also the practice of inclusive methodologies that create a collaborative learning environment where all students feel valued and respected.

The interaction between students, teachers and the school community as a whole is also fundamental for the creation of an inclusive environment (Silva *et al.*, 2025b). It is essential that there is a collective awareness about the relevance of inclusion and respect for diversity. A joint and collaborative effort can encourage behavioral changes and actions that promote inclusion, allowing students with specific needs to feel part of the group while other students cultivate empathy and respect for diversity (Silva *et al.*, 2025b).

Educational inclusion, according to Araújo and Silva (2025), is not only about policies and guidelines; it is a cultural change involving all participants in the educational process. The authors believe that educational inclusion is the construction of a fairer society where everyone has the same opportunities to learn. To continue on this path, it is essential to carry out a continuous diagnosis of pedagogical practices, as well as evaluations that take into account the progress of each student according to their needs and abilities. The search for inclusion must be a continuous search for improvement in the quality of teaching, offering solutions to enable learning for all (França *et al.*, 2025; Pires, 2025).

Educational inclusion can be a complex goal that requires a joint and multidisciplinary effort in which the uniqueness of each student is considered and respected. For Riboli and Pertuzzatti (2025), overcoming pedagogical barriers and creating a welcoming environment are essential steps to ensure that all students, especially those with specific educational needs, can achieve their goals and experience the full development of their potential. By prioritizing inclusion in the educational scenario, we contribute to forming not only competent individuals, but also conscious, responsible and supportive citizens.

2 METHODOLOGY

The study is an applied research, with a mixed approach (qualitative and quantitative), and an exploratory case study. The objective was to evaluate the pedagogical effectiveness

of a wireless computational tool made with ESP32 microcontroller and *Radio-Frequency Identification* (RFID) module, which was designed to help in the literacy process of children with learning difficulties in the writing system.

2.1 CONTEXT AND PARTICIPANTS

The research took place in a public school in the municipality of Camboriú in Santa Catarina, together with a literacy teacher from the basic education network. There were ten children from 8 to 10 years old regularly attending the 2nd and 3rd years of elementary school. It was reported by the pedagogical team that these children were presenting chronic difficulties in reading and writing.

For a more detailed analysis, three participants were chosen as cases for closer observation, considering their school history, the level of development of phonological awareness and the degree of difficulty in grapheme-phoneme correspondence.

2.2 DESCRIPTION OF THE WIRELESS COMPUTING TOOL

The instrument developed was a wireless computational tool using the RFID system (it is composed of the ESP32 microcontroller and the RFID module). It was programmed to identify labels containing letters, syllables, and words to be learned. When the card is brought close to the reading surface, the student receives immediate sound feedback, making sure that the answer is right or wrong. This contributed to the self-correction process and helped to reinforce the grapheme-phoneme relationship.

The tool does not automatically store data or log logs. The researchers evaluated the students' performance based on observation, analysis of written productions, as well as their manual records throughout the workshops. The practical implementation was supported by ten literacy workshops held over five weeks, reading, writing and phonemic identification activities. Such activities were carried out assisted by the researchers and by a literacy teacher, actively participating in the group, who collaborated in the pedagogical practices planned by the researchers.

2.3 DATA COLLECTION PROCEDURES

Data collection was based on three complementary sources:

- 1. Participant observation:** the researchers manually recorded the number of successes and errors that the students made during the activities mediated by the tool,

in addition, they wrote down behaviors such as engagement, attention, frustration, and forms of self-correction.

2. Written productions and oral readings: the students carried out spontaneous reading and writing activities before and after the workshops, which made it possible to analyze the evolution in the domain of the writing system.

3. Teacher feedback and field diary: teachers shared their impressions about the tool, addressing aspects such as pedagogical adequacy, student engagement and identified difficulties.

Finally, the data were treated qualitatively, through content analysis (Bardin, 2011), focusing on engagement, autonomy, necessary pedagogical help and use of phonological awareness. The numerical records produced manually (hits and misses by activity) were allocated in simple tabulations to allow descriptive analysis.

2.4 ETHICAL ASPECTS

The study was carried out in accordance with the general principles of Resolution No. 466/2012 of the National Health Council, particularly regarding confidentiality, anonymity and free consent. The project was endorsed by the Ethics Research Committee of the Federal Institute of Santa Catarina (IFC).

3 RESULTS AND DISCUSSION

3.1 EVIDENCE OF PERFORMANCE OBSERVED DURING THE USE OF THE TOOL

During the workshops, it was possible to observe a progressive improvement in the accuracy and fluidity in the performance of the task by the students. Although the tool did not store data automatically, the researchers manually recorded the successes and errors of each student in each activity, allowing them to identify patterns of evolution.

The descriptive analysis of these records showed that:

- students started to make **fewer syllable identification errors**, especially in the most common combinations (ba, ca, la, pra, tra);
- there was a **visible reduction in the teacher's need for mediation**, as immediate sound feedback allowed self-correction;
- students demonstrated greater speed in decision-making, even without formal automatic measurement;

- Three students initially classified as "with high phonological deficit" began to identify simple syllables with greater confidence.

These results were organized in simple tables based on the researchers' records, allowing them to monitor the performance throughout the workshops.

Table 1

Participant A1

PRETEST	ACTIVITY - A	ACTIVITY - B
READING AND AWARENESS OF RHYMES	WORD SYLLABLE RECOGNITION	RECOGNITION OF WORD PHONEMES
Rhyming AWARENESS	SLABIC AWARENESS	PHONEMIC AWARENESS
1 - Who lives in Caco's house?		
A: Pre-test: Magco	MA-CA-CO	/m/a/c/a/c/o/
A: Post-test: APE	MA-CA-CO	M/A/C/A/C/O
2 - Who lives in the beautiful house?		
A: Pre-test: Beautiful	CABOITO	c/a/b/o/i/t/o
A: Post-test: CABRITA	CA- BR - ITA	C/A/B/R/I/T/A
3- Who lives in the cement house?		
A: Pre-test: cement	JU O	Did not complete
A: Post-test: DONKEY	JU-ME-NTO	J/U/M/E/N/T/O

Source: the authors (2025)

Table 1 shows the evolution of some activities of participant A1, a 9-year-old child. She is in the third year of elementary school and has speech problems. It is in the syllabic phase with sound value in the literacy process. This level of development is when the child is able to give sounds to syllables, but does not yet have a total correspondence between grapheme and phoneme. This shows that it needs mediated activities to help phonological awareness and the structuring of the writing system little by little.

3.2 QUALITATIVE ANALYSIS OF INTERACTIONS

Content analysis revealed three emerging core categories:

1. Engagement and motivation: students demonstrated greater willingness to repeat the activities and satisfaction with the sound feedback of the tool, perceived as a "game of letters";
2. Autonomy and self-correction: immediate feedback reduced teacher dependence and favored self-correction of spelling errors;

3. Pedagogical mediation: the role of the literacy teacher remained essential to guide the didactic sequence, reinforcing the complementary character of technology.

Direct observation showed that there was an increase in participation and attention maintained during activities, especially among children who had more difficulties at the beginning. These results confirm the researchers' hypothesis, a principle also defended by Felipe (2015), that linguistic and phonological mediation, when supported by technological resources, increases the chances of meaningful learning.

3.3 SYNTHESIS AND EDUCATIONAL IMPLICATIONS

The results show that the wireless technology used was a good cognitive and pedagogical mediator, bringing clear gains in student performance and motivation. By combining physical and computational interactivity, the system increases the chances of digital and educational inclusion in literacy situations for children with problems learning to write. These findings confirm the central hypothesis that tangible interaction, mediated by an accessible and responsive computer system, enhances the literacy process. The research reinforces the need for continuing teacher training focused on the use of assistive technologies and intelligent tools in the school context.

3.4 ANALYSIS OF THE INTERACTION AND USABILITY OF THE TOOL

The responsiveness, clarity and level of engagement generated by the tool's physical interface, which consists of RFID cards and sound feedback, were evaluated. It was found that the use of multimodal stimuli (tactile, auditory and visual) prolonged the time students dedicate to activities and decreased distraction behaviors. This evidence supports the usability principles presented by Norman (2006) and Papert (1980), emphasizing that tangible design enriches active and exploratory learning.

In order for students with different cognitive and motor needs to be able to use the tools in an intuitive and motivating way, it is essential that assistive technologies are easy to use. Recent research suggests that engagement increases when the interface provides instant feedback and various forms of sensory stimulation, expanding student autonomy and reducing the need for constant teacher intervention (Reinert Junior; Coutinho, 2024). Therefore, usability should be evaluated not only by ease of use, but also by the ability to maintain student engagement and interest in inclusive environments.

3.5 COGNITION AND MEDIATION IN THE PROCESS OF TECHNOLOGY-ASSISTED LITERACY

The wireless computational tool was incorporated as a symbolic mediator of the process of internalization of grapheme-phoneme relations. Technology, by offering, from immediate self-correction, the Zone of Imminent Development (Prestes; Tunes, 2022), linked to the transition between the potential and actual level of performance, does not replace the role of the teacher, but expands the necessary conditions for individualized learning.

In addition, technological mediation increases the cognitive repertoire of students by offering interactive experiences that consolidate essential skills such as phonological awareness and visual recognition of writing symbols. Mediation based on technological resources allows each student to advance at their own pace, favoring a more inclusive and personalized literacy (Abrão; Del Pino, 2016). Teacher monitoring continues to be very important to ensure that dialogued mediation helps to overcome specific difficulties and to promote the meaningful use of technology in the educational process.

3.6 TEACHER PERCEPTIONS AND RECONFIGURATION OF LITERACY PRACTICE

The reports of the teachers' narratives highlighted the relevance of diversifying teaching strategies and increasing the engagement of the tool by students. Linked to this, teachers highlighted the ease of use and potential for adaptation to the students' ability to understand. However, the need for continuing education in educational technologies was also immediately pointed out, as reiterated by Felipe (2015), who argues that (psycho)linguistic and technological competence is essential for the very performance committed to training. In addition, recent evidence proves that, although assistive technologies mean a transformational potential, this breadth depends on the institutional offer of continuing technical and pedagogical training.

According to Cavalcante, Marques and Nunes (2024), training results in greater security for pedagogical use, which translates into greater investment and quality in the mediation of learning and school inclusion. The challenge is to extend this support to the entire education network, minimizing inequality in the promotion of these technologies.

3.7 INCLUSION AND DIGITAL EQUITY IN LITERACY

The tool was created using accessible components and open architecture, making it possible to use it in schools with limited budgets. This indicates that it can be a beneficial

technology for all, promoting equal access to learning experiences through technology. The research shows that the popularization of technologies for teaching depends on training and infrastructure policies that ensure pedagogical and technical sustainability.

In addition, digital equality in literacy needs strong public policies that guarantee not only the distribution of devices, but also quality internet access, adequate infrastructure, and technical support in schools (Silva *et al.*, 2025a). Without these investments, new technologies can increase existing differences rather than diminish them. Digital literacy for all is therefore also a social justice issue that needs the union between government, business and school.

4 FUTURE PERSPECTIVES

The tool's data collection structure allows for the integration of artificial intelligence (AI) models, which can recognize error patterns and suggest personalized interventions. Future versions may include voice recognition modules and algorithms that suggest activities, thus expanding the possibilities of early diagnosis and personalization of teaching.

In this context, adding AI to the literacy process not only improves the monitoring of individual learning, but also makes the chances of quick and customized interventions that are very important to deal with the various challenges easier (Azambuja; Silva, 2024). This combination of techniques can help in a more active, interesting and student-focused literacy, respecting their own way and helping in effective digital inclusion.

5 CONCLUSION

The analysis of the highlighted items shows that assistive technology, especially when used with tangible interfaces and multimodal feedback, increases active learning, engagement, and autonomy of students with literacy difficulties. Technological mediation, together with pedagogical practices, strengthens individualized learning, without replacing the role of the teacher, whose continuous technical and pedagogical training is essential to maximize the benefits of technology.

Digital equity emerges as a structural challenge that must be addressed through integrated public policies to ensure access, infrastructure, and training. Finally, future perspectives show that AI will be a great ally to personalize teaching, make more accurate diagnoses, and increase educational inclusion.

These findings underscore the importance of coordinated investment in technology, training, and inclusive policies to truly change literacy processes in Brazil, guaranteeing the broad right to education for all.

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**MARKETING AND ADVERTISING STRATEGIES FOR THE LAUNCH OF AN
ECO-FRIENDLY PAINT MADE FROM CRYSTAL PET: THE BIOPINT CASE**

**ESTRATÉGIAS MERCADOLÓGICAS E PUBLICITÁRIAS PARA O
LANÇAMENTO DE UMA TINTA ECOLÓGICA À BASE DE PET CRISTAL: O
CASO BIOPINT**

**ESTRATEGIAS MERCADOLÓGICAS Y PUBLICITARIAS PARA EL
LANZAMIENTO DE UNA PINTURA ECOLÓGICA A BASE DE PET CRISTAL:
CASO BIOPINT**

 <https://doi.org/10.56238/sevened2025.036-072>

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ABSTRACT

The present article analyzes the influence of an ecological advertising campaign on the acceptance of the sustainable paint BioPint, produced using crystal PET waste and recycled Styrofoam in the communities of Ixcaquixtla and Tepexi de Rodríguez, Puebla. The study was structured with a descriptive and mixed approach, using surveys and interviews conducted with residents of both municipalities. The results showed a high willingness to consume ecological products, growing interest in recycling, and a positive evaluation of the advertising message. The BioPint proposal was perceived as innovative, useful, and representative of the community effort. The analysis demonstrated that sustainable marketing can transform purchasing attitudes by linking environmental awareness with local development. The research concludes that combining environmental education, communicative transparency, and responsible production strengthens consumer trust and promotes the adoption of green alternatives in rural contexts.

Keywords: Marketing and Advertising Strategies. Ecological Paint. Crystal PET. Biopint. Sustainable Marketing.

RESUMO

O presente artigo analisa a influência de uma campanha publicitária ecológica na aceitação da pintura sustentável BioPint, elaborada com resíduos de PET cristal e isopor reciclado, dentro das comunidades de Ixcaquixtla e Tepexi de Rodríguez, Puebla. O estudo foi

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estruturado com abordagem descritiva e mista, por meio de questionários e entrevistas aplicados a habitantes de ambos os municípios. Os resultados mostraram alta disposição para o consumo de produtos ecológicos, interesse crescente pelo reciclagem e uma avaliação positiva da mensagem publicitária. A proposta da BioPint foi percebida como inovadora, útil e representativa do esforço comunitário. A análise permitiu demonstrar que o marketing sustentável pode transformar atitudes de compra ao vincular a conscientização ambiental ao desenvolvimento local. A pesquisa conclui que a combinação de educação ambiental, transparência comunicativa e produção responsável fortalece a confiança do consumidor e impulsiona a adoção de alternativas verdes em contextos rurais.

Palavras-chave: Estratégias Mercadológicas e Publicitárias. Pintura Ecológica. PET Cristal. Biopint. Marketing Sustentável.

RESUMEN

El presente artículo analiza la influencia de una campaña publicitaria ecológica en la aceptación de la pintura sustentable BioPint, elaborada con residuos de PET cristal y unicel reciclado dentro de las comunidades de Ixcaquixtla y Tepexi de Rodríguez, Puebla. El estudio se estructuró con enfoque descriptivo y mixto, mediante encuestas y entrevistas aplicadas a habitantes de ambos municipios. Los resultados mostraron alta disposición hacia el consumo de productos ecológicos, interés creciente por el reciclaje y valoración positiva del mensaje publicitario. La propuesta de BioPint fue percibida como innovadora, útil y representativa del esfuerzo comunitario. El análisis permitió demostrar que la mercadotecnia sustentable puede transformar actitudes de compra al vincular conciencia ambiental con desarrollo local. La investigación concluye que la combinación de educación ambiental, transparencia comunicativa y producción responsable fortalece la confianza del consumidor e impulsa la adopción de alternativas verdes en contextos rurales.

Palabras clave: Estrategias Mercadológicas y Publicitarias. Pintura Ecológica. PET Cristal. Biopint. Marketing Sostenible.

1 INTRODUCTION

In recent decades, humanity has experienced an unprecedented industrial expansion that has increased production, transformed consumption habits, and modified the relationship with the natural environment. Although economic progress was evident, the environmental cost proved unsustainable: pollution, accumulation of plastic waste, deforestation, resource depletion, loss of biodiversity.

The United Nations Environment Programme (UNEP, 2023) estimates that more than 400 million tonnes of plastic are generated per year, with recycling of less than 10%. Mexico contributes more than six million tons, ranking among the fifteen countries with the highest volume of waste. In Puebla, SEMARNAT (2024) reports that only three out of ten PET bottles are recycled; the rest remains in landfills or is incinerated, releasing toxic gases.

Against this backdrop, BioPint emerges, an ecological paint made from crushed glass PET waste along with recycled Styrofoam scraps. The project seeks to reduce the environmental impact generated by the use of plastics and offer a sustainable option within the domestic paint market. The initiative was born at the Higher Technological Institute of Tepexi de Rodríguez, where a group of young people identified the need to take advantage of recyclable materials to create useful products.

This article analyzes the BioPint case from a marketing approach, with the purpose of evaluating the effectiveness of its advertising strategies, considering the relationship between ecological communication, environmental education, and consumer behavior. The research aims to demonstrate that a sustainable strategy based on authentic messages can strengthen public trust, modify perceptions, and encourage responsible purchasing decisions.

1.1 PROJECT OVERVIEW

BioPint represents an entrepreneurial proposal focused on ecological innovation. It was created at the Higher Technological Institute of Tepexi de Rodríguez, in Puebla, with the purpose of transforming crushed crystal PET waste together with recycled Styrofoam into ecological white paint. The result combines quality, durability, low cost, composition free of toxic solvents.

The product is made through controlled recycling that reduces the use of petroleum-based compounds. Each liter of paint uses about 200 grams of PET, equivalent to ten plastic

bottles. With a monthly production of 10,000 liters, the positive environmental impact implies the reduction of more than 100,000 discarded containers.

BioPint is aimed at consumers aged 33 to 55 with an interest in improving their home, average purchasing power, willingness to try economical alternatives. The distribution areas include the municipal capitals of Tepexi de Rodríguez and Ixcaquixtla, where the market is dominated by traditional brands such as Comex, Pintumex and Sayer Lack. Its value proposition stands out for its ecological character, competitive cost, social commitment, and local origin.

The project is based on the circular economy. Each stage seeks to reduce waste, optimize resources, and strengthen the environmental education of the community. The process includes collection, cleaning, crushing, mixing, packaging, marketing. The entire cycle takes place in the region, which generates employment, promotes ecological awareness through practice.

1.2 STATEMENT OF THE PROBLEM

Plastic pollution is one of the greatest environmental challenges of the 21st century. According to the Organisation for Economic Co-operation and Development (OECD, 2023), only 9% of the world's plastic receives recycling treatment; the rest remains in landfills or contaminates rivers, lakes, coasts, agricultural soils, affecting flora, fauna, and human health.

In Mexico, the National Association of Plastic Industries (ANIPAC, 2024) estimates a production of more than eight million tons per year, with recovery of less than two million. In rural municipalities, the situation is aggravated by the absence of collection programs, environmental education, and specialized infrastructure. Waste accumulates in public spaces, ravines, neighborhood roads, deteriorating the urban image, affecting air quality.

Recycling represents a viable alternative to reduce environmental impact, although it faces sociocultural barriers. A part of consumers are wary of green products. The Kantar Worldpanel study (2024) indicates that only 38% of Mexicans consider sustainable brands trustworthy; Most associate "green" with high prices or less durability.

At BioPint, the difficulty encompasses production and recognition within the local market. The community of Tepexi de Rodríguez has little environmental information; Consumers prioritize immediate cost, without valuing ecological impact, which limits the adoption of sustainable alternatives.

2 OBJECTIVES

2.1 GENERAL OBJECTIVE

Design a sustainable marketing strategy with the purpose of positioning BioPint ecological paint within the local market through advertising actions that promote environmental education and strengthen the positive perception of the consumer.

2.2 SPECIFIC OBJECTIVES

1. Analyze the socioeconomic environment of the target communities to identify factors that influence the purchase decision.
2. To evaluate the consumer's perception of organic products within the regional market.
3. Design an advertising campaign based on the AIDA model to capture attention, arouse interest, generate desire, stimulate action.
4. Formulate sustainable communication strategies according to the cultural profile of the target audience.
5. Measure results through indicators of recall, credibility, and purchase preference.

2.3 HYPOTHESES AND ASSUMPTIONS

The research is based on the principle that ecological advertising has the capacity to transform perceptions and modify consumption habits when the message is authentically constructed.

2.4 NULL HYPOTHESIS (H_0)

The application of sustainable marketing strategies does not significantly influence consumer acceptance of BioPint ecological paint.

2.5 ALTERNATE HYPOTHESIS (H_1)

The application of sustainable marketing strategies significantly influences consumer acceptance of BioPint ecological paint.

2.6 ASSUMPTIONS

- Consumers place value on brands that demonstrate real environmental commitment.
- Emotional communication increases confidence in new products.
- Ecological knowledge has a direct influence on the willingness to buy.

- Community identity strengthens the credibility of local projects.

3 JUSTIFICATION

The study has environmental, economic, and social relevance. In the environmental field, BioPint reduces the accumulation of plastic waste by reusing PET glass. Each liter of paint uses about 200 grams of recycled plastic, equivalent to ten soda containers. With a monthly production of 10,000 liters, the positive impact exceeds 100,000 bottles recovered.

From an economic perspective, the Mexican paint market exceeds 2,500 million dollars per year, according to the National Chamber of the Paint and Ink Industry (2023). Less than 7% of national companies offer organic products. BioPint's proposal fills this gap through a sustainable, accessible option, aligned with the circular economy.

In the social aspect, the project promotes citizen participation, generates local employment, strengthens the culture of recycling. The process involves inhabitants of the region in tasks of collection, cleaning, crushing, formulation, packaging, which distributes benefits within the community.

The research is justified in the marketing field because it shows that sustainability can become a competitive advantage. According to Kotler (2022), brands with a purpose achieve greater loyalty, with an increase of approximately 35% compared to companies focused on functional attributes.

BioPint represents an example of responsible innovation, capable of combining profitability, positive environmental impact, social commitment. The research provides an academic perspective by integrating sustainable marketing, ecological advertising, circular economy within the Mexican rural context, in addition to serving as a model for future ventures.

4 THEORETICAL FRAMEWORK

4.1 HISTORICAL EVOLUTION OF PAINTINGS

The use of color as a protective and decorative element has accompanied humanity since ancient times. The first pigments applied to rock date back more than 30,000 years; Prehistoric groups mixed clays, charcoal, pulverized minerals, animal fat to fix the color in stone, wood, or bone. In ancient civilizations, the pigment acquired symbolic value. In Egypt, blue was related to aquatic divinities; red represented vital energy. The Romans used mixtures of lime with metal oxides to protect walls, an early form of waterproofing.

With the Renaissance, linseed oil was incorporated as a binder. Since the eighteenth century, industrial development transformed pigment production with petroleum-based chemical processes. This evolution increased the availability of the product, although it introduced toxic compounds.

The growth of modern construction intensified the consumption of coatings. According to the International Council on Paints and Inks (2024), global consumption exceeds 40 billion liters per year with a growth rate of close to 4%. However, traditional production generates emissions, hazardous waste, and high energy expenditure.

4.2 BACKGROUND OF ECOLOGICAL PAINTS

The first organic formulations emerged in Europe during the 1980s. Swedish research showed that replacing solvents with water reduced volatile organic compounds (VOCs) by up to 90%. Beckers Paints introduced a line certified by the NORDIC SWAN label, a symbol of environmental compliance.

In 1990, Benjamin Moore launched the Natura line in North America, free of aromatic solvents. In Mexico, interest appeared in the late 1990s, although the lack of tax incentives limited its development. The global market for eco-friendly paints exceeds \$9 billion with a projected growth of 8% per year, according to Grand View Research (2024). These formulations employ vegetable oils, natural resins, mineral pigments, recycled plastics, biodegradable binders.

BioPint embraces this trend by integrating shredded PET with Styrofoam waste, partially replacing petrochemical polymers. The final blend has low VOC level, uniform texture, durable finish.

4.3 TECHNICAL CLASSIFICATION OF PAINTS

Paint is defined as a mixture of pigments, binders, solvents, additives. Its classification depends on the base, finish, use, chemical composition:

- Water-based paints: use water as a solvent, have low toxicity, fast drying.
- Oil paints: use vegetable or synthetic oils, generate a resistant protective layer, release polluting compounds.
- Synthetic paints: made with plastic resins derived from petroleum, they offer high durability and high environmental impact.

- Ecological paints: they use renewable or recycled materials, reduce emissions, facilitate cleaning, biodegradation.

BioPint's product belongs to the category of eco-friendly recycled base paint, with components derived from PET, glass and processed Styrofoam.

4.4 ENVIRONMENTAL STANDARDS AND REGULATIONS

The production of eco-friendly paints is governed by international standards. ISO 14001 establishes environmental management guidelines to reduce waste and control emissions. EPA sets VOC limits on coatings. In Mexico, NOM-123-SEMARNAT-1998 regulates VOC emissions during the manufacture of paints; NMX-AA-162-SCFI-2012 defines criteria for products with recycled content. Meeting these standards is an essential requirement for access to sustainable markets. BioPint applies equivalent principles through controlled artisanal processes that minimize the use of solvents.

4.5 FUNDAMENTALS OF GREEN MARKETING

Green marketing is a strategy aimed at satisfying consumer needs through environmentally responsible practices. According to Peattie (2001), this approach involves redesigning the entire business system. Production, distribution, communication and after-sales decisions must be aligned with environmental conservation.

Global interest in responsible consumption increased steadily. The Global Sustainability Barometer (2023) shows that seventy percent of consumers prefer brands with verifiable environmental commitments. However, only thirty percent fully trust sustainability-related advertising information. This credibility gap requires transparent communication strategies.

BioPint is inserted within this logic by promoting authenticity, social commitment and coherence between message and practice.

4.6 SUSTAINABLE ADVERTISING

Sustainable advertising is conceived as a responsible communication process that seeks to balance commercial benefit with environmental education. According to Uceda García (2008), the effective ecological message must generate collective awareness, not just the desire to buy.

Visual resources, language, emotional tone and media support must convey ethical coherence. A sustainable campaign informs, persuades, educates, without resorting to exaggeration or false promises.

BioPint uses visual communication strategies based on neutral colors, short messages and local testimonials. That combination strengthens trust and reinforces the emotional bond with the audience.

4.7 ECO-FRIENDLY CONSUMER BEHAVIOR

The organic consumer represents a central axis of today's marketing. Their behavior arises from a cultural change motivated by environmental crises, technological advances, and greater access to information. Ottman (2011) defines it as one that incorporates ethical values into its economic decisions to reduce its environmental impact and support collective causes.

This consumer combines environmental awareness, proactive attitude, and consistent behavior. The green gap persists, because although 78% of Mexicans prefer organic products, only 42% buy sustainably (NielsenIQ, 2023). Psychological, social, and cultural factors determine their decisions, with the perception of personal benefit predominating over collective concern.

PROFECO (2024) reports greater sustainable adoption in consumers with secondary education and urban areas. In rural areas, the lack of knowledge about terms such as biodegradable or recycled limits the acceptance of green proposals.

BioPint faces that challenge. Their strategy is based on simple communication, clear language, concrete examples. The idea of "giving new life to plastic" generates immediate emotional connection.

The VALS model places the buyer of BioPint between believers and compliers, with community attachment, practical orientation, and a disposition towards projects with social value.

4.8 CORPORATE SOCIAL RESPONSIBILITY

Corporate social responsibility (CSR) is a voluntary commitment that integrates ethics, sustainability and respect for stakeholders. Carroll (1999) described it through a pyramid composed of four levels: economic, legal, ethical, and philanthropic compliance.

Organizations that reach the top levels transcend profitability, consolidate reputation, strengthen legitimacy.

In the Latin American context, CSR has been linked to the search for social trust. ECLAC (2023) argues that companies with active sustainability programs manage to increase their brand value by up to forty-six percent. In addition, environmental commitment generates competitive advantages by reducing operating costs and improving the relationship with local authorities.

In Mexico, the Association of Socially Responsible Companies (2024) registers more than one thousand five hundred certified organizations, although most belong to industrial or financial sectors. Few initiatives come from rural micro-enterprises, which makes the BioPint project unique.

Social responsibility within BioPint is manifested in various practices: plastic waste collection within the community, training on recycling, female labor inclusion, partial reinvestment of profits in cleaning campaigns. The project promotes environmental co-responsibility through example. This coherence between discourse and action strengthens its market legitimacy.

From a marketing perspective, CSR translates into reputation. Kotler (2022) states that companies perceived as responsible achieve loyalty levels up to thirty-five percent higher than conventional ones. Trust becomes an intangible resource that increases brand value and amplifies word-of-mouth recommendation.

4.9 GREEN BRANDING AND ECOLOGICAL POSITIONING

Corporate social responsibility (CSR) represents a voluntary commitment based on ethics, sustainability, respect for stakeholders. Carroll (1999) structured it into a pyramid with four levels: economic, legal, ethical, philanthropic. Organizations that reach higher levels transcend profitability, consolidate reputation, strengthen legitimacy.

In Latin America, CSR is linked to social trust. According to ECLAC (2023), companies with sustainable programs increase their brand value by up to 46%. Environmental commitment provides competitive advantages by reducing operating costs, improving ties with local authorities.

In Mexico, the Association of Socially Responsible Companies (2024) registers more than one thousand five hundred certified organizations, concentrated in industrial or financial sectors. Few come from rural micro-enterprises, which makes BioPint a unique case.

BioPint demonstrates its CSR through plastic waste collection, community training, female labor inclusion, and reinvestment of profits in clean-up campaigns. This coherence between discourse and action reinforces its market legitimacy.

From a marketing perspective, CSR is reflected in reputation. Kotler (2022) states that responsible companies achieve up to 35% higher loyalty. Trust becomes an intangible resource that increases brand value, enhances word-of-mouth recommendation.

4.10 EMOTIONAL COMMUNICATION WITHIN SUSTAINABLE MARKETING

Sustainable marketing uses emotion as a vehicle of persuasion. Kotler (2019) highlights that emotionally charged messages achieve greater recall, generate empathy, and modify attitudes. Emotion acts as a bridge between rationality and action.

The human brain processes visual stimuli faster than logical arguments. For this reason, environmental communication requires symbolic images that awaken sensitivity. A photograph of clean oceans produces greater impact than a list of technical data.

BioPint implements emotional communication based on three axes: hope, community pride, shared responsibility. Each ad highlights tangible benefits of the product along with testimonials from neighbors who collaborate in the collection of plastic. This strategy generates collective identification and transforms the act of buying paint into an ecological contribution.

Batra and Ray (2020) point out that emotion increases willingness to pay up to twenty percent when the message conveys social purpose. In the case of BioPint, emotional connection becomes an essential tool to overcome cognitive barriers and achieve differentiation from industrial brands.

4.11 LATIN AMERICAN PERSPECTIVE ON RESPONSIBLE CONSUMPTION

Responsible consumption in Latin America presents an uneven development. Economic crises, educational levels and the structure of markets have a direct influence on the adoption of sustainable practices. ECLAC (2023) recognizes an average growth of seven percent per year in the demand for green products within the region, although mistrust of the authenticity of brands persists.

Brazil, Chile and Colombia lead the organic market with public policies focused on environmental certifications. Mexico is making progress through recycling programs

promoted by universities and civil associations, although the lack of tax incentives limits the expansion of green microenterprises.

The Latin American public values the social component as much as the ecological one. According to Latinobarómetro (2024), sixty-three percent of consumers prefer products that benefit local communities. This cultural characteristic favors projects such as BioPint, which integrate environmental benefits with direct social impact.

The phenomenon of conscious consumption acquires relevance in young generations. The so-called centennials show sensitivity to environmental causes, but demand digital transparency. For this reason, Latin American brands need to strengthen communication channels through social networks with verifiable information and real testimonials.

4.12 THEORETICAL APPLICATION TO THE BIOPINT CASE

The application of the theoretical foundations allows us to understand the marketing structure of BioPint. The project is based on three conceptual pillars: green marketing, social responsibility, emotional communication. His proposal coincides with the principle of sustainable development set out in the Brundtland Report (1987), aimed at satisfying present needs without compromising future resources.

The advertising campaign employs the AIDA model, which organizes the consumer's response into four stages. Attention is obtained through visual resources that highlight the recycled origin of the product. The interest arises when presenting data on plastic pollution. Desire is built through the emotional connection with the producing community. The action is driven by local promotions that incentivize the initial purchase.

Positioning is strengthened through proximity strategies. BioPint participates in school fairs, recycling workshops, community events. This direct interaction generates trust, a determining factor in rural contexts with limited digital penetration.

From a theoretical perspective, the case demonstrates that sustainable marketing can be applied in microenterprises with low budgets. Ecological purpose, ethical coherence, and social participation function as sources of authentic differentiation. BioPint exemplifies a replicable local innovation model, whose success depends on maintaining a balance between environmental message, product quality, and collective benefit.

5 CONCEPTUAL FRAMEWORK

5.1 PAINTING CONCEPT

Paint is one of the oldest materials created by humans. Its initial function was symbolic or ritual, as shown by the cave paintings of Lascaux. Over time, it served to protect surfaces, thermally insulate, improve aesthetics.

Technically, it is a mixture of pigments, binders, solvents that when applied form a protective film. Marrufo (2020) describes it as a colloidal system whose performance depends on the chemical interaction of its components.

The global market exceeds 170 billion dollars annually according to Statista (2024). This sector generates a high environmental impact due to volatile organic compounds and heavy metals. In Mexico, more than 850 thousand tons are produced each year according to the National Association of Paint and Ink Manufacturers (2024).

BioPint addresses this situation through ecological paint made with PET and recycled Styrofoam, reducing plastic pollution, petrochemical dependence and integrating technical innovation with environmental commitment.

5.2 ESSENTIAL COMPONENTS

The performance of a paint depends on four elements: pigments, binders, solvents, additives.

Pigments provide color, opacity, resistance. They are classified as natural or synthetic; metal waste is polluting. BioPint takes advantage of the white tone of PET glass, avoiding toxic pigments.

The binder binds particles together and forms an adherent film. Common resins come from petroleum. BioPint replaces them with recycled Styrofoam polymers, reducing environmental impact.

The solvent regulates viscosity and facilitates application. Instead of harmful organic solvents, BioPint uses purified water, ensuring safety and zero VOC emissions.

Additives improve shine, durability, drying, resistance. Natural compounds without heavy metals are used in organic formulas.

Grand View Research (2023) indicates that water-based paints account for 60% of global consumption. BioPint joins this trend with a biodegradable, harmless, local product.

5.3 TECHNICAL AND ENVIRONMENTAL CLASSIFICATION

Paints can be classified according to chemical composition, type of application or environmental impact. The technical classification distinguishes water, oil, epoxy, acrylic or vinyl formulations. Each type is adapted to specific surface and climate conditions.

The environmental criterion differentiates three main categories:

- Conventional paints, which contain aromatic solvents and metallic pigments.
- Low-VOC paints, with reduced emissions but still based on petroleum derivatives.
- Eco-friendly paints, completely free of toxins and made with biodegradable or recycled components.

According to Allied Market Research (2024), the market for ecological paints is growing at a rate of more than six percent per year, driven by emission reduction policies and environmental certification programs.

In Latin America, the consumption of sustainable paints still accounts for less than five percent of total coatings, although forecasts point to steady growth. Mexico participates with an approximate production of 120 thousand tons per year of water-based coatings.

BioPint is part of this emerging trend. Its product not only replaces polluting materials, but also incorporates the concept of circular economy. Each litre produced avoids the generation of approximately two hundred grams of plastic waste, thus contributing to national waste reduction targets.

5.4 ECO-FRIENDLY PAINT CONCEPT

Eco-friendly paint arises as a response to the need to reduce the environmental impact caused by petrochemical substances. Grand View Research (2024) defines it as a mixture free of heavy metals, with a water-based basis and biodegradable components.

Its purpose is to preserve the protective function of the coating, reduce risks to human health, reduce carbon footprint, and ensure indoor safety. The development began in Europe during the 1990s with standards such as ISO 14024, focused on eco-labeling. In Mexico, adoption is progressing slowly, although demand is growing steadily in schools, hospitals, and homes.

The INECC (2024) calculates that solvents in traditional coatings generate five hundred thousand tons of VOCs per year, an alarming figure in the face of urban pollution.

BioPint represents a sustainable local alternative. Its production uses low-energy consumption tools, manual recycling processes, community employment. Each package reflects green technology, environmental education, social entrepreneurship.

5.5 RECYCLING CONCEPT

Recycling is one of the pillars of sustainable development. SEMARNAT (2024) defines it as the process by which waste is transformed into useful inputs through collection, separation, cleaning, and revaluation.

Globally, the production of plastics exceeds 400 million tons per year, according to the UN Environment (2023), of which less than 10% is effectively recycled. In Mexico, about eight million tons are generated annually, equivalent to more than six hundred bottles per inhabitant.

PET accounts for around 40% of all recyclable plastics due to its strength and ease of processing. Its recovery avoids the emission of three kilograms of carbon dioxide for every kilogram recycled and reduces energy consumption by 60%.

On the other hand, Styrofoam (expanded polystyrene) presents a greater challenge due to its low density and light volume. In the country, barely 3% of this waste is recycled, which causes accumulation in landfills and visual pollution.

BioPint turns that problem into opportunity by combining both materials to create a stable polymer base. The shredding of the PET and the incorporation of the pulverized Styrofoam generate a matrix with a uniform texture, suitable for domestic coatings.

This process promotes the circular economy by reducing waste, generating employment and promoting environmental education. In this sense, recycling transcends its traditional function to become an engine of economic and social transformation within the communities of Ixcaquixtla and Tepexi de Rodríguez.

5.6 CONCEPT OF SUSTAINABILITY

Sustainability is defined as the ability to meet present needs without compromising the ability of future generations to meet theirs. The concept was established in the Brundtland Report (1987), a document that marked the basis of modern environmental thinking. Its essence lies in the harmonization of three dimensions: economic growth, social justice and ecological balance.

In the business sphere, sustainability translates into production models that minimise environmental impact, promote energy efficiency and strengthen collective well-being. ECLAC (2024) states that companies that apply sustainable practices achieve average increases of 18 percent in productivity due to the reduction of waste and the saving of resources.

Sustainability is expressed through innovation, environmental education and community participation. It is not limited to the adoption of clean technologies, but involves cultural transformation. In industrialized countries, public policies encourage the transition to the low-carbon economy. In Latin America, progress is uneven, although there are community projects that demonstrate their viability.

BioPint embodies the principle of sustainability by combining ecological innovation with social commitment. Its production model uses low-consumption machinery, recycled inputs and local distribution, which reduces emissions. In addition, it generates jobs within the community and promotes environmental awareness through informative workshops. Each liter of paint manufactured symbolizes the convergence between efficiency, equity and environmental respect.

5.7 MARKETING CONCEPT

Marketing is the set of activities aimed at identifying needs, creating value and establishing satisfactory exchanges between organization and consumer. According to Kotler (2022), its objective is to generate lasting relationships based on trust, purpose and satisfaction.

The concept has evolved from simple promotion to comprehensive experience management. Modern marketing analyzes preferences, values, and behaviors to deliver meaningful solutions. Within the global context, consumers are looking for products that reflect personal identity and ethical coherence.

In Mexico, the Mexican Institute of Competitiveness (IMCO, 2023) highlights that 70 percent of consumers consider environmental responsibility a determining factor when choosing a brand. This paradigm shift forces companies to design communication strategies based on transparency.

BioPint uses marketing as an educational and social tool. The strategy is not focused on consumption, but on cultural transformation. The main message communicates that each purchase contributes to reducing plastic waste. That narrative generates local pride and a

sense of belonging. The consumer does not only acquire paint, but also active participation in an environmental cause.

Marketing then becomes a vehicle for change, capable of modifying habits, stimulating reflection and consolidating ecological identity.

5.8 GREEN MARKETING CONCEPT

Green marketing is defined as the application of environmental principles within the marketing process. Peattie (2001) describes it as the incorporation of respect for the environment in every decision related to product, price, place and promotion. This approach seeks compatibility between commercial success and ecological responsibility.

The growth of green marketing reflects a profound cultural shift. NielsenIQ (2023) reports that 73 percent of Latin American consumers prefer sustainable brands, although only 32 percent fully trust their messages. This difference shows the need for authenticity.

In Europe, the European Union regulates ecological communication through guidelines against greenwashing, a practice that consists of exaggerating environmental attributes. In Mexico, the Federal Consumer Protection Agency (PROFECO) has initiated information campaigns to prevent misleading advertising in this area.

Green marketing demands consistency. It is not enough to offer a recycled product; it is essential to demonstrate real impact. BioPint applies this principle by openly displaying its PET collection, crushing and mixing process. Transparency in communication generates trust, a fundamental element to achieve customer loyalty.

The differential value of BioPint lies in turning waste into opportunity. The consumer perceives authenticity, which reinforces the reputation and consolidates the positioning within the regional organic segment.

5.9 ECO-FRIENDLY ADVERTISING CONCEPT

Ecological advertising represents a form of communication aimed at promoting responsible attitudes towards the environment. Uceda García (2008) defines it as a strategy that educates, informs, and inspires through messages based on truth and scientific evidence.

Its purpose goes beyond selling products, as it seeks to raise environmental awareness. To achieve this, it resorts to positive narratives, images of hope and verifiable

data. Authenticity becomes its guiding principle, as a brand loses credibility when its speech contradicts its actions.

Globally, green advertising is growing at the pace of international climate commitments. Global Advertising Review (2024) estimates that more than 40% of current advertising campaigns include some ecological component; however, only a part meets verifiable ethical criteria.

In the Mexican context, environmental communication still faces challenges related to ecological literacy. Many consumers are unfamiliar with terms such as "carbon neutral" or "biodegradable", which forces them to design clear, simple and visually forceful messages.

BioPint responds to this need for transparency through campaigns that show the process of collecting bottles, crushing and mixing PET. That visual clarity reinforces the credibility of the message and reflects real engagement.

CIRCULAR ECONOMY CONCEPT

The circular economy proposes a production model that replaces the linear logic of extracting, manufacturing, discarding with a system of continuous use. The Ellen MacArthur Foundation (2023) estimates that its global application would reduce waste by 50% and use of virgin materials by 40% by 2050.

It is based on prolonging the life cycle through repair, reuse, recycling, redesign, in order to minimize waste and maximize value.

In Mexico, the National Program for the Circular Economy (2024) promotes recycling and ecodesign in SMEs, seeking to raise the national recovery rate to 35% in the next decade.

BioPint exemplifies this model: it transforms collected PET into paint, distributes it locally, and reincorporates empty containers into the process. This dynamic converts waste into resources, strengthens regional self-sufficiency, promotes environmental education, improves family economy, reinforces local identity.

6 METHODOLOGY

6.1 TYPE OF STUDY

The methodological design adopted corresponds to a descriptive study with a mixed approach, which combines quantitative and qualitative analysis. The choice of this type of research responds to the need to understand both the patterns of behavior of the organic consumer and the symbolic perceptions associated with the BioPint product.

The descriptive approach allows detailing the characteristics, attitudes and purchasing habits within the target audience, without manipulating variables. According to Hernández Sampieri (2022), this type of research seeks to specify properties of observable phenomena, in this case, the acceptance of an ecological paint within rural markets.

The quantitative component makes it easier to measure frequency, trend and consumer preference through structured surveys. The qualitative dimension adds depth to the analysis by incorporating testimonies, perceptions and motivations expressed in semi-structured interviews. The integration of both approaches offers a complete vision of the market phenomenon.

6.2 POPULATION OR UNIVERSE

The population under study is made up of the inhabitants of the municipal capitals of Ixcaquixtla and Tepexi de Rodríguez, Puebla, where the initial distribution of BioPint ecological paint is concentrated.

According to data from the National Institute of Statistics and Geography (INEGI, 2024), Ixcaquixtla has 9,863 inhabitants, while Tepexi de Rodríguez has 10,877 residents. Collectively, the universe amounts to 20,740 people.

The study focuses on the adult segment between 33 and 55 years of age, the range that concentrates the greatest decision-making power in the household. Within this group, 52 percent are women and 48 percent men, according to local estimates. Most belong to socioeconomic levels D and D+, which coincides with BioPint's target audience.

Knowledge of the population allows us to define segmentation strategies and adjust the advertising message according to the cultural, educational and economic conditions of the environment.

6.3 SAMPLE

The sample was selected using non-probabilistic convenience sampling, a technique recommended for research with limited resources or in communities with restricted access.

The sample size was calculated based on the formula for finite population:

$$n = \frac{N \times Z^2 \times p \times q}{E^2 (N-1) + Z^2 \times p \times q}$$

where N represents the size of the population (20,740), Z equals 1.96 for a 95% confidence level, p and q are assumed to be 0.5, and E corresponds to the margin of error of 7%.

The result obtained was 183 people, a figure that guarantees sufficient representativeness. Of that total, 95 correspond to Ixcaquixtla and 88 to Tepexi de Rodríguez.

The selection was made within public spaces, local businesses and private homes, prioritizing occupational and school diversity.

6.4 INSTRUMENT DESCRIPTION

The main collection instrument was a structured questionnaire of 25 items, designed to measure level of knowledge, environmental perception, purchase intention and disposition towards sustainable products.

Each item was formulated on a five-level Likert scale, ranging from "strongly disagree" to "strongly agree." The structure of the instrument was divided into five sections:

1. Sociodemographic data, to identify age, gender, occupation and monthly income.
2. Consumption habits, with questions about the frequency of buying paint and the criteria for choice.
3. Ecological knowledge, focused on notions about recycling, pollution and biodegradable materials.
4. Perception of BioPint, aimed at evaluating trust in the brand, interest in its composition and the valuation of the advertising message.
5. Willingness to purchase, focused on the probability of acquiring ecological paint at a competitive price.

The questionnaire was validated by three specialists in sustainable marketing from the Tecnológico Nacional de México, Tepexi de Rodríguez Campus, who reviewed the clarity, relevance and congruence of the questions. A pilot test was applied with 20 participants to verify understanding and response time.

The instrument achieved a Cronbach's alpha reliability index of 0.89, a value that indicates high internal consistency.

6.5 DATA COLLECTION PROCEDURE

Data collection was carried out during the months of May and June 2024. The process was developed in three consecutive stages: planning, application and systematization.

During the planning stage, authorization was obtained from municipal authorities and support from local businesses to carry out the surveys. In addition, a group of five student volunteers were trained in interview techniques and ethical management of information.

In the application stage, the questionnaires were distributed in person. Each participant received a brief explanation about the purpose of the study, ensuring anonymity and confidentiality. The average application required fifteen minutes per person.

Subsequently, in the systematization phase, the data were coded in spreadsheets. Incomplete records were eliminated to ensure statistical validity. The quantitative results were processed using the IBM SPSS Statistics version 26 program, while the qualitative testimonies were organized with the Atlas.ti software, in order to identify patterns of opinion.

The statistical analysis included frequency distribution, averages, simple correlations and graphical representation. Open-ended responses were interpreted using thematic analysis to identify recurring perceptions about the product.

The methodological procedure allowed obtaining reliable information on the degree of acceptance of the BioPint product, the level of ecological awareness of the inhabitants and the opportunities for improvement within the advertising campaign.

6.6 RESEARCH QUESTION

How does the implementation of an ecological advertising campaign influence the perception, acceptance and willingness to purchase of adult consumers in Ixcaquixtla and Tepexi de Rodríguez compared to the sustainable paint produced by BioPint?

6.7 HYPOTHESIS

The implementation of an ecological advertising campaign, with an educational and emotional focus, significantly increases the acceptance and preference for BioPint sustainable paint in the local market, by strengthening the symbolic association between responsible consumption and community well-being.

6.8 SPECIFIC CASES

- The positive perception of recycled products is related to greater purchase intention.
- The consumer's prior environmental knowledge conditions the brand's valuation.
- Clear and transparent visual communication increases trust and recognition.

6.9 STATISTICAL INFORMATION MANAGEMENT PROCEDURE

The information collected through the questionnaires applied to consumers in the municipal capitals of Ixcaquixtla and Tepexi de Rodríguez was manually organized in tables prepared in spreadsheets. Subsequently, we reviewed the consistency of the responses and removed incomplete or inconsistent records to ensure the reliability of the data.

Once the information base was refined, simple counts were carried out to obtain frequencies and percentages that would allow the identification of general trends around the level of knowledge, perception and acceptance of BioPint ecological paint.

To analyze the results, basic measures of central tendency (mean and mode) were calculated in order to determine the average degree of acceptance towards the product. In addition, cross-comparisons were made between variables such as age, educational level, and willingness to purchase, in order to detect possible differences in response patterns according to the respondent's profile.

Finally, the data were represented by descriptive graphs and tables, which facilitated the visual interpretation of the results and allowed the quantitative information to be contrasted with the qualitative observations derived from the spontaneous comments of the participants.

7 RESULTS

The application of the ecological advertising campaign aimed at adult consumers in Ixcaquixtla and Tepexi de Rodríguez made it possible to identify relevant changes in the perception, interest and willingness to buy sustainable paint made by BioPint. From the review of the public's reactions, the comments obtained during the promotional activities and the direct observation of the behavior of the participants, various findings were obtained that strengthen the understanding of the impact generated by the implemented strategy.

First, it was observed that messages focused on PET recycling and local environmental benefits aroused a high level of curiosity among the inhabitants, especially in people who did not know sustainable paint alternatives. The clarity of the message allowed most participants to associate the product with an eco-friendly solution that is accessible and relevant to their community.

In addition, the in-person demonstrations and educational narrative used in the campaign made it easier for consumers to understand the process of making the painting, which increased confidence in its quality and usefulness. This understanding was key for

many people to express a favorable attitude towards trying the product in their homes or businesses.

Another relevant result was the identification that consumers prefer to start with simple options before venturing into specialized colors. In this sense, the introduction with a basic shade was perceived as an advantage, as it facilitates the initial acceptance of the product by adapting to different types of homes and projects, allowing the introduction of ecological paint without generating barriers to choice.

Finally, during the interactions, it was detected that the campaign generated a positive perception of the environmental commitment of the BioPint project. This aspect strengthened the emotional connection with the brand and motivated various consumers to consider the purchase not only out of aesthetic necessity, but also as a way to contribute to the care of the community environment.

Together, these results show that the advertising campaign managed to position BioPint as a viable, reliable and environmentally responsible option for families in both municipal capitals, laying the foundations for a sustained growth in its acceptance and interest within the local market.

8 DISCUSSION

The results obtained confirm that BioPint ecological paint was well received by the population of Ixcaquixtla and Tepexi de Rodríguez, which shows that consumers begin to value sustainable alternatives when they are presented with clear and accessible information. The high willingness to purchase the product, even without knowing it beforehand, reflects an openness towards responsible consumption and an opportunity to strengthen environmental education in both communities.

Most of the participants expressed interest in local products, which shows that regional identity directly influences the purchase decision. This suggests that communication strategies should continue to highlight the community-based nature of the project and its contribution to the local economy.

Likewise, the acceptance of the slogan and visual elements of the campaign indicates that the ecological message was understood and valued. However, the results also show that the level of technical knowledge about recycling is still limited, so future campaigns could incorporate clearer and more practical educational content.

The difference observed between municipalities reinforces the importance of adapting dissemination strategies to the social and educational context of each area. While in Ixcaquixtla environmental awareness is more linked to formal education, in Tepexi the interest is mainly related to health and risk reduction by solvents.

Taken together, the findings demonstrate that BioPint not only managed to position itself as a viable eco-friendly paint, but also promoted a positive perception about recycling and sustainable development. This confirms that communication with an environmental focus can generate social and commercial impact, as long as the message is consistent with the values and needs of the community.

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**KNOWLEDGE SHARING AND THE SUSTAINABLE DEVELOPMENT GOALS: A
PERSPECTIVE FROM BRAZILIAN RESEARCHERS**

**COMPARTILHAMENTO DO CONHECIMENTO E OS OBJETIVOS DE
DESENVOLVIMENTO SUSTENTÁVEL: UM OLHAR DOS PESQUISADORES
BRASILEIROS**

**INTERCAMBIO DE CONOCIMIENTO Y LOS OBJETIVOS DE DESARROLLO
SOSTENIBLE: UNA PERSPECTIVA DE INVESTIGADORES BRASILEÑOS**

 <https://doi.org/10.56238/sevened2025.036-073>

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ABSTRACT

This article discusses the relevance of knowledge sharing in the context of the Sustainable Development Goals (SDGs) of the 2030 Agenda, focusing on the work of Brazilian researchers. The research is exploratory and qualitative in nature, based on theoretical contributions from Information Science, Interdisciplinarity, Administration, Sociology, and knowledge management. It analyzes how collaborative practices, open access policies, and research networks can strengthen the integration between science and sustainability. The theoretical results indicate that, although there have been significant advances in Open Science initiatives, cultural, institutional, and structural barriers persist that limit the effectiveness of scientific sharing in Brazil. It concludes that promoting knowledge sharing

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represents not only a strategy for innovation and equity, but also an ethical commitment to global sustainability.

Keywords: Knowledge Sharing. Open Science. Sustainable Development Goals. Informational Sustainability. Scientific Research.

RESUMO

O presente artigo discute a relevância do compartilhamento do conhecimento no contexto dos Objetivos de Desenvolvimento Sustentável (ODS) da Agenda 2030, com foco na atuação dos pesquisadores brasileiros. A pesquisa tem caráter exploratório e natureza qualitativa, fundamentando-se em aportes teóricos da Ciência da Informação, Interdisciplinaridade, Administração, Sociologia e da Gestão do Conhecimento. Analisa-se como práticas colaborativas, políticas de acesso aberto e redes de pesquisa podem fortalecer a integração entre ciência e sustentabilidade. Os resultados teóricos apontam que, embora haja avanços significativos em iniciativas de Ciência Aberta, ainda persistem barreiras culturais, institucionais e estruturais que limitam a efetividade do compartilhamento científico no Brasil. Conclui-se que promover o compartilhamento do conhecimento representa não apenas uma estratégia de inovação e equidade, mas também um compromisso ético com a sustentabilidade global.

Palavras-chave: Compartilhamento do Conhecimento. Ciência Aberta. Objetivos de Desenvolvimento Sustentável. Sustentabilidade Informacional. Pesquisa Científica.

RESUMEN

Este artículo analiza la relevancia del intercambio de conocimiento en el contexto de los Objetivos de Desarrollo Sostenible (ODS) de la Agenda 2030, centrándose en el trabajo de investigadores brasileños. La investigación, de carácter exploratorio y cualitativo, se basa en aportaciones teóricas de la Ciencia de la Información, la Interdisciplinariedad, la Administración, la Sociología y la gestión del conocimiento. Analiza cómo las prácticas colaborativas, las políticas de acceso abierto y las redes de investigación pueden fortalecer la integración entre ciencia y sostenibilidad. Los resultados teóricos indican que, si bien se han producido avances significativos en las iniciativas de Ciencia Abierta, persisten barreras culturales, institucionales y estructurales que limitan la eficacia del intercambio científico en Brasil. Concluye que promover el intercambio de conocimiento representa no solo una estrategia para la innovación y la equidad, sino también un compromiso ético con la sostenibilidad global.

Palabras clave: Intercambio de Conocimiento. Ciencia Abierta. Objetivos de Desarrollo Sostenible. Sostenibilidad de la Información. Investigación Científica.

1 INTRODUCTION

Knowledge sharing has emerged in recent decades as one of the fundamental pillars for building a more just, equitable, and sustainable society. As a consequence, the dissemination of scientific and technological information is essential as a central strategy for achieving the Sustainable Development Goals (SDGs) established by the United Nations 2030 Agenda (UN, 2015). In the Brazilian scenario, the performance of researchers and higher education institutions play a strategic role in the consolidation of collaborative practices that favor the democratization of knowledge and the advancement of open science (CNPq, 2025).

However, despite the progress achieved, knowledge sharing still faces significant obstacles related to academic culture, competitiveness for productivity metrics, and regional inequalities that impact the national scientific ecosystem. In this context, this study proposes a reflection on how Brazilian researchers have been contributing to the strengthening of informational sustainability and to the implementation of the SDGs based on knowledge-sharing practices.

Knowledge sharing is one of the fundamental pillars for advancing global sustainability and fulfilling the United Nations 2030 Agenda (UNESCO, 2025). Information and knowledge, when managed collaboratively, allow the creation of innovative and inclusive solutions to the economic, social, and environmental challenges that mark the twenty-first century (ZIVIANI *et al.*, 2023a; SAPIENZA & MATTAR, 2024; FONSECA *et al.*, 2022; SILVA; GOHR, 2025).

According to Davenport and Prusak (1998, p. 5), "knowledge is a fluid mixture of condensed experience, values and contextual information that provides a framework for the evaluation and incorporation of new experiences and information". In this way, sharing knowledge means expanding the collective capacity to understand and transform realities.

In the context of the Sustainable Development Goals (SDGs), knowledge sharing plays a strategic role, especially due to the emphasis given by the 2030 Agenda to the strengthening of global cooperation mechanisms and the exchange of scientific and technological knowledge as a basis for sustainable development. Thus, the dissemination of practices, technologies and information among different social actors enhances the efficiency of public policies and expands the reach of sustainable initiatives (UN, 2015).

Teaching and research institutions, in this context, play a central role in the creation of open and collaborative knowledge ecosystems. Valentim (2019) argues that knowledge management should be understood as a strategic practice that integrates processes of

identification, sharing, and application of organizational knowledge, contributing to innovation and social transformation, a concept confirmed by Correa, *et al*; (2019). This perspective dialogues with the principle of Open Science (CNPq, 2025), which seeks to democratize access to scientific production, strengthen collaborative networks, and ensure transparency in the use of research results (LEITE & COSTA, 2008).

In addition, knowledge management and sharing have direct implications for informational sustainability, a concept that refers to the ability of organizations to maintain continuous flows of reliable and accessible information to support sustainable decisions (ALVES & VALENTIM, 2022). The incorporation of sharing practices, especially mediated by digital technologies and innovation networks, favors the construction of a fairer, more participatory and resilient knowledge society.

Therefore, knowledge sharing is not limited to a technical action, but is consolidated as an ethical and political commitment to the principles of sustainable development (TERRA, 2015; UNESCO, 2017). Its effectiveness depends on the integration between public policies, organizational culture and technological infrastructure capable of promoting the open and responsible circulation of knowledge. As Nonaka and Takeuchi (1997) point out, knowledge grows when it is shared, becoming a dynamic resource that drives both organizational and social development.

In this sense, the alignment between knowledge sharing and the Sustainable Development Goals is essential for the consolidation of an economy based on learning, collaboration and innovation. The creation of environments that value the informational exchange and the collective production of knowledge represents not only a management strategy, but a decisive step towards a more sustainable and inclusive future.

2 THEORETICAL FOUNDATION

To structure the study, some chapters were organized that deal with the central theme of the study. Initially, KM and its organizational and scientific perspectives are discussed. Afterwards, a brief discussion was held on knowledge sharing and open science. The third point addresses the vision of Brazilian researchers and informational sustainability. The fourth topic addresses the challenges and opportunities for science sharing in Brazil.

2.1 KNOWLEDGE MANAGEMENT AND KNOWLEDGE SHARING: ORGANIZATIONAL AND SCIENTIFIC PERSPECTIVES

Knowledge management (KM) has become one of the strategic pillars of contemporary organizations, being fundamental for innovation, competitiveness and institutional sustainability (TOMAÉL & ALCARÁ, 2007; DUARTE, 2017; ZIVIANI, F. *et al.*, 2023a). According to Nonaka and Takeuchi (1997), knowledge is an organization's most valuable resource, as it enables the continuous creation of value and competitive differentiation. In this context, KM involves the set of processes that aim to identify, create, store, share and apply knowledge, in order to enhance organizational learning and collective performance.

According to Davenport and Prusak (1998, P. 5), knowledge management comprises "a systematic process of creating, sharing and using knowledge to achieve organizational objectives". This definition highlights the importance of sharing as an essential link between the production and application of knowledge. Knowledge, when it remains restricted to individuals or departments, loses a significant part of its strategic value, and sharing is the means that guarantees its circulation and transformation into innovation. As discussed by Ziviani *et al.* (2023b), knowledge sharing in knowledge-intensive organizations involves collaborative practices and institutional mechanisms that strengthen information management.

Organizational culture plays a central role in this process. According to Valentim (2008), KM depends on an environment that stimulates trust, collaboration and the exchange of knowledge among the members of the organization. The author argues that "knowledge management is only effective when the institutional culture favors practices of sharing and valuing information as an organizational asset" (VALENTIM, 2008, p. 47). This perspective reinforces the interdependence between human, technological, and structural factors in the success of KM initiatives.

In addition, knowledge sharing is a complex social process, influenced by individual and collective aspects. Terra (2005) highlights that sharing depends on mechanisms of incentive, trust and recognition, as well as technological infrastructures that facilitate access and dissemination of information. A relevant fact is that technology acts as support, but it is the collaborative organizational culture that defines the degree of effectiveness of the process, as stated (ZIVIANI *et al.*, 2023a). In this sense, it can be seen that "Sharing knowledge is a strategic element for the development of activities aimed at scientific research

and innovation in the academic or organizational environment." (ZIVIANI *et al.*, 2023, p. 420a).

In the context of information science, KM and knowledge sharing are understood as informational practices aimed at creating value and democratizing knowledge. According to Alvarenga Neto (2008, P. 62), sharing is a fundamental stage in the spiral of knowledge, as it "allows for the transformation of tacit knowledge into explicit knowledge and the dissemination of it widely in the organizational environment". This process is essential for continuous learning and for strengthening institutional capacities.

Therefore, knowledge management and sharing strategy represent complementary and indispensable dimensions to organizational innovation. Sharing expands the reach of the knowledge produced, strengthens collaborative networks and consolidates a culture of permanent learning. Thus, it can be stated that the effectiveness of KM depends directly on the quality of the sharing practices implemented, the cultural and technological conditions available, and the collective commitment to the strategic use of information (TOMAÉL; ALCARÁ & DI CHIARA, 2005; ANGELONI, 2008; BARBOSA & NAVES, 2014).

2.2 KNOWLEDGE SHARING AND OPEN SCIENCE

From an interdisciplinary perspective, knowledge sharing is understood as a dynamic process of collective exchange and construction that involves cognitive, social and technological dimensions (DAVENPORT & PRUSAK, 1998). In academic environments, this process is achieved through collaborative networks, digital repositories, open access publications, and inter-institutional cooperation, which expand the social impact of science (VALENTIM & CERVANTES, 2008).

Knowledge sharing is one of the fundamental pillars for the advancement of contemporary science and the consolidation of a more collaborative and transparent academic culture. In the context of Open Science, this practice plays a strategic role in promoting the democratization of access to scientific information and the strengthening of cooperation networks between researchers, institutions, and society (STUEBER & TEIXEIRA, 2024).

According to Santos and Costa (2021, p. 45), "Open Science represents a paradigmatic transformation in the way scientific knowledge is produced, communicated, and used, prioritizing openness, collaboration, and transparency at all stages of the investigative process". This perspective broadens the reach of scientific research and enables greater

social impact of the results, since knowledge is no longer restricted to specific groups and starts to circulate in a more equitable way.

The sharing of data, codes, and publications is, therefore, one of the central axes of this movement. As Fecher and Friesike (2013) argue, Open Science is not limited to the free availability of scientific articles, but involves a profound cultural change in research practices, valuing reproducibility, interdisciplinary cooperation and citizen engagement. Thus, the sharing of scientific knowledge becomes an instrument of innovation and social *accountability*.

In the Brazilian context, public science and technology policies have sought to incorporate the principles of Open Science, especially through institutional initiatives of digital repositories and open data policies. According to Menezes and Oliveira (2020), the adoption of these practices in universities and national research centers still faces challenges related to technological infrastructure, organizational culture, and the absence of institutional incentives. However, there are important advances in the integration of cooperative networks and the creation of interinstitutional platforms that strengthen the open scientific ecosystem (CARVALHO, 2022; CUNHA & SANTOS, 2022; VALENTIM & GELINSKI, 2023; MIRANDA, BARROS & OLIVEIRA, 2023).

The culture of sharing is also closely linked to knowledge management, which, as defined by Davenport and Prusak (1998), consists of the process of creating, disseminating and using knowledge to generate value and innovation. In the scientific environment, this means structuring mechanisms so that the knowledge produced is accessible, reusable, and subject to integration into new research (FUGITA, 2017; FREIRE, 2019; ALBAGLI, 2020). In this way, sharing is no longer an isolated act and becomes an integral part of the scientific information management policy (ALBAGLI, MACIEL & ABDO; 2015; AMARO, 2018, GOUVEIA, 2019).

Thus, it can be seen that knowledge sharing and Open Science are complementary dimensions of the same logic of innovation and social responsibility. By encouraging cooperation, transparency, and equitable access to information, these practices contribute to the consolidation of a more inclusive, ethical, and common good-oriented model of science (ALBAGLI, MACIEL & ABDO; 2015; STUEBER & TEIXEIRA, 2024).

Open Science is a contemporary paradigm that seeks to make scientific production more accessible, transparent, and reproducible, stimulating societal engagement and collaborative innovation. According to UNESCO (2021), Open Science practices promote the

democratization of knowledge and contribute directly to the SDGs, especially those aimed at quality education (SDG 4), innovation and infrastructure (SDG 9) and partnerships for development (SDG 17). It is relevant to note that Albagli, Maciel and Abdo (2015), Brazilian researchers, published a study on the need for public policies aimed at Open Science.

In Brazil, public policies such as the CAPES Journal Portal (2025), SciELO, and institutional repositories have strengthened this culture of openness, albeit unevenly across areas of knowledge.

2.3 BRAZILIAN RESEARCHERS AND INFORMATIONAL SUSTAINABILITY

Informational sustainability has been consolidated as an emerging and interdisciplinary approach, which recognizes information as an essential element for the sustainable development of contemporary societies. In the Brazilian context, researchers from different areas, but especially from the area of Information Science, have been discussing the strategic role of information and knowledge in the promotion of ethical, inclusive and environmentally responsible scientific practices. This discussion is directly connected to global agendas, such as the United Nations (UN) Sustainable Development Goals (SDGs), particularly those related to quality education, innovation, and effective institutions (SDGs 4, 9, and 17). ALBAGLI, MACIEL & ABDO, 2015; GERALDO, PINTO & DUARTE, 2022; BARATA, 2019)

According to Valentim (2021), informational sustainability "presupposes the creation, use, sharing, and preservation of information in an ethical, equitable, and responsible manner, in order to ensure its availability and accessibility for future generations" (VALENTIM, 2021, p. 45). This conception expands the traditional notion of sustainability, which is often restricted to the environmental and economic dimensions, incorporating the informational dimension as an indispensable pillar for knowledge governance.

In Brazil, researchers have contributed significantly to the theoretical consolidation of the concept. Alves and Valentim (2022) highlight that information and knowledge management, when guided by principles of informational sustainability, favors the creation of collaborative and innovation ecosystems. According to the authors, "sustainable information is intrinsically linked to the ability of organizations to manage their information flows in a continuous, transparent and collective learning-oriented way" (ALVES; & VALENTIM, 2022, p. 118).

The integration between informational sustainability and Open Science is another highlight in Brazilian research. Araújo and Freire (2020) argue that informational sustainability depends not only on technological infrastructure, but also on a scientific culture that values openness, data reuse, and interdisciplinary collaboration. In short, "informational sustainability requires ethical practices of sharing, respect for authorship, and appreciation of epistemic diversity" (ARAÚJO & FREIRE, 2020, p. 15).

Internationally, authors such as Capurro (2019) and Floridi (2013) reinforce the ethical and philosophical dimension of informational sustainability. Floridi (2013) introduces the concept of *infosphere*, understood as the global information environment that sustains human and technological interactions. For the author, "the sustainability of the *infosphere* depends on informational policies that promote collective informational well-being and reduce inequality in access and use of information" (FLORIDI, 2013, p. 89). This vision is echoed in Brazilian scientific production, which seeks to articulate sustainable informational practices with digital and scientific inclusion policies.

In addition, Capurro (2019) argues that informational sustainability implies an ethical commitment to "care for the informational being", recognizing that the production and consumption of information affect the quality of human interactions and the legitimacy of knowledge. This philosophical perspective inspires Brazilian researchers to think of information as a living resource, which must be preserved and cultivated for the benefit of the community.

In the field of public policies, informational sustainability gains relevance as Brazil seeks to align its scientific and technological policy with the guidelines of Open Science and research data management. According to Miranda and Cunha (2022), "informational sustainability in Brazilian public universities requires the integration of data policies, technological infrastructure, and training of researchers" (MIRANDA & CUNHA, 2022, p. 64). Such initiatives aim to reduce information gaps and strengthen information governance in the academic sphere.

The Brazilian literature also highlights the importance of training sustainable information skills. According to Silva and Costa (2021), promoting informational sustainability implies developing "critical and ethical skills for the responsible search, use, evaluation, and sharing of scientific information" (SILVA & COSTA, 2021, p. 72). This means that informational sustainability is not restricted to the technical preservation of data, but involves the human and cognitive development necessary for a balanced informational ecosystem.

The contribution of Brazilian researchers, therefore, is not limited to theorizing, but also to practical application in knowledge management programs, digital libraries, institutional repositories, and open data initiatives. This practice reflects an integrated view of information as a public good and a factor of cognitive justice. Informational sustainability, in this context, is consolidated as a strategic tool to promote equity in access to information and the appreciation of science as a common good (STUEBER & TEIXEIRA, 2024; VALENTIM, 2023).

As Valentim (2023) points out, "informational sustainability is a path to the democratization of science and to strengthen public trust in scientific institutions" (VALENTIM, 2023, p. 53). This view reinforces the need for researchers, managers, and public policy makers to work collaboratively to consolidate ethical, transparent, and inclusive informational practices.

Thus, Brazilian scientific production has proven to be relevant for the advancement of the international debate on informational sustainability, articulating theoretical, ethical and political dimensions. By promoting open access, digital preservation, and informational responsibility, Brazilian researchers contribute to the construction of a fairer, more sustainable, and socially committed science.

2.4 CHALLENGES AND OPPORTUNITIES FOR SCIENTIFIC SHARING IN BRAZIL

Scientific sharing is an essential pillar for the advancement of Open Science and for the democratization of knowledge. In Brazil, this process faces a series of structural, cultural, and technological challenges that directly impact the production and dissemination of scientific knowledge. At the same time, significant opportunities arise associated with the consolidation of public policies, the expansion of digital infrastructure, and the adoption of collaborative practices between researchers and institutions (KURAMOTO, 2008; BRAZIL, 2025; SAYÃO, & SALES, 2022; OLIVEIRA & FERREIRA, 2022; LEITE, COSTA & ALVES, 2022; SOUZA, M. *et al*, 2023).

According to Ferreira and Santos (2021), the sharing of data and research results "is one of the central elements of the open science paradigm, as it encourages transparency, reproducibility, and the reuse of knowledge" (FERREIRA & SANTOS, 2021, p. 45). However, in the Brazilian context, obstacles persist related to the absence of standardization in institutional repositories, the lack of institutional incentives and the cultural resistance of part of the scientific community, which still maintains practices of restricted circulation of

knowledge (KURAMOTO, 2008; OLIVEIRA & FERREIRA, 2022; LEITE, COSTA & ALVES, 2022;).

The literature points out that the challenge is not limited only to technological infrastructure, but also to the formation of a culture of sharing. Valentim (2020) observes that "the consolidation of collaborative practices depends on the recognition of information as a public and strategic good" (VALENTIM, 2020, p. 32). In this sense, the role of universities and funding agencies in the creation of policies that value the openness of data and interoperability between information systems is fundamental (SAYÃO & SALES, 2022).

At the same time, opportunities emerge from the digital transformation of scientific research itself. Initiatives such as the Brazilian Network of Digital Repositories, Brapci, and the Fiocruz Repository represent advances in the integration and visibility of national scientific production (ALVES & VALENTIM, 2022). In addition, the Open Science framework proposed by UNESCO in 2021 and its adhesion by Brazil expand the horizon of possibilities for international collaboration and the strengthening of information governance.

Another relevant aspect is the alignment between scientific sharing practices and the graduate evaluation guidelines established by CAPES (2025). According to Alves and Valentim (2022), the incorporation of Open Science indicators in evaluation processes "can stimulate a paradigmatic change in the way academic production is understood and valued" (ALVES & VALENTIM, 2022, p. 118). Thus, sharing is no longer just a technical requirement and becomes a strategic indicator of scientific quality.

Therefore, the challenges for scientific sharing in Brazil are related to overcoming cultural barriers, expanding digital infrastructure, and creating incentive mechanisms. On the other hand, the opportunities are promising, especially in the face of the growing appreciation of open science and institutional initiatives that promote the management and dissemination of knowledge. The future of Brazilian scientific research will depend, to a large extent, on the ability of its institutions to transform sharing into a collective and structuring value (VALENTIM, 2023; STUEBER & TEIXEIRA, 2024).

3 METHODOLOGY

The present research is characterized as exploratory and qualitative in nature. According to Gil (2019), the exploratory study aims to provide greater familiarity with the problem, making it more explicit or building hypotheses based on a set of preliminary observations. The choice for a qualitative approach is justified by the interest in understanding

the perceptions, practices, and meanings attributed by Brazilian researchers to the sharing of scientific knowledge, especially in the context of the Sustainable Development Goals (SDGs) proposed by the United Nations (UN) 2030 Agenda.

According to Minayo (2022), qualitative research enables the analysis of social phenomena from the perspective of the subjects and the contexts in which they are inserted, prioritizing the understanding of relationships and meanings to the detriment of quantification. Thus, it seeks to understand how collaborative practice and the dissemination of scientific knowledge can contribute to the achievement of the SDGs and the strengthening of scientific and social sustainability in Brazil.

The study is based on interdisciplinary theoretical contributions from Information Science, Administration, Education, Sociology and anchored in the literature of Knowledge Management, which offer conceptual tools to analyze the processes of production, organization, sharing and use of knowledge in the academic sphere.

Information Science, according to Borko (1968) and Le Coadic (2004), is concerned with the informational cycle and the role of information as a strategic resource for decision-making and innovation. Knowledge Management, on the other hand, according to Nonaka and Takeuchi (1997), involves processes of creation and dissemination of knowledge in organizations, favoring collective learning and continuous innovation.

By integrating these two approaches, it is intended to understand how open access policies, collaborative networks, and open science practices contribute to the generation of social impact and to the fulfillment of SDG goals.

This study was developed in two complementary stages, of a bibliographic and empirical nature.

In the first phase, a Bibliographic and Documentary Review was carried out. In this phase, an integrated and critical review of the literature was carried out, with the objective of identifying and analyzing studies that addressed knowledge sharing, Open Science and its relationship with the SDGs. The SciELO, Brapci, Scopus and Web of Science databases were consulted, using descriptors such as: knowledge management, knowledge sharing, Open Science, SDGs, 2030 Agenda, scientific collaboration, informational sustainability and sustainable research.

The selection criteria included: a) Works published between 2015 and 2025; b) Texts in Portuguese, English or Spanish) Scientific articles, dissertations, theses and institutional reports of government or international agencies. It should be inferred that this first phase of

the research did not consider the methodological aspects and scientific rigor required for a Systematic Review of the Literature. Therefore, the studies highlighted in the research results were selected for the convenience of the researchers based on the scientific production of Brazilian research groups that deal with the themes of this study.

In addition, official documents were analyzed, such as: a) UN and UNESCO Reports on the 2030 Agenda; b) Plans and guidelines of CAPES and CNPq related to Open Science and the internationalization of research; and c) Institutional policies of Brazilian universities aimed at sustainability and knowledge management. The analysis of this stage allowed us to theoretically contextualize the discussion and identify gaps and opportunities for Brazilian researchers.

In the second stage, an empirical research was carried out. The focus of this study was concentrated on the collection of primary data (GIL, 2019) with Brazilian researchers involved in projects aligned with the SDGs. Semi-structured interviews were conducted, as it allows flexibility and depth in the answers, as recommended by Triviños (2015). The interviews were conducted online (via Google Meet or Zoom), lasting approximately 40 to 60 minutes, through a Free and Informed Consent Form (ICF).

The data collection instrument was developed based on the theoretical foundation discussed in the previous chapter, in government reports, in the UN 2030 Agenda and in UNESCO reports. Fifteen (15) open questions were established that allowed for dialogue with the interviewed researchers.

The sample was intentional and non-probabilistic, comprising 10 researchers, selected based on the following criteria: a) Work in graduate programs recognized by CAPES; b) Participation in projects or research groups focused on sustainability or SDGs; c) Recent scientific production on knowledge management or open science; and d) Be a CNPq PQ researcher. The data were recorded, transcribed and organized into thematic categories.

The transcriptions of the interviews resulted in a volume of approximately 310 (three hundred and ten) pages of qualitative text. Only part of this volume of data was used in this study. Therefore, a vast and rich material with experiences with the development of scientific research in Brazil is still available for other analyses. A relevant strategy for future studies may be to use qualitative data analysis software NVIVO, MAXDATA or ATLAS TI.

The Brazilian researchers interviewed and their main credentials to participate in this study are identified as shown in Table 1.

Table 1

Profile of the Brazilian Researchers interviewed

Code name	Country Region	University	Area of expertise according to CAPES	Length of Work at the HEI (years)	Productivity Grant Category	Years of SDG Theme Research
WEIGHT 1	Southeast	Public	Communication, Information and Museology	18	1C	8
WEIGHT 2	Northeast	Public	Communication, Information and Museology	21	2	10
PESQ 3	Southeast	Public	Education	20	Senior	5
PESQ 4	North	Public	Education	11	2	10
WEIGHT 5	South	Toilet	Public and Business Administration, Accounting Sciences and Tourism	6	2	6
PESQ 6	Midwest	Public	Right	18	1B	9
PESQ 7	Southeast	Toilet	Public and Business Administration, Accounting Sciences and Tourism	15	1B	9
PESQ 8	Northeast	Public	Public and Business Administration, Accounting Sciences and Tourism	23	1B	11
PESQ 9	North	Public	Education	12	2	12
PESQ 10	Midwest	Toilet	Right	10	2	8

Source: Survey Data, 2025.

In Brazil, the researcher with a Research Productivity (PQ) scholarship stands out among his peers, valuing his scientific production according to normative criteria, established by CNPq, and specific, by the Advisory Committees (CAs) of CNPq (2025). For category 1, the researcher will be classified into four different levels (A, B, C or D), based on comparison between their peers and on data from the last 10 (ten) years, including the one that demonstrates the capacity for continuous training of human resources. For category 2, in which there is no level specification, the researcher's productivity will be evaluated, with emphasis on published works and guidelines, both referring to the last 5 (five) years (CNPq, 2025).

The analysis and treatment of the data was conducted according to the principles of content analysis, according to the methodology of Bardin (2016), which is structured in three phases: a) Pre-analysis: floating reading and organization of the material; b) Exploration of the material: identification of thematic categories and subcategories; c) Treatment and

interpretation: inference and interpretation of the results in the light of the theoretical framework.

In this way, it was possible to identify patterns, barriers and opportunities in the sharing of scientific knowledge, as well as to understand how collaborative practices and policies of Open Science have been incorporated into the Brazilian academic culture.

To validate the results, methodological triangulation was used, articulating the data sources of the Bibliographic and Documentary Review, Interviews with researchers and Analysis of institutional documents (CAPES, CNPq and universities). According to Flick (2018), triangulation allows different perspectives on the phenomenon studied to be confronted, increasing the consistency and reliability of the research.

The research respected the ethical principles defined by Resolution No. 510/2016 of the National Health Council (2016), ensuring the anonymity of the participants and the use of the data exclusively for scientific purposes. All interviewees agreed to the Informed Consent Form (ICF).

4 PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS

The results of the study were organized into categories and subcategories described as follows: Initially, the view of Brazilian researchers on knowledge sharing is discussed. Subsequently, the result of sustainable technology and the sharing of knowledge in scientific research is presented. Next, Open Science is discussed from the point of view of Brazilian researchers. Closing the data analysis, the issue of Factors and Barriers to Knowledge Sharing among Brazilian Researchers, Good Practices and Strategies for Knowledge Sharing is addressed and at the end there is an overview of Brazilian research on SDGs.

4.1 KNOWLEDGE SHARING ACCORDING TO BRAZILIAN RESEARCHERS

The researchers interviewed in this study were unanimous in stating that in recent decades, the topic of knowledge sharing, whether in terms of research data, scientific results or collaborative practices, has gained increasing attention in the Brazilian scientific community. The researchers report several benefits and challenges of this process in the national context, in agreement with studies such as the one by Ziviani *et al.*, (2023a).

A highlight in the interviews with researchers was Open Science. In Brazil, it is observed that the Open Science movement is associated with the idea of making research and scientific data accessible to all, as a means of accelerating scientific progress, increasing

transparency, and expanding the social impact of investigations, according to the researchers interviewed and the UNESCO report published in 2025. It should be recognized that Brazilian researchers such as Albagli, Maciel and Abdo (2015) and Amaro (2018) discuss the relevance of Open Science in their studies before structuring public policies in this regard.

Emphasizing the practice of knowledge sharing, Brazilian researchers have expressed support for open data, digital repositories, prepublications, and reuse of results, as ways to improve collaboration and the quality of scientific research. The researchers' position is in line with what is stated in the study by Dias (2025, p. 41) on Open Science public policies in Brazil between 2020 and 2023, in which it can be stated that "the dissemination of Open Science depends on policies that guarantee the resources, infrastructure, and incentives necessary to increase collaboration and transparency in research". Therefore, it can be stated that for Brazilian researchers, knowledge sharing is not just a technical or individual issue, but involves institutional infrastructure, financing, institutional incentives, and organizational culture, in line with studies by Valentim (2020) and Ziviani *et al.* (2023a).

When it comes to research data, the researchers report that there are trends that influence the sharing and reuse of research data in Brazil, highlighting the lack of clear regulations, technological barriers, fears about the misuse of data, and limited resources for maintaining or preserving repositories, which is in line with the study conducted by Silva, Prado and Araújo (2022). In this way, Brazilian researchers realize that, although there is a willingness to share knowledge, there are substantial practical obstacles.

In collaborative contexts such as partnerships between Brazilian and foreign researchers, important issues are also verified. Agreeing with the study by Almeida, Silva and Queiroz (2017) on the Science without Borders program, it is verified that knowledge sharing occurs through meetings, seminars, and the preparation of articles together, but is influenced by individual, collective, organizational and cultural factors. The researchers interviewed report that there are challenges related to language differences, expectations of collaboration, and recognition of authorship of research and publication of results. Thus, Brazilian researchers consider knowledge sharing as a complex process, which transcends the simple availability of data and involves human and institutional relations as factors to be observed and considered.

One issue reported by the interviewees is related to the theoretical foundation of the studies. These state that they are always considered relevant foreign studies, research and

publications, and ongoing research or results published in Brazilian journals are rarely cited by foreign researchers.

On the other hand, Brazilian researchers also point out the need for science not only to be focused on publication and accumulation of institutional goods, but rather on real impact on society. Thus, it is evident that the results of the research produce social, economic and technological impact.

When asked about the innovation environment in Brazil, the researchers stated that they share knowledge in innovation environments and pointed out that trust between actors, the clarity of norms, and the definition of who shares are essential for the flow of knowledge to really happen. Thus, the researchers agree with the results of the study by Scarabelli, Sartori, and Cruz Uripia (2023) who investigated how the connection between researchers, technology, and innovation occurs. Therefore, this insight reveals that knowledge sharing is as much a matter of organizational culture as it is of structure.

Brazilian researchers consider knowledge sharing relevant not only for academic collaborators, but also for society in general. In the interviews, it was possible to observe that the researchers hope that the results will reach society as a whole and not only the scientific community. One researcher (PESQ 2) states that "it is necessary to break down the walls of the University" and dialogue with society about what science is and especially that the country's development takes place within universities. As reinforced by three interviewed researchers (PESQ 3; PESQ 6; PESQ 9): "The results need to reach society in general" and not only the scientific community. One must be concerned with doing science for the social purpose.

The researchers point out that in the Brazilian context, research data management practices reflect a combination of individual, institutional, and technological factors. Researchers demonstrate a positive perception of the benefits of knowledge sharing, such as greater visibility, collaboration, and academic impact, but often use local resources, such as hard drives and institutional servers, to the detriment of structured digital repositories, agreeing with studies by Carvalho, (2022) and Miranda, Barros, and Oliveira (2023).

Studies such as Lima (2020) indicate that the adoption of institutional or national repositories is still heterogeneous, being strongly influenced by institutional policies, funding incentives, and evaluation requirements, while gaps in documentation and interoperability hinder reuse and scientific reliability in the view of researchers who are in line with the results of the study by Azambuja (2021).

In addition, knowledge management in graduate programs reveals diverse practices, including the use of spreadsheets, specific software, and digital repositories, with barriers such as fear of misuse, the absence of clear standards, and difficulty in standardizing metadata, reinforcing the need for institutional policies and continued training to strengthen knowledge sharing, which is also evident in Dias' study; Anjos and Araújo (2019).

Dialoguing about the process of knowledge sharing with Brazilian researchers, some reflections emerge. First, a field linked to opportunities in which knowledge sharing is perceived as a way to expand collaboration, accelerate innovation, better use of research results, greater visibility of Brazilian science and greater social impact. The adoption of open science practices, data repositories, international collaboration, and innovation environments favors scientific knowledge to contribute to sustainable development, reinforcing studies developed by Sayão and Sales (2022) and Leite, Costa, and Alves (2022) and a practice historically researched and shared by Kuramoto (2008).

The other field is a dimension of barriers in which researchers recognize that there are relevant barriers and the absence or fragility of technological infrastructure, limitation of financial resources, lack of clear and consistent policies, institutional culture that still favors "closure" or control over data, bureaucratic issues and obstacles, in addition to issues of recognition, authorship and incentives. These factors make it difficult to fully implement knowledge sharing.

Based on interviews with researchers, some good practices can be established for the effectiveness of knowledge sharing. The issue of establishing cooperation platforms that include the equitable participation of Brazilian and foreign researchers is evident, ensuring that local issues are prioritized. Promote academic mobility and exchange of researchers, with institutional support and targeted funding. Encourage international co-authorship and joint publication, including in accessible languages. Promote the formation of transnational networks of practice that involve producers and users of knowledge. Ensure the translation and dissemination of results to the Brazilian reality, ensuring that the knowledge shared is not limited to academia, but reaches public policies, the productive sector and civil society. Monitor and evaluate international collaboration through SDG impact indicators. Strengthen data and information management, promote open data infrastructure, and institutional integrity and sharing policies. The results described by the interviewees are in line with studies developed by Carvalho (2022); Cunha and Santos (2022); Miranda, Barros and Oliveira (2023).

4.2 SUSTAINABLE TECHNOLOGY AND KNOWLEDGE SHARING IN SCIENTIFIC RESEARCH

For the field of sustainable technology, these perceptions have interesting implications in the view of the researchers interviewed and directly linked to the SDGs. Brazilian researchers working with green technology, renewable energy, sustainability, or the environment consider that: i) the sharing of data and results between research groups, companies, government, and civil society organizations can accelerate the adoption of sustainable technologies; ii) the creation of specific repositories, collaborative platforms or national/international networks facilitates the exchange of knowledge on good practices, failures and innovations. These issues are also discussed in the studies by Oliveira and Ferreira (2022) and Leite, Costa and Alves (2022).

Therefore, they state that it will be necessary to overcome the bureaucratic processes of universities and invest in infrastructure, foster open science policies in the environment of sustainability, promote institutional incentives for those who share, and modify the academic culture to value both production and sharing. In this sense, it reinforces that CAPES (2025) started to adopt the sharing and transfer of knowledge as a structuring pillar of the evaluation of graduate programs. In this way, the researchers report that the evaluation criteria have changed significantly. Graduate programs are no longer evaluated quantitatively and start to have a qualitative evaluation. Most of the interviewees stated that the change in the form of evaluation was positive and will bring good results in the long term. These results can be confirmed in the research by Sayão and Sales (2022).

Knowledge sharing has been consolidated as a strategic axis for scientific advancement and the sustainable development of contemporary societies. In the context of the United Nations (UN) 2030 Agenda, the Sustainable Development Goals (SDGs) demand a new posture from the scientific community, guided by collaboration, transparency, and the open circulation of scientific information. In this sense, Brazilian researchers play a relevant role in promoting collaborative practices that strengthen open science and the democratization of access to knowledge.

From an interdisciplinary perspective, knowledge sharing is understood as a dynamic process that involves the creation, dissemination and use of information in formal and informal networks (DAVENPORT & PRUSAK, 1998). According to a UNESCO report (2024), in Brazil, the process of knowledge sharing has been enhanced by open access policies and the expansion of digital platforms that favor interoperability and scholarly communication,

such as SciELO and the CAPES Institutional Repository (CAPES, 2025). Such initiatives reinforce the importance of a more reliable and inclusive information infrastructure, capable of supporting scientific production in line with the SDGs, especially the goals aimed at quality education (SDG 4), innovation (SDG 9) and partnerships for development (SDG 17).

However, knowledge sharing still faces structural challenges in the Brazilian scenario, according to the interviewees. Cultural barriers, academic competitiveness, bureaucracy of the research funding system, and regional inequalities limit the full adoption of collaborative practices among researchers, which is in line with the study by Valentim and Cervantes (2020).

The reports of the interviewees indicate that the absence of institutional incentives and the evaluation based exclusively on quantitative metrics reduce the recognition of initiatives aimed at cooperation and the social dissemination of knowledge. Thus, there is a need to rethink the role of universities and graduate programs as spaces for mediation and collective construction of scientific knowledge. In this sense, one should consider the change in the rules for evaluating graduate programs defined by CAPES for the 2025-2028 quadrennium, which strengthens knowledge sharing as a cross-cutting criterion (CAPES, 2025).

The integration between knowledge sharing and sustainability presupposes a broader view of science, capable of articulating academic production with social demands. According to Nonaka and Takeuchi (1997), knowledge is transformed into value when it circulates among individuals and organizations, stimulating innovation and continuous learning. In the context of the SDGs, such circulation allows scientific knowledge to go beyond the walls of academia and effectively contribute to sustainable solutions at the local, regional and global levels.

Therefore, looking at Brazilian researchers reveals both significant advances and persistent challenges. The consolidation of a culture of sharing requires integrated scientific policies, mechanisms for recognizing open science, and the strengthening of information governance in the country. More than an institutional requirement, knowledge sharing must be understood as an ethical and collective commitment to sustainability and global equity.

4.3 INSTITUTIONAL CONTEXT: OPEN SCIENCE IN BRAZIL

In Brazil, the Open Science movement has gained ground as part of the State policy to make research and especially scientific data more accessible, reusable, and transparent. It is observed that all the calls for research published by CNPq and CAPES are demanding

as a criterion the clear and effective description of how data management and dissemination of primary data by researchers will be carried out. It is evident that high-impact scientific journals are demanding that the database, statistical or qualitative analyses and appreciation by the University's Research Ethics Committee be made available at the time of submission of the article.

In 2025, the Ministry of Science, Technology, and Innovation (MCTI, 2025) discussed guidelines to consolidate open science in the country, involving funding agencies, educational institutions, and civil society (BRASIL, 2025). At the institutional level, there are studies that map public and institutional policies for open science in Brazil between 2020-2023, showing that, although there are initiatives, there is still a lack of a consolidated federal policy. In this sense, it is possible to see initiatives by CAPES and CNPq aimed at the field of open science.

In the reports of Brazilian researchers in relation to open science, it can be seen that Brazilian researchers are inserted in an environment in which it is increasingly expected that data, methods and results will be made available in an open way, including beyond the academic community. All interviewees demonstrated the need for a public policy that favors open science and are in favor of the practice of public data.

Open science is a strategy that favors knowledge sharing. There are studies on the Open Science practices of the Brazilian academic community that analyze Brazilian scientific production and confirm that there are already open access and open data initiatives as part of knowledge sharing practices.

It should also be noted that there are factors that influence the sharing and reuse of research data in Brazil. Studies, according to a CAPES report (2025), have identified both incentives (e.g., greater visibility, acceleration of science) and barriers (e.g., infrastructure, lack of recognition) for researchers.

It was reported by a researcher (PESQ 7) interviewed that there are collective learning initiatives, communities of practice and collaborative projects in Brazil. The researcher pointed out that in a Brazilian knowledge-intensive public company (tropical agriculture) it was identified that researchers used informal and formal practices of collective learning, interrelationships in communities of practice, and knowledge sharing as a continuous process. Another researcher (PESQ 1) pointed out that in multidisciplinary socio-environmental projects, it was identified that knowledge management (KM) practices involved sharing between different actors, and that this also occurs among Brazilian researchers in the environmental field.

Regarding the infrastructure and support platforms for open science, the researchers mentioned that in the institutional field it is already possible to see the implementation of digital platforms (institutional repositories, databases, preprints) as a support for the sharing of open science.

It was reinforced by the interviewees that Brazilian researchers are encouraged to adopt open licenses, deposit data in interoperable repositories, adopt open codes and promote reproducibility. These incentives are strategies essentially conducted by CAPES, CNPQ, state development agencies, social organizations, international entities and private companies.

The researchers report that the strategic practice of encouraging the culture of open science, which involves actions such as publication in open access journals, the use of Creative Commons licenses, and detailed documentation of methods and results, is a way to promote open science that is available for broad access. Silva, Braga Prado, and Araújo (2021) state that institutional policies of incentive and academic recognition are crucial for researchers to adopt habits of sharing data and research results, increasing the visibility of scientific productions and stimulating future collaborations.

According to UNESCO and CAPES reports (2025), an open science strategy is understood as the practice of depositing research data in open access repositories, ensuring that the data is interoperable and reusable (following FAIR principles – Findable, Accessible, Interoperable, Reusable). Concentrate scientific publication in open access journals, or in preprint versions, to expand the reach of research. Participate in communities of practice (BA) and collaborative networks, both academic and interdisciplinary, to exchange experiences, methods, and results. Use open licenses to allow the reuse of the results, and document the code, methods, metadata for others to replicate. Include knowledge sharing as part of the project plan, including data dissemination, outreach to society, and citizen science actions, if applicable.

In the context of open science and open data management, the interviewees highlighted the functioning of academic data observatories in Brazil, highlighting that the lack of metadata standardization, the absence of repository maintenance policies, and the limited technical training of researchers and managers constitute important barriers to access and reuse of data. In this sense, the study by Silva, Braga Prado, and Araújo (2021), emphasizes that, although open data initiatives are promising, their effectiveness depends on the

articulation between institutional policies, technological infrastructure, and a culture of sharing within the academic community.

Even with good practices emerging and found in the reports of researchers and institutional reports, there are obstacles that Brazilian researchers face. Researchers report the lack of adequate infrastructure for storing, preserving and interoperating scientific data. They claim that there is no recognition or reward for researchers who share data. There is often more risk of "losing competitive advantage" by making data available first. The academic culture that still privileges traditional publishing without fully valuing data reuse or open science as part of evaluation. In this sense, the change in the evaluation of Qualis CAPES will cause a change in the behavior of researchers, as the paradigm of quantitative evaluation becomes less valued due to the quality of the research and its scientific productions.

4.4 KNOWLEDGE SHARING AMONG BRAZILIAN RESEARCHERS: FACTORS, BARRIERS AND GOOD PRACTICES

The sharing of knowledge among researchers is a strategic element for scientific advancement, technological innovation, and the promotion of sustainable practices, especially in areas such as Sustainable Information, as evidenced in the Geraldo, Pinto, and Duarte (2022) study. In the Brazilian context, recent studies show that, although there are growing efforts to democratize access to scientific data and information, significant challenges persist that limit the full adoption of sharing practices.

Based on the study by Silva, Braga Prado and Araújo (2021) who carried out a systematic review of the literature on factors that influence the sharing and reuse of research data in Brazil, pointing to individual, organizational, and technological variables as determinants of researchers' behavior. Among the facilitating factors, academic recognition, research visibility, and access to institutional repository platforms stand out. However, the barriers include the lack of adequate infrastructure, the scarcity of consolidated institutional policies, and the concern with the protection of intellectual property, which can generate resistance on the part of researchers.

In studies applied to socio-environmental projects, Silvério, Aihara, and Varvakis (2023) identified that, even in initiatives aimed at sustainability, researchers face challenges related to the interoperability of knowledge management tools, the heterogeneity of data formats, and the difficulty of communication between actors from different areas. These

obstacles show that the sharing of knowledge does not depend only on the goodwill of researchers, but also on the availability of digital and methodological structures capable of supporting the integration and dissemination of information, a strategy that goes against the proposal of Nonaka and Takeuchi (1997).

Thus, it was possible to categorize from the interviews with researchers that the factors and barriers to knowledge sharing among Brazilian researchers are closely linked to three main dimensions: the cultural, which involves attitudes, incentives, and recognition; the organizational, which refers to institutional policies and availability of support; and the technological one, which comprises the infrastructure, tools and interoperability of data. To promote the efficient dissemination of scientific knowledge in critical areas, such as sustainability, it is necessary to address these barriers in an integrated manner, combining incentive policies, training, and investment in digital infrastructure as shown in Table 2.

Table 2

Barriers and good practices in knowledge sharing in scientific research

Dimension	Barriers Identified	Good Practices and Strategies
Cultural	Resistance to sharing for fear of losing competitive advantage Lack of institutional recognition or reward	a) Encouragement of open science and academic recognition policies. b) Fostering a collaborative culture in teams and communities of practice
Organizational	Insufficient or poorly consolidated institutional policies Lack of support and guidelines for data management	a) Creating clear standards and flows for data sharing. b) Adoption of institutional repositories and data observatories.
Technological	Inadequate infrastructure for storage and interoperability Heterogeneity of data formats and digital tools Limited technical training	a) Use of digital platforms and integrated knowledge management tools b) Standardization of metadata. c) Continuous training of researchers in data management and open science

Source: survey data, 2025.

In the context of open data management, Silva, Braga Prado, and Araújo (2021) analyzed the functioning of academic data observatories in Brazil, highlighting that the lack of metadata standardization, the absence of repository maintenance policies, and the limited technical training of researchers and managers constitute important barriers to access and reuse of data. The author emphasizes that, although open data initiatives are promising, their effectiveness depends on the articulation between institutional policies, technological infrastructure, and a culture of sharing within the academic community.

In the face of these barriers, Brazilian researchers have been adopting strategies and good practices aimed at promoting knowledge sharing, both in academic projects and in

socio-environmental initiatives. One of the most relevant strategies consists of the use of digital platforms and repositories, which allow the deposit, organization and dissemination of research data in a structured way. highlight that academic data observatories support interoperability, metadata standardization, and the availability of information in an accessible way, creating conditions for researchers from different institutions to reuse data safely and reliably. Silva, Braga Prado and Araújo (2021),

In addition, the integration of knowledge management tools in collaborative projects has proven effective in facilitating sharing between researchers from different areas. Silvério, Aihara, and Varvakis (2023) point out that, in socio-environmental projects, the use of digital platforms, standardized flows, and shared methodologies contributes to reducing the fragmentation of information, allowing teams to exchange knowledge in a systematic way, even in the face of heterogeneity of data and skills.

Another strategic practice is the encouragement of an open science culture, which involves actions such as publication in open access journals, the use of Creative Commons licenses, and detailed documentation of methods and results. Silva, Braga Prado, and Araújo (2021) state that institutional policies of incentive and academic recognition are crucial for researchers to adopt habits of sharing data and research results, increasing the visibility of scientific productions and stimulating future collaborations.

Finally, technical training and continuing education of researchers are pointed out as fundamental practices. The training of professionals able to handle data, use digital tools, and understand open science policies contributes to reducing technological barriers and strengthening autonomy in information management. This approach also facilitates alignment with international standards for interoperability and data reuse, expanding the impact of Brazilian research in the global context.

4.5 OVERVIEW OF BRAZILIAN RESEARCH ON SDGS

Based on a survey carried out by the Coordination for the Improvement of Higher Education Personnel (CAPES, 2025), it is evident that between 2013 and 2022, about 50 thousand theses and dissertations in Brazil cited or had the SDGs as their theme, with a greater concentration in the areas of Health Sciences, Multidisciplinary and Human Sciences. According to a UNESCO report (2024), the Federal University of Espírito Santo (UFES) mapped that, among its research and extension projects carried out after 2015, about 60% were related to at least one of the SDGs. These studies highlighted SDG 3 (Health and well-

being), SDG 4 (Quality education), SDG 2 (Zero hunger and sustainable agriculture) and SDG 15 (Life on land) (CAPES, 2025).

The researchers interviewed pointed out that the theme of the SDGs began to be shared in the university environment in course collegiate meetings, groups of professors and informal environments. It did not take long, according to the report of the interviewed researcher (PESQ 10) for the theme to reach the classroom environment and research groups.

After this process of informal sharing of themes related to the SDGs, the movement to incorporate the theme into the dissertations and theses of different programs began. As stated by the researcher (PESQ 5), the entire university environment in a broad sense (Schools, Colleges, Departments, Research Groups, Extension Activities and academic and management structures) began to formally formalize and structure how the SDGs impact the university environment and what would be the strategies for teaching, research and extension practices to be aligned with the SDGs.

Another movement reported by the researcher (PESQ 2) was when the pedagogical projects of the courses began to incorporate and require that the activities of the undergraduate and graduate courses be related to one of the 17 areas of the SDGs.

This study was able to capture in the reports of the interviewees some innovative initiatives developed by universities in relation to the SDGs, such as: the monographic works, whether they are undergraduate TCC, Master's dissertations or Doctoral theses, should explicitly state in the text, which of the SDGs the study was contributing to. The University became the locus for extension activities to be directly focused on the SDGs. The researcher reinforces (PESQ 4) that the initiatives, actions and discussions on the SDGs began to occupy the university space in a synergistic way. At first very informal (a period in which it was possible to understand what the SDGs were) and later the academic environment began to formalize, value and recognize the initiatives that had already been incorporated throughout the dynamics of the university.

It is evident in the reports of the interviewees that each department, graduate program and shared spaces began to structure actions related to the SDGs according to the purpose and strategies of each department, college, schools or academic centers. The researchers interviewed state that each space in the university structure adheres to some fields of the SDGs. In the broad sense, the (PESQ 5) said that the dispersed actions when mapped by the higher bodies of the university's management allow us to understand that the academic

environment and especially the scientific research developed in the university environment are attentive to the 17 SDGs of the 2030 Agenda.

Confirming the reports of the interviewed researchers, a systematic review of the Brazilian literature entitled "The dimensions and Sustainable Development Goals after the 2030 Agenda" (RAASCH; LELIS &, BASSO, 2023) in which he analyzed articles from 2016 to 2022 and found the growth of academic production on sustainable development and studies related to the SDGs. However, he pointed out important gaps: few studies propose unified systems for monitoring and measuring SDG indicators. In this sense, this study effectively contributes to the commitment of the 2030 Agenda, by showing that the current moment requires Universities to establish structures and strategies to more effectively manage the actions related to the SDGs carried out in the university environment.

In the field of national policy, the documentary research showed how Brazil's Science, Technology and Innovation Policy (PCTI) incorporated the SDGs from 2016 onwards. The study concludes that, although there is mention of "sustainable development", there are structural difficulties in consistently incorporating the SDGs into financing and planning guidelines (Ribeiro & Oliveira, 2024). Therefore, it is necessary to implement management structures so that actions related to the SDGs in Brazilian universities are planned, organized, directed and controlled by trained human resources who understand the norms of the 2030 Agenda, effectively and transparently manage the financial resources allocated to scientific research applied to the SDGs and opportunely the most relevant issue, establish monitoring, managerial, and scientific indicators focused on the SDGs and establish indicators that can point out the economic, social, technological, human, educational, and sustainable results and impacts of scientific research and actions developed and funded by the university.

Finally, the results and impacts need to dialogue with society so that the population can understand the importance of the theme, actions and investments aimed at the sustainable development of the planet, the country, the regions and especially the environment where citizens live.

The literature retrieved from the databases consulted shows that studies that deal with the SDG theme in Brazilian scientific research follow different strategies. Bibliometric studies and systematic reviews to map scientific production through documentary analysis of public policies, plans, reports, and indicators that deal with the alignment of the SDGs with scientific research point to fragility in relation to the results and impacts generated effectively. Finally, case studies, citizen science projects, and university extension, for example, which aims to

articulate the environment where the individual lives with his community, and researchers focused on the theme of the SDGs, are more effective and cause more significant impact, as pointed out by government reports (BRASIL, 2025).

Based on the understanding that this research did not aim to carry out a Systematic Review of the Literature (RSL) with the protocols and methodological rigor that support the RSL technique. The articles selected from the consulted databases and the literature review carried out by the researchers who authored this study demonstrate that the most recurrent themes in Brazil in SDG research are:

- Health and well-being (SDG 3) – with a large volume of articles and projects.
- Quality education (SDG 4) — appearing in lines of research and extension services.
- Sustainable agriculture (SDG 2), life on land (SDG 15), water and sanitation (SDG 6) also receive attention.
- Affordable and clean energy (SDG 7) and innovation (SDG 9) – although less in volume, are relevant, especially in geoscientific or energy transition research.

Even noticing and verifying advances in research on SDGs in Brazil, the literature and scientific research developed by Brazilian universities point to important challenges:

- Scientific production is dispersed, with a lack of integrated propositions or robust national indicator systems to monitor progress on the SDGs in Brazil (BRASIL, 2025). This fact is due to the lack of a structure within universities that aims to manage actions related to the SDGs.
- In some areas, the integration of the SDGs into science and technology policies or graduate studies is still incipient or symbolic (BRASIL, 2025). Here one can point to the field of more linear and pragmatic sciences.
- The reality of Brazilian social inequalities, regionalization and institutional differences poses obstacles to a uniform advance of the SDGs. (RIBEIRO & OLIVEIRA, 2024) Brazil does indeed have many regional contrasts. This issue must be observed by public policies aimed at the SDGs.
- The plurality of themes means that some SDG goals do not point to or evidence relevant results for the country. One of the examples is scientific research that does not describe or point out effective indicators. The results of these surveys cause a low incidence of the SDGs associated with industry, innovation or infrastructure in peripheral regions (BRASIL, 2025). A point of reflection for the scientific community

and government agencies in this case is that government investments are in essence aimed only at maintaining employed people instead of promoting the maintenance of jobs associated with investment in innovation, technology and qualification of the workforce.

Brazilian research on SDGs contributes to generating contextual knowledge that adapts the SDGs to the national and regional reality, identifying how global goals can be translated in different states and municipalities. Research aimed at favoring dialogue between science, technology, innovation, public policies and civil society in the achievement of the SDGs.

There is also research that seeks to promote education for sustainability, both at the undergraduate and graduate levels, although it is still necessary to expand this insertion.

Finally, it reinforces that the future trend points to greater use of metrics, indicators, big data, artificial intelligence to monitor the SDGs, in addition to greater articulation between educational institutions, government and the private sector, the so-called Triple Helix. These points were highlighted by the researchers interviewed in reports.

In the global context of science and innovation, the sharing of knowledge between researchers from different countries is increasingly relevant to promote the United Nations (UN) SDGs. From the perspective of the relationship between Brazilian and foreign researchers, the production of scientific knowledge is an essential resource for sustainable development. Collaboration between national and international researchers facilitates the exchange of methodologies, data, cultural and technological perspectives. A point reported by the interviewees is that research groups abroad always have Brazilian researchers. Initiatives such as CNPq (2025) that invests resources to repatriate Brazilian researchers with high scientific reputation are worth mentioning.

A highlight is that in September 2015, 193 countries signed the 2030 Agenda, which defines 17 SDGs aimed at combating poverty, inequality, climate change, among others. A point of attention is that scientific research based on and guided by the SDGs requires interdisciplinary and international participation (UN, 2015).

5 CONCLUSION

Knowledge sharing, when integrated into the principles of the SDGs, takes on an ethical, social and strategic dimension. The experience of Brazilian researchers highlights

the need to strengthen the culture of scientific collaboration and open data, ensuring that the knowledge produced in the country contributes to global sustainable development.

The study presents as a first conclusion that by promoting knowledge sharing, it establishes a way to expand the social impact of science, reduce informational asymmetries, and consolidate knowledge governance focused on equity, innovation, and sustainability. In summary, Brazilian researchers are increasingly aligned with the SDG agenda, but they still face structural, methodological and scale challenges. It is essential that there be greater institutional articulation, the creation of indicators adapted to Brazil, academic training and awareness, in addition to a stronger commitment of public policies to the 2030 agenda. The agenda provokes a reflection on the relevance of moving to a development model aligned with sustainability.

Knowledge sharing between Brazilian and foreign researchers is an essential strategy to advance the SDGs in Brazil and globally. Despite the challenges, the adoption of good practices and cooperation policies can contribute decisively to overcoming knowledge asymmetries and promoting a more inclusive, contextualized, and impact-oriented science. To this end, it is necessary that institutions, government, academic communities, and civil society strengthen collaboration platforms, research infrastructure, and policies to encourage internationalization with equity.

Regarding open science in Brazil, the results reflect that data management is influenced by individual (perception, fear of misuse), institutional (infrastructure, policies, incentives) and technological (tools, repositories) factors. Another point is that sharing practices are still heterogeneous: some researchers adopt open repositories, while others keep data locally. Factors influencing the practice of open science are lack of standardization, poor documentation, poor interoperability, and absence of specific training. Finally, formal incentives, open science culture, and capacity building are essential to promote the sharing of knowledge and research data in Brazil.

However, studies and interviews with researchers show that Brazilian research is part of a global network, but faces asymmetries of knowledge and challenges such as language, funding, infrastructure, and access.

Co-authorship between Brazilian and foreign researchers, as well as academic mobility (internships, post-doctorates, visits) foster exchange. The production analysis on the SDGs shows a growing presence of international collaborations in Brazil. Thus, there is a consolidated path to expand research on SDGs with exchanges between Brazilian and

foreign researchers. However, research on sustainability and sustainable development developed in partnership with researchers shows how internationalization and the focus on the SDGs permeate the training of students and the sharing of pedagogical practices.

However, to conclude this study pointing out pragmatic results, it is emphasized that the benefits and impacts of knowledge sharing on scientific development must observe the different cultural and scientific perspectives, a factor that can enrich research. Strengthening local capacity for SDG-oriented knowledge production. To give greater international visibility to Brazilian research, which can generate more funding and collaboration.

This study shows that the generation of solutions more adapted to the local context based on global knowledge are more relevant from the point of view of social impact. However, the study reinforces that it is necessary to reduce knowledge asymmetries between developed and developing countries.

To overcome the challenges and barriers to knowledge sharing, it is necessary to advance in the issue of language and communication: although English is the lingua franca of science, Brazilian researchers face challenges in publishing in English and international communication. In the field of infrastructure and financing: full participation in international networks requires resources for mobility, access to the database and collaboration platforms. It is essential to reduce power and agenda asymmetries: in international collaborations, there may be imbalance in the definition of the research agenda, the recognition of local partners, and the accessibility of data.

This study has the following limitations: the small number of interviews and the foundation in many scientific data in the area of Information Science. As a suggestion for future studies, it is suggested to expand the number of interviewees and present an RSL with foundations and criteria in the literature.

ACKNOWLEDGMENT

The authors would like to thank the Minas Gerais Research Foundation (FAPEMIG), the National Council for Scientific and Technological Development (CNPq) for funding the Postdoctoral Fellowship Abroad to one of the researchers who authored this study, and the Coordination for the Improvement of Higher Education Personnel (CAPES).

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**FEEDBACKINSIGHT-AI: A SYSTEM FOR TRIAGE, CLASSIFICATION, AND
SUMMARIZATION OF CUSTOMER FEEDBACK USING ARTIFICIAL
INTELLIGENCE**

**FEEDBACKINSIGHT-AI; SISTEMA DE TRIAGEM, CLASSIFICAÇÃO E
SUMARIZAÇÃO DE FEEDBACK DE CLIENTES COM INTELIGÊNCIA
ARTIFICIAL**

**FEEDBACKINSIGHT-AI: SISTEMA DE TRIAJE, CLASIFICACIÓN Y RESUMEN
DE COMENTARIOS DE CLIENTES CON INTELIGENCIA ARTIFICIAL**

 <https://doi.org/10.56238/sevened2025.036-074>

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ABSTRACT

This article proposes FeedbackInsight-AI, an automated system for triaging, classifying, and summarizing customer feedback using Artificial Intelligence (AI) and Natural Language Processing (NLP) techniques. The objective is to optimize the handling of large volumes of messages received by companies, reducing response time and enabling more efficient information analysis. The study is based on a qualitative and descriptive approach, using machine learning models applied to sentiment analysis and text categorization. The methodology involves integration between communication (Gmail), management (Trello), and data analysis (Google Sheets) APIs, utilizing state-of-the-art language models (like GPT-4). The proposal aims to contribute to the advancement of intelligent automation in customer service processes and data-driven decision-making in organizations.

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Keywords: Artificial Intelligence. Automation. Customer Feedback. Natural Language Processing. Sentiment Analysis.

RESUMO

O presente artigo propõe o FeedbackInsight-AI, um sistema automatizado de triagem, classificação e sumarização de feedbacks de clientes por meio de técnicas de Inteligência Artificial (IA) e Processamento de Linguagem Natural (PLN). O objetivo é otimizar o tratamento de grandes volumes de mensagens recebidas por empresas, reduzindo o tempo de resposta e permitindo uma análise mais eficiente das informações. O estudo parte de uma abordagem qualitativa e descritiva, com base em modelos de aprendizado de máquina aplicados à análise de sentimentos e categorização textual. A metodologia envolve a integração entre APIs de comunicação (Gmail), gestão (Trello) e análise de dados (Google Sheets), utilizando modelos de linguagem de última geração (como GPT-4). A proposta visa contribuir com o avanço da automação inteligente de processos de atendimento e tomada de decisão em organizações orientadas por dados.

Palavras-chave: Inteligência Artificial. Automação. Feedback de Clientes. Processamento de Linguagem Natural. Análise de Sentimentos.

RESUMEN

Este artículo propone FeedbackInsight-AI, un sistema automatizado de triaje, clasificación y resumen de comentarios de clientes mediante técnicas de Inteligencia Artificial (IA) y Procesamiento de Lenguaje Natural (PLN). El objetivo es optimizar el manejo de grandes volúmenes de mensajes recibidos por empresas, reduciendo el tiempo de respuesta y permitiendo un análisis más eficiente de la información. El estudio parte de un enfoque cualitativo y descriptivo, basado en modelos de aprendizaje automático aplicados al análisis de sentimientos y categorización textual. La metodología implica la integración entre APIs de comunicación (Gmail), gestión (Trello) y análisis de datos (Google Sheets), utilizando modelos de lenguaje de última generación (como GPT-4). La propuesta busca contribuir al avance de la automatización inteligente en los procesos de atención al cliente y toma de decisiones basada en datos en las organizaciones.

Palabras clave: Inteligencia Artificial. Automatización. Feedback de Clientes. Procesamiento de Lenguaje Natural. Análisis de Sentimientos.

1 INTRODUCTION

The growing digitalization of relationships between companies and consumers generates a significant volume of unstructured data, especially in communication channels such as emails and online forms. Such data contains valuable information about user satisfaction, criticism, and suggestions, but manual analysis of this content is often unfeasible and inefficient (FERREIRA, 2025).

According to Boente (2025), the adoption of AI-based automation systems allows you to reduce operational bottlenecks and increase accuracy in message screening. Dos Santos (2025) reinforces this perspective by proposing human-computer interaction models that balance logical reasoning and cognitive adaptation, based on fuzzy logic.

Several studies point to the potential of AI in automated text processing. Russell and Norvig (2022) highlight that intelligent systems are capable of inferring human intentions and classifying language patterns with a high degree of accuracy. Goodfellow, Bengio, and Courville (2016) define deep learning as an essential tool for capturing complex semantic nuances. LeCun, Bengio, and Hinton (2015) demonstrate that convolutional neural networks and transformers have extended the reach of AI in linguistic interpretation tasks.

In addition, Domingos (2015) explains that the success of intelligent systems depends on the quality of the training data and the integration architecture between analysis layers. Haenlein et al. (2019) add that in the business context, AI not only processes information but redefines the way decisions are made. Marr (2020) emphasizes the importance of explainable and ethical systems that ensure transparency and reliability. Finally, Nielsen (2020) argues that automation should be accompanied by feedback mechanisms, allowing humans to maintain control over decision-making processes.

Given this scenario, the FeedbackInsight-AI project emerges as an innovative proposal to automate the processing of customer feedback, classifying them according to category and sentiment, generating automatic summaries, and integrating the results into organizational management platforms. This article describes the design, methodology and development of the system, highlighting its applicability in corporate and academic environments.

1.1 GOALS

This subsection details the objectives that guided the development of the project.

1.1.1 General Objectives

Develop an automated system for screening and analyzing customer feedback using Artificial Intelligence, focusing on textual classification, sentiment analysis and automatic summarization, integrating the results with data management and analysis tools.

1.1.2 Specific Objectives

- a) connect the system to the corporate email inbox via Gmail API;
- b) automatically process the textual content of incoming emails;
- c) apply generative AI models to classify messages and generate summaries;
- d) automatically record the results in Google Sheets;
- e) create corresponding tasks in Trello, allowing you to track the resolution;
- f) ensure security and scalability of the system in a cloud environment (GCP or AWS).

2 THEORETICAL FRAMEWORK

This section presents the fundamentals Conceptual than Support or development of FeedbackInsight-AI, addressing the main areas of knowledge that converge in the project: Natural Language Processing (NLP), Sentiment Analysis and Process Automation based on APIs.

2.1 NATURAL LANGUAGE PROCESSING (NLP) AND LANGUAGE MODELS

Natural Language Processing (NLP) is a field of Artificial Intelligence focused on the interaction between computers and human language. The goal is to enable machines to "understand", interpret and generate language effectively (RUSSELL; NORVIG, 2022).

To address the complexity and nuances of human communication, such as those found in customer feedback, NLP has evolved significantly with the advent of deep learning. As detailed by Goodfellow, Bengio, and Courville (2016), deep neural network architectures are essential for capturing complex semantic patterns.

In this context, Large-Scale Language Models (LLMs) stand out, such as Transformer (LECUN; BENGIO; HINTON, 2015), which are the basis of tools such as GPT-4. These models are trained on vast textual datasets, allowing them to perform sophisticated tasks such as intent classification, abstract generation, and pattern inference with high accuracy, being the core technological foundation of FeedbackInsight-AI.

2.2 SENTIMENT ANALYSIS IN THE BUSINESS CONTEXT

Customer feedback management is a pillar for strategic decision-making. However, the large volume of unstructured data (emails, comments, forms) makes manual analysis unfeasible (FERREIRA, 2025). Sentiment Analysis, a sub-area of NLP, is the computational technique used to extract and classify opinions, emotions, and attitudes (positive, negative, or neutral) present in texts.

In the business landscape, AI is not limited to processing information; it redefines how decisions are made (HAENLEIN et al., 2019). By applying Sentiment Analysis, FeedbackInsight-AI allows the organization to identify automatically the polarity of a message, prioritizing critical cases (negative sentiment) or identifying strengths (positive sentiment) immediately.

2.3 PROCESS AUTOMATION AND SYSTEM INTEGRATION (APIS)

The value of AI data processing is maximized when its results are integrated directly into operational workflows. Automation, in this project, is what connects textual analysis to practical action. According to Boente (2025), the adoption of automated systems allows the reduction of operational bottlenecks and increases accuracy in task screening.

This integration is technically made possible by the use of Application Programming Interfaces (APIs). FeedbackInsight-AI uses an ecosystem of APIs (Gmail, Trello, Google Sheets) that allows disparate systems to communicate in a standardized way. AI acts as the central "brain" that, after processing information (email), triggers events on other platforms (creating a card in Trello and registering in Sheets), establishing a cohesive and automated workflow.

This system aligns with Nielsen's (2020) vision of Human-AI interaction, where automation does not replace the human, but provides the feedback mechanisms (the card in Trello) for humans to maintain control and supervision over decision-making processes.

3 METHODOLOGY

The methodology used is based on an agile and interactive approach, structured in four main steps: a) Data Collection and Extraction: Gmail API is used for continuous monitoring of messages in specific folders; b) pre-processing: The textual content is cleaned and tokenized, removing noise and metadata; c) Intelligent analysis: AI models (such as GPT-4 and Gemini) are used for semantic classification, identification of sentiments (positive,

neutral or negative) and summarization; d) Integration and Storage: Results are automatically sent to Google Sheets, while tasks are created in Trello for tracking.

The development was conducted in a cloud environment, with unit tests and integration testing at each delivery sprint. This methodology ensures robustness and scalability, as proposed by Nielsen (2020) and Boente (2025).

3.1 PROMPT ENGINEERING AND FLOW ORCHESTRATION

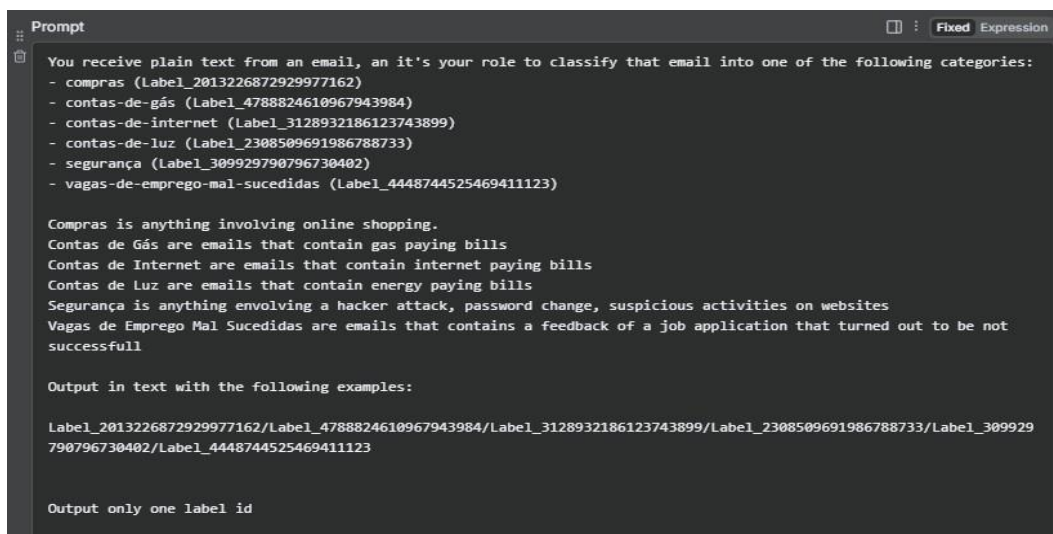
The effectiveness of Large-Scale Language Models (LLMs) in enterprise tasks depends directly on the quality of the instructions provided, a discipline known as Prompt Engineering. In the development of FeedbackInsight-AI, the interaction with the Gemini model was orchestrated through the n8n automation platform, which allows the construction of visual workflows and the manipulation of data between APIs.

For the task of sorting emails, it is not enough to ask the AI to "read the message". It was necessary to build a structured prompt that acts as a translation layer between the natural language of the customer's email and the technical structure of Gmail (which uses numeric IDs for labels).

Figure 1 shows the configuration of the worker node on n8n, where the system prompt is set.

Figure 1

Classification Prompt structure in n8n



```

Prompt
You receive plain text from an email, an it's your role to classify that email into one of the following categories:
- compras (Label_2013226872929977162)
- contas-de-gás (Label_4788824610967943984)
- contas-de-internet (Label_3128932186123743899)
- contas-de-luz (Label_2308509691986788733)
- segurança (Label_309929790796730402)
- vagas-de-emprego-mal-sucedidas (Label_4448744525469411123)

Compras is anything involving online shopping.
Contas de Gás are emails that contain gas paying bills
Contas de Internet are emails that contain internet paying bills
Contas de Luz are emails that contain energy paying bills
Segurança is anything involving a hacker attack, password change, suspicious activities on websites
Vagas de Emprego Mal Sucedidas are emails that contains a feedback of a job application that turned out to be not successfull

Output in text with the following examples:

Label_2013226872929977162/Label_4788824610967943984/Label_3128932186123743899/Label_2308509691986788733/Label_309929790796730402/Label_4448744525469411123

Output only one label id
  
```

Source: Prepared by the authors (2025).

As noted in Figure 2, the prompt strategy used three fundamental techniques to ensure response accuracy:

- a) Role-Playing Definition: The initial statement "You receive plain text from an email, and it's your role to classify..." contextualizes the model, restricting its scope of action to a specific classification task.
- b) Label ID Mapping: One of the technical challenges of the Gmail API is that it does not accept label names (such as "Purchases"), but rather unique identifiers (e.g., Label_2013...). To avoid an extra code processing step, the prompt instructs the AI to associate the semantic concept directly with the technical ID. For example, you define "Shopping is anything involving online shopping" and associate that with the corresponding ID.
- c) Output Constraint: The final statement "Output only one label id" is critical for automation. It prevents the AI from generating conversational text (such as "Here's the ID you asked for..."), ensuring that the response is only the raw data needed for the next step in the automation flow.

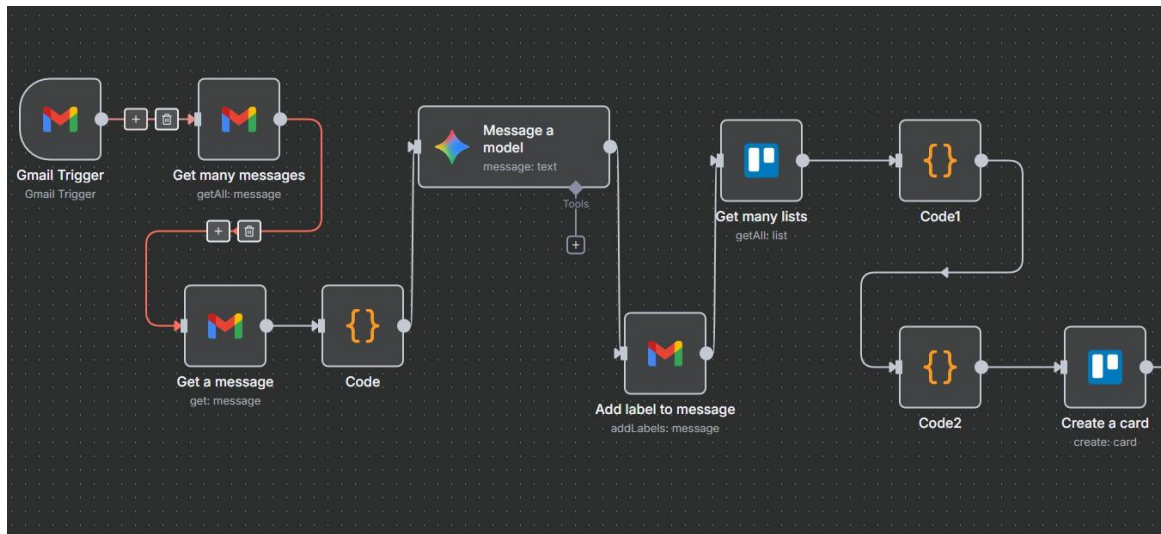
This hybrid approach, where the prompt in English is used to process intents (even from emails in Portuguese) and return structured data, optimized response time and reduced system misinterpretation.

3.2 IMPLEMENTATION FROM ALGORITHMS FROM TREATMENT AND INTEGRATION

The orchestration between the email services, artificial intelligence and the management tool (Trello) required the development of custom JavaScript scripts (Node.js) within the n8n automation platform. The architecture of the solution was designed in a linear and modular way, as illustrated in Figure 2.

Figure 2

Workflow Implemented in n8n



Source: Prepared by the authors (2025).

The flow starts with a trigger in Gmail and goes through stages of extraction, cleaning, classification via AI and, finally, the creation of the management artifact (Card). Below are detailed the critical algorithms developed to ensure data integrity.

3.2.1 Sanitization and pre-processing of text

Corporate emails often contain HTML formatting, scripts, and metadata that constitute "noise" for the language model. Sending this raw content would increase token consumption (cost) and could degrade the quality of AI interpretation.

To solve this, a cleaning algorithm via Regular Expressions (Regex) was implemented, responsible for removing HTML tags, styles and excess spaces, extracting only the relevant plain text.

Figure 3

Text Cleaning and Extraction Algorithm

```

Function executed on n8n 'Code' node
return $input.all().map((item) => {
  Retrieves the email's HTML body or empty string
  let html = item.json.html || '';
  Removes style blocks (<style>) and scripts (<script>)
  html = html.replace(/<style[\s\S]*?</style>/gi, '');
  html = html.replace(/<script[\s\S]*?</script>/gi, '');
  html = html.replace(/</>/g, '');
  Removes all remaining HTML tags, keeping only the text
  let plainText = html.replace(/<\/?[ ^>]+(>|$/g, ' ');
  Removes duplicate whitespace and normalizes plainText =
  plainText.replace(/\s+/g, ' ').trim();

  Preserves the original subject
  let subject = item.json.subject;
  item.json.plainText = plainText;
  Returns the cleaned object to the next node
  return { json: { plainText, subject } };
});

```

Source: Prepared by the authors (2025).

3.2.2 Logical Routing and Trello Integration

After the classification performed by the Gemini model, the system receives a Label ID from Gmail. The next technical challenge is to translate this ID from the

Google ecosystem for a corresponding List ID in the Trello ecosystem, where the card will be created.

A mapping algorithm (Hash Map) was developed that associates the sort keys with the destination columns, ensuring that an email classified as "Security", for example, is routed to the correct list in the management board.

Figure 4

Mapping and Payload Creation Algorithm

```

Retrieves the data from the original email and the AI
response const emails = $('Code').all();
const labels = $("Message a model").all();
return emails.map((email, index) => {
  Extracts the text from the AI's suggested
  label const label =
labels[index].json.content.parts[0].text.replaceAll('"',
  '').toString();
  Mapping (From-To): Gmail Label ID -> Trello List ID
  const labelToList = {
    'Label_2013226872929977162': '68e7405b209733f7edd0c81d',
Shopping
    'Label_2308509691986788733': '68e7409c37f2490ab9f95823',
Electricity Bills
    'Label_309929790796730402' : '68e740a4943635c9f7cf3d1c',
Safety

    'Label_3128932186123743899': '68e74096a0f2485b05c08a6c',
Internet Accounts
    'Label_4448744525469411123': '68e740b57db269eb7bd4107b',
Job Vacancies
    'Label_4788824610967943984': '68e7409197c3a647a9c43e86',
Gas Bills
  }
  Select the corresponding list ID const
  listId = labelToList[label];
  Returns the formatted payload to the Trello API return
  {
    plainText: email.json.plainText,
    title: email.json.subject,
    listId: listId
  }
  ..

```

Source: Prepared by the authors (2025).

This middleware code layer ensures interoperability between APIs, allowing the decision made by Artificial Intelligence to become a practical organization action without human intervention.

4 RESULTS AND DISCUSSIONS

The results of the project are presented through the development artifacts that define the system: the functional and non-functional requirements, the execution schedule and the use case diagram that illustrates the interaction of users and systems.

4.1 SYSTEM REQUIREMENTS

The requirements gathering defined the scope of the system, separating its functionalities (RF) and its operating restrictions (RNF).

4.1.1 Functional requirements

Table 1

Details the functions that the system must perform

Code	Description
RF01	Connect to Gmail via API.
RF02	Identify new emails in a specific folder.
RF03	Submit content for AI analysis.
RF04	Return category, sentiment and summary.
RF05	Automatically create a card in Trello.
RF06	Record the results in Google Sheets.
RF07	Mark emails as processed.

Source: Prepared by the authors (2025).

4.1.2 Non-functional requirements

Table 2

Lists the RNFs that define the quality and performance criteria of the system

Code	Description
RNF01	Execution in Cloud environment (GCP or AWS).
RNF02	Time processing $\leq 10s$ by email.
RNF03	Secure authentication via OAuth2.
RNF04	Scalability towards until 10,000 emails/month.
RNF05	Records of error and status logs.

Source: Prepared by the authors (2025).

4.2 DEVELOPMENT TIMELINE

The project was executed in eight weeks, following the planning detailed in Table 3.

Table 3

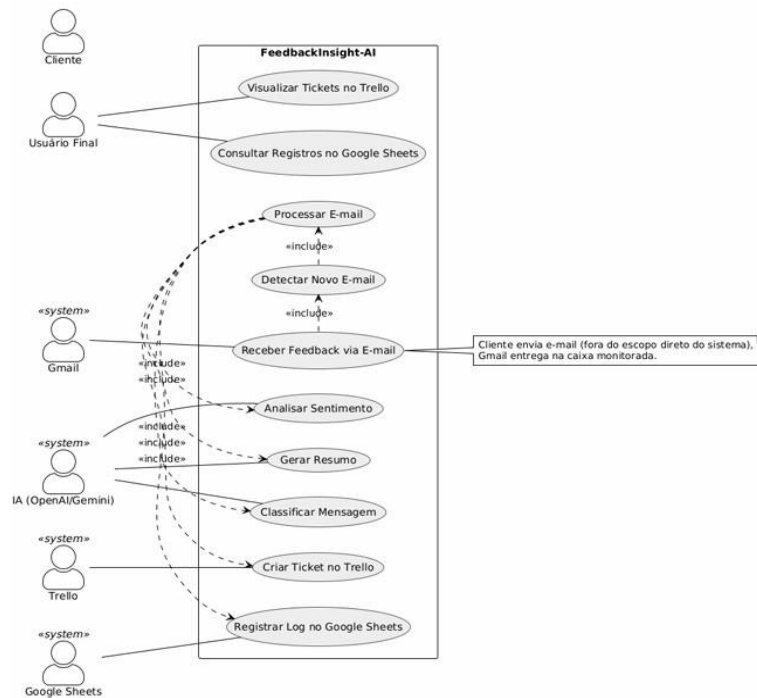
Development Schedule

Week	Activity	Accountable	Deliverable
1	Definition of scope and requirements	Team	Requirements document
2	Environment configuration (APIs and cloud)	Philip	Environment ready
3	Gmail API integration	Matheus	Functional extraction
4	Implementing AI analytics	Philip	Rating and summary
5	Trello API Integration	Matheus	Tickets Automatic
6	Integration with Google Sheets API	Team	Logging
7	Unit and integration testing	Team	Test Report
8	Cloud deployment and final documentation	Team	Active system

Source: Prepared by the authors (2025).

4.3 USE CASE DIAGRAM

Figure 5
Use Case



5 CONCLUSION

The FeedbackInsight-AI project demonstrated the technical and practical feasibility of applying AI models in corporate feedback analysis and management processes. The integration between communication APIs, advanced language models, and productivity platforms represents a significant advance for companies that deal with a high volume of textual information.

As a result, the system contributes to reducing response time, improving demand prioritization, and data-driven decision-making. In future work, it is recommended to include continuous learning modules (supervised machine learning) and analytical dashboards for real-time visualization.

Thus, FeedbackInsight-AI consolidates itself as an innovative and scalable tool, aligned with contemporary demands for intelligent automation and digital transformation.

ACKNOWLEDGMENT

I want to leave here my gratitude to everyone who was part of this journey — which was intense, full of ups and downs, but totally transformative.

I thank my advisor professor, Ricardo Marciano, for his patience, for his accurate guidance and for always showing the way when everything seemed to be chaos.

To my co-worker, Matheus Marques, for being a key player in this project — both helping in the development and having the very idea that gave rise to everything. It was very much worth the partnership.

To my girlfriend, Ana Clara Gonçalves, who has always supported me, believed in me and reminded me, on the most complicated days, that my dreams are worth the effort. Without you, I wouldn't have held on tight.

And, of course, to my father. Even though I was stubborn as hell and made some very dubious decisions along the way, he never stopped supporting me for a second. This support was essential for me to get here.

To all of you: thank you very much. You were part of this tour in a way that I will carry with me for the rest of my life.

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STUDY OF THE ANALOGIES PRESENT IN VOLUME 'COMPOSIÇÃO E ESTRUTURA DOS CORPOS' DA COLEÇÃO 'SER PROTAGONISTA: CIÊNCIAS DA NATUREZA E SUAS TECNOLOGIAS'

ESTUDO DAS ANALOGIAS PRESENTES NO VOLUME 'COMPOSIÇÃO E ESTRUTURA DOS CORPOS' DA COLEÇÃO 'SER PROTAGONISTA: CIÊNCIAS DA NATUREZA E SUAS TECNOLOGIAS'

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 <https://doi.org/10.56238/sevened2025.036-075>

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ABSTRACT

Analogies are instruments used in teaching that contribute to the success of teaching and learning processes, because they can make an unknown concept (target concept) be understood, when compared to a known concept (analogous concept). The dissemination of its use in Natural Sciences and their technologies textbooks has boosted the demand for evaluations on the way they are being used. Thus, this work aims to present results of a study on the analogies found in volume 'Composição e estrutura dos corpos', from the collection 'Ser Protagonista: ciências da natureza e suas tecnologias'. After complete and detailed reading, we identified only three analogies in book. They were discussed and classified according to a system proposed by some researchers. Hardly any of them discuss important aspects related to their objectives. We highlight the importance and the need for more discussions on the use of analogies, especially in initial teacher training courses, so they can be used in a way that does not harm learning.

Keywords: Target Concept. Analogous Concept. Chemistry Teaching. Textbook.

RESUMO

Analogias são instrumentos empregados no ensino que contribuem para o sucesso dos processos de ensino e aprendizagem, pois podem fazer um conceito desconhecido (conceito alvo) ser compreendido, quando comparado a um conceito conhecido (conceito análogo). A disseminação de sua utilização em livros didáticos da área das Ciências da Natureza e suas tecnologias impulsionou a demanda de avaliações sobre a maneira como estão sendo empregadas. Assim, este trabalho objetiva apresentar resultados de um estudo sobre as analogias encontradas no volume 'Composição e estrutura dos corpos', da coleção 'Ser Protagonista: ciências da natureza e suas tecnologias'. Após a leitura integral e minuciosa da obra, identificamos apenas três analogias que foram discutidas e classificadas de acordo com um sistema proposto por alguns pesquisadores. Praticamente todas elas não discutem aspectos importantes relacionados aos seus objetivos. Evidenciamos a importância e a necessidade de mais discussões sobre o uso desses instrumentos, principalmente nos

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cursos de formação inicial de professores, para que possam ser utilizados de maneira a não prejudica o aprendizado.

Palavras-chave: Conceito Alvo. Conceito Análogo. Ensino de Química. Livro Didático.

RESUMEN

Las analogías son herramientas didácticas que contribuyen al éxito de los procesos de enseñanza y aprendizaje, ya que facilitan la comprensión de un concepto desconocido (concepto objetivo) al compararlo con un concepto conocido (concepto análogo). El uso generalizado de analogías en los libros de texto de Ciencias Naturales y sus tecnologías ha impulsado la demanda de evaluaciones sobre su aplicación. Por ello, este trabajo pretende presentar los resultados de un estudio sobre las analogías presentes en el volumen «Composición y Estructura de los Cuerpos», de la colección «Ser Protagonista: Ciencias Naturales y sus Tecnologías». Tras una lectura completa y minuciosa del trabajo, se identificaron solo tres analogías que se discutieron y clasificaron según un sistema propuesto por algunos investigadores. Prácticamente ninguna de ellas aborda aspectos importantes relacionados con sus objetivos. Resaltamos la importancia y la necesidad de profundizar en el uso de estas herramientas, especialmente en la formación inicial del profesorado, para que se utilicen de forma que no obstaculicen el aprendizaje.

Palabras clave: Concepto Objetivo. Concepto Análogo. Enseñanza de la Química. Libro de Texto.

1 INTRODUCTION

The textbook plays a fundamental role in the teaching and learning processes. For many teachers who, more specifically, work in Basic Education, this instrument becomes the most used resource during their classes, if not the only one. When it comes to teaching in the area of Natural Sciences and its technologies, this reality is very present in the work of teachers, as these are contents that often do not find more appropriate methodologies for their exploration other than those based on the use of textbooks (MUNAKATA, 2016).

However, when reflecting on the true role of this pedagogical instrument, Oliveira (2012, p. 26) argues that "[...] it is through the dialogue between scientific knowledge, the teacher's discourse and his own discourse that the student apprehends the meanings produced in the scientific construction", and that, therefore, the textbook should be an instrument capable of promoting the construction of the student's knowledge and, therefore, should constitute a material capable of contributing to facilitate the learning process.

In this sense, textbooks in the area of Natural Sciences and their technologies often resort to some artifices, analogies, which are also widely used by teachers during their classes. These devices have been used for a long time, both in formal and informal education and, in particular, have been guaranteed to be present in textbooks. In view of this, analogies have become targets of studies by many researchers from the most different areas (DUIT; 1991; GATES; JULIÃO, 2016; MÓL, 1999; MARTIN; JUSTI, 2000; OLIVEIRA, 2012; THIELE; TREAGUST, 1994).

Duit (1991) and Thiele and Treagust (1994) define analogy or analogical reasoning as a comparison between a 'known concept', also called an 'analogous domain' or an 'analogous concept', and an 'unknown concept', also called a 'target concept'. In other words: an analogy constitutes the use of a concept already well understood by the learner to facilitate the understanding of another that is being learned.

It is from this understanding that Francisco Júnior (2009) draws attention to the importance of evaluating the way they are being used, both in the classroom by teachers and in textbooks, since they have become relevant instruments in enhancing the learning of scientific concepts. Thus, for this scholar, it is necessary to observe, especially in these books, the number of them used, the level of understanding of the concepts worked on and the possibility of generating misinterpretations about the target concept to be learned.

In this dimension, Bozelli and Nardi (2006) emphasize the importance of promoting discussions about analogies in initial teacher training courses, especially those used in formal

education. This could avoid the continuity of the disorderly use of these instruments in the classroom without prior study. In other words, it is necessary to analyze the advantages and disadvantages that these devices can bring to the learning process. In the opinion of these researchers, it is of fundamental importance that the teacher knows how to use analogical reasoning correctly, minimizing the problems related to the understanding of the concepts worked on in the classroom.

Considering this important aspect for the work of teachers and, especially, for teachers who are in the process of training, Francisco Júnior (2009), based on the studies of Thiele and Treagust (1994), suggested a system composed of ten categories that has contributed significantly to a better understanding of analogies. This system makes it possible to understand how they can become important allies for the success of teaching and learning processes. The ten categories are summarized in Table 1.

Table 1

System of criteria for classification of analogies

ORDER	CRITERION	DESCRIPTION
1	Quantity and frequency of analogies	It determines the quantity and frequency of analogies identified in the analyzed work.
2	Content of the target concept	Defined by the content(s) or topic(s) of Chemistry, Physics or Biology that constitutes the target concept of the analogy;
3	Analogical relationship between the analogous concept and the target concept	It considers the type of similarities between the analogous concept and the target concept, which can be: - Structural: the similarities are of the structural type; the similarities are physical in nature; - Functional: the operation or behavior of the analog is similar to the target.
4	Presentation format	- Verbal: analogy presented only by text; - Illustrative: presented only through illustrations; - Verbal-illustrative: presented through text and illustration.
5	Level of abstraction of analogous and target concepts	It identifies the degree of materiality established between the analogue and the target, respectively. It can be: - Concrete-abstract; - Concrete-concrete; - Abstract-abstract.
6	Position of the analogy in relation to the target concept	Indicates the order of the analogy in relation to the target concept. It can be: -Before; -After; - During the presentation of the target concept; - In the margins of the textbook page.

7	Analogy Enrichment Level	It verifies the extent of the relationship between the analogue and the target, which can be: - Simple: the list does not highlight similar attributes; - Enriched: the ratio highlights similar attributes; - Extended: uses more than one analogue.
8	Analogy Mapping Level	It identifies whether the author presents a discussion about the correspondences between the analogue and the target.
9	Presence of pre-topic guidelines	It identifies characteristic terms and expressions announcing the presence of analogy.
10	Presentation and discussion of limitations	It verifies the existence of excerpts evidencing the limitations of the analogy. It can be: - Does not recognize the existence; - Recognizes the existence; - Recognizes the existence and discusses it;

Source: adapted from Francisco Júnior (2009).

Considering, therefore, the scenario outlined so far, the objective of this work was to present the results obtained from a study carried out on the analogies present in a textbook in the area of Natural Sciences and its technologies, adopted in high school classes in Brazilian public schools.

2 METHODOLOGY

The research was developed with the aim of identifying, discussing and classifying the analogies present in the volume 'Composition and structure of bodies', from the collection 'Being a Protagonist: natural sciences and their technologies'. Aimed at Brazilian high school students, the book covers Chemistry, Physics and Biology content.

This collection bears the signature of several authors and has André Zamboni and Lia Manguilhott Bezerra as editors. Its first edition was published in 2020, by the publisher SM Educação, from São Paulo.

The investigation conducted to produce the results presented here can be characterized from the perspective of a qualitative approach, without, however, neglecting its quantitative aspect, since the numbers obtained constituted important data for a better understanding of the phenomenon studied. From the point of view of its objectives, it can be classified as exploratory, as it brings important contributions to the collection of studies on analogies present in books adopted in High Schools (MALHEIROS, 2011).

For its development, we followed a schedule that consisted of practically two moments. The first consisted of a bibliographic survey, cataloguing and acquisition of the material to be analyzed, followed by a thorough and complete reading of the work, in order to identify the analogies present in it.

The second comprised some stages: 1) classification of the analogies identified in the book, we used a system composed of 10 (ten) categories established by Francisco Júnior (2009), according to the studies developed by Thiele and Treagust (1994); 2) organization of results and; 3) preparation of the final research report.

To facilitate the recognition of the presence of an analogical reasoning contained in the analyzed work, we used, during the readings, the definitions of analogy developed by the main researchers in the area: THIELE; TREAGUST (1994); DUIT (1991); MÓL (1999); GATES; JULIÃO (2016); MARTIN; JUSTI (2000); OLIVEIRA (2012), among others.

Still in the process of recognizing the analogies of the work, we used textual elements such as '... similar to ...', '... making an analogy ...', '... that's like...', '... analogously ...', which are characterized as indicators of analogies (FRANCISCO JÚNIOR, 2009).

3 RESULTS AND DISCUSSIONS

Throughout the process of careful reading of the work, we noticed that its texts do not make a clear and elucidative approach to the contents presented, despite the work being adequate both to the level of understanding of the student for whom it is intended, and to the level of work to be performed by the teacher. In other words, the authors do not delve into the subjects explored in a way that allows greater accessibility to the understanding of what is being explained. This will be demonstrated later.

Moreover, similar to other works, the book presents some vulnerabilities, such as, for example, the lack of references to contextualizing and specific circumstances of the contents, which could be related to the daily lives of students from different Brazilian geographic regions.

The analogies identified and classified, as well as the quantity and frequency in which they were arranged in the book are discussed in this article according to the proposal and criteria of Thiele and Theagust (1994). On the last page of this work, we present Table 2, which summarizes the results and discussions presented below.

3.1 THE ANALOGIES IDENTIFIED: DISCUSSIONS AND CLASSIFICATION

The first classification criterion, 'Quantity and frequency of analogies', refers to the result of the quantitative analysis of their presence throughout the work. Regarding this aspect, we find a very small number: only 03 (three) analogies are present in the entire book. Another observation that causes strangeness is the fact that it has a frequency of only 0.3

analogies per chapter, an extremely small amount when compared to other works (FRANÇA, 2017).

In addition, they are distributed in a very irregular way: the 03 (three) analogies are located in Unit 1 of the book. The first was found in chapter 1, the second in chapter 3, and the third is located in the section 'Specific guidelines and comments', intended exclusively for teachers, and refers to chapter 4. It is worth noting that the work contains a total of 10 chapters distributed by 3 Units, over 260 pages.

In her work, França (2017) observed that one of the works she analyzed, containing 20 (twenty) chapters, presents 11 (eleven) analogies, that is, a frequency of 0.55 analogies per chapter. The other criteria will be discussed as each analogy is presented individually.

3.2 FIRST ANALOGY

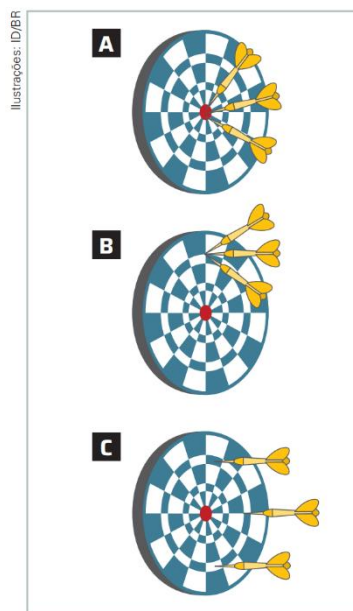
Figure 1 shows the first analogy identified in the book. Inserted on page 20, chapter 1 (Units of measurement and properties of matter) of Unit 1 (What materials are made of), this analogical reasoning addresses content related to the concepts of 'precision, correctness and errors'. The authors make a comparison of the results of darts thrown at a bullseye and the concepts of precision and accuracy: 'The concepts of precision and accuracy can be represented by the distribution of darts thrown at a bullseye, ...' (ZAMBONI; BEZERRA, 2020, p. 20).

The analogous concept or domain (known concept) of this analogy is represented by the distribution of darts thrown at a bullseye, as shown in the illustration in the book, presented here in Figure 1. The target or unknown concept refers to 'precision' and 'accuracy'. When discussing the location of the data released in the three sets (A, B and C), the authors show the association between the results of the launches and the target concepts. This discussion is highlighted in the red rectangle in Figure 1.

With respect to the third criterion, analogical relationship between the analogous concept and the target concept, we observed that the domains share structural attributes, which allows us to classify the analogy as 'structural', since the aspects used by the authors to explain the target concepts refer to the physical form with which the results are presented.

Figure 1

Presentation of the first analogy, Chapter 1, Unit 1, p. 20



Fonte de pesquisa: KOTZ, J. C.; TREICHEL, P. M. J. *Química geral e reações químicas*. 5. ed. São Paulo: Pioneira Thomson Learning, 2005. v. 1.

Precisão, exatidão e erros

A **precisão** ou **repetibilidade** de uma medida indica o quanto as medidas repetidas estão próximas umas das outras. Os cientistas tentam obter valores mais precisos realizando muitas medidas e calculando a média dos resultados.

A **exatidão** mostra que o valor de uma medida está muito próximo do valor comumente aceito como referência (também denominado **valor real**).

Contudo, medidas precisas podem resultar em valores inexatos. Erros desse tipo ocorrem quando, por exemplo, um resíduo sólido fica no prato de uma balança. Se esse resíduo não for percebido e retirado, todas as pesagens posteriores apresentarão um **erro sistemático**: os valores obtidos serão precisos (ou seja, próximos entre si), porém a massa média obtida será inexata (distante do valor real), pois incluirá a massa do resíduo.

Há também os **erros aleatórios**, que podem ter várias causas. Leituras incorretas executadas pelo operador do instrumento de medição e mudanças nas condições experimentais, por exemplo, podem levar a medidas imprecisas e inexatas.

Os conceitos de precisão e exatidão podem ser representados pela distribuição de dardos lançados contra um alvo, como nas figuras ao lado. A figura **A** mostra que o atirador foi preciso e exato, porque todos os dardos atingiram o centro do alvo. A figura **B** mostra que o atirador foi preciso, mas não foi exato, pois os dardos não atingiram o centro do alvo (apesar de todos eles acertarem o mesmo ponto). A figura **C** indica que o atirador não foi nem preciso nem exato.

Algarismos significativos

Source: Zamboni and Bezerra (2020, p. 20).

The format of the presentation (fourth criterion) can be characterized as being 'illustrative/verbal', as the analogy is presented (Figure 1) through a text accompanied by an illustration, which enriches the authors' explanation of the target concepts.

As for the fifth criterion, level of abstraction of the analogous and target concepts, this analogy can be classified as being of the 'concrete/abstract' type, because the analogous concept, exposed by means of an illustration showing the way in which dice thrown against a target were distributed in three situations, has a concrete nature, while the target concepts (precision and accuracy), exposed by the authors in the first two paragraphs of Figure 1, they concern abstract entities, that is, they subsist thanks to the concrete entities represented by the analogous concept.

In the sixth criterion, we analyze the position of the analogy in relation to the target concept. In this case, we observe that this concept was presented before analogical reasoning, so that the position of this analogy is characterized as 'after'.

The seventh criterion refers to the level of enrichment of the analogy, and in the case of this analogy, we can classify it as being of the 'enriched' type, although the connections between the analogous and target concepts have not been exhaustively explored. The authors forgot to mention that each javelin thrown represents a measurement made by

scientists in their research. By comparing these measurements (positions of the darts), the researchers would be able to evaluate the precision and accuracy of their measurements.

As for the eighth classification criterion, the level of mapping done by the author, we can say that the authors showed the existing correspondences between the elements of the analogous and target concepts, as an attempt to familiarize the student with the target concept. However, this mapping could be more substantial if the correspondences between the darts and the scientists' measurements had been highlighted.

Regarding the ninth criterion, the presence of a pre-topic orientation, this analogical reasoning does not present it. At no time do the authors call attention, through a characteristic expression, to the presence of analogy, that is, it fails to strategically introduce the reader to the understanding of analogy.

In the last criterion of classification, presentation and discussion of limitations, this analogy can be framed as not recognizing the existence of aspects and attributes that converge for a good understanding of the target concept. Among some that we could list, and which were not explored by the authors, are: the shape of the darts (numerical values), the target (real or correct value), the way the data is manipulated (the way scientists obtain their measurements), etc.

3.3 SECOND ANALOGY

The second analogical reasoning (Figure 2) is located on page 44, chapter 3 (Quantum Physics) of Unit 1 (What Materials Are Made Of). It addresses the content related to the 'wave-particle duality', comparing experiments. The authors seek to show the relationship between the 'Interference patterns of an electromagnetic wave' (analogous concept), observed from Young's experiment, with the 'Distribution patterns of spheres launched in a double-slit experiment' (target concept), carried out by De Broglie. The main purpose of this comparison is to make the reader understand the wave-particle duality, a property inherent to the nature of the behavior of matter.

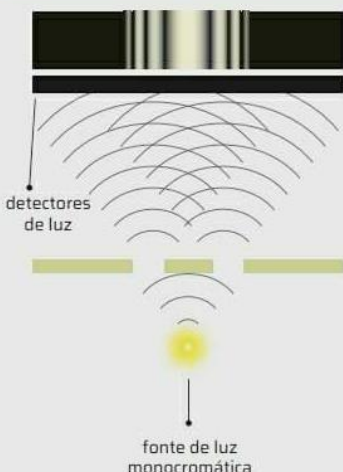
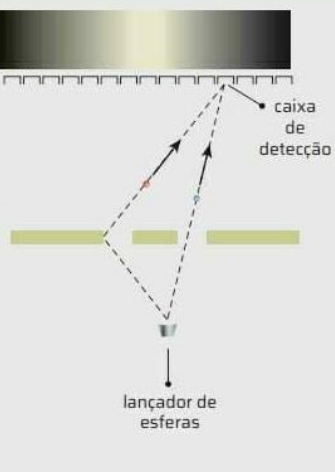
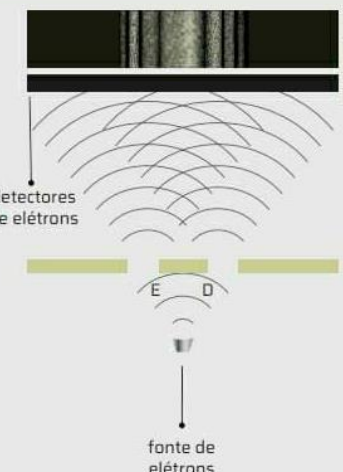
The analogous concept worked on it refers to the "double-slit experiment for electromagnetic radiation carried out by the British physicist and physician Thomas Young (1773-1829), as represented below" (ZAMBONI; BEZERRA, 2020, p. 44). Here, this is shown in Figure 2.

Although the authors explain Young's experiment, this analogous concept is quite complex, making it difficult for students to understand the target concept. Possibly, a simple

experiment carried out by the teacher in the classroom could contribute to a better understanding of the phenomenon and meaning of wave-particle duality.

Figure 2

Presentation of the second analogy, Chapter 3, Unit 1, p. 44

Situação 1: Padrões de interferência de uma onda eletromagnética	Situação 2: Padrões de distribuição de esferas lançadas em experimento de dupla fenda	Situação 3: Padrões de interferência de um feixe de elétrons
 detectores de luz fonte de luz monocromática	 caixa de detecção lançador de esferas	 detectores de elétrons fonte de elétrons
O experimento de Young consistiu em fazer uma luz monocromática incidir sobre duas fendas próximas. Depois de a luz passar pelas fendas, ocorria interferência. O resultado foi um padrão de linhas paralelas no anteparo.	Por analogia com o experimento de Young (situação 1), De Broglie propôs que um feixe de partículas também seria difratado, ao passar por uma fenda dupla. Empregando um arranjo experimental similar ao de Young, porém com esferas suficientemente pequenas para passar pelas fendas, De Broglie obteve um padrão de distribuição das esferas.	Um experimento semelhante com somente um feixe de elétrons foi realizado quatro anos depois da proposição formulada por De Broglie. Clinton J. Davisson (1881-1958) e Lester H. Germer (1896-1971) montaram um arranjo experimental similar ao de Young e lançaram um feixe de elétrons sobre as fendas duplas. Foram obtidos os mesmos padrões de interferência de quando se lançaram ondas eletromagnéticas (situação 1).

Source: Zamboni and Bezerra (2020, p. 44).

This difficulty in understanding the analogous concept leads us to two questions: Does the student master the analogous concept used by the analogy? If not, how will he be able to understand the target concept?

When making use of an analogy, it is necessary to consider that the student (re)recognizes and understands the analogous concept. Thus, if the student does not master the content studied before the analogy is presented, that is, he is not familiar with the analogous concept, he may not be able to understand the target concept, since the two domains will be worked on in an associated way. This means that analogies of this nature can compromise the understanding of the concept they propose to clarify (FRANCISCO JÚNIOR; FRANCIS; OLIVEIRA, 2012).

As for the third criterion, analogical relationship between the analogous concept and the target concept, we can classify this analogy as being of the 'structural/functional' type, because the analogous and target concepts share both structural (existence of slits in the equipment of the experiments) and operational (passage of light and spheres through the slits) aspects.

In the fourth criterion, presentation format, we again have an analogy of the 'illustrative/verbal' type, since the authors use texts and illustrations to try to familiarize the reader with the target concept (Figure 2).

'Concrete/concrete' would be the type of classification of this analogy in relation to the fifth criterion of analysis, level of abstraction of analogous and target concepts. The analogous concept briefly describes an experiment carried out by Young, and the target concept uses the description of "an experimental arrangement similar to Young's, but with spheres small enough to pass through the cracks" (ZAMBONI; BEZERRA, 2020, p. 44).

Regarding the sixth criterion, the position of the analogy in relation to the target concept, it is certainly of the 'after' type, because, as in the first analogy studied, it was positioned after the description of the target concept, that is, the authors explain the behavior of a wave from electromagnetic interference and only then describe the analogy to 'reinforce' the understanding of the target concept.

Analyzing the seventh criterion, the level of enrichment of the analogy, it was possible to see that this analogy portrays a 'simple' type. Although the authors present a text that seeks to explore the association between the concepts worked, no additional relationship was shown between the analogue and the target, which could denote an extension of their similarities, which demonstrates the lack of enrichment of this analogical reasoning.

Unfortunately, it was not possible to identify any kind of discussion, debate or description, promoted by the authors, listing and explaining the elements existing in the analogous and target concepts that share similarities, in an attempt to familiarize the reader with the target concept. Thus, we can say that this analogy does not contemplate the eighth criterion of analysis: level of mapping done by author.

Regarding the ninth criterion, the presence of pre-topic guidance, the existence of the term used by the authors when presenting the analogy, "... By analogy..." (ZAMBONI; BEZERRA, 2020, p. 44), allows us to say that 'yes', this analogical reasoning has a pre-topic, since this term announces the existence of an analogy.

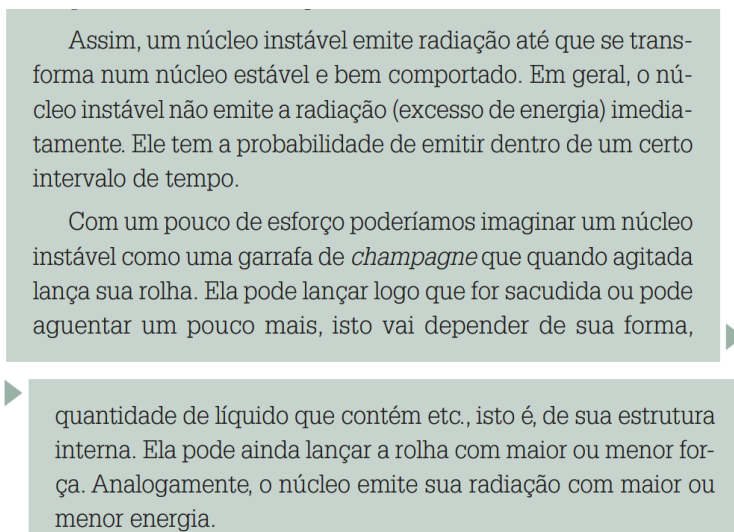
Regarding the tenth criterion for analysis, presentation and discussion of limitations, we can say that there are no references to the existence of these elements in the information provided by the authors. Thus, we must consider a certain negligence in this aspect, since the analogous concept uses light as an element that propagates, while the target concept uses small spheres. Certainly, different behaviors will have to be observed, starting with the fact that light will propagate in all directions, while each sphere will move in a single direction.

3.4 THIRD ANALOGY

The third analogy (Figure 3) is located in a complementary text on the subject explored in chapter 4 (Nuclear Physics) of Unit 1 (What materials are made of), and addresses the content 'Radioactivity'. In this analogical reasoning, the authors make a comparison between 'a bottle of champagne that when shaken releases its cork' (analogous concept) and 'instability of an atomic nucleus' (target concept).

Figure 3

Presentation of the third analogy, Chapter 4, Unit 1, p. 201-202



Source: Zamboni and Bezerra (2020, p. 201 and 202).

With respect to the third criterion, analogical relationship between the analogous concept and the target concept, we can classify this analogy as being of the 'functional' type, because its use explores the similar functional and behavioral aspects between the concepts worked, that is, the way in which the release of a cork by a shaken bottle of champagne and the emission of radiation by an atomic nucleus behave. There are no common and explicit structural elements that can be used for a better understanding of the target concept.

In the fourth criterion, presentation format, we classify this analogy as being of the exclusively 'verbal' type, since it is presented only through an explanatory text. It is worth highlighting the appeal exposed by the authors, evoking the use of the reader's imagination: "With a little effort we could imagine an unstable nucleus like a champagne bottle that, when shaken, releases its cork" (Figure 3).

Considering the fifth evaluation criterion, level of abstraction of analogous and target concepts, we consider this analogy to be of the 'concrete/abstract' type, since it uses an analogical concept of concrete aspects (a bottle of champagne that when shaken drops its cork) to explain an abstract target concept (the instability of an atomic nucleus).

In the sixth criterion of analysis, position of the analogy in relation to the target concept, similar to the previous analogies, we classify it as 'after', that is, it was presented after the concept to be learned had been explained.

As for the seventh criterion, level of enrichment, this analogy was considered 'simple', because we did not observe the presence of elements that would explain the similarity of their attributes. For example, the authors did not exploit the fact that, in the atomic nucleus, the agitation promoted in the champagne bottle would correspond to the energy needed by the nucleus for the emission of radiation to occur.

When considering the level of mapping done by the authors, the eighth criterion used to study these analogies, we did not identify discussions showing the possible correspondences between the concepts, whose objective would be to familiarize the reader with the target concept. The text shown in Figure 3 even denotes a certain intention in exposing a mapping, "She can still throw the cork with greater or lesser force. Analogously, the nucleus emits its radiation with greater or lesser energy" (ZAMBONI; BEZERRA, 2020, p. 202), however, the authors chose not to prosper.

Regarding the ninth criterion, presence of pre-topic orientation, in this analogy an expression and a term were identified that characterize his text as containing this type of didactic strategy: 'With a little effort we could imagine [...]' and 'Analogously, [...]' (Figure 3). In this sense, Gonçalves and Julião (2016) highlight the importance of using pre-topics in textbooks, as it allows the reader a certain 'preparation' for reading the text containing the analogy, contributing to the promotion of the functionality of this instrument and, consequently, a better understanding of the target concept.

Like the analogies discussed above, this analogical reasoning does not recognize the existence of its limitations, and it is therefore up to the reader to identify them. The absence

of this element, according to Francisco Júnior (2009), can generate obstacles during the process of using analogy, causing the student to understand the target concept in an unsatisfactory way or even in a completely mistaken way.

4 FINAL CONSIDERATIONS

The results of this research brought to light some important aspects concerning the analogies presented in the volume 'Composition and structure of bodies', from the collection 'Being a Protagonist: Natural Sciences and their Technologies'. One of the most significant refers to the small number of analogies identified in the book, only three, meaning a very low frequency. This observation reveals a certain lack of interest on the part of the authors in the use of these didactic tools, which can be of great help in the learning of Chemistry, Physics and Biology, whose contents are, in general, considered difficult to understand.

The first analogy was considered to be of the enriched type, although the authors have promoted an almost insignificant discussion about the relations between the concepts worked. The other two, being of the simple type, do not present any reference to this criterion. The book does not explore the aspects of the analogous concept attributes that contribute to the understanding of the target concept. In other words, the authors do not highlight the relationship between similar attributes or use another analogue to familiarize the reader with the target concept.

When it comes to mapping, the first analogy presents it, but in a very stunted way. On the other hand, the two other analogies are highly deficient in this criterion, since their texts do not discuss or show the similarities and dissimilarities between the analogous and target concepts worked. This shows that the book did not adequately explore the potential of these instruments, which may mean difficulties in understanding students.

In none of the analogies do the authors discuss the limitations related to their uses. The absence of these discussions allows for misinterpretations by readers, which can make the understanding of the target concepts difficult or distorted. However, the enrichment, mapping and limitations of these analogies can be explored by the teacher who adopts this book and uses them in the classroom. For this, it is necessary for the teacher to do a previous study and planning, in order to ensure success in the use of these instruments.

In the third analogy, the authors evoke the use of the reader's imagination to understand the text that presents it. This leads us to the question: and if the student does not know the analogous concept, can he understand the target concept? We highlight here a

certain precariousness in the choice of this analogy, since in order to achieve its objectives in a satisfactory way, it is imperative that the analogous concept be very familiar to the learner.

Finally, we highlight that, from this study, it is evident the need to foster, in teacher training courses, discussions about the choice of the textbook to be adopted by future teachers and the appropriate use of analogies, which are very present in books in the area of Natural Sciences and their Technologies. These discussions can contribute to a better performance of these professionals, making the learning of Chemistry, Physics and Biology content less complicated for students.

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APPENDIX

Table 1

Classification of the analogies found in the book 'Composition and structure of bodies' from the collection 'Being a protagonist: Natural Sciences and their Technologies'

Nº analogia	Capítulo	Conteúdo	Conceitos (análogo-alvo)	Relação analógica	Apresentação	Nível de abstração	Posição	Nível de enriquecimento	Mapeamento	Pré-tópicos	Limitações
1	1	Precisão, exatidão e erros	Distribuição de dardos lançados contra um alvo – Precisão e exatidão	Estrutural	Ilustrativo/ Verbal	Concreto/ Abstrato	Depois	Enriquecida	Sim	Não	Não
2	3	Dualidade onda-partícula	Padrões de interferência de uma onda eletromagnética - Padrões de distribuição de esferas lançadas em experimento de dupla fenda	Estrutural/ Funcional	Ilustrativo/ Verbal	Concreto/ Concreto	Depois	Simples	Não	Sim	Não
3	4	Radioatividade	Uma garrafa de champagne que quando agitada lança sua rolha - um núcleo atômico instável	Funcional	Verbal	Concreto/ Abstrato	Depois	Simples	Não	Sim	Não

Source: Authors.

**CLIMATE CHANGE AND THE CIRCULAR ECONOMY: IMPACTS AND
SUSTAINABLE ALTERNATIVES IN THE AÇAÍ PRODUCTION CHAIN**

**MUDANÇAS CLIMÁTICAS E A ECONOMIA CIRCULAR: IMPACTOS E AS
ALTERNATIVAS SUSTENTÁVEIS NA CADEIA PRODUTIVA DO AÇAÍ**

**CAMBIO CLIMÁTICO Y ECONOMÍA CIRCULAR: IMPACTOS Y ALTERNATIVAS
SOSTENIBLES EN LA CADENA DE PRODUCCIÓN DEL AÇAÍ**

 <https://doi.org/10.56238/sevened2025.036-076>

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ABSTRACT

Climate change has a direct impact on the circular economy, as changes in climate variables such as air temperature compromise the production of açaí. The gap that motivated this research is in terms of understanding the interaction between climate change, the circular economy and açaí and the effect of this on riverside communities. Therefore, the objective of this research is to understand this triad interferes in the riverside community socially and economically. The methodology used was the secondary investigative (desk research), obtaining the literature to compose the corpus of this research, in electronic links that store literature related to the theme of this research. The data obtained and analyzed indicated that climate change interferes in two ways in the production of açaí, by increasing the precipitation rate and flooding of areas where the clump is inserted. The circular economy acts to mitigate the accumulation of solid waste, especially burning and deposition in open air lessons, especially of the pits and current in a positive way in riverside communities since the use of this waste can replace income in rainy seasons. As for açaí, the analysis of the data obtained indicated that climate change causes a loss in flowering until it is lost, which determines a decrease in biodiversity diversity. Therefore, continuous studies and research, especially in the North region, must proliferate more and more, and unite riverside communities, higher education institutions and local governments in search of feasible solutions to climate change.

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Keywords: Floods. Inundations. Temperature Rise Trends. Riverside Communities.

RESUMO

As mudanças climáticas têm interferência direta na economia circular, pois as alterações de variáveis climáticas como a temperatura do ar, comprometem a produção do açaí. O gap que motivou esta pesquisa é quanto a compreensão quanto a interação entre as mudanças climáticas, a economia circular e o açaí e o efeito disto sobre as comunidades ribeirinhas. Por isso, o objetivo desta pesquisa é entender esta tríade interfere na comunidade de ribeirinhos social e economicamente. A metodologia empregada foi a investigativa secundária (desk research), a obtenção das literaturas para composição do corpus desta pesquisa, em links eletrônicos que armazenam literaturas relacionadas ao tema desta pesquisa. Os dados obtidos e analisados indicaram que as mudanças climáticas interferem de duas maneiras na produção do açaí, pela elevação da taxa da precipitação e alagamento de áreas onde a touceira está inserida. A economia circular atua de forma a mitigar o acúmulo do resíduos sólidos, especialmente a queima e a deposição em lições a céu aberto, especialmente dos caroços e atual de forma positiva nas comunidades ribeirinhas já que o uso deste resíduos pode substituir a renda em épocas de chuva. Quanto ao açaí, a análise dos dados obtidos indicou que as mudanças climáticas, provoca uma perda na floração até perda dela, o que determina diminuição da diversidade da biodiversidade. Então, estudos e pesquisas contínuas,, especialmente na região Norte, devem proliferar cada vez mais, e unir as comunidades ribeirinhas, a instituições de ensino superior e os governantes locais em busca de solução exequíveis às mudanças climáticas.

Palavras-chave: Alagamentos. Inundações. Tendências de Aumento de Temperatura. Comunidades Ribeirinhas.

RESUMEN

Las cambios climáticos tienen una interferencia directa en la economía circular, ya que las alteraciones de variables climáticas, como la temperatura del aire, comprometen la producción del açaí. El vacío que motivó esta investigación se refiere a la comprensión de la interacción entre los cambios climáticos, la economía circular y el açaí, y el efecto de esta relación sobre las comunidades ribereñas. Por ello, el objetivo de esta investigación es entender cómo esta tríada interfiere social y económicamente en la comunidad de ribereños. La metodología empleada fue la investigación secundaria (desk research), obteniendo la literatura para la composición del corpus de esta investigación a partir de enlaces electrónicos que almacenan estudios relacionados con el tema. Los datos obtenidos y analizados indicaron que los cambios climáticos interfieren de dos maneras en la producción del açaí: por el aumento en la tasa de precipitación y por la inundación de las áreas donde se encuentran las matas. La economía circular actúa de manera que mitiga la acumulación de residuos sólidos, especialmente la quema y la disposición a cielo abierto, en particular de los huesos del fruto, y tiene un efecto positivo en las comunidades ribereñas, ya que el uso de estos residuos puede complementar los ingresos en épocas de lluvia. En relación con el açaí, el análisis de los datos indicó que los cambios climáticos provocan una pérdida en la floración, e incluso su ausencia, lo que genera una disminución en la diversidad de la biodiversidad. Por lo tanto, estudios e investigaciones continuas, especialmente en la región Norte, deben proliferar cada vez más y unir a las comunidades ribereñas, las instituciones de educación superior y los gobiernos locales en la búsqueda de soluciones viables frente a los cambios climáticos.

Palabras clave: Inundaciones. Crecidas. Tendencias de Aumento de Temperatura. Comunidades Ribereñas.

1 INTRODUCTION

Climate change has caused numerous impacts on crops, and global warming intensifies these effects by increasing the frequency and severity of droughts and floods, which negatively affects the development of agricultural crops, including açai trees (Dias 2014; Mendes, 2024). These climatic variations interfere with the growth, flowering, and fruiting of açai (Jesus, 2021; Santos; Porro, 2024), tree belonging to the species *Euterpe oleracea* Mart., Family Arecaceae (Nascimento, 2008). All these factors act negatively on the production of açai.

The problem can be aggravated by the incorrect disposal of açai biomass residues as an environmental risk factor from the progressive growth of the *E. oleracea* agroindustry, in the state of Amazonas, a fact that has a strong influence on the worsening of the greenhouse effect and intensification of climate change (Miranda et al., 2022). This harms the economy of riverside communities (Campos; Cardoso, 2025), because, although it is a heliotrophic plant, when there is a tendency to increase the temperature excessively, the açai tree is impaired in terms of the development of the palm, the fruit and the tree itself (Cameli; Silva, 2023; Homma, 2006).

On the circular economy, whose Bill No. 1,874, in addition to the indirect regulation in article 7, item XI, Law No. 12,305 (Brasil, 2022; 2010). In the view of Leda, Mota and Cereto (2025), this economy builds a promising approach by promoting the regeneration of materials and the efficient use of inputs, and an incentive to reflect on the way products are created and consumed. This concern focuses on extending the useful life of raw material and strengthening the conservation of the Amazon.

In this context, in the 2000s, Cunha (2024) and Lemos (2024), stated that it represents a significant increase in demand for the açai fruit. In the view of Almeida et al. (2017), this occurred because the residual regeneration of açai, from the seed, is exploited by this new economy that, among so many products that it can generate, such as handicrafts. In this aspect, Pimentel (2025) reports that the handlers of this Ver-o-Peso street market already allocate this waste for handicrafts and fertilizer.

In addition, this research reports that research for the production of biofuels and bio asphalt has been advancing at UFPA since 2016. The açai tree is identified by Miranda et al. (2022), as a palm tree typical of the floodplain region of Central and South America. Santos and Porro (2024) state that the juice is widely used to feed the population of these locations, as an important source of income, from this palm tree. In this context, Pinheiro (2023)

mentions that this production chain includes extractives, farmers, intermediaries, processing industries, and artisanal scouts, playing a key role in generating income for many small producers.

In the research carried out by the Amazon Environmental Research Institute (IPAM, 2018) and da Silva (2019), they evidenced other uses for the açai pit: in civil construction, oil production, handicrafts for internal decorations, cosmetics, among others Medicine is also helped with the pit, as Lemos (2024) described that the generation of "açai coffee" is an alternative for the control of diabetes mellitus, from the roasted and ground seed.

Regarding climate change, Cameli and Silva (2023) report that it affects economic activities based on açai, which becomes worrying, especially for communities dependent on the family extractive production chain, which is currently considered one of the most sustainable in Brazil. Another problem, in the view of Bentes et al. (2024), involves the need for local communities, researchers, and public managers to actively participate in joint solutions that balance productivity and sustainability in the face of climate change.

All these arguments justified this research, and increased its relevance, because the understanding of what is already published in the relationship between climate change, circular economy and açai, should be disseminated to the population both consumers and handlers of this fruit, especially with regard to this type of economy, and that it will contribute to sustainability. Therefore, the objective of this research is: to understand and interpret how much climate change interferes in the circular economy, harms the communities that manipulate açai.

2 METHODOLOGY

For the study in question, the secondary investigative method (desk research) was used, that is, information already contained in publications on a topic that, in this research, involved: climate change, circular economy and açai. For Neves and Conerejo (2012), the document is an object to be investigated. The use of this method is justified because these authors report that the role of the scientific article is always to narrate a story, and this will be the basis to support the theoretical part of this study.

Due to the expansion of the subjects involved here, and the association between them, there was no concern about the type of literature, as National School of Public Administration (ENAP.GPV, 2021) argued that, regardless of the classification of literature, this method is effective for this type of research. This is in line with what is described by Macedo (2022).

This author stated that access to different academic sources such as hemerographic sources, as well as books, e-books, scientific articles, newspapers, forums, technical reports, among others, broadens the final discussion.

2.1 OBTAINING THE DATA

Secondary data were obtained from electronic links whose databases are related to research and publications aligned with the theme of this research, such as the Coordination for the Improvement of Higher Education Personnel – CAPES, institutional repositories such as the State University of Pará – UEPA, Federal University of Pará – UFPA; University of the Amazon – UNAMA, among others. The selection of literature followed the criterion of identifying keywords in three sections: title, abstract, and keywords (Table 1).

Table 1

Model for data entry regarding literature selection

		Title	Summary	Keywords	$\bar{x}$	$\pm$	σ
Açaí.	Components	Açaí					
		Pit					
		Fruits					
		Pulp					
		Waste					
		Wine					
	Nomenclatures	<i>E. oleracea</i>					
		<i>E. precatoria</i>					
		Açaizal					
	Variables	Açaí-da-mata					
		Açaizeiro					
		Design circular					
		Circular economy					
		Environmental impacts					
		Climate change					

Source: authors (2025).

2.2 DEFINITION OF THE SAMPLE

The sample was defined based on the establishment of three inclusive criteria. This action was based on the report by Andreza et al. (2024) who identified: 1) free and open access; 2) Portuguese and English language; 3) involve the central theme of this research. The time frame was between 2016 and 2025, the last 10 years, with the insertion of four previous surveys: Fleck and Bourdel (1998); Homma et al., (2006); IBGE, (1993) and

Nascimento (2008), with emphasis on the last five years: 2021- 2025. An inclusion criterion was developed for the selection of literature (Table 2).

Table 2

Arguments for inclusion and exclusion of the literatures used in the composition of this research

Inclusion	Exclusion
Publication in English and Portuguese	Other Languages
Be Available in full	Partial availability of the publication
Published in the last decade (2016-2025)	Published before the temporal cut.
Have free access, that is, without charge.	Need for remuneration for access
Present, in the title or Abstract or Keywords: açai, stone, fruits, pulp, waste, wine, <i>Euterpe oleracea</i> , <i>E. precatoria</i> , açai-da-mata, açai-da-mata, açai tree.	There are none of the selective descriptors in the three defined sections.

Source: authors (2025).

2.3 STATISTICAL ANALYSIS OF THE DATA

The data obtained after selecting the literature regarding the relationship between climate change, circular economy and açai, the Excel 5.0 software was used, with Descriptive Statistics, and then tabulated according to the guidelines stipulated by the Brazilian Institute of Statistical Geography – IBGE (1993). Nonparametric analysis was applied due to the non-normality of the data contained.

Principal Component Analysis – PCA, was applied to reduce the size of the data used (Bertarelli Júnior, 2016), especially the descriptors. Finally, the box plot was applied, since the data were non-parametric, and the literature was grouped according to the component sections of this research. For the APC, the Kaiser method was applied. In this method, Fleck and Bourdel (1998) state that it is used to determine eigenvalues higher than one, that is, statistically significant. For the APC, the Kaiser method Applied.

3 RESULTS

3.1 SELECTIVE DESCRIPTORS

In the application of the selective descriptors, six variations "açai" were used. The data obtained and analyzed indicated that this vernacular term was the most prolific (120 ± 128). Four of them were used less frequently: fruits, pulp, residues and wine (0.3 ± 0.6). As for scientific nomenclature, *E. oleracea* was more described (12.3 ± 8.7). In the ABSTRACT

section, the values (15.9 ± 26.2) of occurrence of the selective descriptors were higher (Table 3).

Table 3

The selective descriptors isolated and associated with the Boolean descriptors were used to select the literature

	Descriptors Selective	Title	Summary	Keywords	$\bar{x}$	$\pm$	σ
1	Açaí	28	107	20	51.7	$\pm$	48.1
2	Pit	4	12	4	6.7	$\pm$	4.6
3	Fruits	1	35	2	12.7	$\pm$	19.3
4	Pulp	1	7	0	2.7	$\pm$	3.8
5	Waste	5	28	6	13.0	$\pm$	13.0
6	Wine	0	0	0	0.0	$\pm$	0.0
7	<i>E. oleracea</i>	7	13	7	9.0	$\pm$	3.5
8	<i>E. precatória</i>	1	0	0	0.3	$\pm$	0.6
9	Açaizal	0	4	0	1.3	$\pm$	2.3
10	Açaí-da-mata	1	1	1	1.0	$\pm$	0.0
11	Açaizeiro	0	9	0	3.0	$\pm$	5.2
12	Designer circular	1	1	1	1.0	$\pm$	0.0
13	Circular economy	0	6	1	2.3	$\pm$	3.2
14	Environmental impact	0	5	0	1.7	$\pm$	2.9
15	Climate changes	4	11	4	6.3	$\pm$	4.0
$\bar{x} \pm \sigma$		3.5 ± 6.9	15.9 ± 26.2	3.1 ± 5.1			

Source: authors (2025)

It can be seen in table 1 that studies on climate change in the Amazon and the effects on açaí are still scarce (5.7 ± 3.8). The most critical is related to the environmental impacts due to improper disposal of residual components such as the stone after mechanical agitation to obtain the groove (0.3 ± 06). However, research on the circular economy with the reuse of this "Amazonian food" has advanced (7.7 ± 5.0). The eigenvalues validated and analyzed by the Kaiser criterion (> 1), for the 15 selective descriptors used, indicated that the selective descriptor "açaí" (98.8%), represents that, for the choice and selection of literatures, represent the others very well, and was more efficient among all the others used (Table 4).

Table 4

Eigenvalues and values for variance found

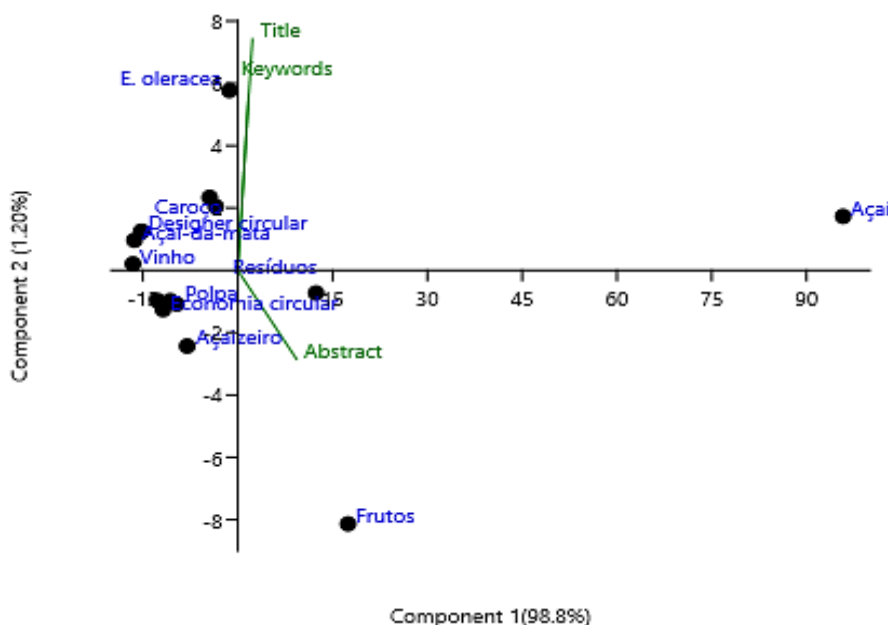
PC	Eigenvalue	% variance
1	803.466	98.813
2	9.09705	1.1188
3	0.551318	0.067803

Source: authors (2025)

In the Principal Component Analysis (PCA) it was confirmed that this quantitative (15) was used in the selection of the literature to compose the corpus of this research, both in the title, in the abstract and in the keywords (Figure 1).

Figure 1

Analysis of the main components regarding the selective descriptors applied

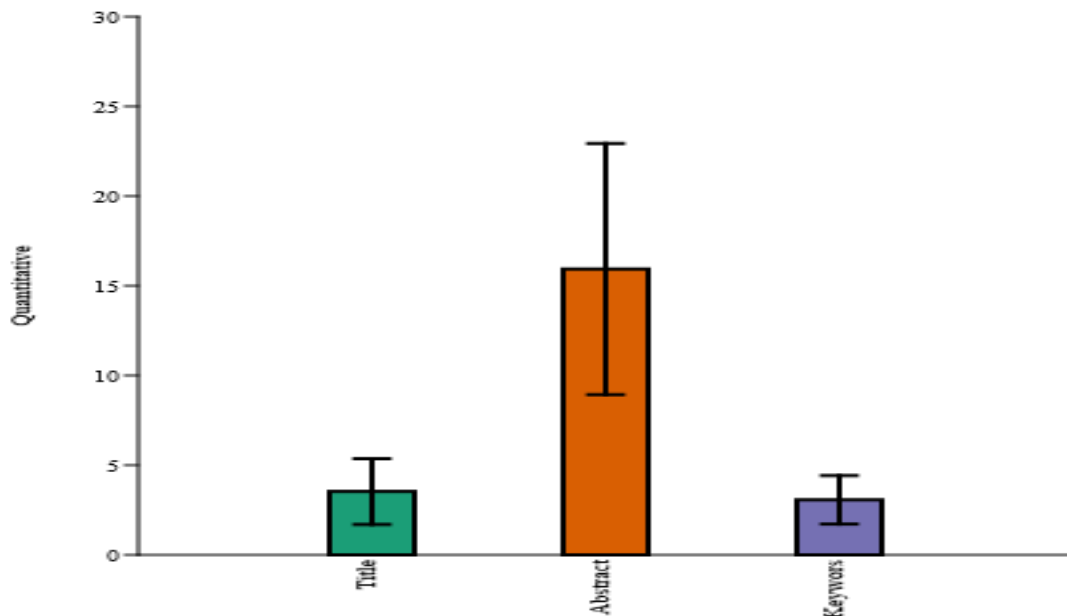


Source: authors (2025)

In the reading of the scores generated, it was verified in Figure 1 that two selective variables "fruits ($\approx 17\%$) and residues ($\approx 12\%$)" correlate directly and positively with the variable "açaí" ($\approx 95.7\%$). This shows that the choice of this descriptive selector was effective in the selection of literatures for the composition of the corpus of this research. In the verification of the distribution of the data used for the selection of the literature, the central tendency of the three sections analyzed in the selected literatures, the maximum limit reached was in the abstract, followed by the title and ending with the keywords (Figure 2).

Figure 2

Central trend and quartiles of distribution of the application of selective descriptors in the three sections of the selected literature

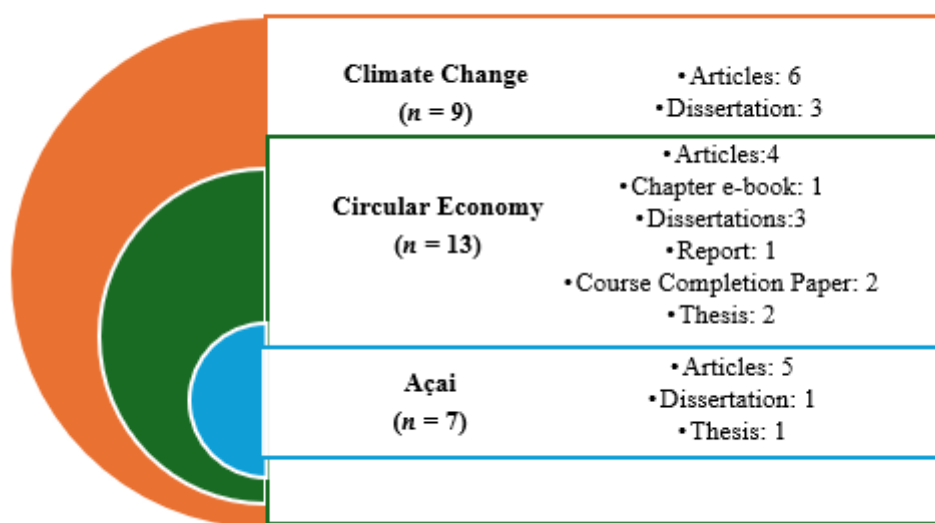


Source: authors (2025)

After selecting the literatures ($\Sigma = 29$), they were inserted in the component sections of this research according to the pre-established order for the composition of the bodies of this research (Figure 3).

Figure 3

Distribution of literature was published between 2016 and 2025, according to the three sections that make up the corpus of this research



4 DISCUSSION

4.1 CLIMATE CHANGE

Regarding the social and environmental aspects of the Amazon region, Campos and Cardoso (2025) state that climate change is a key factor in the negative impact on açaí production, the balance of ecosystems and, mainly, on the economy of riverside communities (Homma et al., 2006; Cordeiro et al, 2024). On the other hand, Miranda et al. (2022) indicated the incorrect disposal of *E. oleracea* biomass residues as an environmental risk factor from the progressive growth of the açaí agroindustry in the state of Amazonas. In the eastern Amazon, Moraes et al. (2023), have already identified serious climate changes that are causing trends of increase in air temperature, harming the production of açaí.

From this perspective, Moraes (2025) explains that methane gas (CH_4) is one of the main greenhouse gases, and that during the irregular disposal of the açaí seed, an organic material that has an anaerobic decomposition, the fermentation of this waste and the release of this gas occurs, thus contributing to climate change. In addition, Strapasson and Ribeiro (2025) describe that the intensive cultivation of açaí and the expansion of its areas is one of the main causes of the reduction of plant diversity, where the implementation of monoculture on native vegetation affects not only biodiversity, but also ecological resistance against the intensified greenhouse effect.

The high intensity of this effect may generate food insecurity for the riverside population, mainly. In this regard, Vieira (2024) reveals that in addition, there will be a

compromise in the economy of local communities in the Amazon that are directly affected by droughts and heat waves arising from climate change. Igawa, Fonseca and Bendini (2025), wrote that perennial crops act as an alternative to control this climate problem, and açai is extremely important for carrying out these mitigation actions, as it is the main perennial crop in the Amazon biome.

4.2 CIRCULAR ECONOMY

For the circular economy, there are several uses for the açai seed after pulp extraction. Among them, the generation of biofertilizers. In this context, Oliveira Neto et al. (2025), report that the post-extraction seed tends to act directly on three soil conditions: 1) it increases water retention; 2) increases soil fertilization; reduces losses from surface runoff and volatilization. Pinto (2022) presents as a circular economic factor, the formation of biopolymeric packaging, since in these stones and fibers, there are bioactive compounds such as anthocyanins, polyphenols and flavonoids.

From another point of view, Leda, Mota and Cereto (2025) present the circular economy as a promising approach by promoting the regeneration of materials and the efficient use of inputs, and this encourages reflection on the way products are created and consumed. This concern focuses on extending the useful life of raw material and strengthening the conservation of the Amazon. In this context, Cunha (2024) reports that the 2000s represented a significant increase in demand for the açai fruit, and the excellent news is provided by Lemos (2024), when he wrote that riverside communities in the northern region of Brazil use roasted and ground stone powder at fairs and artisanal stores as antioxidant products beneficial to health.

Such conservation is better explained in the report by Baia et al. (2025). He confirms that the Açai represents 95% of the national production. As a result, there was an expansion of the industrial sectors and extractive rural workers. Regarding these data, Cordeiro et al (2024) highlight that, when comparing the economic data of a city in government sources and the primary dynamics of the municipality, the production of açai assumes a great influence on income generation and growth rate influencing the increase in livelihoods and family farming, reflecting in the significant improvement of the quality of life of the local community.

In view of this, Cameli (2023) elucidates that the açai fruit started to be consumed by other states in Brazil in addition to the northern region, gaining the national and international market, becoming a versatile tool for the productive sectors since all parts of its palm tree

can be used. Herminio (2023) warns that despite the economic advantage, the processing of the crop generates a large amount of waste that is often disposed of inappropriately, which induces the potential for the development of value-added products.

In the context of this economy, the seed is already inserted for the production of cement, in the municipality of Primavera, state of Pará, at the Votorantim Cimentos plant. Another insertion in the circular economy is reported by Pinto (2022), who studied the bioactive compounds inserted in the seed, which can generate new packaging with biopolymeric characteristics. Miranda et al. (2022), add that they can be used to generate new seedlings, in addition to coal (generated at 1050 ° C), and other fuels such as ethanol, without forgetting fertilizers, bran and fertilizer.

4.3 AÇAÍ

Climate change represents one of the greatest environmental challenges of our time. Cameli and Silva (2023), indicated that this directly affects ecosystems and food production across the globe. This also occurs in the Amazon region, with one of the most consumed products by the local community: açaí. This fruit plays a fundamental role in the food, economy and culture of the Amazonian populations. Studies carried out by the Institute for Environmental Research (IPAM, 2018) and Pinto (2021), identified that the advance of climate change threatens the sustainability of this production chain.

Such climate changes interfere with the generation of fruits, and this is already noticeable to the riverside producers of açaí, Almeida et al.(2017) and Tregidgo et al. (2020) report that this statement is already present in the statement reported in riverside dwellers in the Amazon, where most of them (77%) verified a decrease of around 45% in relation to fruits in times of high temperatures. Dias (2014) found that low productivity occurs in the rainy season, and the opposite in the dry season. This harms the riverside community, both in terms of food and the economy.

This is corroborated by Jesus (2021), when he wrote that the trend of increases in temperatures, the change in the rainfall regime, and the more frequent occurrence of extreme events, such as prolonged droughts and intense floods, interfere with the growth, flowering, and fruiting of açaí. Moraes et al. (2023), stated that, although açaí is dependent on a high volume of water, especially those events arising from climate change. The contrast to this statement is provided by Silva (2019), has already found that in the northeast of the state of Pará, there is already a reduction in the precipitation rate.

5 CONCLUSION

Climate change, especially the trend of rising air temperature, causes a decline in the percentage of air humidity. However, in some locations there are variations in precipitation rates, which increases the volume of water in seas and oceans in the Amazon. This fact causes a drop in the production of açaí, which may generate a decrease in the food supply of riverside dwellers, as well as interfere with their financial income, and this has already been carried out from the point of view of riverside communities in the states of Amazonas and Pará.

As for the circular economy, in view of these decreases, it may compromise studies and research on products derived from açaí seeds, with regard to coffee powder, composting to improve soil fertility, especially in areas that may be subject to soil recovery. The generation of biofuels and medicinal products for the control of Diabetes Mellitos. So, in addition to the food commitment, the secondary products that could add income to the riverside dwellers. Even the research now being carried out by the universities of Pará would suffer a drop.

With regard to açaí, as a profitable fruit and feed not only the riverside community but thousands of consumers nationally and internationally. To avoid this, there is already a proposition that tackling climate change with an expansion of science and technology. Another perspective is the loss of blooms and, consequently, biodiversity, and solutions must be integrated between researchers, riverside communities, governors and other authorities involved in the dimension of loss of this plant.

All these confrontations must be carried out urgently, since climate change has already reached high levels of extreme events for riverside communities that feed and generate income from the production of açaí. We suggest that research be intensified in two sectors: circular economy and mitigating the effects of climate change.

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**THE POWER OF IMAGES: OSCAR WILDE AND MICHELANGELO ANTONIONI
REVISITED**

**O PODER DAS IMAGENS: OSCAR WILDE E MICHELANGELO ANTONIONI
REVISITADOS**

**EL PODER DE LAS IMÁGENES: OSCAR WILDE Y MICHELANGELO
ANTONIONI REVISITADOS**

 <https://doi.org/10.56238/sevened2025.036-077>

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ABSTRACT

What senses can we make of works by Oscar Wilde and Michelangelo Antonioni in contemporary times, when the fast-paced rhythm of cyberspace and hypermodern society demands even greater awareness and consciousness of our existence than, perhaps, at the times of the first publications of *The Picture of Dorian Gray* in 1890 and 1891, as much as the premiere of the film *Blow-Up* in 1966 and its release in 1967? We intend to show how both narratives read uncommittedly to literary criticism in the context of health humanization proposed by the Laboratory of Humanities (hereafter referred to as Labhum) at the Federal University of São Paulo opened transcultural possibilities for the better understanding of hypermodernity.

Keywords: Hypermodernity. Transculturality. Portraits. Subjectivity. Humanization.

RESUMO

Que sentidos podemos atribuir às obras de Oscar Wilde e Michelangelo Antonioni na contemporaneidade, quando o ritmo acelerado do ciberespaço e da sociedade hipermoderna exige uma consciência e atenção ainda maiores sobre nossa existência do que, talvez, na época das primeiras publicações de *The Picture of Dorian Gray* em 1890 e 1891, assim como da estreia do filme *Blow-Up* em 1966 e de seu lançamento em 1967? Pretendemos mostrar como ambas as narrativas, lidas sem compromisso com a crítica literária no contexto da humanização em saúde proposta pelo Laboratório de Humanidades (doravante denominado Labhum) da Universidade Federal de São Paulo, abriram possibilidades transculturais para uma melhor compreensão da hipermodernidade.

Palavras-chave: Hipermodernidade. Transculturalidade. Retratos. Subjetividade. Humanização.

RESUMEN

¿Qué sentidos podemos atribuir a las obras de Oscar Wilde y Michelangelo Antonioni en los tiempos contemporáneos, cuando el ritmo acelerado del ciberespacio y de la sociedad hipermoderna exige una conciencia y atención aún mayores sobre nuestra existencia que, quizá, en los momentos de las primeras publicaciones de *The Picture of Dorian Gray* en 1890

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y 1891, así como del estreno de la película *Blow-Up* en 1966 y su lanzamiento en 1967? Pretendemos mostrar cómo ambas narrativas, leídas sin compromiso con la crítica literaria en el contexto de la humanización en salud propuesta por el Laboratorio de Humanidades (en adelante Labhum) de la Universidad Federal de São Paulo, abrieron posibilidades transculturales para una mejor comprensión de la hipermodernidad.

Palabras clave: Hipermodernidad. Transculturalidad. Retratos. Subjetividad. Humanización.

1 INTRODUCTION

In its work of promoting reflection on humanization in healthcare, the Laboratory of Humanities, developed by the Center for History and Philosophy of Health Sciences at the Federal University of São Paulo (Bittar, Souza, Gallian, 2013; et Gallian, Lima, De Benedetto, Guzman, 2014) recently selected the novel *The Picture of Dorian Gray* in dialogue with the film *Blow-Up* as the core of its discussions within a group composed of undergraduate and graduate students in the fields of health sciences.

Readings beyond literary criticisms allowed participants to articulate the relationship between their own lived experiences as human beings working in the health sector and the portraits that gradually emerged through the reading of *The Picture...* and in dialogue with *Blow-up*. The immediate identification of the most striking features of the main characters—namely, Dorian Gray himself, Basil Hallward, and Lord Henry Wotton in the novel and Thomas, the photographer interpreted by David Hemmings in the film *Blow-up*—led the participants to relate these human types and their roles on the stage of human dynamics, regardless of any historical period or, rather, beyond any of them, thus allowing a cultural transposition of the aesthetic experience from the late 19th century, when the novel was published in two versions (1890 and 1891) along with the 1960's and early 1970's European experiences to today 2025 in the Brazilian Portuguese context of each one of the Labhum individual's experiences.

Another relevant aspect was the interartistic dialogue, that is, the convergence between the reading of Wilde's novel and Antonioni's film. In both, the notion of the portrait as a

metonym of human individuality, subjectivity and experience prevailed: it is in the portrait that the marks of life lie—the very marks that would have aged Dorian, had it not been for the pact made with the devil; it is in the portrait that the lines of expression are etched, framing either life itself or what one chooses to show of it, as in the case of the models that are the photographer's object in the film, the driving force behind the film narrative adapted from Julio Cortázar's short-story “Las Babas del Diablo” (1959); it is in portraits that we deposit our best moments and memories, as much as the usages of images in social media nowadays. The portraits of the models, immortalized or discovered by the photographer—as in the case of the photograph pointing to a crime—are memory maps or, at least, routes back to identification(s) (Hall, 1998) just as in the painted portrait by Basil, a vain attempt to eternalize the very subject of the painting, Dorian Gray and his awesome beauty. In all of

these cases, the search for essence amid that which is transient and what may be enduring involves a more or less humanized gaze— that of both the reader and the viewer, of the healthcare practitioner responsible for treatment and, at the same time, a full individual with subjective and circular experiences.

The transposition of times and spaces/geographies make evident the classic hue of both narratives (the novel and the film) at stake, once transculturality goes beyond the frontiers of time and space, working as an ideal approach for comparativisms and artistic and/or critical readings. Moreover, it helps us understand contemporaneity once characters, their features, attitudes, and behaviors are paralleled, such as found in all comments elaborated along the Labhum meetings as well as their outcome, as we shall partially see here later.

In order for us to better comprehend such transcultural approach in practice, let us first contextualize the hipermodern *zeitgeist* which has been the basis of departure for most participants to engage in our activities at the Labhum.

The term “hypermodernity” was coined by the contemporary philosopher Gilles Lipovetsky (2005) in order to explain our human condition that followed post-modernity in its praise of progress and reason, which justifies the fast-paced rhythm in all (or nearly all) human activities: people’s time, our usage of technology, consumerism, and individualism as stated by Zygmunt Bauman (2000). Most probably, the latter finds direct connection with that which is central in both narratives here dealt with: the individual as central figure in the (mis)understanding of humanism. Dorian Gray, as metonym of aestheticism, materializes hedonism, as much as the photographer Thomas in his egocentric activities as such. Aestheticism is best comprehended as artificialism, once it inverts many matters of common sense, some of which, even moral ones. Indeed, aestheticism, for instance, defines art as superior to nature and it believes that the latter copies the former. The same applies to the senses as being higher than the intellect or that which is shallow, better than whatever else is profound; feeling, superior to reason. Therefore, masks are seen as more authentic than one’s own individuality, one of the reasons why portraits are so relevant during Decadentism and throughout the XIX century (Mutran, 2002).

Once social and subjective lives in hypermodernity are marked by the overwhelmingly digital rhythm of ephemeral experiences and intensified movements of change that lead to the lack of deep, personal bonds, creating (and, with pardon to the irony, endlessly recreating) the illusion of perfection in all that is human becomes central to some sense(s) of – or, rather,

lack of them? - belonging(s). After all, being human is making mistakes, having faults, failing to be perfect. However, hypermodern societies have promoted the increase of practices that refer to “well-being“, which in their turn, promulgate individualism and individuality at their extreme. The explicit side-effect of it is loneliness, which is the same we see happening with Dorian Gray and Thomas. The former, as a never-ageing man, is unable to follow new generations as part of them; the latter, disconnected to all those who surround him. Lipovetsky points out to consumerism as the immediate (and, unfortunate) hipermodern reply to the matter of loneliness. Unable to establish real human bonds, people rely on materialism, attaching their beings to having(s).

Thus, the convergent factor between Wilde’s novel, Antonioni’s film and our daily, contemporary lives lie precisely there in the hedonism of portraits, photos, images and stories as they unfold but the naive, aesthetic experience of one (or two) stage(s) of life – bearing in mind the seven phases of life as described in Jacques’ monologue in the play *MacBeth* by William Shakespeare, “All the world’s a stage of life”⁴ . Furthermore, it reveals our need for masks, particularly in the social media nowadays, the virtual space of (“perfect”) existence, where “the true self“ is shown, complying to matters of individual “well-being“: being free, loved, praised, recognized as a social being, amongst other universally recognized feelings of belonging.

Therefore, while the aesthetic experience of both Dorian and Thomas particularly evolve from hedonism and the need to express personal identities associated with vital eternity, contemporary exposure in social media relates to it as much as masks are concerned. For they provide individuals with senses of reality in spite of being simulacra, thus, covering the world’s participants in their “best” features, as they enable individuals to reply to the hypermodern demands of extreme production, allowing them with senses of belonging in societies that are dehumanized of errors, faults or mistakes, at the same time

⁴ All the world’s a stage,/And all the men and women merely players;/They have their exits and their entrances;/And one man in his time plays many parts,/ His acts being seven ages. At first the infant,/ Mewling and puking in the nurse’s arms;/And then the whining school-boy, with his satchel/ And shining morning face, creeping like snail/ Unwillingly to school. And then the lover, / Sighing like furnace, with a woeful ballad/ Made to his mistress’ eyebrow. Then a soldier,/ Full of strange oaths, and bearded like the pard,/ Jealous in honour, sudden and quick in quarrel,/ Seeking the bubble reputation/ Even in the cannon’s mouth. And then the justice,/ In fair round belly with good capon lin’d,/ fith eyes severe and beard of formal cut,/ Full of wise saws and modern instances;/ And so he plays his part. The sixth age shifts/ Into the lean and slipper’d pantaloone,/ With spectacles on nose and pouch on side;/ His youthful hose, well sav’d, a world too wide/ For his shrunk shank; and his big manly voice,/ Turning again toward childish treble, pipes/ And whistles in his sound. Last scene of all,/ That ends this strange eventful history,/ Is second childishness and mere oblivion;/ Sans teeth, sans eyes, sans taste, sans everything. (W.Shakespeare. *As You Like It*. Act II Scene VII Line 139),

that they promise everlasting happiness – as is the case of the term “well-being”, even broadly applied to Health Sciences.

At the heart of *Blow-Up* is a deep questioning of perception and reality. The photographer believes he may have inadvertently captured evidence of a murder in the background of a photo, but as he enlarges the image, it becomes more abstract and inconclusive. This invites us to read the story in epistemological matters regarding the frontiers between truth and perception or reality and simulacrum, once photographs are the media – and in the case of the novel *The Picture of Dorian Gray*, the portrait is. In both cases, the photographs taken by Thomas in the film and Basil’s painting of Dorian Gray in the novel, there seems to be an almost obsessive search for meaning, as well as an ultimate need for truth, always deferred by the “shadows” that displace the truth(s). Moreover, in our hypermodern, digital era, how do images work as to help us search for reality? Or, yet, is reality only a series of simulacra moments in which the truth is underveiled? Photographs, pictures and paintings are document and illusion. Yet the connection between this idea depicted by both the reading of novel and the watching of the film from the standpoint of each one of the Labhum participants’ subjectivity has opened horizons for awareness of our humanity, weaved in interactions, bonds and relationships in our encounters as well as in the everyday practices of diverse health professionals. We present below some of the participants’ partial reports at the end of the Labhum experience with Wilde’s and Antonioni’s narratives as focus – their names have been changed for fictitious ones in order to preserve their identities. The choices of the excerpts are to do with various topics of interest to us, namely:

- I- Diversity of participants as regards age, professional area in health services and relationships.

“It’s exciting to explore this new reading alongside colleagues of different ages and professions, and to reinterpret art together.” (Ana)

“... the shallow relationships developed by the protagonists [...] are still able to reveal their true essence to just a few people.” (Antonieta)

“... as much as we dislike it, we need to admit that in some ways we may be like them (the characters); we are a bit of Dorian Gray, we are other bits like Thomas in the film and in some aspects we are indeed similar to Lord Henry, Sybill Vane and even the girls being photographed by Thomas. A bit of each, depending on the occasion and with those we are interacting...” (Gabriela)

II- The literary and film narratives in dialogue with contemporary lives and the communication in social media today.

“In the book, I saw Harry as the embodiment of evil — a demon who captivates, a transgressor who fascinates, much like so many influencers today.” (Ana)

“Every day we try to change the perception of what we dislike in our reality, posting photos that make our lives seem less ordinary than they are. Every day we search for ways to conquer time and prolong our appearance of youth.” (Bruna)

III-The power of images and their role in helping us reflect upon reality x fantasy.

Moreover, the search for beauty as pleasure and truth and the use of it as protective disguise against harsh realities

“In both works, the protagonist places more trust in the image than in lived reality—revealing the power, and the danger, of visual perception, while questioning the very notion of reality.” (Lica)

“In the film we have a photographer without scruples, surrounded by young women who are not exactly naïve... A professional in search of the perfect shot, of art, of truth, of the meaning of life (...) the doubt: what is concrete and what is abstract? What is false and what is true?” (Ilán)

IV- The Labhum as relief, a cozy environment against the harsh reality of rational discourse

“I felt I was entering a space of welcome and attentive listening, where the focus was on collective reflection, exchanging perceptions, and questioning our own ways of seeing the world.” (Rodrigo)

“I thought it was really great that the conversations changed many of my initial perceptions and certainly transformed my rereading of the novel and in dialogue with the film this time.” (Ilán)

“My daily life is very scientific, rational, always in a hurry. So, taking a few hours each week to engage in group reflection, to understand feelings, to humanize ourselves, was essential time for me, particularly, with the focus on Wilde and Antonioni.” (Marcela)

“...the whole atmosphere of reading the novel, discussing it in dialogue with the film made me feel part of a collaborative, constructive, and collective learning community.” (Karla)

We understand that the particularized Labhum experience reported here has been able to promote participatory, open discussions on various themes in dialogue with the plural community of students who showed real life connections between the arts (literature and film)

and their own lived experiences in our contemporaneity, as parts of the selected examples above testify.

In this sense, the Labhum has brought forth possibilities of (self)awareness that help health care professionals and academics to assess their own humanized positions as such in relation to whom they are as thorough individuals, i.e., within and beyond their working contexts, facilitating their beings more thoroughly – and not just technically as has been much of the programs under the name of trainings on well-being. The fact that both narratives (the novel and the film) have been discussed in transcultural dialogue – due to the temporal and geographical transpositions, added to the linguistic translation of the novel into Portuguese – has allowed room for Wilde's and Antonioni's narratives beyond their critical readings as they have integrated people's moments of enjoyment in alignment with reflections that may help them go beyond their usual, everyday practices. This certainly reinforces the role of literature and the arts in humanizing processes, particularly, today. Furthermore, it points out to the need to simply read classical literature which entails universal values transculturally. And this has been the case with Oscar Wilde and *The Picture...*

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DENTAL WEAR IN RUMINANTS: A SYSTEMATIC REVIEW

DESGASTE DENTÁRIO EM RUMINANTES: REVISÃO SISTEMÁTICA

DESGASTE DENTAL EN RUMIANTES: UNA REVISIÓN SISTEMÁTICA

 <https://doi.org/10.56238/sevened2025.036-078>

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ABSTRACT

This article aims to discuss the main challenges and possibilities related to the continuing education of public school teachers, highlighting public policies, training practices and the importance of teacher engagement in this process. The methodology is a bibliographical research with a descriptive and exploratory approach. The results showed that the continuing education of public school teachers is a complex challenge, but essential for the construction of quality education. Ensuring adequate conditions so that teachers can participate in relevant training, connected to their reality, is a commitment that must be assumed by managers, public policies and society in general. In this sense, it was concluded that overcoming structural difficulties and valuing the professional development of teachers are necessary paths to transform public education into a more effective and humanizing learning space.

Keywords: Professional Development. Continuing Education. Public Policies.

RESUMO

O presente artigo tem por objetivo discutir os principais desafios e possibilidades relacionados à formação continuada de professores da rede pública, destacando políticas públicas, práticas formativas e a importância do engajamento docente nesse processo. A metodologia se trata de uma pesquisa bibliográfica de abordagem descritiva e exploratória. Os resultados mostraram que a formação continuada de professores da rede pública é um desafio complexo, mas fundamental para a construção de uma educação de qualidade. Garantir condições adequadas para que os professores possam participar de formações relevantes, conectadas à sua realidade, é um compromisso que deve ser assumido por gestores, políticas públicas e pela sociedade em geral. Nesse sentido, concluiu-se que superar as dificuldades estruturais e valorizar o desenvolvimento profissional dos professores são caminhos necessários para transformar a educação pública em um espaço de aprendizagem mais efetivo e humanizador.

Palavras-chave: Desenvolvimento Profissional. Formação Continuada. Políticas Públicas.

RESUMEN

El presente artículo tiene como objetivo discutir los principales desafíos y posibilidades relacionados con la formación continua de los docentes de la red pública, destacando las

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políticas públicas, las prácticas formativas y la importancia del compromiso docente en este proceso. La metodología consiste en una investigación bibliográfica con un enfoque descriptivo y exploratorio. Los resultados mostraron que la formación continua de los docentes de la red pública es un desafío complejo, pero fundamental para la construcción de una educación de calidad. Garantizar condiciones adecuadas para que los docentes puedan participar en formaciones relevantes y conectadas con su realidad es un compromiso que debe ser asumido por los gestores, las políticas públicas y la sociedad en general. En este sentido, se concluyó que superar las dificultades estructurales y valorar el desarrollo profesional de los docentes son caminos necesarios para transformar la educación pública en un espacio de aprendizaje más efectivo y humanizador.

Palabras clave: Desarrollo Profesional. Formación Continua. Políticas Públicas.

1 INTRODUCTION

Brazilian livestock plays a central role in the national economy and has a prominent position worldwide, especially in the breeding of ruminants for the production of food and raw materials such as meat, milk, wool and leather. In 2020, Brazil maintained the largest cattle herd in the world, with 217 million head, equivalent to 14.3% of the global total, followed by India with 190 million (EMBRAPA, 2021). In the same year, the country recorded a record production of 35.4 billion liters of bovine milk, while sheep and goat herds reached 20.6 million and 12.1 million head, respectively (IBGE, 2021).

The development of ruminant livestock in several countries, such as Brazil, occurs in a heterogeneous way in relation to form, being mostly empirical and extensive, with low technological levels and zootechnical results. Livestock farming is found in contrasting situations, employing from technological solutions to less sustainable ones (CAMPELLO, 2017). Goat farming, for example, in most farms does not express a significant productivity potential due to management problems, low labor and technological levels, nutritional and sanitary disorders, and high mortality rates in young and adult animals (CAMPELLO, 2017; AGOSTINHO, 2017).

Inherent to animal husbandry are its needs and difficulties, such as health problems that can compromise both production and animal welfare. It is possible to specifically observe animal oral health and relate it directly to these factors. Having their presence pre-dated, oral lesions are among the most common types of pathology reported in archaeological sets of animal bones (HOLMES *et al.*, 2021).

Dental problems in goat farming are not part of the common concerns of rural producers and veterinarians. The reasons for this worrying lack are because these conditions are silent, chronic, not diagnosed by routine procedures and, apparently, in popular culture, have little impact on the profitability of the economy's activity, which is not real (CAMPELLO, 2019).

Abnormal chewing and rumination are sensitive indicators of many disorders, including infectious diseases. Although low productivity is the main reason for cattle slaughter, dental diseases are rarely considered as a possible explanation. Diseases such as periodontitis can be painful, leading to inefficient chewing with consequent loss of body condition and weight, increased susceptibility to diseases, animal suffering, and decreased productivity, with consequent economic impacts (BORSANELLI *et al.*, 2021).

As Campello (2017) puts it, periodontal diseases are among the most different forms of infection that affect both humans and animals. Excessive wear of the dental crown is a factor observed in both, being a lesion characterized by the irreversible loss of dental structure from the external surface, without bacterial involvement, which, by promoting dentin exposure, can develop tooth sensitivity. Associated with diseases such as periodontitis, they cause retraction and possible loss of teeth. Routine clinical examination of the oral cavity of cattle is essential for the disease to be diagnosed in a live animal (BORSANELLI *et al.*, 2021). Since oral health is an initial factor in animal nutrition, its importance in growth, weight gain, productivity and quality of life is understood, identifying in this area a great potential for impact due to its relevance in economic and animal welfare issues. Thus, the central problem of this work is to understand what are the characteristics of tooth wear in ruminants and the main methods used in its analysis in the scientific literature. The objective of this work is to investigate the causes and patterns of this wear, as well as to review and discuss the methodologies used in its evaluation. To achieve the proposed objective, a Systematic Literature Review (RSL) was developed.

2 THEORETICAL FRAMEWORK

Between 2020 and 2021, Brazil approached the mark of 250 million head of cattle, sheep and goats, standing out worldwide as one of the major ruminant breeders. According to Borsanelli *et al.* (2021), diseases related to the dentition of these animals can be painful and generate inefficient chewing, with consequent losses of body condition and weight, and increased susceptibility to diseases. Even though the main reason for cattle slaughter is low productivity, dental disease is rarely considered a possible explanation.

In this way, the suffering caused by dental diseases affects the quality of life and animal welfare, contrary to what is inferred in the five animal freedoms, proposed by the Farm Animal Welfare Council of England in 1965, specifically in the third point, which guarantees freedom from pain, injury or disease.

From an economic point of view, in addition to the fundamental factor of decreased productivity, dental diseases are a population problem that even affect animals with higher added value and selected genetics, thus promoting significant economic impacts (CAMPELLO, 2017, BORSANELLI *et al.*, 2021). Regarding the approach to quantifying tooth wear in ruminant animals, it is possible to find works in literature that they collaborate, directing steps of the proposed project, or even reiterating its relevance.

Wicpolt et al. (2022) point to reports of periodontitis cases around the world since the Neolithic period and, even so, when investigating cases of periodontitis in sheep in Pernambuco, they define the disease as little known by veterinarians and cattle breeders in the region, causing economic losses by interfering with the productive performance of the animals. As it is a disease diagnosed by visual inspection, the methodology used was the dental analysis of live animals and the capture of images for registration, in addition to microscopy of samples of slaughtered animals. The method of visual inspection by a professional in the area is satisfactory for purely qualitative analyses.

Comparing different diets in groups of goats, Hatt *et al.* (2019) concluded that tooth wear is more related to dietary characteristics — such as resources, content, and distribution of phytoliths — than to environmental factors, such as dust and sand, highlighting the need for more in-depth studies. The analysis of the abrasives present in the digestive tract was performed by computed tomography, a method considered reliable due to its technological precision, although it requires sedation and individual handling of the animals.

In a complementary way to Hatt et al. (2019), Ackermans et al. (2020) apply the same computed tomography methodology in sedated animals during 17 months of experiments, this time comparing the diet of each group to tooth wear factors such as tooth morphology and loss of volume of the dentition. Again, reliable quantitative results are generated by the method, but it is still possible to highlight its considerable cost of implementation, given the use of commercial computed tomography equipment.

Considering human tooth wear and the solutions employed, Machado *et al.* (2022) analyze the feasibility of using an intraoral scanner for monitoring erosive wear. Bovine teeth were used as specimens, submerged in acid and reevaluated every 24 hours. The results obtained are satisfactory with the perception of a loss of 0.5 mm per layer of analysis. The intraoral scanner is a portable tool, used in dental offices that has accuracy and reliability. However, its high cost is an unfavorable factor for its application.

From an interrelational perspective, the application of human technologies in animal contexts can offer effective and integrated solutions. The use of these technologies, combined with data analysis and artificial intelligence systems, enables the creation of informational bases that help in decision-making. Thus, the development of a tool capable of quantifying tooth wear in ruminants could favor research that relates this wear to diseases, variations in management, productivity (of meat and derivatives) and environmental factors, such as soil types and additives aimed at improving plant production.

At the same time that efficient production generates positive economic results, it contributes to the fulfillment of the UN Sustainable Development Goals for Brazil. Producing with smaller investments or in larger quantities at the same cost makes the product cheaper, attractive to the market and facilitates access to the final consumer. This perspective directly affects the 2030 Agenda on the topic of Zero Hunger and Sustainable Agriculture, reducing hunger and ensuring access to food (2.1), meeting nutritional needs (2.2) and increasing the productivity and income of small producers (2.3). Adequate consumption of inputs is related to Responsible Consumption and Production, efficiently using natural resources (12.2). Accessible technological development strengthens scientific capacities and generates tools to shift to more sustainable patterns of production and consumption (12.a).

The relevance of the theme presented and the lack of tools with the same objective present a substantial and innovative contribution of work to agribusiness, in addition to its concern with animal welfare, productivity and the possibility of technological development.

3 METHODOLOGY

3.1 THEME AND OBJECTIVE

The systematic literature review (RSL) described below follows the parameters proposed by Fabbri et al. (2016) and aims to investigate publications on tooth wear in ruminant animals, their contributions to the topic and to gather relevant information for the analysis and quantification of wear. Thus, the objective of the review is to define and rank the main causes of tooth wear in ruminants present in the literature, as a way to visualize the affected species, understand the generating factors and direct the collection of information and measurement of wear.

3.2 TOOL AND PROTOCOL CONSTRUCTION

For the management and elaboration of the review protocol, the systematic bibliography review management software *StArt* (*State of the Art through Systematic Review*), developed by the Software Engineering Research Laboratory of the Department of Computing of the Federal University of São Carlos (LaPES-UFSCar), was used. The steps proposed by the application itself were followed during the completion.

3.3 DATABASES, JOB PROFILES, PERIOD AND LANGUAGES.

The searches for papers were carried out in the *Scopus* and *Web of Science*

databases, due to their international coverage and academic reliability. The work profile was not limited to articles only, even though these were the only results obtained. Likewise, there was no restriction regarding the selection period, given the interest for the review in visualizing the emergence of the theme as outlined by the descriptors and its development over the years. As for the language, works were selected in English, due to its scope, and in Portuguese.

3.4 KEYWORDS AND BOOLEAN OPERATORS

For the initial survey of papers, keywords were defined that covered the widest possible range of results that did not distance themselves from the theme: *Ruminant; Dental Wear; Tooth Wear; Dental Volume; Tooth Volume; Dental Abrasion; Tooth Abrasion; Dental Attrition; Tooth Attrition*.

At the same time, several combinations of Boolean operators were tested for each database and those that resulted in the largest number of articles presented were applied.

For the *Web of Science* database, the local filter *ALL FIELDS* was applied, using the expression: *"ruminant* AND (tooth wear OR tooth volume OR tooth abrasion OR tooth attrition OR dental wear OR dental volume OR dental abrasion OR dental attrition)"*

For the *Scopus* database, the local filter *ARTICLE TITLE, ABSTRACT, KEYWORDS* was applied, using the expression: *"ruminant* AND ("tooth wear" OR "tooth volume" OR "tooth abrasion" OR "tooth attrition" OR "dental wear" OR "dental volume" OR "dental abrasion" OR "dental attrition")"*

3.5 SELECTION STAGE AND CRITERIA

During the selection stage, criteria were defined for the use of the articles: 1 – Language: the work should be in English or Portuguese; 2 – Access: it was necessary to have access to the full text; 3 – The work should deal with ruminant animals; 4 – The work should address the issue of tooth wear in these animals;

In addition to the above criteria, duplicate jobs, those that appear in both databases, were removed. In this step, the titles, keywords and abstract of each article are read to make the selection.

3.6 EXTRACTION PHASE

For the data collection from the works selected for the extraction phase, questions

were elaborated about the approach to the theme in the work under analysis. Each following question could, depending on the application, accept one or several options as an answer. In question 1, we sought to list the motivation for the use of tooth wear at work. *Question 1 - Approach to the causes of wear (single option): A - Use wear to define other characteristics. (Age of fossil/animal and/or other) (wear and tear as a means); B - Analyzes/Explores causes for wear (wear as an end).*

In question 2, there was a survey of the possible causes or influences for the exhaustion, which were explored or only mentioned in the study. *Question 2 - Causes explored/cited (multiple options): A - Diet; B – Genetics; C – Occlusion; D – Others.*

The interest of question 3 is not only about which animals are treated, but mainly about meat animals and everyday human interaction, since most studies use tooth wear to classify fossils. The terms such as cattle, goats, sheep, and deer are not formal taxonomic categories, but rather common groups used to bring together animals with certain similar biological characteristics. All of the animals we are discussing belong to the Kingdom *Animalia*, Phylum *Chordata*, Class *Mammalia*, Order *Artiodactyla* (even-toed ungulate mammals such as oxen, deer, giraffes, etc.), and Suborder *Ruminantia*. *Question 3 - Taxonomy – Groups (Multiple Options): A – Cattle; B – Sheep; C – Goats; D – Cervids; E – Others.*

For question 4 we raised the methods of identification and classification of the wear that each work uses. What differentiates the "visual inspection" and "images" options is that in the former, the analyses are carried out directly on the copy, whether it is an original or a faithful replica. In the second, there is the need or choice of the author to capture and use the images for analysis. *Question 4 – Method of Identification (Multiple Options): A – Visual Inspection; B – Images; C – Others;*

Question 5 considers the relevance of the theme of tooth wear within the reviewed study and observes 2 situations: It only mentions wear, but does not quantify and/or qualify it methodologically; it applies some method of identification and/or quantification. *Question 5 – Methodological Approach (Single Option): – Only mentions wear and tear (does not quantify); B – Applies identification method.*

4 RESULTS AND DISCUSSIONS

Following the selection stages and criteria proposed in the methodology presented, with a survey carried out in October 2024, a total of 204 works were identified. 140 papers

were obtained for the *Web of Science database* and 64 papers for the *Scopus database*. With no restriction on the selection period, works were found between 1989 and 2024.

After the selection phase, we obtained 54 duplicate articles (26.47% of the total initial papers), 77 (37.74%) rejected articles and 73 (35.78%) accepted articles, moving forward to the data extraction phase.

The questions for the collection of data from the extraction phase would accept one or more answer options, to be defined by their application. Addressing the causes of wear in question 1, 60 studies used wear to define characteristics such as the age of the animal and the age of the fossil. The highest occurrences of the use of wear were to characterize diets of fossil species and in the validation of methods of identifying wear for species under study. On the other hand, in the second alternative of the first question, 13 studies specifically explored the causes of burnout. Thus, we see a distribution table of 82.2% of the articles using wear only as an instrument and the other 17.8% with a direct interest in investigating the causes of wear.

To survey the possible causes or factors that influence the exhaustion, question 2, of multiple options, considered from the interest of the work in the causes or only the allusion to these items. The diet of the animals appears in almost all of the 73 studies accepted for data collection, in 95.9% of them. Far from the references to diet, causes such as genetic factors (8.2%) and occlusion (6.8%) appear.

Among the other causes investigated for tooth wear, the geographic position of the herd and the season of the year of presence of the animals in the region of interest frequently appear, as many studies use the analysis of wear to reconstruct the customs of fossil species, or even the vegetation of the animals' time of life. In any case, geographical position and season of the year end up being indirectly related to diet, as they affect the supply of different food sources. In addition, rare studies were found that explored causes such as gender and oral infections.

Regarding the taxonomic groups present in the works, the use of wear analysis for the characterization of fossils and extinct species is reinforced, participating in the composition of the item *others* in a frequency of 34 works. The frequency of *deer*, appearing in 23 works out of the 73 under analysis. The search for beef animals and daily human interaction returned in ascending order: *sheep* with 10 results, *cattle* 14 and *goats* 16, referring to 13.7%, 19.2% and 21.9% respectively.

For the distribution of wear identification and classification methods, it is important to emphasize that one identification method does not necessarily cancel out another in the same work. The item *Visual Inspection* refers to analyses made directly on the copy or replica and has a frequency in 54.8% of the works. With a frequency close to the previous item of 58.9%, the *use of images* is the main characteristic among the methods for identifying and classifying wear. Regarding the *item others*, studies were found that used palpation, measurements with instruments such as calipers, or even chemically quantifying the loss of calcium ions in arches submerged in an acid medium. In all, the item others encompasses 27.4% of the works.

Finally, the number of studies that apply methods to identify/qualify/quantify wear. Of the 73 studies used for data collection, only 11 of them did not apply known methods. On the other hand, 62 used some method, whether this was the target of the research or not.

In summary, what the questions proposed by this systematic literature review were able to clarify is that most of the studies use the analysis of tooth wear as a tool, not being a direct concern and that its main use is in the characterization of extinct and fossil species, which indicates an opportunity for its use in beef animals, considering its economic and social relevance. Also, that diet is the fundamental factor for wear and tear and that the poignant results of wear and tear analyses are obtained through visual methods, with images or not.

Below, we will discuss the methods of identification and/or quantification of tooth wear in ruminants located during the performance of this RSL, in a historical and relevant organization.

4.1 METHODS OF WORKING WITH TOOTH WEAR

As a starting point identified by RSL, Walker and Teaford (1989) list studies on the use of electron microscopes in the analysis of mammalian tooth wear that emerged in the 1960s, and became common to surface analysis due to factors such as their resolution, non-destructive testing and ease of use. Still, the motivations for the development of wear studies present in the bibliography include the determination of the causes and rates of wear, jaw movement patterns, to find patterns of diet and animal behavior, and reconstruction of diets for paleontology.

Most of the wear analysis cases identified by Solounias *et al.* (1994) until then, he used the mandibular first molar for wear analysis. For measurements performed with a microscope, the authors made molds of the maxillary second molars. The molar wear rates were investigated based on tooth height values and growth lines (cementum-enamel junction)

seeking a better understanding of the wear patterns in several species. The conclusions obtained by the work at the time were relevant to the development of the theme, such as the significant variation between different species of ruminants, reflecting their diets and environmental adaptations, crucial impact of diet and its abrasiveness on wear, implication on the evolution of species in relation to their feeding strategies and *habitat*, and also the modeling of wear patterns in paleontology.

The induction of tooth wear is proposed by Kaiser *et al.* (2009) as coming from 2 different situations: the contact of the tooth with food, classified as abrasion and the contact of the tooth with another tooth, treated by attrition. Each of them can be more or less present according to the type of diet, considering the animal's food source. Also, these animals can be divided into navigators, grazers and intermediaries. The authors' objective is to compare the wear and tear in 19 species of animals in captivity with data from free-living animals. Their conclusions reinforce the interference of the abrasive diet in the wear and consequently in the longevity of the animals, where captivity presents greater hygiene in the supply of food and generates lower rates of tooth wear.

4.1.1 Mesowear Method

Developed by Solounias and Fortelious (2000), the mesowear method has been widely used since its presentation because it is relatively fast and reliable in the characterization of wear. The method is based on the development of the veneers of the occlusal surfaces of the posterior teeth, created by the friction of feeding, taking into account two variables: The occlusal relief (*Occlusal Relief*), which is classified as high or low according to the depth of the valley formed by the cusps; The *cusp shape* (*Cuspid Shape*) which includes three attributes according to the degree of development of the facets: sharp, rounded and flattened, (KAISER *et al.*, 2009).

In the application of the Mesowear method in their first proposal, Kaiser *et al.* (2009) perform visual inspection of the teeth, using a magnifying glass when appropriate. The first samples were photographed and plotted on paper, but once the standards were set to the satisfaction of the authors, the rest of the material was recorded through direct scoring.

Kaiser *et al.* (2010) analyzed 37 species of ruminants of the *families Bovidae, Giraffidae* and *Cervidae*, using the *Mesowear* method in the second and third molars. Dental molds were made and the images were digitally processed to quantify the angle of alignment of the enamel ridges. The method proved to be effective, but dependent on manual steps.

Ozaki *et al.* (2010) investigate the relationship between feeding habits, molar wear and life expectancy in wild sika deer populations. They observed that the wear of the M1 and M3 molars increases with grass consumption and decreases with rainfall. M3 showed a stronger correlation with life expectancy, as it maintained masticatory function for longer than M1.

Other approaches to the *Mesowear* method are found during RSL. Fraser *et al.* (2014), with the aim of improving the usefulness of the method, propose a new scoring system with additional categories of wear, analyzing both maxillary and mandibular posterior teeth. The new mesowear system expanded the categories from four to five. Following the traditional method, the cusps were classified according to relief (high or low) and occlusal shape (sharp, rounded, very rounded, rounded-flattened, or flattened-flat). Each combination received a score from 1 to 5, representing increasing degrees of wear. The average score per species was used in the analyses.

For each scoring system, the extent to which the upper and lower teeth mesowear scores were able to differentiate species with different types of diet was evaluated. The analyses were performed using the R software, using single-factor analysis of variance and Tukey's test for comparisons between groups, or the *Kruskal-Wallis* test when the data did not meet the criteria of the analysis of variance. The authors found that the new expanded mesowear scoring system improves the correct classification rates of the diet and has high repeatability. Also, that the mesowear scores of the mandibular teeth are consistently lower than those of the maxillary teeth. Although the new scoring method reduces the difference in wear between the upper and lower arches, this variation may be associated with anodontics, i.e., the fact that the posterior teeth of the mandible are narrower than their maxillary counterparts.

4.1.2 Microwear Method

Microwear is the quantification of microscopic marks, pits and scratches on the teeth, resulting from chewing different types of food. Pits form as a result of enamel-to-enamel contact; while scratches are formed by abrasive items such as phytoliths or earth being rubbed across the enamel surface. The texture of tooth microwear is used as a dietary indicator in paleoecology and vertebrate ecology. Unlike *mesowear*, which has characteristics of greater proportions and describes wear and tear throughout life, *Microwear* is determined only by the last meals, given that small changes in diet are enough to generate

microscopic marks. (FRASER *et al.* (2011), KAISER and BRINKMANN (2006), FRANCISCO *et al.* (2018)).

The analysis of the texture of tooth microwear observes parameters related to surface complexity, such as anisotropy and heterogeneity of enamel veneers at the micrometric scale. Other microwear analysis approaches are based on *ISO standard* roughness and texture parameters.

Francisco *et al.* (2018), using part of the parameters above, propose a new approach where, instead of a single parameter characterizing the entire surface, they perform surface samples generating 9 derived parameters with the aim of expanding the set of parameters. Samples were shaped, scanned and the identification of the most discriminative parameters was conducted through an automated procedure. In its initial form, the method incorporates the usual statistical tools, correlation analyses, and the necessary mathematical tests. The results indicate that a simplified version of the procedure is more efficient in identifying the desired discriminative parameters. And that the new method significantly improves the discriminatory power of tooth wear compared to previous approaches.

Due to its microscopic profile, microwear presents greater difficulties in visualization and analysis than mesowear.

A variety of measurement methods are available to collect topographic data from surfaces on a microscopic scale. These methods can be broadly grouped into contact and non-contact methods. Contact surface sensors inspect surfaces with a needle sensor (diamond or ruby tip), which moves over the surface mechanically under constant pressure. It converts the vertical and horizontal movements of the needle into an electrical signal. Non-contact methods are, for example, the laser tip scanning method, light refraction and diffraction methods, interferometric coherence, acoustic emission, and confocal scanning microscopy (KAISER and BRINKMANN, 2006). Next, we will discuss methods of topographic data collection and analysis present in the RSL.

4.1.3 Roughness

Worn tooth enamel resembles industrial technical surfaces, and can be described by surface roughness parameters defined by ISO standards, which statistically characterize the microtexture in different applications. (KAISER and BRINKMANN, 2006; SCHULZ *et al.*, 2010). The roughness parameters describe undulations and irregularities, characterizing vertical, horizontal and hybrid aspects of the topography. Together, they constitute an

effective statistical tool for analyzing the microtexture of surfaces. (KAISER and BRINKMANN, 2006).

Kaiser and Brinkmann (2006) investigated whether tooth microwear could be characterized by consolidated parameters of surface roughness, finding a strong similarity between industrial surfaces and microscars in molars of herbivores, based on molds of the arches of three bovine species. Using diamond-tipped profilometry on the maxillary second molar, 895 measurements confirmed that industrial roughness parameters describe the same scale as microwear, distinguish dietary groups, and quantify the balance between attrition and abrasion. These parameters reflect the influence of diet and establish a direct link between *the Microwear and Mesowear methods*.

Schulz *et al.* (2010), used texture parameters from ISO/DIS 25178-2 and Scale-Sensitive Fractal Analysis (SSFA) in 3D models by microscopy to quantify tooth microwear in herbivores. The authors evaluated the potential of these parameters as standardized tools and suggested that they reflect the relationship between abrasion and attrition, indicating lower bolus abrasiveness compared to ingested foods. Similarly, both Winkler *et al.* (2013) and Kubo and Fujita (2021), applied surface roughness parameter systems to describe microwear and perform paleontological analyses. The results demonstrated high efficacy and complementarity between the parameters, allowing quantitative and comparable analyses, reinforcing the potential of ISO standards as a standardized methodological basis for studies of tooth microwear.

4.1.4 Other Methods

Several other methods of identification and analysis of tooth wear were identified in the systematic review, although with a low frequency of occurrence when compared to the previous ones. Veiberg *et al.* (2007) applied three-dimensional scanning to analyze the relationship between growth and tooth wear in Svalbard reindeer, obtaining accurate 3D models of the first molar (M1) and ensuring high consistency and quality in the measurements. Similarly, Gailer and Kaiser (2014) used 3D structured light scanning to evaluate the masticatory efficacy in cattle, relating the functional shape of the postcanine teeth to the biomechanical properties and abrasiveness of the diet, with complete virtual reconstructions of the dental arches. Gailer *et al.* (2016) used 3D scanning to analyze tooth shape and function, concluding that masticatory efficiency does not depend on an ideal

morphology and emphasizing the accuracy of the method as a reliable tool to integrate different analytical approaches.

Ackermans *et al.* (2018) applied computed tomography to evaluate tooth wear in goats under diets of different abrasiveness, confirming the reliability of the method, but highlighting its practical limitations due to the need for sedation of the animals. Similarly, Karme *et al.* Wang *et al.* (2016) utilized CT scans in a mechanical chewing experiment and observed that tooth tissue loss varies even in similar microwear patterns, warning against direct inferences about diet or wear rate.

4.2 FINAL CONSIDERATIONS - SYSTEMATIC LITERATURE REVIEW

The information obtained from the RSL contributes to elucidate previously raised issues and to outline the academic interest in the theme. Even without time constraint in the filters, the extensive Boolean expressions used in the searches resulted in a limited number of works. Even so, only 73 studies on tooth wear in ruminants were included (accepted) in the review, which highlights the specificity of the topic. Several methods of identifying tooth wear were found in about 85% of the studies, most of which were based on visual inspection and image analysis.

The greater recognition of wear and tear as a tool for inferring diet, and not as an indicator of oral problems, is a portrait of its wide application in paleontological studies. This finding arouses interest in the application of tooth wear in animal groups that provide immediate return and direct impact, whether in economic, ecological or animal welfare terms. In this context, a low representation of beef animals was observed among the studies reviewed, with only 16 studies involving goats, 14 with cattle and 10 with sheep, reinforcing the opportunities for expanding this approach.

The methods identified in the literature for the analysis of tooth wear have evolved from simple visual inspections to the use of electron microscopy, three-dimensional scanning and computed tomography. Molar teeth are the main targets of investigation due to their masticatory function, varying between the first, second and third molars.

The mesowear method has been of great relevance in the development of research since its proposal, being continuously adapted to the needs of the authors and to the advancement of data collection technologies. The search for greater repeatability and reliability has led the microwear approach (*Microwear*) to integrate technological tools, such as three-dimensional scanning and industrial surface roughness (ISO) parameters. The

choice of the method of analysis should be aligned with the specific objectives of each study. *Mesowear* reflects the wear accumulated over months or years, analyzing the occlusal relief and the shape of the cusps, while *Microwear* shows changes that occur at shorter intervals, from hours to days, and gains robustness with the use of standardized tools (FRASER and THEODOR, (2011); STRANI et al. (2018)).

5 CONCLUSION

The systematic review gathered and analyzed the main approaches to tooth wear in ruminants, highlighting their scientific and productive importance. The results showed the predominance of visual inspection and image analysis methods, as well as advances in electron microscopy, 3D scanning and computed tomography, reflecting technological advances and the search for greater precision in the analyses.

It was found that tooth wear has been widely explored as an indicator of diet, especially in paleontological studies, but it is still little applied in species of zootechnical interest, such as cattle, goats and sheep. This gap points to significant opportunities to expand this approach to productive contexts, with the potential to have a direct impact on the health, well-being and efficiency of herds.

Thus, the study contributes to consolidate existing knowledge, identify limitations and point out future directions for the development of tools that quantify tooth wear in ruminants. This practical application can support professionals and researchers in making decisions aimed at sustainable management, increased productivity, and promotion of animal welfare, strengthening the integration between science and agricultural production.

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COP-30 AND THE FUTURE OF CLIMATE GOVERNANCE: BRAZIL'S ROLE IN THE TRANSITION TO SMART AND RESILIENT CITIES UNDER THE GIS CYCLE

COP-30 E O FUTURO DA GOVERNANÇA CLIMÁTICA: O PAPEL DO BRASIL NA TRANSIÇÃO PARA CIDADES INTELIGENTES E RESILIENTES SOB O CICLO GIS

LA COP-30 Y EL FUTURO DE LA GOBERNANZA CLIMÁTICA: EL PAPEL DE BRASIL EN LA TRANSICIÓN HACIA CIUDADES INTELIGENTES Y RESILIENTES BAJO EL CICLO GIS

 <https://doi.org/10.56238/sevened2025.036-079>

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ABSTRACT

The COP-30, to be held in Belém (Brazil), represents a milestone in global climate governance by placing the Amazon at the center of international decision-making on mitigation, adaptation, and climate justice. Considering the strategic relevance of the event and the institutional challenges related to Brazil's ability to implement its climate commitments, this study aims to examine how COP-30 may strengthen the transition towards smart and resilient cities, based on the theoretical framework of the GIS Cycle, Governance, Innovation, and Sustainability. The research adopts a qualitative approach grounded in documentary analysis of official national and international instruments, as well as recent Brazilian experiences involving digital and sustainable governance at the municipal level. The results demonstrate that Brazil has the potential to assume a leadership role in climate governance, provided that implementation, monitoring, and multilevel coordination capacities are reinforced. Additionally, the empirical focus on Belém and its strategic connection with Goiânia reveals opportunities to integrate climate diplomacy with local public policy. It is concluded that the GIS Cycle offers institutional conditions to transform climate ambition into concrete outcomes, enhancing the legacy of COP-30 for Brazilian territories and society.

Keywords: COP-30. Climate Governance. Smart Cities. Sustainability. GIS Cycle.

RESUMO

A realização da COP-30 na cidade de Belém (PA) representa um marco para a governança climática global, ao posicionar a Amazônia no centro das decisões internacionais sobre mitigação, adaptação e justiça socioambiental. Considerando a relevância estratégica do evento e os desafios institucionais brasileiros quanto à implementação de suas metas climáticas, este estudo tem como objetivo analisar em que medida a COP-30 pode impulsionar o país rumo à transição para cidades inteligentes e resilientes, tomando como referência o modelo do Ciclo GIS, Governança, Inovação e Sustentabilidade. Adota-se uma abordagem qualitativa, baseada em análise documental de instrumentos oficiais nacionais e internacionais, bem como de experiências recentes de governança digital e sustentável em

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municípios brasileiros. Os resultados evidenciam que o Brasil possui potencial para assumir papel de liderança na governança climática, desde que fortaleça as capacidades de implementação, monitoramento e coordenação multinível. Além disso, o estudo de Belém e suas conexões estratégicas com Goiânia revelam oportunidades de integração entre diplomacia climática e política pública local. Conclui-se que a consolidação do Ciclo GIS pode contribuir para transformar ambição em resultados concretos, ampliando o legado da COP-30 para o território e para a sociedade brasileira.

Palavras-chave: COP-30. Governança Climática. Cidades Inteligentes. Sustentabilidade. Ciclo GIS.

RESUMEN

La realización de la COP-30 en Belém (Brasil) constituye un hito en la gobernanza climática mundial, al situar a la Amazonía en el centro de las decisiones internacionales sobre mitigación, adaptación y justicia climática. Considerando la relevancia estratégica del evento y los desafíos institucionales relacionados con la implementación de los compromisos climáticos brasileños, este estudio tiene como objetivo analizar de qué manera la COP-30 puede impulsar la transición hacia ciudades inteligentes y resilientes, utilizando como referencia el modelo del Ciclo GIS, Gobernanza, Innovación y Sostenibilidad. La investigación adopta un enfoque cualitativo basado en análisis documental de instrumentos oficiales nacionales e internacionales, así como de experiencias recientes de gobernanza digital y sostenible en municipios brasileños. Los resultados muestran que Brasil puede asumir un papel de liderazgo en la gobernanza climática, siempre que fortalezca las capacidades de implementación, monitoreo y coordinación multinivel. Además, el análisis de Belém y su conexión con Goiânia revela oportunidades para integrar diplomacia climática y política pública local. Se concluye que la consolidación del Ciclo GIS puede transformar la ambición en resultados concretos, ampliando el legado de la COP-30 para el territorio y la sociedad brasileña.

Palabras clave: COP-30. Gobernanza Climática. Ciudades Inteligentes. Sostenibilidad. Ciclo GIS.

1 INTRODUCTION

Climate change is one of the main global challenges of the twenty-first century, with widely consolidated scientific evidence on its environmental, economic, and social impacts (IPCC, 2023). The intensification of extreme events, the threat to biodiversity, and the widening of socio-environmental inequalities demonstrate that the climate crisis cannot be addressed without robust governance mechanisms, based on mitigation, adaptation, and climate justice (Sachs, 2015; UNFCCC, 2022).

At the international level, the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change has established itself as the main multilateral negotiation forum for defining climate commitments, monitoring targets, and cooperation between countries (Hale, 2022; Bodansky, 2016). Since its creation in 1995, the COP has played a central role in the construction of agreements such as the Kyoto Protocol and the Paris Agreement, establishing emission reduction targets and financing instruments for the ecological transition.

The holding of COP-30 in Belém do Pará reflects the recognition that the Amazon is a key player in the global climate balance, not only for its biophysical regulatory function, but for its strategic role in the planetary agenda of emissions and land use, as shown by recent data from the *Climate Action Tracker* and the updated instruments of the Nationally Determined Contribution (NDC).

International climate governance and its national and local materializations today constitute a field of disputes, innovations, and reconfiguration of state capacities in the face of a crisis of a civilizational nature.

Brazil, the sixth largest emitter of greenhouse gases in the world and with almost half of its emissions linked to land use and change, occupies a unique position on the global climate agenda.

At the same time as it faces international pressures to reduce deforestation, the country has strategic opportunities to project itself as a global leader in the ecological transition, especially with the recent improvement of the national targets established in its updated Nationally Determined Contribution (NDC), which foresees a reduction of between 59% and 67% in emissions by 2035, with a focus on climate justice and clean development.

However, structural and institutional challenges persist, such as the mismatch between diplomatic ambition and operational capacity, the limitation of regulatory and technological

instruments, and the incomplete consolidation of the Brazilian Emissions Trading System (SBCE).

In this scenario, climate governance in Brazil lacks integrated mechanisms that ensure planning, execution, and continuous monitoring, especially at the municipal level, where the effects of the climate crisis are manifested more directly.

It is in this context that the importance of innovative models of public management capable of guiding climate policies with efficiency, social legitimacy, and institutional intelligence emerges. The GIS Cycle, Governance, Innovation and Sustainability, proposed in the author's previous theoretical development, represents a systemic approach that articulates public value, evidence-based decision-making, technological innovation and sustainable resilience as guiding principles of state action.

COP-30 constitutes a critical window: either Brazil consolidates a new cycle of climate governance, decentralized, digital and results-based, or the historic opportunity will be dispersed after the event, losing the potential for structural transformation.

In view of this, this article seeks to analyze how COP-30 can boost the Brazilian climate transition, focusing on the application of the GIS Cycle to the construction of smart and resilient cities, through an illustrative study of Belém (PA), host of the event, and strategic connections with Goiânia (GO), a municipality where concrete experiences of integrated and digital governance of urban planning are developed.

Thus, the central question that guides this investigation can be stated as follows: *How can Brazil transform the diplomatic protagonism of COP-30 into concrete results of climate governance in the territory, taking the GIS Cycle as a reference?*

To answer it, the study has the following objectives:

General Objective:

Analyze the possibilities of strengthening Brazilian climate governance from COP-30, based on the GIS Cycle model.

Specific Objectives:

- a) Characterize Brazil's pre-COP-30 climate scenario and its institutional gaps;
- b) Evaluate the construction of the climate agenda in Belém and the challenges of the post-event legacy;
- c) Identify possible connections with smart governance experiences in Goiânia;
- d) Propose strategic recommendations guided by the GIS Cycle.

This approach seeks to contribute to the theoretical and practical advancement of climate governance in the country, articulating global commitments with local capacities, so that the legacy of COP-30 goes beyond diplomatic discourses and becomes public innovation, urban sustainability, and environmental justice.

2 THEORETICAL FRAMEWORK

Confronting the climate crisis requires not only ambitious diplomatic commitments, but above all institutional capacity to implement effective public policies on a territorial scale. Understanding the conceptual foundations that structure this agenda is an indispensable condition for analyzing the challenges and opportunities facing Brazil in the context of COP-30.

In this sense, the theoretical framework presented aims to situate climate governance in the broader field of sustainable development, highlighting its multi-scalar nature and its intrinsic link with social justice, technological innovation, and urban resilience.

By examining the Brazilian regulatory framework, its operational gaps, and the strategic role of cities, especially in the Amazon, the text outlines the analytical bases necessary to understand why climate implementation must be territorialized, intelligent, and results-oriented. Finally, the GIS Cycle is introduced as an original Brazilian proposal for improving governance capabilities, capable of converting ambition into concrete deliveries and contributing to COP-30 leaving a lasting legacy in the country and in the world.

2.1 CLIMATE GOVERNANCE AS A PILLAR OF SUSTAINABLE DEVELOPMENT

Climate governance can be understood as the multi-scalar institutional arrangement that coordinates policies, actors, and instruments to mitigate greenhouse gas emissions and promote adaptation to the impacts of global warming (BODANSKY, 2016; BIERMANN et al., 2010). It is a field that involves both the international system and national and subnational governments and organized civil society, configuring itself as a challenge of polycentric governance (OSTROM, 2010), in which responsibilities, competencies and capacities must be distributed in a cooperative manner.

In the framework of sustainable development, Sachs (2015) and the IPCC (2023) emphasize that there is no effective climate action without socio-environmental justice, as the impacts of the climate crisis fall unequally on vulnerable populations. This reinforces the principle of "common but differentiated responsibilities", consolidated in multilateral

agreements since Rio-92 and deepened in the Paris Agreement (UNFCCC, 2015; HALE, 2022).

In Brazil, a previous study by the author shows that the climate normative framework is relatively sophisticated, but there are still relevant deficiencies in federative integration, implementation and monitoring of results, especially at the municipal scale, where climate impacts are felt directly and on a daily basis.

This asymmetry between normative ambition and real institutional capacity is pointed out by Osborne (2010) as a structural dilemma of collaborative governance: interdependent policies require technical, technological, and managerial capacities that are not always available in subnational entities.

From the point of view of the state of the art of governance, Klimanov (2021) and Peters (2022) indicate that successful climate governance systems have three essential characteristics:

Table 1

Structuring components of climate governance

Structuring element	Expected result
Multilevel coordination	Reduction of overlaps and regulatory gaps
Evidence-based governance	Continuous monitoring of policy effects
Adaptive and responsive capability	Quick fixes and institutional learning

Source: Author.

Brazil is in the process of consolidating these three key components of climate governance, multilevel coordination, evidence-based governance, and adaptive institutional capacity.

International examples demonstrate the relevance and feasibility of these elements: in the European Union, the existence of binding targets and sectoral climate plans ensures clarity of roles and responsibilities, strengthening climate governance and monitoring of results; New Zealand has an independent Climate Change Commission, responsible for establishing annual metrics and monitoring compliance with national targets, ensuring transparency and *accountability* on the decarbonization trajectory. In the Brazilian case, although the transition is underway, emerging initiatives indicate important advances, as is the case in Goiânia, where digital and integrated governance has been implemented that

articulates strategic planning, public budget, and performance indicators to guide decisions and monitor government deliveries.

These examples signal possible paths for strengthening climate governance in the country.

In summary, governing the climate is fundamentally transforming ambition into results, activating state and social capacities so that international goals materialize in the territory, a global requirement and a particularly Brazilian urgency.

2.2 BRAZILIAN CLIMATE POLICY: CLIMATE PLAN AND NDC

Brazilian climate policy is structured by international commitments signed under the United Nations Framework Convention on Climate Change (UNFCCC), with emphasis on the Paris Agreement, which requires countries to develop progressively more ambitious goals (UNFCCC, 2015; HALE, 2022).

It is noted that the country consolidated its Nationally Determined Contribution (NDC), updated in 2024, setting the goal of reducing between 59% and 67% of greenhouse gas emissions by 2035, with an emphasis on climate justice and clean development.

However, the Brazilian Emissions Trading System (SBCE), although innovative, still lacks a digital operational structure, transparency, and systemic oversight.

The state of the art demonstrates that climate goals are only effective when operated by intelligent governance systems, with continuous monitoring and accountability (HALE, 2022; MECKLING, 2021).

It must be considered that the national performance still has significant governance gaps. Brazil remains among the largest global emitters, with 2.5% of global emissions and high dependence on the land use and change sector (LULUCF), and its climate performance remains classified as insufficient to limit warming to 1.5°C.

This situation reinforces the IPCC's diagnosis (2023), according to which climate goals without the capacity for implementation, measurement, and accountability tend not to materialize.

From a regulatory point of view, there have been recent advances such as the creation of the Brazilian Emissions Trading System (SBCE) in 2024, with the aim of providing a carbon pricing mechanism. However, the operationalization of this system is still incipient, as it depends on digital infrastructure, methodological standardization, and inspection capacity that are not fully established (*Climate Transparency*, 2025).

In view of the facts, it is important to note that Brazil is in a paradoxical situation: it is simultaneously an environmental power and an institutional vulnerable, with high diplomatic ambition, but limited climate execution.

This asymmetry reflects what the literature calls *the implementation gap* (PETERS, 2022; MECKLING, 2021): well-designed policies, but with low operational governance, especially at the subnational level, where climate policy is carried out in a concrete way.

Despite having robust normative instruments, such as the Climate Plan, analyzed in detail by the author, municipalities lack technical and financial resources to carry out urban adaptation actions, prevention of extreme events and control of deforestation in their territories.

COP-30 represents a critical window for reviewing and strengthening national and local capacities, establishing stronger links between climate ambition and state capacity, a theme that the GIS Cycle seeks to structure in a systemic way.

2.3 SMART AND RESILIENT CITIES AS THE EPICENTER OF CLIMATE ACTION

Cities concentrate approximately 70% of global greenhouse gas emissions, in addition to being home to most of the world's population (UN-Habitat, 2020). For this reason, they become the operational center of contemporary climate governance: it is in urban territories that both impacts and responses to climate change manifest themselves in a direct, urgent, and unequal way (IPCC, 2023).

In this context, the concept of Smart City has evolved substantially in recent decades. From an initial eminently technological perspective, the current focus now considers the strategic and socially oriented use of technology, with a focus on quality of life and environmental sustainability (KOMNINOS, 2015; CARAGLIU; DEL BO; NIJKAMP, 2019). Thus, the smart city is, first and foremost, an ecosystem of public innovation, based on data, citizen participation, connectivity, and integrated urban planning.

At the same time, the advancement of the climate agenda reinforced the notion of urban resilience, defined as the ability to anticipate, absorb, and transform impacts associated with extreme events and chronic climate change, while maintaining the functionality of urban systems (MEEROW; NEWELL; STULTS, 2016). In this way, resilient smart cities constitute the new ideal of urban planning in the twenty-first century, combining technology, collaborative governance, and climate justice.

In the Brazilian case, emerging initiatives demonstrate the potential of municipal public innovation to address the climate emergency. Among them, processes that integrate strategic planning, results-oriented budgeting, and digital platforms stand out, strengthening the monitoring of indicators and popular participation. The experience of Goiânia, which articulates PPA, digital governance and institutionalized indicators in the GIS Cycle model, is a concrete example of this smart governance applied to the national context, at an advanced stage of implementation.

On the other hand, cities in the Amazon, such as Belém, host of COP-30, face additional challenges such as socio-environmental vulnerability, historical infrastructure deficits, and territorial inequality, but at the same time they have a unique opportunity to lead the global climate agenda, by transforming their geopolitical position into a bioeconomic power and an international laboratory for sustainable urban policies.

Thus, the city emerges as the main space where climate governance can cease to be a promise and become a reality, through innovation, technology, social participation, and adaptive resilience.

2.4 THE GIS CYCLE AS A BRAZILIAN INSTITUTIONAL INNOVATION FOR CLIMATE GOVERNANCE

In the field of climate governance, organizations such as the IPCC (2023), the OECD (2021), and UN-Habitat (2020) argue that States should adopt management models capable of articulating data science, social participation, federative coordination, and focus on results.

However, most of the widely disseminated methodologies were conceived in contexts historically different from the Brazilian one, with greater institutional stability and lower socioeconomic inequalities. This makes it necessary to develop approaches adapted to realities such as Latin America, marked by strong territorial heterogeneity and administrative weaknesses.

In this scenario, the GIS Cycle, Governance, Innovation and Sustainability, emerges as an original Brazilian contribution to the advancement of climate governance. Developed by the author as a systemic institutional architecture, the model seeks to overcome the fragmentation that historically separates planning, budgeting, technology, and monitoring, unifying these dimensions in a continuous process oriented to public value.

GIS proposes that public administration operates with ethics and social responsibility, permanent monitoring, sustainable innovation, and adaptive resilience, allowing climate policies to effectively convert into verifiable deliverables.

In addition to establishing new governance parameters, the GIS Cycle reinforces the need for the State to adopt decision-making mechanisms connected to society and based on evidence, expanding the government's capacity to correct course, anticipate risks, and respond in a coordinated manner to climate demands.

This perspective is convergent with contemporary international discussions on collaborative governance (OSBORNE, 2010) and polycentric governance (OSTROM, 2010), but incorporates the differential of a territorialized view of climate action.

The experience of Goiânia, which has been applying principles of the GIS Cycle in the development of its medium-term planning, illustrates the potential of the model as a tool for public transformation.

In this case, the articulation between planning, budget, popular participation and indicators has allowed greater precision in the prioritization of policies, conferring institutional intelligence to the urban climate management process.

This example demonstrates that GIS is not restricted to the theoretical field, constituting itself as an applicable and replicable method in different realities.

More than that, the GIS Cycle presents itself as an institutional innovation that offers Brazil a better capacity to align diplomatic ambition and territorial implementation, allowing commitments made in global arenas, such as COP-30, to generate concrete effects on people's lives.

For this reason, it is a strategic proposal both to strengthen municipal governance and to position the country as an international reference in integrated, inclusive and sustainable climate management models.

3 METHODOLOGY

The research adopts a qualitative approach, with an analytical and propositional character, centered on the evaluation of the role of COP-30 in strengthening Brazilian climate governance and in the formulation of the GIS-COP30 model.

The study is based on documentary analysis of national and international instruments, such as the NDC updated in 2024, climate monitoring reports, regulations on the sustainable transition, and institutional documents related to public governance and the GIS Cycle.

At the same time, a review of specialized literature on climate governance, smart cities, government innovation and urban resilience was carried out, in order to ensure alignment with the state of the art.

The analysis is organized in three stages: diagnosis of the pre-COP-30 climate scenario; evaluation of legacy opportunities associated with the event in Belém do Pará; and the proposal of the GIS-COP30 framework as an instrument for the local implementation of Brazilian climate goals.

In addition, the cases of Belém, due to their strategic role in COP-30, and Goiânia, due to the adoption of integrated digital governance practices, are examined. Thus, the methodology allows for the articulation of international commitments, national capacities, and municipal strategies aimed at climate action.

4 RESULTS AND DISCUSSION

Understanding Brazil's role in contemporary climate governance requires an analysis that goes beyond the normative dimension and considers the real capacity to implement public policies. After discussing, in the theoretical framework, the foundations of climate governance, national policy and the centrality of cities in the sustainability agenda, this section presents the findings of the research, structuring a critical reflection on the Brazilian situation on the eve of COP-30. The objective is to highlight how the country articulates, or fails to articulate, its diplomatic protagonism with the operational challenges of the territory, especially at the municipal level.

From this diagnosis, the transformative potential of COP-30 and its relationship with the institutional innovation proposed by the GIS Cycle are explored, demonstrating concrete paths for the consolidation of smart and resilient cities in Brazil. Thus, the results and discussions that follow make explicit the gap between ambition and state capacity, while pointing out strategies and opportunities to overcome it.

4.1 BRAZIL IN THE PRE-COP-30 CLIMATE SCENARIO: DIPLOMATIC AMBITION, LIMITED EXECUTION

Brazil occupies a strategic position in global climate governance as one of the main environmental powers on the planet, responsible for the largest tropical forest in the world and for relevant ecosystem services that regulate the regional and global climate. This role was reaffirmed in the last rounds of UNFCCC negotiations, with the update of the Nationally

Determined Contribution (NDC), which established the goal of reducing greenhouse gas emissions by 59% to 67% by 2035, incorporating principles of climate justice and sustainable transition.

However, the technical diagnosis shows dissonance between ambition and implementation. According to the *Climate Action Tracker*, Brazil remains among the largest global emitters, with approximately 2.5% of global emissions, and its level of commitment is still classified as "Insufficient" to limit global warming to 1.5°C.

This assessment stems from the country's persistent dependence on the land use and land use change (LULUCF) sector, associated with deforestation in the Amazon and Cerrado, as well as structural challenges in the energy, industry, and transport sectors.

Institutional analysis reinforces this asymmetry. Although Brazil has advanced in the modernization of regulatory instruments, as demonstrated by the creation of the Brazilian Emissions Trading System (SBCE), technical studies warn that the operationalization of this mechanism depends on robust digital infrastructure, methodological standardization, and inspection capacity that are still under development.

The picture is reinforced by the IPCC (2023), which states that climate policies only produce results when supported by continuous systems of monitoring, accountability, and evidence-based governance.

These gaps are accentuated at the subnational level, where climate impacts are manifested with greater intensity. Brazilian municipalities often lack specialized technical teams, adequate digital platforms, or financial resources to structure effective mitigation and adaptation actions, which limits the country's ability to meet international goals consistently across the territory.

Thus, the pre-COP-30 scenario reveals a paradox: Brazil has the best environmental conditions to lead the global climate transformation, but still finds it difficult to operate this leadership internally, especially in its municipal dimension. This finding reinforces the urgency of governance models that connect diplomatic ambition with local execution, which will be deepened in the following subsections.

4.2 NATIONAL CLIMATE GOVERNANCE GAPS

Despite relevant advances at the diplomatic and regulatory level, Brazilian climate governance still has structural limitations that hinder the execution of the goals established in the NDC and compromise the coherence between ambition and implementation. Such

gaps are manifested, above all, in the capacity for federative articulation, in the low degree of institutionalization of evidence-based management and in the territorial inequalities that mark municipal capacities.

The first gap concerns multilevel coordination. Although the federal government drives the international climate agenda, the execution of actions is predominantly local, especially in Brazil, where a large part of emissions is associated with territorial dynamics (land use, fires, disorderly urbanization). The lack of systematic cooperative arrangements between the Union, states and municipalities results in disjointed policies, with overlapping of actions and institutional vacancies.

Table 2

Gaps in Brazilian climate governance and their impacts on the territory

Governance Gap	Impact on the Territory
Insufficient federative coordination	Disconnection between national goals and municipal reality
Poor data governance	Lack of policy monitoring and remediation
Local climate finance gap	Difficulty in operationalizing plans and actions
Unequal socio-environmental vulnerability	Climate injustice and increased population risk
Limited institutional capacity in municipalities	Slowness and fragmentation of public enforcement

Source: Author.

A second weakness concerns technological and informational maturity. Climate governance requires systems capable of measuring emissions, modeling risks, monitoring targets, and assessing impact in a transparent and continuous way. However, many Brazilian municipalities still operate without data, without indicators and without integrated digital platforms, which compromises both the quality of decisions and accountability to society.

In addition, the challenge of climate finance remains, especially in municipal entities, which have low budgetary capacity to implement urban adaptation actions, green infrastructure, sanitation, sustainable mobility, and environmental enforcement. The absence of permanent financial mechanisms aggravates the dependence on sporadic transfers and isolated projects, making it difficult to continue policies.

Finally, socio-spatial inequalities, especially accentuated in the Amazon and urban peripheries, make climate justice an operational challenge. The most vulnerable populations are also the most exposed to extreme events, but less contemplated by investments and

resilient solutions. This asymmetry reveals that climate policy still does not reach those who need it most.

Given this scenario, it becomes evident that strengthening climate governance in Brazil requires investment in subnational state capacities, with a focus on technology, institutional intelligence, and social participation. COP-30 emerges as a strategic opportunity to review governance arrangements, modernize instruments, and foster territorial resilience, especially in the Amazon and in capitals with national prominence, such as Belém and Goiânia.

In summary, without local capacity to transform guidelines into concrete deliveries, Brazil runs the risk of remaining a potential climate power, but not in realization.

4.3 COP-30 AND THE AMAZONIAN LEGACY: THE ILLUSTRATIVE STUDY OF BELÉM (PA)

The choice of Belém do Pará as the host of COP-30 represents a historic milestone for climate governance by repositioning the Amazon as not only an environmental, but also a geopolitical, socioeconomic, and technological protagonist of the global ecological transition. The city, located at the interface between the urban and the forest, symbolizes both the challenges of Brazilian climate governance and its potential for leadership in sustainable development models.

In this context, the Amazon bioeconomy emerges as a strategic vector capable of combining biodiversity conservation with income generation, employment, and social inclusion. It is an economic paradigm based on the sustainable use of forest resources and on scientific-technological knowledge associated with sociobiodiversity, dialoguing with the care economy and with traditional knowledge that has historically sustained ways of life in the region. COP-30 offers a unique opportunity to structure clean production chains, value the standing forest and position the Amazon as a world hub for socio-environmental innovation.

However, for the bioeconomy to become a strategic reality and not just a discourse, it is essential to face structural deficits in the urban territory. Belém presents critical challenges in basic sanitation, mobility, drainage, housing, land regularization and waste management, factors that intensify vulnerabilities in the face of extreme events such as floods, heat islands and water contamination.

For these reasons, we understand that the legacy of COP-30 must include investments in resilient urban infrastructure, ensuring that climate adaptation advances in an integrated manner with the reduction of socio-spatial inequalities.

This dimension refers directly to climate justice. In the Amazon, traditional populations, indigenous people, quilombolas, riverside dwellers, and residents of urban peripheries are those who, in addition to contributing less to the climate crisis, suffer the most from its effects. Therefore, any policy linked to COP-30 must ensure effective social participation, fair sharing of economic benefits and protection of territories of community life. This implies recognizing that Amazonian climate governance cannot be built without the living Amazon and without the Amazonians.

The Belém study demonstrates that COP-30 is not just an event, but a turning point capable of redefining the Amazonian development model, expanding institutional, technological, and financial capacities for climate implementation. What is at stake is not the construction of an infrastructure for a meeting of heads of state, but the construction of permanent infrastructures for the future.

That said, the articulation between the Amazonian legacy and the innovative experiences of municipal governance already implemented in other Brazilian capitals, such as Goiânia, reveals ways to disseminate and accelerate the institutional strengthening necessary to achieve climate goals in the territory.

In summary, Belém becomes a showcase of the world, but it should, above all, become a reference for Brazil itself, inaugurating a new stage of national climate governance.

4.4 STRATEGIC CONNECTIONS WITH GOIÂNIA (GO)

The experience of Goiânia reveals relevant advances in strengthening municipal public governance through the integration between strategic planning, results-oriented budgeting, social participation and digital technologies. This perspective has allowed the municipality to structure a management model based on data, indicators and transparency, which positions it as a national reference in the practical application of instruments aimed at territorial climate action.

The implementation of integrated digital platforms, associated with the monitoring of government programs and projects, contributes to qualifying real-time decision-making, ensuring responsiveness and social control. Such mechanisms allow public managers to anticipate risks, monitor performance, and correct strategic directions, reducing waste,

increasing efficiency, and increasing the legitimacy of climate policies. The use of data thus becomes an essential institutional infrastructure, as recommended by international organizations for urban governance in the context of climate change (UN-Habitat, 2020; IPCC, 2023).

In addition to the technological dimension, Goiânia has sought to reinforce the democratic character of management by expanding mechanisms for citizen participation and social co-responsibility. This includes the active involvement of communities and local actors in defining public priorities, ensuring that government decisions reflect real needs of the territory. By bringing the decision-making process closer to the populations affected by the policies, it contributes to reducing inequalities and strengthening climate justice at the local scale.

The articulation between strategic planning, digital governance, budgeting, and social participation translates an advanced model of municipal management aligned with the requirements of the sustainable transition. These elements constitute fundamental pillars of the GIS Cycle, setting a concrete example of how climate governance can be institutionalized within the operational capacities of the Brazilian State, in a continuous and verifiable way.

This experience shows that strengthening local governance does not depend exclusively on large-scale structural transformations, but can be achieved through incremental, integrated, and intelligent institutional innovations. Goiânia's trajectory demonstrates feasible paths for other Brazilian cities, including Amazonian capitals such as Belém, to advance in the consolidation of governance systems capable of transforming climate goals into tangible results for the population.

In summary, the experience of Goiânia indicates that Brazil already has solid domestic references to subsidize the legacy of COP-30, supporting the construction of smart, resilient cities oriented towards sustainable public value.

4.5 GIS-COP30 FRAMEWORK: AN INTEGRATED MODEL FOR CLIMATE IMPLEMENTATION IN THE TERRITORY

The GIS-COP30 framework proposes an operational framework capable of connecting international climate commitments with the institutional reality of municipal governments, overcoming the gap between diplomatic ambition and public execution. Its design incorporates continuous flows of planning, monitoring, and social participation that ensure adaptive and responsive governance, driven by data and sustainable public value.

Figure 1

GIS-COP30 cycle: integrated climate governance model



Source: Author.

It is a multi-scale model, which recognizes the different levels of responsibility of climate governance: the environmental diplomacy of the Union, the regulatory and coordinating attributions of the states, and the implementation of policies at the municipal level, where environmental and social impacts are directly manifested. By positioning the municipality as a protagonist agent of climate implementation, GIS-COP30 reinforces the principle defended by the IPCC (2023) that climate resilience is built "from the bottom up", in permanent interaction with national capacities.

The operation of the model is structured in five integrated axes, organized in a cycle format fed back by an operational flow:

1. Local Climate Strategic Planning - Establishes objectives and priorities based on territorial diagnoses and alignment with national (NDC) and global (SDG, Paris) goals.
2. Data Governance and Analytics - Collection and processing of environmental, social, and economic data to inform decisions, monitor emissions, and anticipate risks.
3. Green Budget and Sustainable Finance – Direct linkage between climate goals and resource allocation, including climate fundraising and internationalized partnerships.

4. Social Participation and Climate Justice - Expansion of democratic control and co-production of solutions, ensuring equitable distribution of benefits and protection of vulnerable populations.
5. Monitoring, Transparency and Learning Cycle - Continuous indicators, auditing of results and institutional learning, allowing quick adjustments and maintaining public accountability.

The articulation of these elements transforms GIS-COP30 into an institutional infrastructure for climate implementation, capable of generating verifiable improvements in people's lives. Its originality consists in bringing the climate to the center of public governance, linking environmental policies to city management, in sanitation, mobility, housing, land use and government digitalization.

The model was designed to be replicable, adaptable to different municipal realities and applicable especially in regions with strong socio-environmental inequality, such as the Amazon. In this way, it constitutes an unprecedented Brazilian contribution to strengthening the capacities to implement the Paris Agreement, expanding the legacy of COP-30 and positioning the country as an international reference in the construction of smart, resilient cities committed to sustainable public value.

Finally, GIS-COP30 represents the operational link between climate geopolitics and municipal public management, converting global commitments into concrete and permanent actions in the territory.

5 CONCLUSION

COP-30 represents a historic opportunity to reposition Brazil as a protagonist of international climate governance, aligning its expressive diplomatic ambition with the capacity for territorial implementation, especially at the municipal level, where climate action gains concreteness. The present study demonstrated that the country has exceptional environmental conditions and important geopolitical capital, reinforced by the commitment made in the NDC 2024, but still faces structural limitations that prevent the full achievement of its objectives, among which the following stand out: weaknesses in federative coordination, low technological maturity, insufficiency of local climate financing, and socio-spatial inequalities that unevenly affect the distribution of risks and benefits of the green transition.

The article presented the GIS Cycle as a Brazilian institutional innovation, capable of linking planning, public budgeting, climate data, social participation and continuous monitoring, structuring the implementation of smart and resilient climate policies in the territories. The experiences analyzed, Belém as an Amazon showcase for COP-30 and Goiânia as a national reference in integrated digital governance, show that strengthening municipal capacity is a strategic condition for global goals to be converted into positive results for the most vulnerable populations, as advocated by international organizations such as IPCC (2023) and OECD (2021).

Despite its contributions, it is recognized that the study has methodological and empirical limitations. Concentrating the analysis on a municipal illustrative study reduces the comparative scope and requires additional tests in different Brazilian socio-environmental contexts, considering realities with less administrative capacity. In addition, political dimensions of the climate transition, such as institutional resistance, asymmetries in federative cooperation, and veto behaviors, require future analytical expansion, especially in the interactions between the Union, states, and municipalities.

Another central challenge that requires deepening is climate financing, an indispensable element for cities to implement urban adaptation actions, green infrastructure, environmental sanitation, sustainable mobility, and territorial monitoring programs. The consolidation of the Brazilian Emissions Trading System (SBCE), combined with the expansion of financial instruments such as international funds (GCF, GEF), *green bonds*, carbon credits and Brazilian sustainable taxonomy, is a decisive component for the economic viability of the transition.

The future research agenda foresees the preparation of a new article aimed exclusively at the analysis of climate financing mechanisms and their role in municipal governance, focusing on the operationalization of SBCE, innovative partnerships, and the strengthening of subnational capacities to capture, manage, and account for climate resources. It is expected that such developments will increase the empirical robustness of the GIS-COP30 model and contribute to guide its large-scale application.

In summary, COP-30 should not only be a diplomatic milestone, but an institutional watershed, capable of territorializing, digitizing, and democratizing climate action in Brazil. The strengthening of local state capacities, articulated with the GIS Cycle, makes it possible to transform international commitments into concrete policies oriented to sustainable public

value, ensuring that the country advances from potential climate power to climate leadership in realization.

5.1 FINAL CONSIDERATIONS AND CLIMATE TRANSFORMATION AGENDA

COP-30 inaugurates a decisive phase for Brazil to convert its diplomatic recognition into effective climate governance, structured in robust municipal capacities and guided by sustainable public value. The implementation of the GIS Cycle, by articulating planning, technology, financing, and social participation, demonstrates that it is possible to transform global goals into verifiable results in the territory, especially in cities that face deep socio-environmental inequalities and greater exposure to climate risks. The continuity of this research will seek to mature local climate financing instruments and strengthen the application of the GIS-COP30 model in different realities, contributing to the legacy of COP-30 being lasting, inclusive and territorialized. In short, it is about ensuring that the Brazilian climate transition is not only necessary, but inevitable, prioritizing social justice, institutional innovation, and urban resilience.

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THE IMPASSES OF EXTRACTIVE RESERVES IN BRAZIL: CONFLICTS AND INTERESTS THREATENING A FISHING COMMUNITY IN CEARÁ

OS IMPASSES DAS RESERVAS EXTRATIVISTAS NO BRASIL: CONFLITOS E INTERESSES QUE AMEAÇAM UMA COMUNIDADE PESQUEIRA NO CEARÁ

LOS IMPASSES DE LAS RESERVAS EXTRACTIVAS EN BRASIL: CONFLICTOS E INTERESES QUE AMENAZAN A UNA COMUNIDAD PESQUERA EN CEARÁ

 <https://doi.org/10.56238/sevened2025.036-080>

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ABSTRACT

This article describes the history of the fishing community of Prainha do Canto Verde, located on the east coast of Ceará, and the struggle of its residents for the preservation of artisanal fishing and against the threats of real estate speculation. This struggle resulted in the community's transformation into an environmental conservation unit, and Prainha do Canto Verde was officially included in the list of Brazilian Extractive Reserves (RESEXs) in 2009. The status of Extractive Reserve did not prevent the continuation of predatory fishing or real estate speculation in the region, leading to internal disputes among its residents. This conflict was fueled by external agents whose tourism ventures were threatened by the creation of the RESEX and, more recently, by the arrival of vacationers who buy land and houses from fishermen at prices below market value. This confluence of factors and the ineffectiveness of environmental protection policies and agencies, such as the Chico Mendes Institute for Biodiversity Conservation (ICMBio), have threatened the development and continued existence of Prainha do Canto Verde as an environmental conservation unit. By describing this scenario, based on field research conducted with a group of native people, as well as data collected from documentary and bibliographic sources, the article aims to provide elements for reflection on the problems and impasses surrounding extractive reserves in Brazil and their environmental protection policies.

Keywords: Extractive Reserve. Conservation Unit. Traditional Communities. Environmental Preservation Policies.

RESUMO

O artigo descreve a história da comunidade pesqueira da Prainha do Canto Verde, localizada no litoral leste do Ceará, e a luta de seus moradores pela preservação da pesca artesanal e contra as ameaças de especulação imobiliária. A luta resultou na transformação da comunidade em unidade de conservação ambiental, e a Prainha do Canto Verde passou a configurar oficialmente na lista das Reservas Extrativistas (RESEXs) brasileiras em 2009. A condição de Reserva Extrativista não evitou a continuidade da pesca predatória nem da especulação imobiliária na região, fato que levou a uma disputa interna entre seus moradores, estimulada por agentes externos que tiveram seus empreendimentos turísticos

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ameaçados com a criação da RESEX e, mais recentemente, pela chegada de veranistas que compram terras e casas de pescadores com preços abaixo do valor estimado pelo mercado. Essa confluência de fatores e a inoperância das políticas e órgãos de proteção ambiental, como o Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio), têm ameaçado o desenvolvimento e a permanência da Prainha do Canto Verde enquanto unidade de conservação ambiental. Ao descrever esse cenário, com base em uma pesquisa de campo realizada com um grupo de nativos, além de dados coletados em fontes documentais e bibliográficas, o artigo objetiva trazer elementos para uma reflexão sobre os problemas e impasses que cercam as reservas extrativistas no Brasil e suas políticas de proteção ambiental.

Palavras-chave: Reserva Extrativista. Unidade de Conservação. Comunidades Tradicionais. Políticas de Preservação Ambiental.

RESUMEN

Este artículo describe la historia de la comunidad pesquera de Prainha do Canto Verde, ubicada en la costa este de Ceará, y la lucha de sus habitantes por la preservación de la pesca artesanal y contra las amenazas de la especulación inmobiliaria. Esta lucha culminó con la transformación de la comunidad en una unidad de conservación ambiental, y Prainha do Canto Verde fue incluida oficialmente en la lista de Reservas Extractivas (RESEX) de Brasil en 2009. El estatus de Reserva Extractiva no impidió la continuación de la pesca depredadora ni la especulación inmobiliaria en la región, lo que generó disputas internas entre sus habitantes. Este conflicto se vio alimentado por agentes externos cuyos proyectos turísticos se vieron amenazados por la creación de la RESEX y, más recientemente, por la llegada de turistas que compran terrenos y casas a los pescadores a precios inferiores al valor de mercado. Esta confluencia de factores y la ineficacia de las políticas y agencias de protección ambiental, como el Instituto Chico Mendes para la Conservación de la Biodiversidad (ICMBio), han puesto en peligro el desarrollo y la continuidad de Prainha do Canto Verde como unidad de conservación ambiental. Al describir este escenario, basado en una investigación de campo realizada con un grupo de indígenas, así como en datos recopilados de fuentes documentales y bibliográficas, el artículo pretende aportar elementos para la reflexión sobre los problemas e impases que rodean las reservas extractivas en Brasil y sus políticas de protección ambiental.

Palabras clave: Reserva Extractiva. Unidad de Conservación. Comunidades Tradicionales. Políticas de Preservación Ambiental.

1 INTRODUCTION

The conflicts and interests that threaten the preservation of the Extractive Reserve of the fishing community of Prainha do Canto Verde, located in the municipality of Beberibe-CE, almost 115 km from the capital Fortaleza, are the focus of this work. Created in 2009, as a result of the community's struggle for the preservation of the land and artisanal fishing, the Prainha do Canto Verde Reserve becomes the scene of internal conflicts, motivated by the interference of external agents and the ineffectiveness of policies to preserve the sustainable use of natural resources by residents. Structured in three parts, the article addresses the struggle for the conquest of the Reserve, the emergence of conflicts and the impasses that today surround its existence as an environmental and cultural conservation unit.

The Extractive Reserves (RESEXs) in Brazil were created in the early 1990s, after the assassination of political activist Chico Mendes, as an institutional response to the threats of territorial expropriation, environmental devastation and marginalization (economic, social and cultural) of traditional populations. In 2000, through Law No. 9,985/2000, the National Congress and the Federal Senate approved the implementation of the National System of Conservation Units (SNUC), the body responsible for the regulation and creation of RESEXs in the Brazilian territory.

In addition to approval and regulation, the SNUC is responsible for promoting the sustainable development of RESEXs through research, environmental education and ecological tourism activities. However, the insufficiency of inspection and structure, resulting from government budget limitations, and the pressure of illegal economic activities denounce the weaknesses of the policies for the preservation and development of the RESEXs. This scenario makes them at the mercy of the impasses and conflicts of interest that surround their dynamics and existence.

The research data were produced from the memory and report of a group of residents who acted in the struggle for the implementation of the RESEX, participated in its developments and today experience — both as subjects and victims — the consequences of the impasses involving the disputes of interests around Prainha do Canto Verde as an environmental conservation unit. By describing this history from the perspective of the natives, and including bibliographic and documentary sources, the work aimed to reflect on the possibilities and limits of the policies for the preservation of Extractive Reserves in Brazil.

2 THEORETICAL FRAMEWORK

From a historiographical balance of the existing impasses in the community, which emerged after its decree as RESEX, a gap was identified. Although two studies partially dialogue with the proposal of this research, they are not sufficient to overcome this shortcoming. Such works are: *Memorial de Canto Verde: Knowledge of life and struggle of the people of the sea*, by Márcia Ribeiro (2017), and *Tourism and solidarity economy*, by Viviane Medeiros (2019). Although relevant, they do not focus on the contemporary impasses related to the RESEX in the fishing community. Nevertheless, they will be used as a reference to enable comparative analyses and theoretical crossings that strengthen the proposed discussion.

In order to adequately address the analyzed reality, we adopted a theoretical framework selected based on the relevance of its concepts in relation to the object and theme investigated. In this context, we consider it appropriate to mobilize the following concepts: Territory, according to Milton Santos (1984), understood not only as form, but as used territory, being the result of the articulation between objects and actions and the expression of human and inhabited space; Traditional Community, which, according to Carmo Thum (2017), comprises a social group that establishes historical links with a physical space, transforming it into a collective territory through the work and permanence of its founders; and Collective Memory, from the perspective of Maurice Halbwachs (2013), which transcends the individual sphere, since the memories of each subject are constituted in relation to the social group to which they belong.

3 METHODOLOGY

In methodological terms, the work was based on the perspective of Oral History (Cardoso, 2010), adopting the semi-structured interview as the main instrument for data production. The interviews were conducted with a group of native residents who, in addition to having participated in the struggle and creation of the Prainha do Canto Verde RESEX, today occupy different positions on the board of interests and perspectives in relation to the problems that the community faces as an environmental conservation unit. In this sense, the interviewees are understood as the main historical agents, and the fishing community, as the social space where their experiences are constituted.

The interviews, conducted in 2024, were recorded (with an average duration of 60 minutes), subsequently transcribed, and then carefully analyzed, in order to ensure the fidelity

and integrity of the discourses obtained. For the proper management of this type of source, essential resources were used, highlighting the use of voice recorders and the adoption of a field diary to record the observations and reflections of the researchers. In addition to the field data, the work involved bibliographic and documentary research.

4 ANALYSIS AND DISCUSSION

4.1 THE STRUGGLE OF THE COMMUNITY OF PRAINHA DO CANTO VERDE FOR THE RESEX

According to the reports of the residents themselves, the first inhabitants of the area began to occupy the territory in the nineteenth century, during the period of the liberation of the enslaved. These individuals were emancipated in 1870 by a plantation owner from a neighboring village, today called Campestre da Penha. Regarding the formation of the community, the information provided by Galdino (2010, p. 29) can be observed:

The first families of the community were formed by the couples: Joaquim Fernandes do Nascimento Girão – "Caboclo" (1853-1949), who married Maria da Conceição "Filismina", and "Zé Cariri", who married Mrs. "Chica Benvinda", sister of Joaquim Caboclo. Together, they built the first house in the place, a mud house, which was inhabited by the twelve children generated by the first couple who helped to compose the base of the community's family tree. Later, other families related to Zé Cariri appeared; as well as the Baratas and Raimundo Caboclo who had a son named Raimundo Canto Verde, who lived in the neighborhood and constantly came to fish. Then, as a result of the large amount of "green", at the time existing in the place, he started to call it Prainha do Canto Verde, which gave the community its name.

The locality appears as an environment conducive to the survival and well-being of those who lived there. From the tranquility and natural beauty to the contribution of the sea, which, through fishing, provided food of animal origin and, consequently, collaborated for the sedentarization in that space. These elements made the community attractive to other families, such as the Quinins, Firminos, Correias and Dantas. With the development of community life, problems related to coexistence and collective survival arose. At that time, families were numerous (with an average of fifteen children) and faced difficulties in maintaining the support of the members. Due to the lack of nutritional support, many children did not survive the first months of life. In addition, the lack of educational institutions or actions contributed to the maintenance of illiteracy in a large part of the population. Those who

showed greater interest in education sent their children to the neighboring community of Jardim, where they were initiated in their studies through Professor Joaquim Nel.

In the late 1970s and early 1980s, personalities emerged driven by speculative plans, possibly aimed at developing sun and beach tourism of great proportions. The residents of the community received news that an individual named Antônio Sales Magalhães claimed to have bought the area corresponding to the community of Canto Verde. At that moment, the first processes of mobilization and resistance of the residents in defense of their territory and the right to remain in the place began. Through discussion circles, residents collectively sought strategies and alternatives to face the presence of the intruder. As one community leader recalls:

[...] there was always a boy here who passed by my house, who was Til³, then he said that they were going to allot here and we didn't know anything, you know [...] Around 1980 I saw a man there, I still remember it as if it were today, with those measuring machines [...] then we heard that they were going to sell the land on the hill, then we immediately realized that it could be Prainha. Then at night at school (MOBRAL) there was a teacher (Vilanir) who had a sister (Inez) there at the Defense Center, in the Archdiocese of Fortaleza, defense of human rights and that they helped the poor. We wrote a letter asking for support and people started coming. (Retired, native, and female leader, 67 years old)

Professor Vilanir, through her sister Maria Inez - who at the time was active in the Grassroots Ecclesial Movement (MEB) and in the Center for the Defense and Promotion of Human Rights (CDPDH) - established a fundamental contact that brought external support to the community in its struggle for possession of the territory. In this context, a team from the Archdiocese of Fortaleza, under the leadership of Bishop Dom Aluísio Lorscheider at the time, promptly made a presence in the fishing village with the objective of contributing to the organization and analysis of territorial conflicts. This meeting marked the beginning of an alliance that would be strengthened over time, joining efforts in defense of the community. It is also noteworthy the significant role of CDPDH employees in the formulation of strategies to face real estate speculation. On many occasions, it was these agents who provided the necessary support for the meetings, playing a crucial role in community resistance.

Thus, the support network built between the community and the Archdiocese not only played a fundamental role in the legal action, but also provided the inhabitants of Canto Verde

³ Native and historical protagonist registered by the real estate company as a witness in the process of adverse possession of the lands.

with valuable opportunities to exchange experiences. These interactions occurred both internally - strengthening the ties between the residents themselves - and externally, with other communities in Ceará that faced similar challenges and organized themselves through the Base Ecclesial Communities. The sharing of these experiences, anchored in the struggle against oppression, territorial loss and the defense of local culture and rights, strengthened the collective identity and contributed significantly to the maturation of community organization.

One of the most significant events in the development of collaborations between communities facing similar challenges took place between September 10 and 14, 1985, during the XIII Rural Seminar, promoted by the Archdiocese of Fortaleza, with the presence of Archbishop Dom Aloísio Lorscheider. This event, of a religious nature, brought together most of the Basic Ecclesial Communities (CEBs) of Ceará, including groups from the mountainous region, the hinterland and the coast, as well as representatives from other states. It was a milestone in the consolidation of the work of community organization, providing a space for the exchange of experiences and the strengthening of bonds. From there, Prainha do Canto Verde was officially included in the CEBs network.

Over the years, resistance has strengthened, leading to awareness of the need for a more effective institutional framework. It was in this context that, after several meetings and discussions, the natives created the Association of Residents of Prainha do Canto Verde on April 16, 1989. The recognition of the Association has become crucial for strengthening the defense of legal and juridical interests related to land protection processes.

In 1987, two years before the formalization of the Association, Prainha do Canto Verde received a visit from a Swiss, whose trajectory led him to meet the community during a trip to Jericoacoara. Upon arriving, he found a scenario of active mobilization, in which residents were already organized and engaged in the struggle to defend their territory and their rights. This first contact was decisive for his later involvement with the cause of Prainha do Canto Verde, as he himself reports:

I stayed at Til's house, where I had the opportunity to get to know the community and the group that was organizing to form the residents' association. They were receiving support from the Center for the Defense and Promotion of Human Rights, with the support of the Archdiocese. It was in this environment that I met several people and began to take a deep interest in the history of the community. (Swiss, 82 years old)

Among his several visits to the community, in 1992, the Swiss married a local resident and established permanent residence in Prainha do Canto Verde. Its permanence marked the beginning of a new phase in the process of community struggle and organization, which further strengthened the initiatives aimed at the defense of the territory and the sustainable development of the fishing village. In addition to his direct involvement in local articulations, the initiative to create a fish warehouse came from him, a proposal that, after extensive debate, was approved in a community assembly. The implementation of this project had the financial support of Swiss friends, consolidating itself as a milestone in strengthening the economic autonomy of the community.

Verde faced another problem: the recurrent presence of the *escafandristas*, characterizing a kind of "maritime land grabbing". It is worth mentioning that, since the sea was the main source of livelihood for the community, predatory fishing became a direct threat to local survival. Faced with the growing shortage of lobster due to the illegal activities of these divers, the need for a forceful response has emerged. That answer came on April 4, 1993, when four fishermen embarked on a fearless journey to Rio de Janeiro as a protest against predatory lobster fishing. The crossing, which lasted 74 days, aimed to draw the attention of public opinion to the neglect of the governments (federal, state and municipal) in relation to the Peoples of the Sea and to denounce the predatory fishing that devastated practically the entire coast of Ceará.

The "SOS" symbol stamped on the vessel's sail reinforced the emergency nature of the situation and the need for immediate intervention. The protest achieved wide repercussions, pressuring government officials to direct greater attention to artisanal fishing. To understand the relevance of this mobilization, it is essential to highlight that, during the crossing of the raft, the idea of creating the Terramar Institute was conceived, which had the active participation of the Swiss. The Institute was created with the purpose of strengthening its work with the community, with an emphasis on the areas of fishing and education. In the following years, it consolidated itself as a fundamental agent in expanding knowledge about the daily life of fishing communities, contributing to the improvement of their strategies of resistance and sustainable development.

On June 5, 2009, Decree No. 0-002 granted Prainha do Canto Verde inclusion in the list of Extractive Reserves. With the implementation of this category, the community obtained the ability to control real estate speculation, curb irregular constructions and optimize the inspection of predatory fishing, making the process faster and more efficient. The Chico

Mendes Institute for Biodiversity Conservation (ICMBio) became the body responsible for this supervision, in charge of ensuring harmonious interaction with traditional communities and reinforcing their intrinsic relationship with nature.

4.2 COMMUNITY VULNERABILITIES TO EXTERNAL INTERESTS

The initial expectation was that the implementation of the RESEX would bring a phase of stability to Prainha do Canto Verde. However, this scenario proved to be different from reality, since environmental policy generated a new conflict, now of an internal nature. After overcoming the initial challenges related to territorial speculation, the community was faced with a new battle, resulting from the implications of the RESEX, a fact that introduced an additional layer of complexity to the already challenging context experienced by the residents.

After the transformation of the village into a conservation unit, dissatisfaction and conflicts of interest arose around the preservation policy, given that the residents' expectation of change, fueled by the implementation of the RESEX, was not met. As a result, the credibility of part of the natives began to dissipate in relation to the gains they would have with the conservation unit. These discontents are associated with a set of factors that, even in the face of the testimonies, are not yet satisfactorily evidenced.

Among the main aspects that contributed to the scenario of dissatisfaction, the following stand out: the persistence of predatory fishing; allegations of favoring part of the residents to the detriment of others; impacts on external owners; and the emergence of speculative behavior on the part of external agents interested in taking advantage of the region's natural attractions. Each of these elements has played a significant role in shaping new tensions, both internal and external.

The first factor, referring to the persistence of predatory fishing, proved to be a great disappointment for the community, as it did not meet the great expectations of the residents in relation to the most sensitive aspect for the community. Despite the intense struggles to combat this illegal practice, such as the emblematic trip of the Jangada "SOS" to Rio de Janeiro (mentioned above), the implementation of the RESEX has not solved the problem of predatory fishing, which continues to threaten the traditional way of life of local fishermen. This scenario persists due to the failure of effective enforcement and the continuation of predatory practices that compromise the sustainability of marine resources, which are essential for the community's livelihood. The absence of concrete changes generated

widespread frustration among fishermen, who hoped that the RESEX would provide greater protection for natural resources and create favorable conditions for artisanal fishing.

The second component concerns the allegations of favoritism, since part of the community began to express dissatisfaction when they perceived benefits directed to members linked to the Residents' Association (known as the "old" association). This alleged favoritism generated distrust and contributed to the weakening of social cohesion in the village. The position of the group that was against the implementation of the RESEX was strengthened from the perception that the benefits of the Reserve were not distributed equitably. For these residents, the management of the Reserve favored certain groups or specific interests, generating a generalized feeling of exclusion and inequality in access to the advantages promised by the environmental policy. This scenario fueled a discourse of discontent and intensified criticism of the way the RESEX was managed. The following exposition illustrates this point:

If it's a reserve, it was supposed to have preserved it even as they said, it wasn't supposed to let the people do what they did, then, like, they have a position more for some than for others. If it's to be a reserve it's not in the right rule. The projects when it comes is more on the other side than for everyone in the community, then these little things we put together, together, we don't support, at least I don't support them. (1st secretary of Associação Nova, 55 years old)

In addition, the feeling that the initial promises - such as the improvement of living conditions and the sustainable preservation of the territory and fishing - were not fully fulfilled favored a growing dissatisfaction among the residents. For the discontented, the RESEX not only failed in its distributive role, but also contributed to accentuating internal divisions in the community, creating dynamics of inequality and exclusion. On the other hand, the group that supported the RESEX highlighted the projects developed as a result of its creation, as well as those that already existed before the implementation of the environmental policy and that were maintained or strengthened by the Reserve. A relevant example is the "Geração Muda Mundo" project, implemented in the community in October 2007, with the objective of fostering entrepreneurship among young people.

In addition, the president of the "old" Association, in his interview, stated that the community is contemplated with new projects, which are widely publicized so that all residents have access.

The third aspect corresponds to the impacts on external landowners. With the implementation of the RESEX, some external agents were directly affected, as is the case of a businessman with long-standing property in the village, whose land was included in the delimitation of the Reserve. Feeling harmed by the restriction on the use of his property, this agent began to support and encourage the group of dissatisfied residents, a fact that contributed to the strengthening of new foci of resistance to the RESEX policy within the community.

The delimitation of the area of the Reserve would have made the businessman's plans to carry out real estate speculation ventures unfeasible, leading him to seek support among disgruntled residents for the formation of a new association: the Independent Association of Residents of Prainha do Canto Verde, which later became known as "new association". As pointed out by the pro-RESEX group, the creation of the new association would have been promoted by this businessman as a strategy to contest the restrictions imposed by the Reserve. The version suggests that the businessman, motivated by his own interests, would have sought to "buy" the support of the residents, spreading the idea that the inclusion of the land area in the Reserve would be harmful to the community. In this way, the creation of a new organization marked the reconfiguration of the community scenario, which, with differentiated proposals, began to fight for the reversal of the condition of the village as an environmental conservation unit.

To strengthen his position, the businessman began to act through a local resident who, due to his native status, would enjoy greater trust and legitimacy among dissatisfied residents. Next, let's see the testimony of a resident of the old association:

That's where it started, at that time the businessman already lived here, we learned that he secretly started to create a small group. First, because there the owner of the mercantilism there, who is responsible for finding employees and is responsible, works for this businessman, so he was the one who started to win people. Some say it's deceiving, he has been deceiving some people, but many have fallen for him, but as we already knew the story, we already came from a long history, we didn't fall. That's when he started to say that it wasn't good, that the fishermen didn't accept it. (Native, fisherwoman, 43 years old)

This native, who acts as an intermediary between the interests of the businessman and the local community, currently holds the position of president of the Independent Association of Residents. Next, let us see the version of the facts from the perspective of this intermediary:

So the association was not founded directly by him as they say, now he is a fundamental part of the community, to this day. There are three ambulances donated by the businessman. People say: the businessman split the community, no! We were the ones who split the community [...] he took advantage of the split. (President of the Independent Association of Residents, 39 years old).

According to the current president of the new entity, its foundation took place even before the implementation of the RESEX, more precisely between the years 2004 and 2005. According to him, the association emerged as an alternative to enable resources for social projects, given the lack of support from the Residents' Association for the release of these funds.

Finally, the fourth and final element of internal conflicts refers to the growing speculative character on the part of external agents, interested in the natural beauty of the place and in the desire to acquire land in a community that is still little explored. This movement awakened in local residents the idea of profiting from the sale of land. However, when they were prevented from carrying out negotiations, given the restrictions imposed by the RESEX, discontent increased among residents who were already against the permanence of the Reserve.

This dissatisfaction was supported by a shared consensus on the part of the community: the belief that the families, at the time of the creation of the RESEX, would have the right to two portions of land - one intended for housing and the other for a point of commerce. This rule, which, according to them, had been created as part of an internal agreement of the community during the implementation of the RESEX, began to be demanded, contradictorily, precisely by the residents who expressed their opposition to the permanence of the village as a conservation unit. Thus, with the arrival of external agents interested in the acquisition of land, the residents wished to enjoy a right created, according to them, by the Reserve, which, however, compromised their very existence.

Without having the right of legal possession of the land or the authorization of ICMBio, some residents began to negotiate land in parallel at derisory prices, far below the value practiced in the coastal strips of the region. This scenario stimulated the accelerated growth of the speculative wave. As a result, there was a significant increase in the demarcation and fencing of land by residents. The old "story of the two points of land" lost meaning and control on the part of the Reserve, since the unbridled search for some pecuniary benefit led the natives not only to demarcate the lands on their own, in a disorderly way, but also to sell them at low cost, transforming the territory into a space disputed by whoever arrived first.

The most benefited from this behavior were the outsiders, who not only bought land at derisory prices, but also, in some cases, resold it to other external agents, for values significantly higher than the amount paid to the natives. As the native residents noticed the growing interest of outsiders in acquiring properties, the land gradually began to be more valued, although it remained below the estimated price for the other coastal strips in the region.

These four factors, therefore, caused and accentuated the internal split in the community, culminating in the formation of two distinct groups. On the one hand, the Association of Residents of Prainha do Canto Verde, which played a decisive role in resisting the initial threats and in the process of implementing the RESEX, recognized for its historical relevance and today popularly called "the old" or "old" association. On the other hand, the group of dissatisfied people, who, with the support of the aforementioned external agent, created the Independent Association of Residents, known as the "new" association, with the aim of articulating their demands and claims. Since then, this division has marked the community dynamics, which generates tensions and makes it difficult to build the consensus necessary for the participatory management of the Reserve.

It is important to record the main objectives defended by the group that opposes the RESEX, represented by the "Nova" Association. Understanding these goals is crucial to outline the motivations and foundations of criticism of the Reserve's environmental management policy, revealing the specific demands of this segment of the community.

The first objective of the "new" association is to ensure that residents obtain formal title to their land. This demand is based on the perception that legal land tenure is an essential step to ensure legal certainty and strengthen community autonomy. With the title in hand, residents would have greater stability and conditions to promote local development in a more sustainable and independent way. As the president of the Independent Association of Residents reports: "At the time we won from Henrique Jorge, they were supposed to have distributed the land titles of each resident and it was not done". (president of the Independent Association of Residents, 39 years old).

The second point is related to the demand that the Reserve become a more active instrument of public policies that directly benefit the community. The narrative of the "new" association suggests that, in the current model, the RESEX has imposed bureaucratic and structural barriers that hinder or make unfeasible initiatives that could promote local development. However, there is still a significant gap in relation to the concrete paths or

mechanisms for achieving these goals. There is no clarity about which strategies, resources or legal and legal instruments would be used to make the demands presented viable. This lack of definition reflects the absence of structured planning or effective strategic articulation, which reinforces the need for a more robust process of internal organization of the entity.

On the other hand, the "old" association sustains the narrative of the preservation of the RESEX, justifying its defense in environmental preservation and the sustainable development of the village, in addition to other aspects. A second point of conflict with the "new" association refers to the territorial scope of the RESEX. While the "ova" association argues that the scope of the RESEX's preservation rules should be restricted to the maritime area - and that, according to its members, this would have been the initial agreement for its implementation -, the "old" association and its adherents maintain that the original document always contemplated both the maritime and terrestrial areas. Let us see what the current president of the "old" association said:

The biggest banner of the residents' association was the land, the sea was something we were already discussing, the sea we were already working on the fishing agreements and everything, but the focus was never on the sea, all life was the land, so we were never going to ask for a RESEX just for the sea, we were going to ask for the land, The land was the main one, the land was the main one. You can imagine, why would we ask for a RESEX only by sea, if our main purpose of Prainha was the struggle of the land. This was distorted because the businessman realized that he was going to lose possession of it. The purpose of the new association was not to question the land issue, it was the businessman who created it because it would affect his territory, he who creates the new association. There was an intention behind it, that a part of the residents were "used". Today they are seeing that they are losing, because the big invasion of Prainha that is happening, the big culprit was the new association and the businessman, who divided the community, and it was not easy to maintain and to this day as we are maintaining. So it was made with the intention of defending the businessman (President of the old Association. 46 years old)

Also according to the president of the "old" association, they are not opposed, in principle, to the creation of new associations in the community. The central point of the clash lies in the fact that this new entity proposes measures that, according to him, disrespect the socio-cultural dynamics of the community and the fundamental principles that govern an Extractive Reserve. Therefore, with regard to the objectives of this perspective, the members of the "old" association and their supporters defend the preservation of the RESEX in its initial form, believing that, little by little, the norms concerning its full implementation will be fully implemented by the responsible bodies. This perspective includes the belief that vacationers

who have arrived in the community will be gradually expelled, re-establishing local control over the lands.

In the midst of the disputes between these two sides, we perceive a point at which the residents converge. This aspect concerns the bureaucracy imposed on residents to obtain essential services (such as a point of light), understood as something resulting from the specific norms that configure a RESEX and which, so far, have not been properly regulated. This contributes to the dissatisfaction of residents, especially those who are against their permanence.

I am against the Resex because of this impact it has, which prohibits native people from making a reform, increasing something, you have to ask them for permission. My revolt is more because of this energy business, which we want to put energy into but can't, it's embargoed. If you have a light to put on, if you call Enel, tell ICMBio to ask for authorization. Then because of this whole thing I get disgusted, I'm not going to support something like this that I see is not right. (1st secretary of Associação Nova, 55 years old)

Residents who are supporters of the "old" association, who support the RESEX, are also impacted by this process and express their dissatisfaction, as expressed by one resident:

I support the idea of the extractive reserve for all that it represents: environmental protection, appreciation of traditional communities and a sustainable life model. However, it is difficult not to feel deeply unhappy with the bureaucracy and the delay in having access to something as basic as electricity. Even living in a place where preservation is a priority, you can't ignore the impact that the lack of structure has on people's lives. (Native, 26 years old)

Despite the access to the testimonies recorded here, the scenario of conflicts and narratives around the RESEX is still difficult to understand. As previously exposed, the lack of clarity reflects the multiplicity of existing interpretations and perspectives, with each group constructing narratives according to its own interests and experiences. The fact is that internal conflicts and the absence of effective articulation keep the community in a state of uncertainty, which needs to be overcome so that residents can not only preserve their identity, but also build a more inclusive and sustainable future for all.

4.3 THE DIRECTION OF THE EXTRACTIVE RESERVE: NAVIGATING IS NECESSARY, STAYING IS A CHALLENGE

The impasse in Prainha do Canto Verde is so deep that the community finds itself in constant dependence on jurisprudence, with legal disputes that shape the local dynamics. The current situation is characterized by a true "war of lawsuits", marked by legal clashes between the two groups and by the continuous questioning, by the community, of the actions of ICMBio. This occurs especially when the agency prevents or hinders local residents from accessing new points of light as a reprisal for the improper sale of land to external agents.

In this context, it is questioned about the role that ICMBio, as a federal agency and potential mediator of conflicts, has played in the community. In some episodes, the institution has acted contrary to this role, being perceived not as an agent of mediation, but rather as an institution that adopts an intimidating and sometimes repressive posture, a fact that further aggravates polarization and conflict in the region. There are reports, especially from the dissident group linked to the New Association, that the agency engages in arbitrary and authoritarian behavior when, for example, it confiscates the construction tools of local residents who work as bricklayers in the homes of external agents and imposes fines on them for the alleged illegal work activity against the RESEX. It should be noted that the activity of bricklayer, which most of the residents learned to develop in parallel with fishing, became, according to the testimony of the natives themselves, the second main income or the complementary income of the community.

It is understood that the primary function of the agency is the management, inspection and control of preservation areas. However, considering the specific context of Prainha do Canto Verde, where speculation is already a consolidated reality and there is no viable solution in sight, it becomes pertinent to adopt a more dialogical stance. In this sense, it is suggested that the entity assume a mediator role, promoting debate between the parties involved and seeking alternatives that minimize socio-environmental conflicts while a definitive solution is not established, which may require more incisive measures.

Another aspect to be considered, still in relation to the local source of income of the community, and which makes the situation of the RESEX even more delicate, concerns the job opportunities brought about by the growing presence of outsiders in the community. Although these opportunities are not enough to guarantee local socioeconomic stability, the increase in commerce (small supermarkets, restaurants, sale of handicrafts) and the hiring of local labor (in domestic activities and gardening) today represent a source of income for

residents in the face of the scarcity of other economic activities in the region. Even people who are favorable to environmental policy and maintain greater proximity to the "Old" Association, also act as bricklayers, in commerce and in other activities linked to the new local dynamics, which makes the RESEX scenario even more complex.

It is also worth highlighting the changes in the life expectancy of the new generation of local residents, who, for the most part, do not identify with the profession of fisherman, due to the harsh working conditions that the activity demands, and do not necessarily want to follow the fishing tradition. Expanded access to education has provided many fishermen's children with the completion of high school and, in some cases, entry into higher education. This scenario has generated new professional perspectives and changed the socioeconomic dynamics of the community, directly impacting the continuity of traditional fishing practices.

In the midst of this scenario, in 2024, the Management Plan for the Prainha do Canto Verde Extractive Reserve (RESEX) was approved, through ICMBio Ordinance No. 554, of February 22, 2024. This action, which also had the active participation of the "Nova" Association, presents itself as a possible point of convergence between the divergent interests. The Management Plan is a fundamental instrument to ensure the sustainable management of the territory and the maintenance of the ways of life of traditional populations. However, the question arises as to to what extent it will be effective and whether it can really act as a catalyst to unite the divergent parties for the sake of community preservation and development.

Although the Management Plan suggests the possibility of a new horizon for the RESEX, the persistent impasse, marked by the absence of dialogue and a mediating agent, raises questions about its real effectiveness in overcoming this conflict, especially with regard to two points: 1. To what extent will the community be able to **appropriate** this instrument as a **protagonist** in the search for solutions? 2. Will the Management Plan be sufficient to reverse the situation of impasse and promote a collective understanding? Such questions offer opportunities for future research, allowing a more in-depth analysis of the developments and impacts of the Plan.

5 CONCLUSION

It is important to note that an Extractive Reserve aims not only to protect the territory, but also to ensure the cultural continuity and way of life of a traditional community. It should be noted, however, that culture is not static, especially when inserted in a context close to

urban areas, where external influences are constant and social and economic transformations occur in a natural and accelerated way. In this sense, the community itself is undergoing changes, driven by new demands, aspirations and expectations, especially among the younger generations.

Given this scenario, it is necessary to ask: what does it mean, in fact, to preserve? Preservation cannot be understood as the freezing of a culture in time, preventing its evolution according to the needs and desires of its members. On the contrary, preservation must be understood as the dynamic continuity of cultural identity, collective memory and the well-being of the community, maintaining a constant dialogue with social and economic transformations. This includes the incorporation of contemporary elements and respect for the expectations of the new generations, who often do not see fishing activity as the main source of income, seeking other job opportunities and ways of life.

This debate leads to reflection on the strategic role of ICMBio as manager of the RESEX. Considering the specific context experienced by the community, the hypothesis is raised that the agency, in addition to its role as an inspector of environmental standards, may be able to assume an expanded role as a cultural mediator, facilitator of dialogue and articulator of public policies that promote the socioeconomic sustainability of the community. This would include fostering spaces for negotiation and clarification, enabling an environment of constructive conversations that contemplate both environmental preservation and the economic and social needs of residents.

By articulating cultural preservation with sustainable development, ICMBio will be contributing to the construction of inclusive solutions adapted to the current demands of the community. If these points continue to be neglected, the impasse will tend to perpetuate itself, which will compromise the effectiveness of the preservation policy and the well-being of the local community. Thus, it becomes essential to promote a continuous and participatory dialogue, which allows the community to be a protagonist in the construction of its future, ensuring not only the preservation of its territory, but also the continuity of its cultural identity in constant transformation.

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**FROM THE INDUSTRIAL REVOLUTION TO THE DIGITAL AGE:
CONTRIBUTIONS OF LIFE PROJECTS FROM INTEGRATIVE AND
TRANSVERSAL PERSPECTIVES**

**DA REVOLUÇÃO INDUSTRIAL À DIGITAL: CONTRIBUIÇÕES DO PROJETO
DE VIDA NAS PERSPECTIVAS INTEGRATIVA E TRANSVERSAL**

**DE LA REVOLUCIÓN INDUSTRIAL A LA ERA DIGITAL: APORTACIONES DE
LOS PROYECTOS LIFE DESDE PERSPECTIVAS INTEGRADORAS Y
TRANSVERSALES**

 <https://doi.org/10.56238/sevened2025.036-081>

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ABSTRACT

The Industrial Revolution was one of the most significant and transformative events in human history, and its importance lies in the fact that it fundamentally altered the way societies produce, live, organize themselves, and relate to the world. The Digital Revolution, on the other hand, is a driving force in 21st-century society, which includes the emergence of disruptive technologies. While the former mechanized the production of goods, the latter is automating and digitizing information, communication, and knowledge, which profoundly impacts the lives of students seeking their place in a constantly transforming job market. It is in this context that this study, based on a literature review, seeks to observe how the changes that have occurred from the Industrial Revolution to the Digital Revolution can be addressed in the Life Project from an integrative and transversal perspective, based on the construction of three reflective axes: (i) observing the paths taken from the Industrial Revolution to digital disruption; (ii) reflecting on how the Life Project can contribute to the subjectivity of students in light of an integrative and transversal approach; (iii) To work, using frameworks, on the theme of Industrial Revolutions, technological innovations and their impacts on society and education. Authors such as Bauman (2001), Delors (2003), Luger (2013), Santaella (2003), among others, discuss the proposed themes from different perspectives. It is concluded that the Life Project is the ideal space to address concepts involving the students' professional future, helping them to identify their natural aptitudes and passions, which are the basis for lasting and satisfying professional choices.

Keywords: Industrial Revolution. Digital Revolution. Disruptive Technologies. Life Project.

RESUMO

A Revolução Industrial foi um dos eventos mais significativos e transformadores da história da humanidade e, a sua importância, reside no fato de ter alterado fundamentalmente a maneira como as sociedades produzem, vivem, se organizam e se relacionam com o mundo. Já a Revolução Digital, é uma força que impulsiona a sociedade do século XXI, o que inclui a emergência das tecnologias disruptivas. Enquanto a primeira mecanizou a produção de bens, a segunda está automatizando e digitalizando a informação, a comunicação e o

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conhecimento, o que impacta profundamente a vida dos estudantes que buscam o seu espaço num mercado de trabalho em constante transformação. É nesse viés que, este estudo, pautado em revisão de literatura, busca observar como as mudanças ocorridas desde a Revolução Industrial até a Revolução Digital podem ser abordadas no Projeto de Vida a partir das perspectiva integrativa e transversal, tendo como base a construção de três eixos reflexivos: (i) observar quais foram os caminhos percorridos desde a Revolução Industrial até a disrupção digital; (ii) refletir sobre como o Projeto de Vida pode contribuir com a subjetividade dos estudantes à luz de uma abordagem integrativa e transversal; (iii) trabalhar, a partir de frameworks, a temática sobre as Revoluções Industriais, inovações tecnológicas e seus impactos na sociedade e na educação. Autores como Bauman (2001), Delors (2003), Luger (2013), Santaella (2003), dentre outros, dialogam a partir de diferentes perspectivas sobre os temas propostos. Conclui-se que, o Projeto de Vida é o espaço ideal para abordar conceitos que envolvem o futuro profissional dos estudantes, auxiliando-os a identificar suas aptidões naturais e paixões, que são a base para escolhas profissionais duradouras e satisfatórias.

Palavras-chave: Revolução Industrial. Revolução Digital. Tecnologias Disruptivas. Projeto de Vida.

RESUMEN

La Revolución Industrial fue uno de los eventos más significativos y transformadores de la historia de la humanidad, y su importancia radica en que alteró fundamentalmente la forma en que las sociedades producen, viven, se organizan y se relacionan con el mundo. La Revolución Digital, por otro lado, es una fuerza impulsora en la sociedad del siglo XXI, que incluye el surgimiento de tecnologías disruptivas. Mientras que la primera mecanizó la producción de bienes, la segunda está automatizando y digitalizando la información, la comunicación y el conocimiento, lo que impacta profundamente la vida de los estudiantes que buscan su lugar en un mercado laboral en constante transformación. Es en este contexto que este estudio, basado en una revisión bibliográfica, busca observar cómo los cambios ocurridos desde la Revolución Industrial hasta la Revolución Digital pueden abordarse en el Proyecto de Vida desde una perspectiva integradora y transversal, a partir de la construcción de tres ejes reflexivos: (i) observar los caminos recorridos desde la Revolución Industrial hasta la disrupción digital; (ii) reflexionar sobre cómo el Proyecto de Vida puede contribuir a la subjetividad de los estudiantes a la luz de un enfoque integrador y transversal; (iii) Trabajar, mediante marcos de referencia, sobre el tema de las revoluciones industriales, las innovaciones tecnológicas y su impacto en la sociedad y la educación. Autores como Bauman (2001), Delors (2003), Luger (2013), Santaella (2003), entre otros, abordan los temas propuestos desde diferentes perspectivas. Se concluye que el Proyecto de Vida es el espacio ideal para abordar conceptos relacionados con el futuro profesional de los estudiantes, ayudándolos a identificar sus aptitudes y pasiones naturales, que son la base de decisiones profesionales duraderas y satisfactorias.

Palabras clave: Revolución Industrial. Revolución Digital. Tecnologías Disruptivas. Proyecto de Vida.

1 INTRODUCTION

The Industrial Revolution was a period of great technological and social transformations that began in England, from the second half of the eighteenth century (around 1760). It marked the transition from artisanal and agricultural production processes to large-scale industrial production, through the introduction of machinery and the use of new energy sources. The Digital Revolution, on the other hand, is the term used to describe the profound and accelerated change in society, economy, and culture caused by the proliferation and adoption of digital technologies.

The connection between the Industrial Revolution and the Digital Revolution is seen as a continuation and intensification of the transformations initiated by the former. Both represent waves of deep socioeconomic movements driven by technology. Both the Industrial and Digital Revolutions share transformative characteristics, such as: increased productivity, new sources of power, structural change, reduction of barriers, among other specificities.

The Life Project, whether in a disciplinary way or a cross-cutting theme, has as its main focus to support and guide students in the construction of a plan for their future, addressing the dimensions that range from self-knowledge and self-esteem to the social and professional relationship with the world. Therefore, the contexts in which they followed during the Industrial and Digital Revolutions become fertile ground when addressed, especially when they can be contextualized and connected with the reality of each student.

It is under this dynamic that this study seeks to observe how the changes that have occurred since the Industrial Revolution to the Digital Revolution can be approached in the Life Project from the integrative and transversal perspective, based on the construction of three reflective axes: (i) to observe what were the paths taken from the Industrial Revolution to the digital disruption; (ii) reflect on how the Life Project can contribute to the subjectivity of students in the light of an integrative and transversal approach; (iii) to work, from *frameworks*, on the theme of Industrial Revolutions, technological innovations and their impacts on society and education.

We point out that this research is of a basic nature, as it "aims to generate new knowledge useful for the advancement of science without foreseen practical application", exploratory, since "its purpose is to provide more information on the subject that we are going to investigate, enabling its definition and design"; as a procedure, it presents the literature review, because it is being "elaborated from material already published" such as books, scientific journals, websites, etc. (Prodanov; Freitas, 2013, p. 51-54).

Authors such as Bauman (2001), Delors (2003), Luger (2013), Santaella (2003), among others, help us to build a theoretical basis that dialogues between the many concepts addressed. In addition, this article also proposes a reflection on the evolution of technologies in the Industrial Revolutions over the years, understanding that the Digital Revolution in this first decade of the year 2025, had an impact on the constitution of people's subjectivity, when we consider a biopsychosocial human in the center of a whirlwind of events and information, which is largely due to the speed of simultaneous and civilizational changes, such as the fifth revolution, which is now digital.

We perceive humanity displaced in the face of the speed of innovations, and what draws our attention is the movement that seeks to find itself in the midst of the multiplicity of transformations: how to find security and answers to questions in the various fields of life? And work? And the future? How to find time for the various temporary demands? How to assimilate and accommodate the events in the society of change while maintaining mental health?

In this sense, we understand that the school will be able to collaborate with the approach to the impact on emotional health, as well as in the constitution of students' subjectivity in the face of disruptive processes, whose scenario requires rapid adaptations in the face of the evolutions of digital technologies and, consequently, of AI, with developments that also encompass the world scenario.

Our text is structured in three moments: the first reflects on the path taken by technological innovations from the Industrial Revolution to what we call today as digital disruption; the second observes the contributions of the Life Project from an integrative and transversal approach; the third, which proposes *frameworks* based on the themes discussed, promoting dialogue and reflection in connection with the students' future perspectives.

2 INDUSTRIAL REVOLUTION AND TECHNOLOGICAL INNOVATIONS: PATHS TO DIGITAL DISRUPTION

The Industrial Revolution was not just a series of technological innovations, but rather a radical and multifaceted historical process that marked the transition from an agrarian and artisanal economic system to a modern industrial and capitalist model, permanently altering life, work, and the organization of human society. In the words of Oliveira (2004), the "idea (sic) of the new, of progress, was spreading throughout Europe, which sought to put into

practice new inventions that would adapt to the rhythm of the hallucinating daily life imposed by the new order of work" (Oliveira, 2004, p. 84).

Pioneered in England in the second half of the eighteenth century, it is defined by: substitution of motive power, that is, the exchange of human, animal, hydro or wind energy for mechanical energy generated by new sources, such as mineral coal and, mainly, the steam engine; work migrates from domestic workshops (manufacturing) to factories (machine-making), where the worker becomes subordinated to the rhythm and discipline of the machine; Mechanization and the division of labor allow for the large-scale production of goods at lower costs, ushering in the era of mass production. In the factories, for example, "workers were forced to follow the rhythm of the steam engine, which provided a great boost to the textile sector", within a context in which "time became even more valuable for those who wanted to earn money, so that every minute should be thoroughly used" (Oliveira, 2004, p. 84-85).

In addition to these transformations, we have the consolidation of industrial capitalism through the separation between capital and labor and profound socioeconomic impacts such as, for example, the rural exodus, the intense exploitation of labor, and the redefinition between the relationship of the human being with production, society and the environment. As a result, there was the "intensity of the exploitation of labor (sic), time began to be controlled by industrialists and no longer by artisans" (Oliveira, 2004, p. 86).

The Industrial Revolution (the first, in the eighteenth century), was the indirect and fundamental driving force for the emergence of current digital technologies, including Artificial Intelligence. The connection was not immediate, but a relationship of historical and technological cause and consequence that developed in phases, such as: the establishment of the machine paradigm; the creation of the knowledge base and infrastructure; the technical-scientific revolution (understood as the Third Industrial Revolution); automation on an increasing scale. In other words, "since the First Industrial Revolution, significant technological advances have been altering the economic, political and social organization of societies around the globe" (Oliveira; Vendramini, 2018, p. 41).

The Industrial Revolution was the time when humanity mechanized production, introducing the concept that work could be performed by machines and not just humans or animals. With this, the steam engine and the power loom proved that technology could radically increase productivity and human capacity. Such a mindset established the foundation of continuous technological progress and the belief in engineering's ability to

overcome limits. For Oliveira (2004), the "transition from the artisanal production system to the factory system, in turn, was marked by technical innovations in which the mechanization of work began in the field of textile production" (Oliveira, 2004, p. 85).

The subsequent stages of industrialization have built the necessary foundation for the digital age, as electricity has been introduced as a source of energy, which is essential for all electronic devices and computers. The link between science and industry was also strengthened, leading to the development of advanced physics and chemistry that would be crucial for electronics. The emergence of the latter (transistors, microchips), information technology and telecommunications (*internet*) is the direct step towards digital technology. This phase would not have been possible without the industrial and scientific infrastructure inherited from previous revolutions. It is worth mentioning that microchips, developed in 1971 by Intel, "are present in computers to this day" and were the basis for the development and expansion of personal computing (Godoy, 2025, p. 14).

We can conclude, therefore, that the Industrial Revolutions are, in fact, great historical examples of technological disruptions on a massive scale, since each of these was triggered by a set of innovations that not only improved what existed, but created a radical rupture with the current productive and social model, redefining the world. Lima and Leitão (2021) understand that "disruption has been present in society for thousands of years" whose phenomenon has already been possible to be observed "when man extracted from nature only what was essential for his subsistence", something that was later abandoned, as he started to create and cultivate his own food (Lima; Leitão, 2021, p. 21).

The concept of disruption fits to describe what happened in each phase, as the steam engine and the mechanization of production broke with artisanal production and manufacturing. The factory system and steam power transformed agrarian society into an industrial one and caused profound changes in transportation (railways) and in the organization of labor. In other words, "there was an expansion of the substitution of human and animal energy for inanimate energy, with multiplied efficiency", because "there was an acceleration of the exchange of human capacity for mechanical instruments", as well as "the discovery and/or improvement of methods for obtaining and elaborating raw materials" (Dathein, 2003, p. 1).

Electricity, mass production, and the internal combustion engine introduced the assembly line and large-scale production, which also allowed factories to run continuously, with the automobile redefining personal transportation. Dathein (2003) clarifies that the

Second Industrial Revolution was based on "electricity and steel, with important developments occurring in chemistry, communications" and the use of petroleum (Dathein, 2003, p. 5).

Electronics, Information Technology (IT) and the *internet* have promoted the automation of production processes (robotics) and digitalization, with this, the personal computer and the *internet* have created a new paradigm for communication and data management. As an example, we can cite the "algorithms that control the use of Facebook (sic) and Google (sic)" which "are creating new patterns of behavior and relationships", or even the "use of advanced psychometrics" that "allows the identification of psychological profiles with the ability to predict decisions and behaviors with a high degree of accuracy", while the "use of this technology for commercial and political purposes raises ethical problems that are not being discussed by society" (Magalhães; Vendramini, 2018, p. 42).

Finally, we can say that AI, ³the *Internet* of Things (IoT), *Big Data*⁴ and *Cloud Computing*⁵ are promoting hyperconnectivity and autonomous decision-making in production systems, whose objective is the total integration between the physical and digital worlds (cyber-physical systems), generating more personalized and efficient products and services. The *Internet* of Things or IoT, for example, is a "network of physical objects incorporated into sensors, software (sic) and other technologies with the objective of connecting and exchanging data with other devices and systems over the internet (sic)" and such "devices range from common household objects to sophisticated industrial tools" (ORACLE, 2025, *online*).

The Life Project (PV) discipline presents itself as a key curricular component to assist in understanding the complex and disruptive world we live in, acting in an integrative, transversal way and focused on the subjectivation of education. In other words, such discipline not only prepares the individual for the complex and disruptive world, but enables him to understand his position, his values, and his potential for action in it, making disruption become an opportunity for construction and not just a source of anxiety. It is this subject, therefore, that we will deal with next.

³ Succinctly, we can say that Artificial Intelligence (AI) is a branch of computer science focused on creating machines and *software* that simulate human intelligence. AI has a growing importance and impacts several areas of our daily lives, often without us realizing it, ranging from process improvement to personalized experiences (Luger, 2013).

⁴ *Big Data* is the term used to describe extremely large and complex data sets that cannot be processed or analyzed effectively with traditional data processing tools (Morais et al., 2018).

⁵ *Cloud Computing* is the delivery of on-demand computing resources (such as processing power, data storage, databases, networks, and *software*) over the *internet*, in a pay-as-you-go model (Kolbe Júnior, 2020).

3 THE LIFE PROJECT AND ITS CONTRIBUTIONS IN THE LIGHT OF AN INTEGRATIVE AND TRANSVERSAL APPROACH

The inclusion of PV as a curricular component or cross-cutting theme in Brazilian Basic Education is directly linked to the enactment of the National Common Curricular Base (BNCC, 2017) and, later, to the Secondary Education Reform (Law No. 13,415 of February 16, 2017).

Thus, PV emerges in Basic Education as a response to the need to promote a comprehensive education of students, aligned with the demands of twenty-first century society and having as pillars socio-emotional skills (self-care, self-knowledge, determination, perseverance and ability to make responsible choices), and the skills of planning and protagonism.

The ways of approaching PV can occur in two ways: through the creation of an exclusive curricular component (Life Project), with designated classes and teachers, especially in High School, or, as a transversal theme, where the content is incorporated and worked on in an interdisciplinary way, encompassing all disciplines and involving the faculty in a broader perspective.

PV as a discipline seeks to promote youth protagonism and the development of socio-emotional skills, encouraging students to: reflect on themselves; set objectives; making conscious choices; and tracing paths, acting as a compass that guides the student in building an intentional future aligned with their purposes.

As established by the BNCC (2017), the school "by orienting itself towards the construction of the life project" welcomes young people and assumes the "commitment to the integral formation of students, since it promotes their personal and social development, through the consolidation and construction of knowledge, representations and values", which "will affect their decision-making processes throughout life" (Brasil, 2017, p. 472).

In this sense, the BNCC (2017), by presenting the life project as one of the ten general competencies, becomes a "guiding document for school curricula", which seeks, "through this competence, to reiterate the focus on the student, on student protagonism and on their life project" (Santos; Gontijo, 2020, p. 20).

The main ways in which PV contributes, in the light of an integrative and transversal approach and subjectivation in educational disruption, are aligned with: reconnection of knowledge; expanded worldview; contemporary themes; working with uncertainty; critical and ethical thinking; protagonism and social engagement; self-knowledge as a basis; socio-emotional development; reconnection and meaning. We can say, therefore, that, nowadays,

we perceive that the speed of transformations reverberates in society, which makes it necessary to introject or slide over such "ephemeral" and "liquid" realities (Baumann, 2001).

In view of this, PV acts as an axis that connects and contextualizes the contents and the different areas of knowledge (transversality), which are often taught in isolation in the traditional curricular structure, helping the student to "reconnect" this information, which is essential to deal with the multifaceted and interconnected nature of the problems of the complex world.

According to Araújo and Rufo (2023), the proposition and implementation of "didactic-pedagogical strategies that meet the importance of the life project in school is both necessary and indispensable" as long as it is in the context of "a continuous perspective of integral, critical, reflective, autonomous and diversified education of young people in Elementary and High School" (Araújo; Rufo, 2023, p. 7).

By mobilizing reflection on the personal, social and professional dimensions, as suggested by the pillars of UNESCO (Delors, 2003) - learning to be, to live together, to know and to do - PV transcends the purely intellectual dimension, which allows the student to build a more holistic view of reality, where social, environmental, technological and economic challenges are not seen as isolated disciplinary problems.

The PV can integrate and deepen the discussion on Contemporary Cross-Cutting Themes (TCT), such as Environment, Technology, Globalization and Human Rights, connecting them directly to the student's choices and future. It is important to highlight that these themes seek to "make explicit the connection between the different curricular components in an integrated way" establishing a "connection with situations experienced by students in their realities, contributing to bring context and contemporaneity to the objects of knowledge described" in the BNCC (Brasil, 2019, p. 6).

The complex and disruptive world is marked by uncertainty, ambiguity and non-linearity, so PV stimulates the development of the ability to plan in scenarios of uncertainty, to recognize the need for disruption and transformation (essence of disruption), without clinging to a single and rigid path. And, "the school space, as an institution inserted in the socio-historical-cultural context in which young people are present, must enable reflection on the values, choices and identity of each young student" (Santos; Gontijo, 2020, p. 25).

By providing reflection on one's own choices, values, and impacts on society, PV promotes the formation of critical and autonomous subjects, which is essential to analyze the speed of changes (especially technological/disruptive ones) and make ethical and

responsible decisions in the face of global challenges. Because the "revolutions progress towards new knowledge, skills, and administrative skills" and, in addition, the "ruptures and daily advances make evident the fragility of the most sophisticated instruments of planning, policymaking, and work organization" (Motta, 2022, p. 201).

The complex world requires actions, and, in view of this, PV helps students to perceive themselves as an agent of transformation in their community, stimulating protagonism and engagement in the search for solutions to real problems. For Costa Júnior et al. (2023), "education is faced with new challenges arising from social, cultural, and technological transformations" and, as a result, "contemporary society requires a broader and more diversified education, which goes beyond technical knowledge and provides skills to deal with the complexity of today's world" (Costa Júnior et al., 2023, p. 125).

Disruption in education requires learning to be personalized, so PV puts the individual at the center of the process, encouraging self-knowledge, since it is in the subjectivation of their own stories, skills, and desires that the student finds the purpose to navigate and adapt to constant changes. This characteristic makes us think about the importance of the teacher-student relationship, which "can be reduced to the pedagogical aspect and be characterized by a distant attitude", or, "emphasize almost exclusively the affective or emotional dimension". Therefore, the "choice that the teacher will make between these two modes" will have "an important influence on the student's learning process and on his behavior" (Boutin, 2017, p. 345).

The crisis of purpose and the wear and tear of the traditional school are symptoms of the disruptive world. In view of this, the PV actively works on socio-emotional skills (resilience, empathy, cooperation, autonomy), which are crucial for survival and well-being in an environment of constant instability and pressure. Marino (2018), understands that the crisis established in the school environment "has caused a multiplication of conflicts within it, leading to an increase in the number of students and teachers unhappy with their daily practices", while the origin of these conflicts "lies in the antiquated disciplinary rules and procedures and in their incompatibility in relation to young people in the twenty-first century", with this, the author argues that "schools need to be refounded" where students are transformed into "integral subjects and co-responsible for the learning processes" (Marino, 2018, p. 21-28).

In an era of fragmentation and rapid obsolescence, PV helps students to give meaning to what they learn and their future, transforming the educational experience into something

relevant and applicable to their personal and professional life. In this sense, associating life projects with the world of work "is the result of the profound transformations in today's world, especially in relation to the productive structure, technological development and the intensification of capitalism from the 1980s onwards" (Araújo; Rufo, 2023, p. 9).

We can conclude, therefore, that PV, being articulated in the form of a discipline or cross-cutting theme, not only prepares the individual for the complex and disruptive world, but also enables him to understand his position, his values and his potential for action in it, making disruption become an opportunity for construction and not just a source of anxiety.

In the context of Industrial Revolutions, a *framework* is a logical framework that we can use to analyze, compare, or implement these historical transformations, expanding reflections through the integrality and transversality of PV. This is what we will deal with in the next subtitle.

4 INDUSTRIAL REVOLUTIONS THROUGH *FRAMEWORKS*: INNOVATIONS AND EVENTS THAT IMPACTED SOCIETY AND EDUCATION

Characterized as an agile methodology, since it integrates "a set of practices aimed at enabling fast, non-bureaucratic delivery," a *framework* is a predefined framework, a "skeleton," or a set of tools and guidelines that serves as a basis for developing projects or managing processes more efficiently. In other words, it is "a model or framework that brings together a series of practices", with the following main objectives: to simplify, streamline and standardize the work on complex projects (Vieira; Rodrigues; Villanova, 2024, *e-book*).

An example of a common use of a *framework* is in *software* development, because it is typically composed of ready-made and reusable code; suggestions and rules on how the project architecture should be organized; and resources to assist in development, such as testing and debugging code. We can say, therefore, that *frameworks* provide a solid foundation that allows development teams to build robust and high-quality applications in a much faster and more organized way. According to Netto et al. (2007), with "the development of the *framework* achieves great flexibility", in particular, "from the obtaining of a generic structure of classes that can be instantiated for various realities in a given domain of application" (Netto et al., 2007, p. 16, emphasis in original).

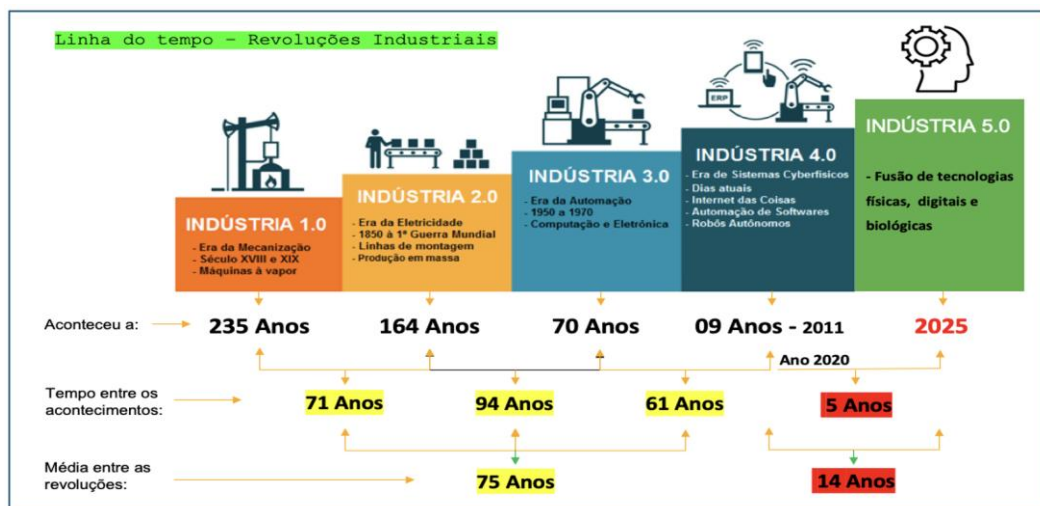
In addition to building *software*, *frameworks* are important instruments for the study and comparison of concepts in the PV discipline, for example, working as structured models and methodologies to organize objectives, develop self-knowledge and outline an action plan

for the future. In the case of the study of Industrial Revolutions, these can transform the discipline (or cross-cutting theme), focusing not only on the past of the industry, but on the future of the individual in the world of work.

The image below (Figure 1) represents, through a *framework*, the timeline of the Industrial Revolutions, from the emergence of Industry 1.0, whose milestones revolved around the steam engine, to Industry 5.0, which is focused on the fusion of physical, digital and biological technologies.

Figure 1

Framework on Industrial Revolutions and their innovations



Source: LinkedIn, 2025.

However, how can this *framework* stimulate reflective thinking, making the student connect their worldview, experiences, and future perspectives in the context of PV? What are the nuances and connections with contemporary transformations that are outlined in this figure?

We can conclude, therefore, that the Industrial Revolutions demonstrate important points in the evolution of society, characterized by a human-historical-technological-cultural-social development. In addition, we can observe that, in the beginning, there is an absence of digital technology, whose world was not yet globalized, was based on more spaced intervals between transitions or technological advances, but which, over time, has evolved, moving from a social and family model to the generation of new technologies through the fusion of physical technologies, digital and biological aspects.

The Industrial Revolution, in its various phases, from this *framework*, becomes a central theme, especially in the axis of the World of Work, as its transformations profoundly shaped society and the labor market we know today. In view of this, the approach is made through a perspective that connects the past, the present and the future, focusing on the development of the skills and abilities necessary for the contemporary world of work.

Thus, it is possible to discuss the change in the mode of production (artisanal, manufacturing and machine-crafting) and how this altered the role of the worker, who ceased to be the owner of the means of production to become the seller of his labor power. From a life project perspective, it is valid to reflect on the importance of autonomy and a sense of belonging at work, generating questions such as: what did the worker lose and gain with this change? How can today's young people seek autonomy and meaning in modern careers?

Therefore, the key piece of this movement is to use history as a mirror for the present, encouraging students to prepare not only for the next career, but for an ever-changing future.

The next image (Figure 2) presents a second *framework* with the function of demonstrating a cut of the Digital Revolution between the years 2019 and 2025, whose focus is on the simultaneous events that affected the various segments of society, such as health, the economy and education, as a result of Covid-19, which emerged in late 2019 and early 2020.

Figure 2

The Digital Revolution between the years 2019 and 2025



Source: The authors, 2025.

The Covid 19 pandemic was not a simple "turning of the key", but an abrupt, overwhelming change, with moments of mismatched information, which stopped the world, work and affected many families, which resulted in a chaos that was established "overnight". In addition, from the restrictions imposed by the pandemic context, such as physical contact, social isolation, the growth of work through the consecration of digital technologies, which, in the period, were widely used, had as their main objective to help society in its relations with the world, especially in the world of work, so that we could continue producing, whether *online*, *offline* or hybrid, synchronous or asynchronous, which led to the emergence of the *home-office*, online classes and meetings, both in educational institutions and in corporations of all sizes.

On the other hand, when we observe the "context of teaching work, the consequences of the pandemic [...] were significant, requiring adaptations on the part of "teachers" to continue teaching, especially when considering the differences between the public and private education networks" (Silva Filho; Andrade; Porto, 2025, p. 26).

We perceive, therefore, that, nowadays, society continues to accelerate to keep up with changes while seeking strategies to perform in the face of demands that arise very quickly, which, for Santaella (2010) means that the "accelerated pace of technological changes" causes "psychic, cultural, scientific and educational impacts" (Santaella, 2010, p. 18).

From the pandemic, there was an intense adherence to digital tools, which generated an exponential advance in solutions and business. A great example of this evolution is Artificial Intelligence (AI), which is a growing reality and generates opportunities in the professional sector, science, education, research, automating processes, such as a large database that allows, in addition to optimization, the consultation of information through the management of complex systems in all areas of knowledge and performance.

Suave (2024), understands that AI is "a field of computer science dedicated to developing systems capable of performing tasks that would normally require human discernment", which "encompasses a wide range of capabilities, which include learning, reasoning, understanding human language, and even creating art" (Suave, 2024, p. 12).

The impact of the Covid-19 pandemic on students' life projects was profound and multifaceted, acting as an accelerator of trends and an agent of crisis in several dimensions. An example was that the global scenario of instability (economic, health, and social) generated a great lack of perspective and uncertainty about the future, which is directly linked to anxiety and pessimism in relation to long-term projects. Many young people felt part of a "*lockdown generation*", with the future on hold. In other words, "our daily life, mentally organized" was modified and, "in this new scenario, uncertainties and insecurities were triggered or intensified" such as "fear and distrust"; "the fear of being contaminated, of getting sick and dying", or even of seeing our income reduced or eliminated (Moretti; Guedes-Neta; Batista, 2020, p. 34).

Social isolation interrupted face-to-face interaction, crucial for social and emotional development in adolescence, which affected the support network and the construction of identity. On the other hand, the lack of access to technologies and *quality internet* (digital inequality) has widened educational disparities, leading to a more pronounced learning loss among low-income youth. Trezzi (2020) understands that the pandemic demonstrated a "generalized technological gap in Brazilian schools", which only worsened "Brazil's situation in relation to other countries" (Trezzi, 2020, p. 7).

The difficulty in keeping up with remote learning, added to the need to supplement family income (due to the economic crisis), led many young people to think about leaving school or giving up the entrance exam/ENEM, who also suffered from job loss and reduced income, exposing them to the fragility of labor relations, impacting younger and less educated workers more deeply. Maia (2023) points out that, even with the "hybrid classes adopted in most schools in Brazil", the latter did not have "adequate support" and "families had many difficulties in adapting" which contributed "to the increase in dropout rates" (Maia, 2023, p. 4).

The health and social crisis scenario has led many to reevaluate what "success" is, prioritizing careers that offer purpose and quality of life instead of just high salaries. We can observe, therefore, that Covid-19 was an experience that proved that the life project is a living and dynamic document, which needs to be constantly reviewed in the light of global and personal changes.

We argue, therefore, that PV has a fundamental and transformative role in preparing Brazilian students for the future, going beyond traditional academic content, as it can encourage students to reflect on their values, interests, abilities and limitations, and to define their dreams and aspirations clearly and consciously. In addition, it promotes youth protagonism, placing the student as the main agent in the construction of their own path, encouraging them to make decisions and take responsibility for them. Finally, by integrating PV into the curriculum, the school contributes to forming not only good professionals, but more aware citizens, prepared and motivated to build a future that makes sense for them and for Brazilian society.

5 FINAL CONSIDERATIONS

Our article was born from some questions, such as: what are the relations between the Industrial Revolution and the Digital Revolution? How, from this relationship, do we arrive at disruptive technologies? How do these interconnections interfere with the PV of our students and how can they be addressed?

The Industrial Revolution and the Digital Revolution are connected in a historical sequence of technological transformations that fundamentally redefine production, the economy, and society. While the first was focused on mechanization (steam engine, water) and then on mass production, electricity and assembly lines, the second is characterized by the invention and dissemination of computers, the development of the *internet* and

telecommunications, that is, it uses the advances of previous revolutions (such as electricity) and adds the layer of information technology.

The link between the Digital Revolution and disruptive technologies is direct and fundamental, since the Digital Revolution is the driving force and the environment that generates, enhances and massifies disruptive technologies. Thus, essentially, the Digital Revolution is the historical-social process of transformation of society based on information technology, and disruptive technologies are the specific innovative elements that cause this transformation.

The Industrial Revolution, the Digital Revolution and disruptive technologies create a scenario of uncertainty and, at the same time, of unprecedented opportunities, forcing students to completely rethink their PV and their educational and professional choices. While the legacy of the Industrial Revolution was specialization and repetition of tasks, the Digital Revolution, driven by disruptive technologies, inverts this logic.

With this, a new mentality emerges: that students need to abandon the idea of a "career for life" and adopt the concept of "Lifelong Learning", whose PV must include the ability to requalify and adapt to each technological cycle. And how to provoke this reflection through an innovative approach? This is how the idea of applicability of *frameworks* came about, as it is an organized and standardized way to work with different knowledge.

The importance of PV in contemporary youth is critical and multifaceted, being the main instrument for young people to navigate the complexity, speed and uncertainty of the twenty-first century. With this, it is no longer just a dream or goal and becomes an essential structure for identity, protagonism, and resilience in a highly volatile world.

The digital society offers an avalanche of information, careers and paths, so the PV works as a compass for young people when fighting paralysis of choice, since in the face of so many options, they can feel overwhelmed; it offers motivation and engagement, because by having a clear vision of the future, the young person attributes meaning to studies and present effort; It provides opportunities to define priorities, which helps to translate abstract dreams into concrete short, medium and long-term goals, directing where to invest time, energy and resources.

Youth is the phase of intense identity construction and, in view of this, PV actively assists in this process, either through self-knowledge as a way of elaborating the project, which requires deep reflection on values, talents, limitations and passions, or through the encouragement of protagonism, because when planning their own future, the young person

becomes the main agent of their history, and not just a passive spectator of the circumstances or expectations of others (family, social), or through the exercise of resilience, because by finding a greater purpose (the "vital project"), the young person develops a greater capacity to deal with frustrations and crises.

PV becomes vital in the face of some adaptations, such as the integral vision (personal, social and professional) of life, the development of non-cognitive skills (critical thinking, planning, ethics, collaboration and emotional intelligence) and social responsibility, which includes the desire to contribute to something that transcends self-interest, aligned with the individual ambitions of the young person with the exercise of citizenship and the search for a common good.

Research involving the theme of PV is important for several reasons, and offers both practical and immediate benefits to the individual and significant contributions to the educational and social area. In addition to the Industrial and Digital Revolutions, other approaches are effective for consolidating learning and broadening our worldview, which makes this subject a fertile ground for our future research.

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**CULTIVATING KNOWLEDGE, REAPING TRANSFORMATIONS: THE
EXPERIENCE OF PRODUCING MEDICINAL PLANTS BASED ON
ECOLOGICAL PRINCIPLES AND PHYTOTHERAPEUTIC PRODUCTS AT THE
MARINGÁ INDUSTRIAL PENAL COLONY, PARANÁ, BRAZIL**

**CULTIVANDO SABERES, COLHENDO TRANSFORMAÇÕES: A EXPERIÊNCIA
DA PRODUÇÃO DE PLANTAS MEDICINAIS EM BASE ECOLÓGICA E
FITOTERÁPICOS NA COLÔNIA PENAL INDUSTRIAL DE MARINGÁ, PARANÁ,
BRASIL**

**CULTIVANDO SABERES, COSECHANDO TRANSFORMACIONES: LA
EXPERIENCIA DE LA PRODUCCIÓN DE PLANTAS MEDICINALES EN BASE
ECOLÓGICA Y DE FITOTERÁPICOS EN LA COLONIA PENAL INDUSTRIAL DE
MARINGÁ, PARANÁ, BRASIL**

 <https://doi.org/10.56238/sevened2025.036-082>

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ABSTRACT

Currently, Brazil has the third largest prison population in the world, behind only the United States and China. In this context, it is essential to discuss proposals that can contribute to mitigating this type of reality. Thus, the research aimed to evaluate the behavior of inmates involved in the production, processing and use of medicinal plants and herbal medicines. The research is being carried out at the Industrial Penal Colony (CPIM), located in the municipality of Maringá, Paraná, from April 2023 to March 2024. It was divided into two Stages: Stage 1: The inmates will be involved in activities related to the implementation unit for the production and maintenance of medicinal plant species (germplasm bank); Stage 2: Processing of medicinal plants and production of herbal medicines. In addition to production and processing, the strategy is to implement a pilot pharmacy specializing in herbal/homeopathic medicines to meet the demands of the Penal Colony. The inmates involved in the production, processing and production of herbal medicines will be evaluated from a psychotherapeutic point of view, a constructivist approach, at the beginning and at the end of the research. The following assessments will be carried out: 1. Performance of the behavior of inmates involved in the different activities of Stages 1 and 2; 2. Application of a semi-structured questionnaire for individual social interviews, at the beginning and end of the research; 3. Carrying out a final workshop and producing experience reports. For the end of this article, the inmates' involvement in the activities of Stages 1 and 2 were evaluated. Considering the foundations of psychopedagogy and the constructivist approaches of Vygotsky and Piaget, gains were perceived by the inmates throughout their involvement in activities related to herbal medicine. Gains include learning, empathy, motivation, interest, bond formation, interdependence and respect, both individually and in groups. These results are in line with the constructivist theories of these two authors, which emphasize the importance of social interaction, active participation and the gradual development of cognitive and social skills.

Keywords: Agroecology. Prisons. Employment and Income. Resocialization.

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RESUMO

Atualmente, o Brasil tem a terceira maior população carcerária do mundo, atrás apenas dos Estados Unidos e da China. Nesse contexto, é fundamental discutir propostas que possam contribuir para mitigação desse tipo de realidade. Assim, a pesquisa teve por objetivo avaliar o comportamento de apenados envolvidos com a produção, processamento e uso de plantas medicinais e de fitoterápicos. A pesquisa está sendo realizada na Colônia Penal Industrial (CPIM), localizada no município de Maringá, Paraná, no período de abril de 2023 a março de 2024. Foi dividida em duas Etapas: Etapa 1: Os apenados estarão envolvidos em atividades relacionadas à implantação de unidade para produção e manutenção de espécies de plantas medicinais (banco de germoplasma); Etapa 2: Processamento de plantas medicinais e produção de fitoterápicos. Além da produção e processamento, a estratégia é implantar uma farmácia piloto especializada em fitoterápicos/homeopáticos para atender demandas da Colônia Penal. Os apenados envolvidos no processo de produção, processamento e produção de fitoterápicos serão avaliados sob o ponto de vista psicoterápico, abordagem construtivista, no início e ao final da pesquisa. As seguintes avaliações serão realizadas: 1. Desempenho do comportamento dos apenados envolvidos nas diferentes atividades das Etapas 1 e 2; 2. Aplicação de questionário semiestruturado para entrevista social individual, no início e ao final da pesquisa; 3. Realização de oficina/workshop final e produção de relatos de experiências. Para fins deste artigo, foram avaliados os envolvimento dos apenados nas atividades das Etapas 1 e 2. Considerando os fundamentos da psicopedagogia e as abordagens construtivistas de Vygotsky e Piaget, foram percebidos ganhos pelos apenados ao longo do envolvimento nas atividades relacionadas à fitoterapia. Os ganhos incluem aprendizagem, empatia, motivação, interesse, formação de vínculos, interdependência e respeito, tanto em termos individuais quanto grupais. Esses resultados estão alinhados com as teorias construtivistas desses dois autores, que enfatizam a importância da interação social, da participação ativa e do desenvolvimento gradual das habilidades cognitivas e sociais.

Palavras-chave: Agroecologia. Presídios. Emprego e Renda. Ressocialização.

RESUMEN

Actualmente, Brasil tiene la tercera mayor población carcelaria del mundo, detrás solo de Estados Unidos y China. En este contexto, es fundamental discutir propuestas que puedan contribuir a mitigar esta realidad. Así, la investigación tuvo como objetivo evaluar el comportamiento de los reclusos involucrados en la producción, el procesamiento y el uso de plantas medicinales y de fitoterápicos. La investigación se está llevando a cabo en la Colonia Penal Industrial (CPIM), ubicada en el municipio de Maringá, Paraná, entre abril de 2023 y marzo de 2024, y fue dividida en dos etapas: la Etapa 1, en la cual los reclusos participan en actividades relacionadas con la implantación de una unidad para la producción y el mantenimiento de especies de plantas medicinales (banco de germoplasma), y la Etapa 2, correspondiente al procesamiento de plantas medicinales y a la producción de fitoterápicos. Además de la producción y el procesamiento, la estrategia incluye la implantación de una farmacia piloto especializada en fitoterápicos/homeopáticos para atender las demandas de la Colonia Penal. Los reclusos involucrados en el proceso de producción, procesamiento y elaboración de fitoterápicos serán evaluados desde el punto de vista psicoterapéutico, con un enfoque constructivista, al inicio y al final de la investigación, mediante: 1) evaluación del desempeño del comportamiento de los reclusos en las actividades de ambas etapas; 2) aplicación de un cuestionario semiestructurado para entrevista social individual, al inicio y al final del estudio; y 3) realización de un taller final y elaboración de relatos de experiencias. Para los fines de este artículo, se evaluó la participación de los reclusos en las actividades de ambas etapas. Considerando los fundamentos de la psicopedagogía y los enfoques constructivistas de Vygotsky y Piaget, se observaron avances entre los reclusos a lo largo de su participación en las actividades relacionadas con la fitoterapia, incluyendo aprendizaje,

empatía, motivación, interés, formación de vínculos, interdependencia y respeto, tanto a nivel individual como grupal. Estos resultados están alineados con las teorías constructivistas de ambos autores, que destacan la importancia de la interacción social, la participación activa y el desarrollo gradual de habilidades cognitivas y sociales.

Palabras clave: Agroecología. Prisiones. Empleo e Ingresos. Resocialización.

1 INTRODUCTION

Currently, Brazil has the third largest prison population in the world, behind only the United States and China. The CNJ data point to the increase in the Brazilian prison population, which, according to Depen's diagnosis, grows at a rate of 8.3% per year. In this march, the number of prisoners could reach almost 1.5 million in 2025, equivalent to the population of cities such as Belém and Goiânia.

The research to be carried out in the Industrial Penal Colony of Maringá is based on the need to solve problems related to education, rehabilitation and professional training of the prison population of the Industrial Penal Colony of Maringá and, in parallel, to contribute to the improvement of health and reduction of social inequality of the population of the Odwaldo Bueno Netto neighborhood in Maringá. For this, the production, processing and use of medicinal plants and herbal medicines, produced by inmates of the Penal Colony, will be strategically used.

The Project is part of the UBUNTU Program, proposed by the Graduate Program in Agroecology, Professional Master's Degree (PROFAGROEC), in partnership with the Center for Agroecology and Sustainable Development (NADS) of the State University of Maringá (UEM). In addition to the medicinal plant production unit, the project will implement the processing unit and a pilot pharmacy specializing in herbal medicines and homeopathic herbal medicines to meet the internal demands of the Penal Colony.

With the name "UBUNTU", which means "I am because you are", it is intended to form a Germplasm Bank, that is, to form a structure that stores the genetic material of various species of medicinal plants, adding knowledge about the repairing effect on the health of the individual, placing a natural and healthy alternative to the use of allopathic medicines due to the great absence of side effects in this alternative and sustainable process.

Therefore, the project's general objective is: To verify the feasibility of building and preparing people in a state of seclusion to generate work, add values with the production of medicinal plants cultivated in an ecological way for use in the form of teas and herbal preparation, recovering both the person and their physical health. And the specific objectives:

- a) To create a Germplasm bank of medicinal plant species in the Penal Colony of Maringá;
- b) To promote the rehabilitation of inmates; and c) qualification for professional activity after rehabilitation.

Medicinal plants contain a wide range of bioactive compounds, such as alkaloids, flavonoids, terpenes and polyphenols, which have relevant pharmacological activities (Silva,

2012). These compounds can act at different cellular levels, influencing biological processes such as inflammation, cellular control, and immune response (Gupta et al., 2015). In addition, many medicinal plants have been investigated for their antioxidant and antimicrobial properties, which are beneficial for their therapeutic utility (Santos et al., 2018).

Despite the vast knowledge accumulated throughout history about the medicinal properties of plants, there are important challenges in the safe and effective incorporation of these treatments into modern medical practice. The lack of standardization in dosage, the natural variability of the compounds present in plants, and the interaction with other drugs are factors that require rigorous investigations (Ferreira, 2019).

The objective of this research was to evaluate the behavior of inmates involved with the production, processing and use of medicinal plants and herbal medicines. The research was carried out at the Industrial Penal Colony (CPIM), located in the municipality of Maringá, Paraná, from April 2023 to March 2024. It was divided into two Stages: Stage 1: The inmates were involved in activities related to the implementation of a unit for the production and maintenance of medicinal plant species (germplasm bank); Step 2: Processing of medicinal plants and production of herbal medicines. In addition to production and processing, the strategy is to implement a pilot pharmacy specializing in herbal medicines/homeopathics to meet the demands of the Penal Colony.

2 LITERATURE REVIEW

2.1 AGROECOLOGY AND SOCIOECONOMIC ISSUES IN BRAZIL

Agroecology is an agricultural approach that integrates principles and practices of ecology into food production, primarily targeting sustainable, natural, ecological, and socially just systems. It seeks to promote biodiversity, the efficient use of natural resources, the resilience of agricultural ecosystems and the well-being of communities linked to the agricultural environment (Gliessman, 2000)

Organic agriculture is a production model characterized by not using synthetic fertilizers, pesticides, modified seeds, animal growth regulators and intense mechanization of activities, aiming to reduce environmental impacts, in addition to growing healthier food products.

The model of a family system of organic production certainly fits into the concept of the science of "Agroecology" generating a healthy diet and a quality of life with a disease

prevention approach within a highly social and environmental focus, (HAMERSCHMIDT, 2000)

The pressure exerted by consumers, increasingly demanding a clean, toxic-free and nutritionally superior product is another factor that has motivated farmers to bet on this production system

Although it represents less than 1% of the global market, the growth forecast for the Brazilian organic food market for this year is 30%, according to projections by the initiative. In Brazil, there are 11,478 organic producers registered in the country, almost all of which are family producers (MAPA, 2022).

The organic system is an agricultural production methodology that does not require the use of chemical inputs and is characterized by a process that takes into account the relationship between soil, plant and environment (MEIRELLES & RUPP, 2014). According to Dias et al. (2015), "agriculture and the consumption of organic products have been expanding in recent years and experts in the sector are predicting growth of 9% or more in developed countries". Also according to Dias et al. (2015), as cited by the United Nations Conference on Trade and Development (UNCTAD, 2013), "there are currently about two million organic farmers, around 80% in developing countries, in addition to the trade in organic products selling 60 billion dollars annually". However, although growing, the arable area destined to organic production in Brazil is estimated at only 0.25% (BUAINAIN & BATALHA, 2007).

Agroecosystems is the fundamental unit of studies in which mineral cycles, energy transformations, biological processes and socioeconomic relations are seen and analyzed together, as stated by Altieri (1980 apud Caporal, 2009).

According to PAULUS (1999),

"The concept of agroecosystem proposed by SCHLINDWEIN & DAGOSTINI (1998) incorporates in its definition spatial-temporal (related to structure), functional and conjunctural aspects which, in some way, are also organizational. In other words, it is a concept that is not limited to considering only the elements of the physical environment, in their biotic and abiotic components, and their interrelationships, but that recognizes aspects of a socioeconomic and cultural order, as elements that are located in the genesis of the different agroecosystems (SCHLINDWEIN & DAGOSTINI, 1998: p.8).

Currently, the development of technologies for the production of medicinal plants is a work that is being done in universities and research institutions, and that is already bringing results that can be readily used by producers. The use of organic cultivation techniques for

production is not accidental. There is research that proves that chemical fertilization alters the content of active ingredients in some species. The use of pesticides not only alters the quality of these principles, but also leaves toxic residues on the plants, which can lead to poisoning of the user. Therefore, pesticides are not allowed in the production process.

The adoption of the organic production system requires a change of mentality and attitude from the producer. It is not enough just to replace chemical inputs with fertilizers and organic products. It is necessary to understand living processes and use all your capacity for observation and relating facts, to make the most of the full potential of natural cycles.

When it comes to medicinal plants, it is very important to consider the content and quality of the active ingredients, which are the products that are of commercial interest. For their preservation, their ecological characteristics must be respected, that is, they must seek to reproduce conditions similar to those found in their places of natural occurrence, for this reason that agriculture is thought of on an ecological basis and especially the care of the soil.

2.2 THE REALITY OF THE BRAZILIAN PRISON SYSTEM

The classification of convicts in the state of Paraná, as well as in many other prison systems, is based on several criteria. Generally, convicts are classified according to the type of crime committed, the length of time to be served, behavior in prison, and other factors. It is important to note that classification policies and specific categories may vary over time and according to state and national legislation. Therefore, it is essential to check the current regulations and procedures of the prison system in the state of Paraná to obtain accurate information.

The classification can usually include:

- Sentence fulfillment regime: Convicts can be classified into different regimes, such as closed regime, semi-open regime and open regime, based on the severity of the crime and the time of sentence to be served.
- Behavior in prison: The behavior of the convict in prison can influence his classification. Those who demonstrate good behavior can obtain benefits, such as regime progression or reduction of sentence.
- Type of crime: Convicts can be classified based on the type of crime they have committed, such as violent crimes, non-violent crimes, crimes against property, among others.

- Special needs: The classification can also be considered as medical, psychological or drug treatment needs of the inmates.
- Dangerousness: The assessment of the dangerousness of the convict can also influence their classification and the need for additional security measures.
- Criminal history: The criminal history of the convict, including previous convictions, can also be taken into account in the classification.
- It is important to emphasize that the classification of convicts must be carried out fairly and in accordance with current legislation, guaranteeing the human rights and dignity of inmates. The prison system should provide opportunities for rehabilitation and rehabilitation whenever possible.

For more detailed information on the classification of convicts in the state of Paraná, consult the Penitentiary Department of Paraná (DEPEN) or the current prison legislation of the state.

The State of Paraná has a prison system model where inmates who arrive receive, in addition to the above classifications, some perks, among the perks are the option to continue their studies.

The tests for the National Exam for the Certification of Youth and Adult Skills for Persons Deprived of Liberty or under socio-educational measure that includes deprivation of liberty (Encceja PPL) 2023 are scheduled for October 17 and 18. This exam, carried out by the National Institute of Educational Studies and Research Anísio Teixeira (Inep), has the function of assessing competencies, skills and knowledge of young people and adults at the level of completion of Elementary School or High School for the purpose of correcting the school flow.

In the state of Paraná, Encceja PPL 2023 had the registration of 10,108 people deprived of liberty (PPL), which represents an increase of 21% compared to the 2022 edition, when the State had 8.4 thousand PPLs registered. Interestingly, this percentage of increase in registrations reached almost the same rate as last year, when there was an increase of 22% compared to 2021.

According to the director of the Criminal Police of Paraná, "For us, this increase in the number of inmates enrolled in Encceja PPL is of great importance because it demonstrates that the PPPR has sought and encouraged people deprived of liberty to study. We have many cases of people who had no schooling when they entered the penitentiary system and through the literacy offered within the units, many managed to complete elementary and high

school and reached higher education. The greater the incentive, the greater the search for qualification", he highlights.

Among the nine administrative regions of the Criminal Police of Paraná (PPPR), the regional of Londrina was the one with the most registrations, with 3,234 PPLs registered, followed by the regional of Curitiba with 2,281 registered; regional office of Umuarama with 1,034 enrolled; regional office of Ponta Grossa with 862 enrolled; regional of Maringá with 784 enrolled; regional of Guarapuava with 661 enrolled; regional office of Foz do Iguaçu with 596 enrolled; regional of Cascavel with 491 registered and regional of Francisco Beltrão with 364 registered.

Paraná is among the states with the highest number of prisoners involved in educational activities, according to the ranking of the National Penitentiary Department. The state has almost 9.5 thousand prisoners enrolled in elementary and secondary, professional and higher education and also in other pedagogical projects. The number, which represents 32% of the total number of inmates in the prison system, places Paraná in fourth place in the ranking, behind Santa Catarina, Maranhão and Pernambuco.

According to Julio Prestes, (2023) Encceja PPL is an initiative that aims to provide education and certification opportunities for individuals who are serving time in the prison system. This approach recognizes the importance of education in social reintegration, in reducing criminal recidivism, and in valuing human dignity. Education is a fundamental tool for the reintegration of inmates into society. Encceja also offers the opportunity to acquire certificates of completion of primary and secondary education, which can increase the chance of employability and improve the prospect of life after prison", explains the head of the Education and Training Division of the PPPR.

With this dedication and enjoying this perk, the convict manages to reduce his sentence. For every 12 hours of study, the right to a reduction of 1 day of sentence is granted. In the case of Encceja, this classification is made according to the grade. If he passes the exam, the convict receives 200 hours of remission and, if he does not reach the grade, he receives 8 hours of remission.

For the participant to be enrolled and apply for Elementary School certification, it is necessary to be at least 15 years old on the day of the tests and not have completed Elementary School. For the participant to apply for High School certification, it is necessary to be at least 18 years old on the day of the tests and not have completed High School. To

apply for certification, the participant must achieve at least 100 points in the objective tests and 5 points in the essay.

2.3 HEALTH OF PERSONS DEPRIVED OF LIBERTY IN BRAZIL

Education is a right of every Brazilian citizen, and it is a duty of the State to offer it regardless of the social, national, cultural, gender or ethnic-racial condition of the individual (Vieira, 2020). In the case of people deprived of liberty, this right, as well as other structural deficiencies found in the Prison System, was not a priority for the Brazilian State (Oliveira, 2017; Quaresma, Dos Santos Rocha & Cruz, 2021).

Article 205 of the Federal Constitution (CF) of 1988 says: "Education, a right of all and a duty of the State and the Family, will be promoted and encouraged with the collaboration of society, aiming at the full development of the person, his preparation for the exercise of citizenship and his qualification for work".

2.4 THE PRODUCTION OF MEDICINAL PLANTS AND PHYTOTHERAPY AS STRATEGIES FOR REHABILITATION IN THE BRAZILIAN PRISON SYSTEM

And the speeches in education and resocialization are essential for life in society, these two words have always gone together. Penitentiaries emerged as a way of punishing the practice of crimes and preventing the practice of new crimes. In Brazil, after the entry into force of Law No. 7,210 of 1984, the law that governs Penal Execution, the penalty began to have, in addition to the purpose of punishment and prevention, mainly the resocialization of the convicted and to provide him with a return to society, whether working or cultivating something.

The use of medicinal plants is an ancient and widespread practice in several cultures around the world. The use of different parts of plants to treat a variety of diseases and health conditions has been widely documented in the scientific and ethnobotanical literature. In this theoretical framework, we will address some relevant aspects about medicinal plants, their historical importance and therapeutic potential.

Since ancient times, plants have been employed as natural sources of treatment and cure of diseases. According to Smith et al. (2007), ancient civilizations, such as the Egyptians, Greeks, and Chinese, already had vast knowledge about the medicinal properties of specific plants. Historical records indicate that traditional medicine in many cultures largely incorporated the use of plants for symptom relief and disease treatment.

Medicinal plants contain a wide range of bioactive compounds, such as alkaloids, flavonoids, terpenes and polyphenols, which have relevant pharmacological activities (Silva, 2012). These compounds can act at different cellular levels, influencing biological processes such as inflammation, cellular control, and immune response (Gupta et al., 2015). In addition, many medicinal plants have been investigated for their antioxidant and antimicrobial properties, which are beneficial for their therapeutic utility (Santos et al., 2018).

Despite the vast knowledge accumulated throughout history about the medicinal properties of plants, there are important challenges in the safe and effective incorporation of these treatments into modern medical practice. The lack of standardization in dosage, the natural variability of the compounds present in plants, and the interaction with other drugs are factors that require rigorous investigations (Ferreira, 2019).

As Ferreira, 2009 cites above, plants have been playing their fundamental role throughout history, that is, when applied and used correctly.

3 MATERIAL AND METHOD

The research was carried out at the Industrial Penal Colony of Maringá (CPIM), located at Estrada Velha para Paiçandu, 2812, Gleba Ribeirão Colombo, municipality of Maringá, Paraná. This work was part of the UBUNTU Program, proposed by the Center for Agroecology and Sustainable Development (NADS) and the Technological Vocational Center in Agroecology and Organic Production (CVT) and the Graduate Program in Agroecology, Professional Master's Degree (PROFAGROEC) of the State University of Maringá (UEM). It has a partnership with DEPEN/CPIM, the Municipality of Maringá (PMM), the Public Ministry of Labor (MPTPR), Federal Justice/PR, State Justice, Milton Santos School (EMS MST). The word UBUNTU, of African origin, means "I am because you are". It involved five (5) inmates aged between 45 and 69 years, all with good behavior and who participate, in parallel, in the activity of olericulture. The five inmates have low education, two of whom only read and write only their names and the rest attended up to the fourth year of elementary school.

The present work is characterized in its methodology, a bibliographic review of the production of medicinal plants on an ecological basis and of herbal medicines in the behavior of inmates of the industrial Penal Colony of Maringá.

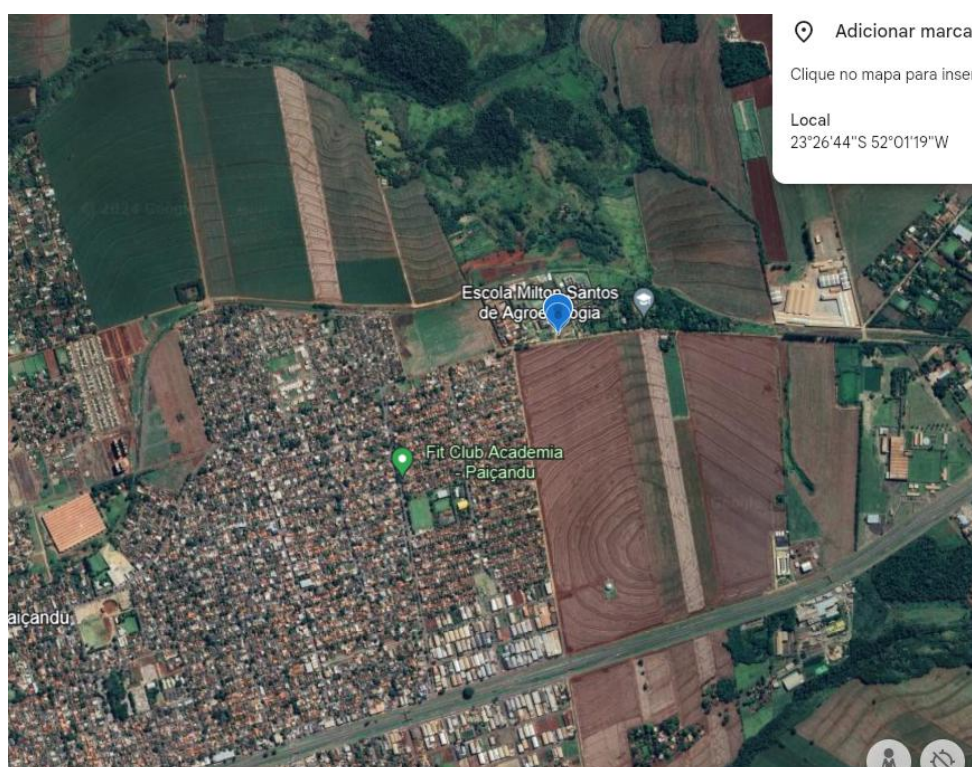
According to Galliano, 1979):

The word science comes from the Latin scientia, which means to learn or to know to know. In knowing, however, this etymological explanation does not help to differentiate scientific knowledge from other types of knowledge [religious, philosophical, family, etc.]. It is necessary to make it clear that science is a special knowledge about reality. For Galliano (1979, p. 16), science "is the rational, systematic, exact and verifiable knowledge of reality"

A case study was carried out in the Industrial Penal Colony of Maringá, Paraná (PEM). And an area for the production of medicinal plant species was installed, which will serve as a base for the production of medicines and the implementation of a community pharmacy specialized in the prescription of herbal medicines to meet the internal demands of the Penal Colony. Agroecological techniques will be used for the production of medicinal plants, which will allow, a posteriori, the certification of the production unit as organic. Figure 1 shows the Penal Colony of Maringá on the map of Maringá.

Figure 1

Map of the Region surrounding the PEM with location



Source: Google Maps, 2024.

The research was developed in two stages. In the first stage, theoretical classes were held on planting on an ecological basis, harvesting and extraction of active ingredients from medicinal plants. In addition, lectures and debates were held on the use of medicinal plants and the importance of contact with nature for mental health. In the second stage, the identification and selection of medicinal plants for cultivation, formation and conduction of the Germplasm Bank was carried out and the participants developed activities related to soil preparation, fertilization, planting, conduction and harvesting of the species and participation in the unconscious evaluation through the clipping of a magazine and pasting on cardboard and at the end self-explanation.

In questionnaire 1 it is to understand what was the knowledge about medicinal plants, to know if they understand the importance of studying these plants, to understand if they are willing to want to learn and finally to know the knowledge acquired in the course.

In the second questionnaire it was to evaluate, the first two questions to know if you learned and if you were motivated by the course, these two answers were individual; in the next two questions it was about contact with the community.

The species were acquired from the Technological Center (CTC) of the Agricultural and Industrial Cooperative of Mandaguari (COCARI), municipality of Mandaguari, Paraná, from the Experimental Farm of Iguatemi (FEI/UEM), belonging to the State University of Maringá (UEM) and from other sources of donation. In the second stage, the inmates were involved in the processing activities of species of the Germplasm Bank and in the extraction and production of herbal medicines. The Production area (germplasm bank) corresponds to 600m² and is composed of the species presented below, with their main characteristics. All Figures have been taken from Google 2024.

Lemon Balm (*Melissa officinalis* L): popularly known as true lemon balm, it is a plant belonging to the Lamiaceae family, which originates in Asia and Europe (Figure 3). It has a very characteristic lemon odor, being widely used in the control of various nervous crises, anxiety, hysteria, and emotions through its tranquilizing and sleep-inducing activity (DA SILVA et al., 2021).

Figure 2

Lemon Balm



Pau d'Álho (*Gallesia integrifolia* Spreng. Harms): also popularly known as ibirarema, it belongs to the Phytolaccaceae family (Figure 4). It is arboreal in size and is native to South America, occurring in Brazil in the Atlantic Forest, Amazon, Cerrado and Caatinga biomes (MARCHIORETTO, 2019).

Figure 3

Garlic stick



Boldo (*Plectranthus neochilus*, Schltr.): is a plant that presents physiological and morphological differences when grown in varied environmental conditions such as light intensity, altitude, humidity. Variations range from the expression of reproduction, sexual or not, to the number of leaves per branch, the distance between nodes, the leaf area and the external morphology of the leaves. Such variations are useful to explain the concept of phenotypic plasticity (LIMA et al., 2017)

Figure 4

Bilberry



Boldo-do-chile (*Peumus boldus*): also known as boldo normal, nacional, it is a medicinal plant originally from the region of Chile, but which is widely used in the Brazilian territory. With a more pleasant aroma than conventional boldo and a not so bitter taste, boldo-do-chile is great for solving issues related to the digestive tract. In addition to therapeutic and spiritual purposes, boldo-do-chile can also be added to any recipe, as a seasoning.

Figure 5

Boldo of Chile



Merthiolate (*Jatropha Multifida*): also known as mercury, pine nut, white spinning top, Paraguayan pine nut, purple pine nut, purgative herb, jalapa, castor bean, purple peon, tiu root. It is used as an antiseptic and antifungal and had gallic acid in its latex, acting on the inhibition of inflammation similar to the commercial drug. The leaves and fruits can also be used as healing, anti-hemorrhagic, laxative, antirheumatic and antihypertensive.

Figure 6

Merthiolate



Alfavaca (*Ocimum gratissimum* L): known as alfavacão, alfavaca-cravo, alfavaca, manjerição-cheiroso, alfavaca-de-vaqueiro, remédio-de-vaqueiro, etc. Originally from the East and subsontaneous throughout Brazil. It is a shrubby plant (it reaches up to 2 m in height), very aromatic and with a smell similar to "cloves". Alfavaca tea can eliminate toxins and fight inflammatory processes, due to the high concentration of flavonoids. In the presence of cold and flu symptoms, cough and sore throat, alfavaca tea is an excellent expectorant of the upper airways, helping to eliminate mucus and secretions.

Figure 7

Basil



Comfrey (*Symphytum officinale* L.): it is a perennial plant of European and Asian origin that has been introduced to the United States and South America. Used in the treatment of burns and wounds, diarrhea, bronchitis; in gargles in throat inflammations.

Figure 8

Comfrey



Swamp cane (*Costus spicatus* Jacq): popularly known as monkey cane, it is a medicinal plant rich in flavonoids, heterosides, tannins and oxalic acid, with anti-inflammatory, diuretic, nephroprotective and tonic properties, and is therefore indicated to assist in the treatment of kidney stones, urinary infection or menstrual changes, for example.

Figure 9

Caninha do brejo



Aloe vera (*Aloe vera*): Grows wild in tropical climates around the world and is cultivated for agricultural and medicinal uses. It is a plant used for various medicinal purposes for many years. It is usually used for skin-related problems (acne, burns, psoriasis, leprosy, etc.). It is known for its effects on wound healing, burns, hemorrhoids, bruises, rheumatic pains and as a laxative and in the treatment of cancer.

Figure 10

Aloe vera



Penicillin (*Alternanthera brasiliana* L.) popularly called evergreen, caaponga, carrapichinho, carrapichinho-do-mato, perpetual-do-brasil, perpétua-do-mato, quebra-panela, cabeça-branca, aconite-do-mato, ervanço, nateira, terramycin, infallible, doril, penicillin (penicillin-vegetal), has its origin from Central America. The infusion of its leaves is considered diuretic, digestive, depurative, and is used for liver and bladder diseases. The population of the Amazon region uses the infusion of the flowers against diarrhea, inflammation and cough (becica), while the decoction of the leaves is used internally in case of stroke. The bath prepared with the leaves is used for "bone displacement".

Figure 11

Penicillin



Mint (*Mentha piperita*): commonly called mint. It is a mild-tasting plant, widely used to make spices, candies and other treats. It has a strong and spicy flavor, it is usually used to flavor toothpaste, candies, gum, etc. Menthol has the ability to stimulate the so-called "cold nerves", which are usually activated by the drop in temperature (cold). But in this case, the nerves are activated by the presence of the substance in our body. Its regular consumption can help in treating symptoms such as pain, bloating, gas, etc. It has action against flu and colds. Menthol is a great decongestant and expectorant, helping to reduce sore throats and dry coughs.

Figure 12

Mentha



Ora-pro-nóbis (*Pereskia aculeata*): it is an edible plant with several medicinal properties, providing several health benefits, such as preventing anemia, improving bowel function, weight loss, preventing premature aging, and lowering cholesterol. It is rich in fiber, protein, iron, vitamin A and vitamin B3, which are nutrients with antioxidant, lipid-lowering, laxative and hypoglycemic properties.

Figure 13

Ora-pro-nobis



The research carried out is characterized as qualitative, exploratory research and, in procedural terms, as action research (TRIPP, 2005).

After all the work was carried out, some forms of evaluations were carried out: 1. Systematization of the experiences of the inmates involved in the process of implementation and processing of medicinal plant species; 2. Application of semi-structured questionnaires for individual social interviews. The questionnaire consisted of questions about previous knowledge of planting, cultural treatments, harvesting and extraction of active ingredients from medicinal plants. The questionnaire was applied at the beginning and at the end of the research; 3. Workshop, with the following progressive activities: 1. Non-specific warm-up; 2. Specific heating; 3. Main activity; 4. Participants' statements; 5. Observation, description and analysis of activities. A more detailed description of the Workshop is presented below: 1. Title: Cultivating Hope: Implementation of a Medicinal Plant Germplasm Bank for Herbal Use; 2. Objective: to rescue the experiences accumulated by the inmates in the process of implanting, conducting, harvesting and processing the species of medicinal plants and relate them to the promotion of physical and mental health, with the learning of practical skills and with the development of therapeutic skills; 3. Materials used: mat, cardboard, scissors, ruler, magazines and glue; 4. Development of activities: 4.1. Introduction (15 minutes); 4.2. Selection of medicinal plants by the participants (15 minutes); 4.3. Group Discussion (30 minutes); 4.4. Poster Creation (30 minutes); 4.5. Presentation of the Posters (15 minutes); 4.6. Participants' testimonies (15 minutes).

In the process of forming the planting of medicinal plants, rock dust was used to fertilize the space used for the idealization of the germplasm bank, the rocking process is an old

method, but still very little explored that is based on the use of rock with specific characteristics due to the presence of nutrients that after being ground becomes a kind of powder. When incorporated into the soil, it promotes a slow release of minerals such as phosphorus and potassium. Through this technique, we sought to equip inmates with a practice that has great potential for sustainability, as it allows the use of mining waste, reduces environmental problems caused by the indiscriminate use of chemical fertilizers, produces better quality food and reduces agribusiness costs (SILVEIRA, 2016 apud JUNIOR, 2020).

In this process of practical and scientific learning, according to Alovisei et al. (2020), basalt powder can be considered as an alternative source of low-cost fertilizer and soil amendment, however, the low solubility of basalt powder indicates that this material cannot be used as the main source of nutrients for plants.

Soil fertility, among other factors, depends directly on the quality of the mother rock, which when ground by physical processes, can be sources of mineral nutrients for the soil.

4 RESULTS AND DISCUSSION

This article analyzes the psychopedagogical impact of practical activities related to the management of medicinal plants in agroecological projects. The results demonstrate that the practical activities contribute significantly to raise the participants' self-esteem and strengthen the sense of accomplishment, corroborating the conclusion presented in the original text.

The monitoring and observation of the inmates involved in the activities of implantation, conduction, processing of medicinal plants and production of herbal medicines allowed the identification of objective characteristics through Questionnaires (Questionnaires 1 and 2) and subjective through the cutting of magazines and pasting on posters (holding a workshop), both in individual and group terms, data shown in figure 14 and subjective data in figure 15.

4.1 PSYCHOPEDAGOGICAL EVALUATION OF CONVICTS

Psychopedagogical evaluation of the participants involved in activities related to soil preparation, planting and conducting medicinal plant species (germplasm bank) and processing and production of herbal medicines

Impact on Self-Esteem and Sense of Accomplishment: because the research work is practical and with a productive bias, it was perceived, throughout the process, that the theoretical-practical activities developed positively influenced the participants' self-esteem and sense of accomplishment.

Hands-on Learning and Application of Knowledge: The activities carried out served as a tangible form of knowledge application, offering a hands-on approach to learning about botany, herbal medicine, and plant care. The knowledge shared was quickly socialized and assimilated by the participants.

Development of Social and Teamwork Skills: the practical activities created a favorable environment for teamwork. Teamwork allowed the development of social, collaborative, and communication skills among participants, essential for positive and productive interactions.

Conflict Resolution and Emotion Management: the collaborative environment contributed to the resolution of conflicts and the management of emotions of the participants, which can be observed by the reduction of negative or confrontational behaviors.

In the graphic data, the convicts worked and evaluated are named as, convict 1: L69; convict 2: R59; convict 3: D51; convict 4: M46 and C45: their characteristics are analyzed and discussed below.

Some parameters were analyzed and placed as a form of individual and collective evaluation, considering that freedom of expression was a point of fundamental importance for them to be able to write or even in the workshop of unconscious projection.

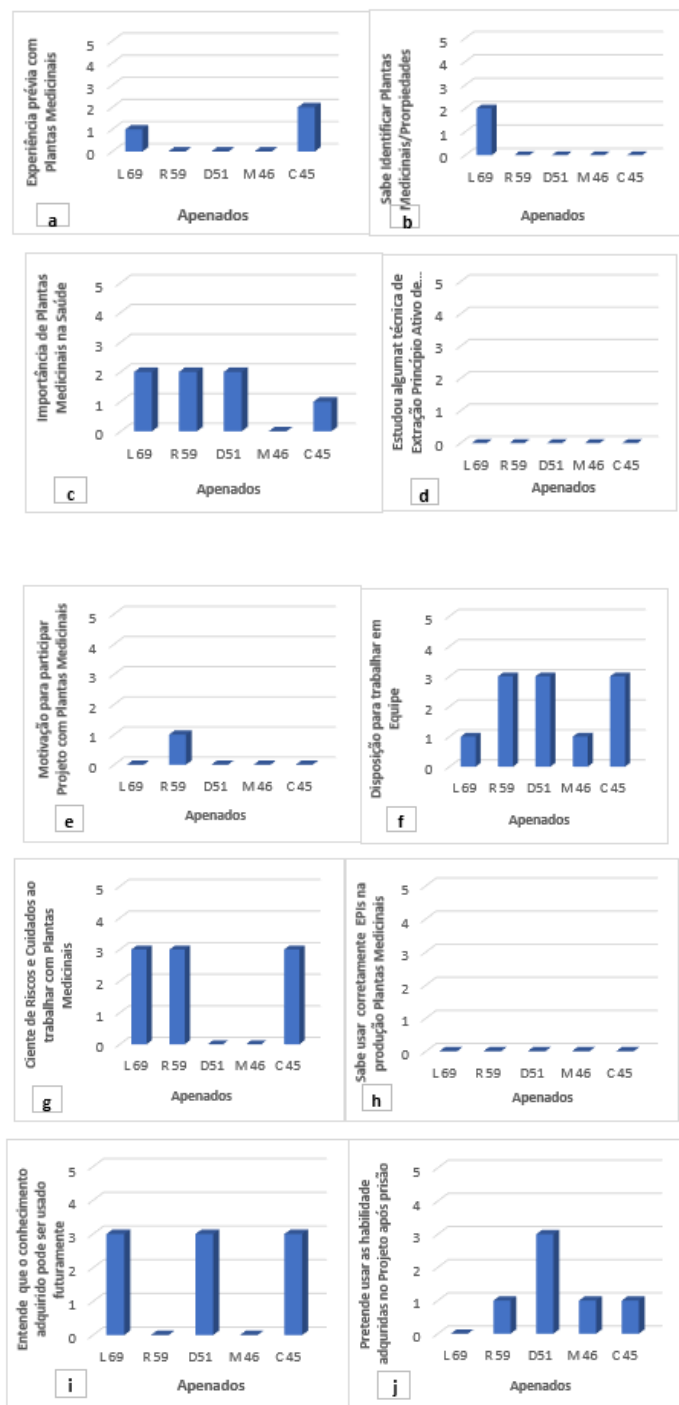
Table 1

Tables of basic characteristics of the convicts

Participant	Age	Schooling	Profession	CHARACTERISTIC
L69	69	FUNDAMENTAL	PORTHOLE	CALM
R59	59	FUNDAMENTAL	MUSICIAN	GOOD PERSON
D51	51	FUNDAMENTAL	ARMBAND	QUIET/SHY
M46	46	FUNDAMENTAL	ARMBAND	DEAF MUTE
C45	45	FUNDAMENTAL	ARMBAND	STRONG/SHY

Figure 14

Characteristics evaluated in the Initial Questionnaire (Questionnaire applied to the inmates participating in the CPIM Research. Maringá. Paraná. Letter: first letter of the participant's name; Number: age of the participant



"The Source of Self-Esteem: Essays, Speeches and Reflections" is an impactful work by renowned writer Toni Morrison, released by Companhia das Letras in 2020. In this volume, Morrison presents us with a series of essays, speeches, and reflections that delve deep into the intricate and multifaceted concept of self-esteem. Through an insightful approach, the author explores themes such as identity, race, gender, and power, revealing how these complex elements shape people's self-image and self-worth.

With her eloquent prose and unique sensitivity, Morrison invites readers on a journey of self-knowledge and reflection on self-esteem. Challenging pre-established concepts, she highlights the importance of recognizing and valuing the diversity of experiences and life trajectories. "The Source of Self-Esteem" not only offers an enriching and provocative read, but also serves as a powerful instrument of empowerment, inspiring readers to embrace their uniqueness and find strength in self-esteem.

Impact on Self-Esteem and Sense of Accomplishment: because the research work is practical and with a productive bias, it was perceived, throughout the process, that the theoretical-practical activities developed positively influenced the participants' self-esteem and sense of accomplishment.

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According to MORRISON (2020), from a therapeutic point of view, contact with nature and the process of growing medicinal plants can have positive effects on the mental health of participants, helping to reduce stress, anxiety, and symptoms of depression. Additionally, using plants for the preparation of natural remedies can encourage self-care practices and promote a more holistic approach to health.

Machado Junior, Romeus de Paula (2023 p.10) Although education is not the only instrument to obtain a decent standard of living, it provides the individual with greater chances of access to better working conditions and coexistence.

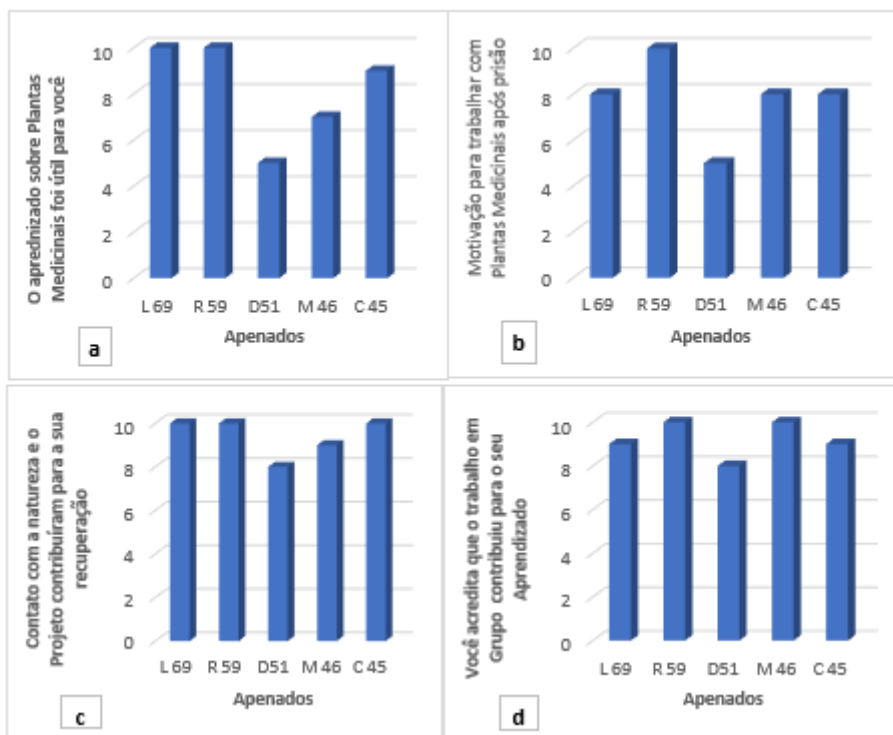
Connection with Nature and Well-Being: the positive impact of interaction with medicinal plants on the psychological well-being of the participants was observed, a fact that points to the importance of involvement and interaction with nature as a determining factor in the production of health and well-being, especially for positively influencing the emotional and mental state of individuals.

The feelings of an incarcerated individual or in Total Institutions, as defined by GOFFMAN (1987), can vary greatly, but generally include anxiety, stress, loneliness, anger, and even depression. Studies show that deprivation of liberty can negatively impact mental health, leading to feelings of isolation and hopelessness (Benelli, 2014). Lack of social contact and limited autonomy also contribute to these feelings. The results of the research point to the potential for reducing these impacts on the physical and mental health of inmates of the Industrial Penal Colony of Maringá.

Using projective techniques, which are psychological methods used to understand unconscious aspects of a person's personality, it was separated letter, name and age in which individuals were named as: L69, R59, D51, M46 and C45. A questionnaire was applied at the beginning of the project, and at the end a questionnaire of 4 questions and to conclude the perceptual work, a poster pasting work was carried out with the aim of verifying unconscious data so that they could be confronted and analyzed with the questionnaires of each individual. The work on cardboard serves to form data that presents vague or ambiguous stimuli to observe the individual's responses and reveal their hidden thoughts, feelings and impulses.

Figure 15

Characteristics evaluated in the Final Questionnaire (Questionnaire 2) applied to the inmates participating in the CPIM Survey. Maringá. Paraná. Letter: first letter of the participant's name; Number: age of the participant



Soon after, we will make the relationship between the conscious (questionnaire) and the unconscious (cut and paste), starting from figure 16 to perceive the relationship between the result of the answers and the poster built where the unconscious projection of the individual's perception is confirmed in relation to the work developed of herbal medicines in the Penal Colony during the process of implantation of the germplasm bank.

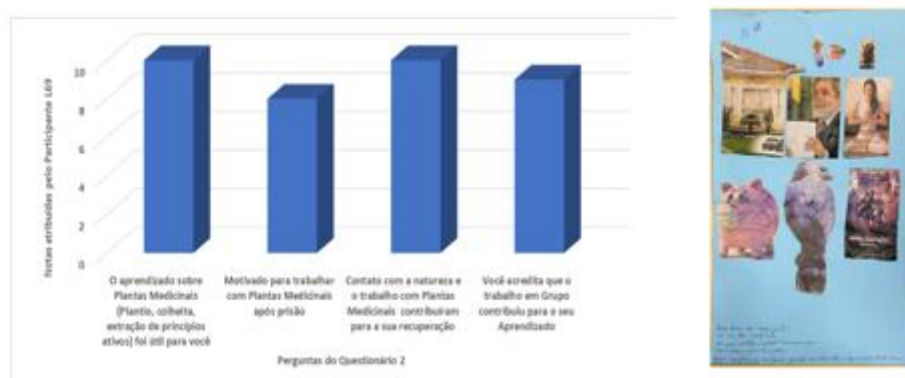
4.2 SUBJECTIVE EVALUATION OF THE CONVICTS

L69 In the first figure pasted on the poster he recalled that he has a house and how he values it at this moment, then he says that he pasted the president's photo because he is his unconditional fan and that it represents his ideals, soon after he presents the woman in a yoga position and comments that it is necessary to meditate and calm down to face life, the figure of the little pig for him represents the planning and saving that everyone should do this, then the harpy eagle recalled that when he was little his father had eliminated a bird of this

size that was almost 2 meters long and was not used and that today he is aware of preservation, finally the last figure represents freedom, as reported in Figure 16.

Figure 16

Conscious (Questionnaire 2) and unconscious (Workshop) responses of Participant L 69, obtained in the final evaluation of the research

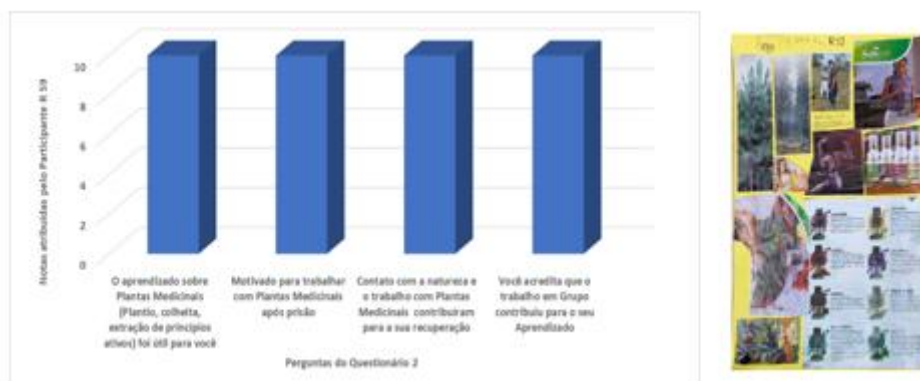


However, I can help create a generic abstract based on the title and theme of the article: The article "Benefits of Herbal Medicine in the Prison Context: A Systematic Review" seeks to analyze the potential benefits of using herbal medicine in prison settings through a systematic review of the literature. It examines relevant studies investigating inmates' use of medicinal plants and the positive impacts on physical and mental health. The article addresses possible therapeutic benefits of medicinal plants in reducing stress, anxiety, and other common health problems in prison populations. In addition, it discusses issues related to the safety, efficacy and implementation of phytotherapy programs in prison institutions.

R59 She reported that the nature placed on her collage poster represents connection and that everything is connected and some know how to use the knowledge of plants and others do not, so she chose figures that represent nature, the first two, third teaching and connection, three figures with women making use of this knowledge and the rest of the figures the final objective is the preparation of herbal medicines to assist in health treatments. As shown in Figure 17.

Figure 17

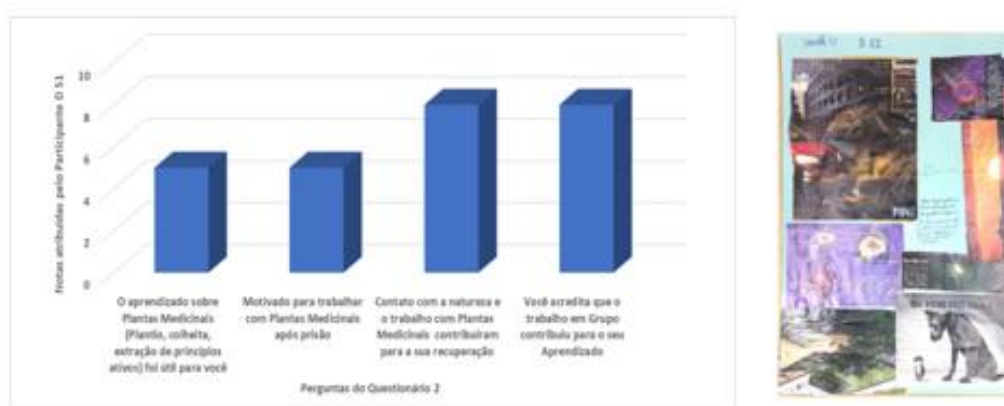
Conscious (Questionnaire 2) and unconscious (Workshop) responses of Participant R 59, obtained in the final evaluation of the research



D51 He is the least communicative of individuals, but he is afraid to impose himself and take his place, so he pasted the first drawing containing a giant iguana, his friend r59 inspires him with music so the second figure of a keyboard and a brain, the third figure for him reminds him of integration, the contrasting figure of the sunset and total darkness represents this fickle thought, Finishing with the figure of the small dog and the big dog that he often feels like the small dog in the photo. As depicted in Figure 18.

Figure 18

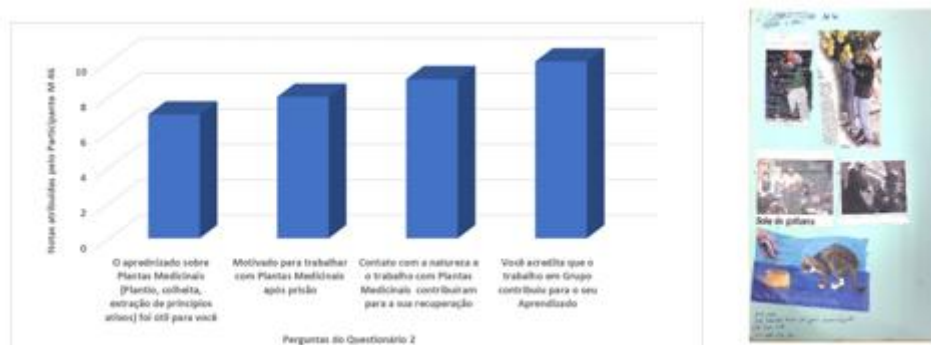
Conscious (Questionnaire 2) and unconscious (Workshop) responses of Participant D 51, obtained in the final evaluation of the research



M46 And the apparently more limited individual, he does not hear or speak, he knows how to read but cannot write, he preferred to put what he misses the most, which is the sound, the figure of the cat by analogy represented their mascot that he found familiar, only the photo of the grape harvest he related to the vegetable garden. Figure 19.

Figure 19

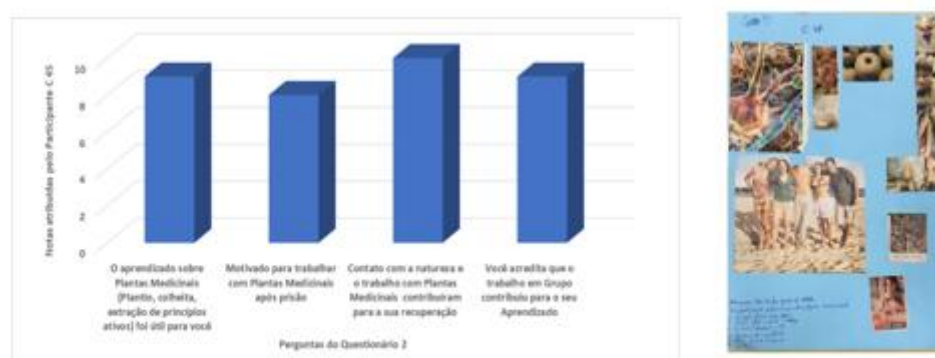
Conscious (Questionnaire 2) and unconscious (Workshop) responses of Participant M 46, obtained in the final evaluation of the research



C45 This individual has cataracts and a lot of difficulty seeing, soon he will have the operation to restore or improve his vision, in the first picture he reported that he knows that plants and cultivation are good for neurons, the photos of strawberries, apples and coffee represent their work in this place, he likes children so 4 photos of children. Figure 20.

Figure 20

Conscious (Questionnaire 2) and unconscious (Workshop) responses of Participant C 45, obtained in the final evaluation of the research



5 CONCLUSIONS

The preliminary results of the research point to the potential of phytotherapy in the production of physical and mental (psychological) health of inmates, justified by the important and growing gains in terms of learning, empathy, motivation, interest, formation of bonds, interdependence and respect throughout the involvement in the processes of the activities carried out. The gains observed could be perceived in terms of the individual and group as they could be observed in a high degree of satisfaction, all closer to 10 on the scale of the corresponding axis of each inmate.

This work in the Penal and Industrial Colony of Maringá proved to be an activity of great importance for the recovery and resocialization of the incarcerated. In addition to providing new skills and possibilities for life projects, the contact with nature and the activities related to the cultivation of medicinal plants provided a therapeutic environment and contributed to the improvement of the mental health of the participants. Therefore, we believe that the continuity of the project is essential for the promotion of the recovery and rehabilitation of the inmates.

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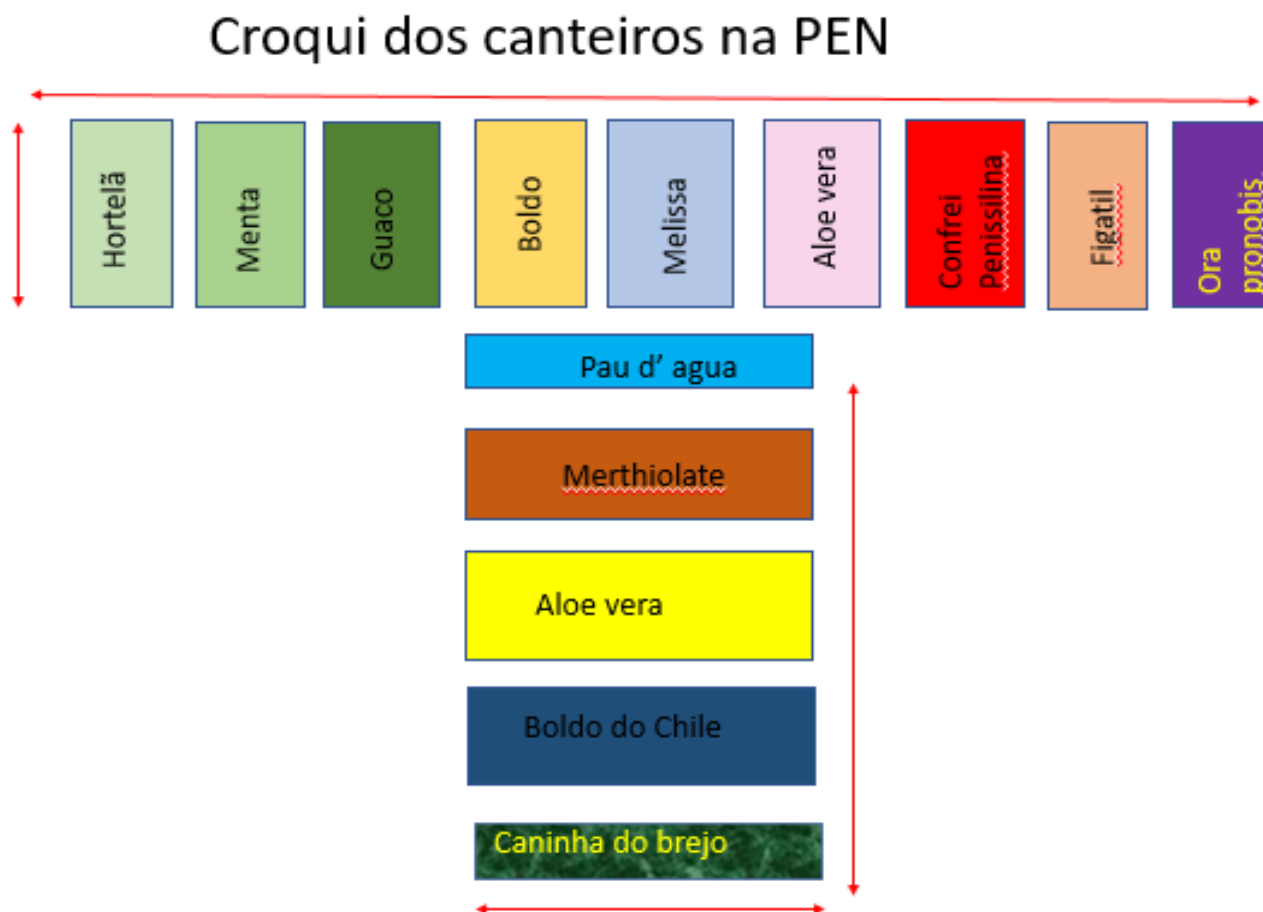
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APPENDIX

Figure 21



QUESTIONNAIRES

Questionnaire 1. Questionnaire to evaluate the inmates of an agricultural penal colony who will be submitted to learning how to plant, harvest and extract active ingredients related to phytotherapeutic knowledge. Initial Phase.

1. What is your previous experience with planting and harvesting plants?
2. Do you know how to identify different types of plants and their medicinal properties?
3. Do you understand the importance of using medicinal plants in human health?
4. Have you ever studied any technique for extracting active ingredients from plants?
5. What is your motivation for participating in this phytotherapy course?
6. Are you willing to work as a team during the process of planting, harvesting and extracting active ingredients?

7. Are you aware of the risks and precautions required when dealing with medicinal plants?
8. Do you know how to properly use personal protective equipment (PPE) while working on the plantation?
9. Do you understand that the knowledge acquired in this course can be applied in the future in your life outside prison?
10. How do you intend to use the skills acquired in this course after serving your sentence?

Questionnaire 2. Questionnaire to evaluate the inmates of an agricultural penal colony who will be submitted to learning how to plant, harvest and extract active ingredients related to phytotherapeutic knowledge. Final Phase.

Inform grade from 0 to 10 and justify the answer.

1. Do you consider that learning about planting, harvesting and extracting active ingredients was useful to you?
2. Did you feel motivated to continue working with plants after serving your sentence?
3. Do you consider that the contact with nature and the activities related to the cultivation of plants contributed to your recovery?
4. You believe that group work contributed to your learning

**DESIGNING TRUSTED HEALTH INFORMATION SPACES: THE CASE OF THE
WINDOWS OF KNOWLEDGE**

**PROJETANDO ESPAÇOS CONFIÁVEIS DE INFORMAÇÃO EM SAÚDE: O
CASO DAS JANELAS DO CONHECIMENTO**

**DISEÑANDO ESPACIOS CONFIABLES DE INFORMACIÓN EN SALUD: EL
CASO DE LAS VENTANAS DEL CONOCIMIENTO**

 <https://doi.org/10.56238/sevened2025.036-083>

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ABSTRACT

In a context marked by an infodemic and the widespread circulation of low-quality content, digital curation becomes a central strategy for ensuring access to reliable health information. This chapter analyses the Windows of Knowledge (WoK) of BIREME/PAHO/WHO as a concrete example of a curation infrastructure implemented within the framework of the Virtual Health Library. Drawing on a literature review on digital curation, information lifecycle and preservation models, in combination with institutional technical documents, it examines the informational architecture of the Windows, their flows of content selection, validation and updating, as well as the technical and organisational requirements for their maintenance. Issues such as usability, accessibility, interoperability with other health platforms and the challenges of continuous updating in highly dynamic knowledge domains are discussed. A SWOT-type analysis explores the initiative's strengths and weaknesses, highlighting opportunities for expansion to new themes and audiences. Concrete examples, such as the Windows dedicated to COVID-19, Mpox, health promotion and the commercial dimension of the determinants of health, illustrate how digital curation can support public policies, health education and evidence-informed decision-making. Finally, the chapter proposes recommendations to strengthen similar initiatives in other institutional contexts.

Keywords: Digital Curation. Health Information. Infodemic. Virtual Health Library (VHL). Windows of Knowledge (BIREME/PAHO/WHO).

RESUMO

Em um contexto marcado por uma infodemia e pela ampla circulação de conteúdos de baixa qualidade, a curadoria digital torna-se uma estratégia central para garantir o acesso a informações confiáveis em saúde. Este capítulo analisa as Janelas do Conhecimento (WoK) da BIREME/OPAS/OMS como um exemplo concreto de infraestrutura de curadoria implementada no âmbito da Biblioteca Virtual em Saúde. Com base em uma revisão de literatura sobre curadoria digital, ciclo de vida da informação e modelos de preservação, combinada a documentos técnicos institucionais, examina-se a arquitetura informacional das Janelas, seus fluxos de seleção, validação e atualização de conteúdos, bem como os requisitos técnicos e organizacionais para sua manutenção. São discutidas questões como usabilidade, acessibilidade, interoperabilidade com outras plataformas de saúde e os desafios da atualização contínua em domínios de conhecimento altamente dinâmicos. Uma análise do tipo SWOT explora as forças e as fragilidades da iniciativa, destacando

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oportunidades de expansão para novos temas e públicos. Exemplos concretos, como as Janelas dedicadas à COVID-19, Mpox, promoção da saúde e à dimensão comercial dos determinantes da saúde, ilustram como a curadoria digital pode apoiar políticas públicas, educação em saúde e a tomada de decisão informada por evidências. Por fim, o capítulo propõe recomendações para fortalecer iniciativas semelhantes em outros contextos institucionais.

Palavras-chave: Curadoria Digital. Informação em Saúde. Infodemia. Biblioteca Virtual em Saúde (BVS). Janelas do Conhecimento (BIREME/OPAS/OMS).

RESUMEN

En un contexto marcado por una infodemia y la amplia circulación de contenidos de baja calidad, la curaduría digital se convierte en una estrategia central para garantizar el acceso a información confiable en salud. Este capítulo analiza las Ventanas del Conocimiento (WoK) de BIREME/OPS/OMS como un ejemplo concreto de infraestructura de curaduría implementada en el marco de la Biblioteca Virtual en Salud. A partir de una revisión de la literatura sobre curaduría digital, ciclo de vida de la información y modelos de preservación, combinada con documentos técnicos institucionales, se examina la arquitectura informacional de las Ventanas, sus flujos de selección, validación y actualización de contenidos, así como los requisitos técnicos y organizativos necesarios para su mantenimiento. Se discuten aspectos como usabilidad, accesibilidad, interoperabilidad con otras plataformas de salud y los desafíos de la actualización continua en dominios de conocimiento altamente dinámicos. Un análisis de tipo FODA explora las fortalezas y debilidades de la iniciativa, destacando oportunidades de expansión hacia nuevos temas y públicos. Ejemplos concretos, como las Ventanas dedicadas a COVID-19, Mpox, promoción de la salud y a la dimensión comercial de los determinantes de la salud, ilustran cómo la curaduría digital puede apoyar las políticas públicas, la educación en salud y la toma de decisiones informada por evidencia. Finalmente, el capítulo propone recomendaciones para fortalecer iniciativas similares en otros contextos institucionales.

Palabras clave: Curaduría Digital. Información en Salud. Infodemia. Biblioteca Virtual en Salud (BVS). Ventanas del Conocimiento (BIREME/OPS/OMS).

1 INTRODUCTION

Information curation in healthcare is a crucial strategy for combating misinformation, especially given the escalating production and dissemination of unverified content. The explosion of digital data and the swift circulation of inaccurate information highlight the indispensable need for mechanisms that ensure access to reliable, evidence-based content. As Tredinnick (2006) argues, "the dematerialisation of information has reduced dissemination costs, but has also compromised the authenticity and traceability of content" (Tredinnick, 2006, p. 106). The democratisation of access to information necessitates effective strategies to minimise the impact of misinformation (Tredinnick, 2016).

Floridi (2013) observes that "ICTs have profoundly affected many aspects of the human condition, including the nature of communication, education, work, entertainment, industrial production and business, healthcare, social relations, and armed conflict" (Floridi, 2013, p. 17). Within the health sector, these changes carry critical implications, as misinformation can lead to misguided decisions, directly affecting public health and well-being (Vosoughi, Roy & Aral, 2018). Furthermore, Floridi (2013) stresses that "freedom of expression in the digital age must be balanced with the responsibility to avoid harm caused by intentional misinformation". The World Health Organisation (WHO) cautions that health misinformation represents one of the primary global threats, particularly during events like pandemics, where the spread of false news can undermine the effectiveness of preventative and therapeutic measures (WHO, 2021).

In this context, health information curation emerges as an essential practice to ensure that healthcare professionals, managers and the general public have access to trustworthy, evidence-based content. Wardle and Derakhshan (2017) highlight that content curation and digital curation are complementary processes involving the selection, organisation, preservation, and provision of information, aiming to add value and facilitate access to reliable data. UNESCO (2003), in its Charter on the Preservation of Digital Heritage, emphasises the necessity of preserving both born-digital data and digitised analogue sources. While content curation focuses on reducing informational noise through expert validation, ensuring information accuracy, digital curation extends this scope by managing digital assets throughout their lifecycle. This process includes data collection, preservation, and value enhancement for present and future use (Beagrie, 2008). In the realm of health information, these practices are fundamental for the efficient management of the vast volume of data generated in the sector, ensuring its accessibility, reliability, and long-term preservation.

Against this backdrop, the Windows of Knowledge (WoK) of the Latin American and Caribbean Centre on Health Sciences Information (BIREME) stands out as a structured tool designed to facilitate the organisation and provision of validated information, promoting qualified access to knowledge. The hypothesis of this study is that the WoK can be considered an efficient model for health information curation, playing a significant role in mitigating the effects of misinformation by delivering validated, systematically organised, and accessible content to diverse audiences. To test this hypothesis, a literature review was conducted in recognised databases, including PubMed, LILACS, and BRAPCI, using keywords such as "Digital curation", "Information curation", and "Digital libraries" in Portuguese and English. Additionally, technical documents from BIREME, such as the Windows of Knowledge: Customisation and Creation Guide (BIREME/PAHO/WHO, 2020), were consulted.

Tools like the Windows of Knowledge exemplify the practical application of digital curation, offering an organised and accessible platform for disseminating reliable health information, free of charge to the user (BIREME/PAHO/WHO, 2020). The WoKs are a strategic resource of the Virtual Health Library (VHL), specifically designed to highlight selected documents and information resources on pertinent topics. Functioning as a Knowledge Window, it draws attention to a representative collection of content, which may or may not be associated with a VHL Network Instance Portal. Following its own methodology, WoKs provide direct access to documents indexed in VHL information sources, alongside links to pre-defined search strategies, external sources, and content updated via RSS, such as blogs, epidemiological bulletins, and news. This approach ensures quick and reliable access to relevant information. Furthermore, content is delivered in a variety of formats, including videos, infographics, and infometrics, enhancing comprehension and usability for diverse audiences.

A study published in *The Lancet* highlighted that during the COVID-19 pandemic, over 80% of information shared on social media about the virus was inaccurate or false (Brennen et al., 2020). This scenario underscores the need for initiatives that promote the curation of reliable content, such as the WoK, which has already been used to highlight validated information on topics like universal health and infectious diseases (BIREME/PAHO/WHO, 2020). Moreover, WHO data indicates that health misinformation directly impacts adherence to treatments and vaccines. In 2019, for instance, vaccine hesitancy was deemed one of the

top ten global health threats, with misinformation being a primary contributing factor (WHO, 2019).

Given these challenges, digital curation in health information context is a vital strategy for promoting health education and combating misinformation. WoKs represent a crucial tool in this process, enabling the organisation and dissemination of validated scientific content, thereby contributing to evidence-based decision-making and the improvement of public health.

2 FOUNDATIONS OF DIGITAL INFORMATION CURATION

Information curation, particularly in the digital sphere, is a field demanding an interdisciplinary approach, integrating technical, theoretical, and practical aspects. According to Dallas (2015), digital curation extends beyond professional administration, encompassing a broad range of stakeholders including researchers, artists, users, and communities, as shared responsibility is vital for effective digital curation. Oliver and Harvey (2016) note the importance of "determining who the stakeholders in the curation process are, because each type of stakeholder is likely to have different knowledge, skills, and understandings about what the digital objects are and how they are used" (Harvey, 2016, p. 76). Tredinnick (2016) asserts that digital information curation must always strike a balance between the neutrality of knowledge organisation and the social responsibility of ensuring access to reliable information (Tredinnick, 2016, p. 224,).

Charles Esche points to inherent limitations and philosophical challenges within curatorial practice, particularly in artistic and cultural contexts (Martinon, 2013). Meanwhile, Harvey (2010) stresses the importance of a proactive approach, where data is planned and structured from its inception to guarantee its long-term utility. Tredinnick (2006) supports this notion, stating that "digital preservation is an essential aspect of information curation, ensuring the permanence of validated knowledge for future generations" (Tredinnick, 2016, p. 46). Floridi (2013) further reinforces this perspective, observing that "we will be in serious trouble if we do not take seriously the fact that we are building the new physical and intellectual environments that future generations will inhabit".

The Curation Lifecycle Model, developed by the Digital Curation Centre (DCC) – an institution dedicated to supporting and promoting digital curation – serves as a foundational approach, highlighting stages such as metadata creation. The principles underpinning this model include:

Holistic Approach: It considers the entire data lifecycle.

Focus on Preservation and Access: It ensures data remains useful and accessible.

Data Valorisation: It adds value to data for future reuse.

Collaboration: It involves various stakeholders in the process.

Adaptability: It can be applied across diverse contexts and disciplines.

Table 1 below summarises the main points of the DCC Curation Lifecycle Model:

Table 1

Main points of the DCC Curation Lifecycle Model

Category	Description
Full lifecycle actions	Apply to all stages of the lifecycle and are represented by four concentric rings in the model.
1. Description and representation information	Assign administrative, descriptive, technical, structural, and preservation metadata, using appropriate standards, to ensure adequate description and control over time. Collect and assign representation information.
2. Preservation planning	Plan preservation throughout the digital material's lifecycle, including plans for managing and administering all curation actions.
3. Community watch and participation	Monitor technological developments and participate in communities to ensure curation practices are up-to-date.
4. Curate and preserve	Perform management and administrative actions to promote curation and preservation throughout the lifecycle.
Sequential actions	Represent the main actions required to curate data as it moves through its lifecycle.
1. Conceptualise	Plan data creation, including defining preservation and reuse requirements.
2. Create or receive	Collect data and ensure it is properly structured and documented for preservation and reuse.
3. Appraise and select	Decide which data should be preserved based on criteria of value and utility.
4. Ingest	Add data to the repository, including assigning persistent identifiers, virus checking, and authenticity verification.
5. Preservation action	Apply preservation techniques, such as migration or emulation, to ensure data accessibility over time.
6. Store	Keep data in a secure and stable environment, with backups and multiple copies to ensure its integrity.
7. Access, use, and reuse	Ensure data is accessible and usable by authorised users, with metadata that facilitates its discovery and reuse.

8. Transform	Modify or reuse data to create new datasets, restarting the lifecycle.
Occasional actions	Actions that may be necessary under specific conditions, but do not apply to all data.
1. Reappraise	Re-evaluate data to determine if it is still relevant or should be discarded.
2. Dispose	Remove data that is no longer considered useful or relevant, following appropriate disposal policies.

Developed by the author based on Oliver and Harvey (2016, pp. 31-34)

According to Higgins (2008), the DCC Curation Lifecycle Model can serve as a valuable tool for planning curation and preservation activities in healthcare environments, ensuring the preservation and sharing of knowledge. This practical and methodological perspective is essential for addressing the technical challenges of digital curation, such as technological obsolescence and the fragility of digital objects. As the field evolves, there is a growing demand for professionals with specialised digital curation competencies, which can be particularly relevant for the effective management of health information in the digital age (Kim et al., 2013).

However, Martinon (2013) highlights Esche's view that curatorial practice is often constrained by external factors, such as financial and bureaucratic interests. He argues that while curation aspires to philosophical or aesthetic coherence, it is frequently compromised by the need to negotiate and manage these conflicting interests (Martinon, 2013, p. 24). This perspective from Esche underscores the tension between theory and practice in curation, a theme equally relevant in the context of digital curation. Both authors acknowledge the importance of reflection and critique in curation. Harvey (2010), for example, stresses the need to reflect on what curation truly means (Harvey, 2010). Both authors make a significant contribution to this discussion, as curation should not be viewed merely as an activity of organising exhibitions or events, but rather as an exploration of the potential for knowledge creation and critical reflection within this practice (Martinon, 2013, p. 241).

Another point of convergence between the authors is the significance of collaboration and knowledge sharing. Harvey (2010) highlights the necessity of a collaborative approach to digital curation, involving a variety of stakeholders, from scientists and researchers to librarians and archivists (Harvey, 2010, p. 93). Esche, in turn, suggests that curation should be a space for dialogue and exchange, where different perspectives and disciplines can converge (Martinon, 2013, p. 241). Despite these parallels, the authors also pinpoint distinct challenges. Harvey focuses on the technical and practical aspects of digital curation, such as

ensuring data accessibility and utility over time. He acknowledges that digital curation is an evolving field, where many practices and standards are still under development (Harvey, 2010, p. 55). This difference in emphasis reflects the multifaceted nature of the information curation process, as "digital curation not only organises information but assigns meaning and value to the knowledge generated" (Tredinnick, 2006, p. 184).

To facilitate understanding of the main concepts discussed by the authors, Table 2 below provides a structured overview of the practices, challenges, and theoretical perspectives related to information curation:

Table 2

Concepts of Curation (Harvey, 2010 and Martinon, 2013)

Concept	Definition/description	Example/practice	Challenges
Data lifecycle	The process encompassing data creation through to preservation and reuse.	Planning for "curation-ready" data from creation.	Ensuring data remains useful and accessible over time.
Metadata	Information describing data, including administrative and technical details, etc.	Creation of robust metadata to facilitate future discovery and use.	Maintaining consistency and utility of metadata across different contexts.
Digital preservation	Actions to keep data accessible beyond technological obsolescence.	Data migration to updated formats.	Dealing with rapid technological evolution and the fragility of digital formats.
Data reuse	Ensuring data can be effectively used in the future.	Open access policies and data sharing.	Balancing accessibility with privacy and copyright issues.
Collaboration and sharing	Joint work between different stakeholders to ensure effective curation.	Development of community standards and practices.	Coordinating efforts between disciplines and institutions with different priorities.
Critical reflection	Curation as an activity beyond mere organisation, exploring its potential for knowledge creation.	Questioning the limits of curation in bureaucratic contexts.	Overcoming financial and bureaucratic interests that restrict curatorial practice.
Risk management	Identifying and mitigating risks that threaten data integrity and accessibility.	Developing contingency plans for technological failures.	Anticipating and responding to unforeseen risks, such

			as natural disasters or hardware failures.
Curation as philosophical practice	Curation as a space for dialogue and reflection, not just organisation.	Exploring connections between science, art, and society.	Maintaining philosophical coherence in the face of external pressures, such as funding.
Access and authentication	Ensuring data is accessible only to authorised users.	Implementing access controls and authentication.	Balancing security with ease of access for legitimate users.
Data transformation	The process of adapting data for new uses or formats.	Data migration to new formats or creation of new datasets.	Maintaining data integrity and authenticity during transformation.

Developed by the author based on Harvey (2010) and Martinon (2013)

Information curation, especially in the digital context, is a complex field that demands a balanced approach between theory and practice. As highlighted in Table 1, curation involves a series of interconnected processes, from the data lifecycle to critical reflection on its role in knowledge creation. Harvey (2010) offers a practical and methodological perspective, emphasising the importance of practices such as creating robust metadata, digital preservation, and data reuse. These concepts are fundamental to understanding digital curation, which goes beyond simple data organisation, also encompassing risk management, data transformation, and ensuring access and authentication. However, the challenges are significant, including dealing with technological obsolescence, maintaining metadata consistency, balancing accessibility with privacy, and coordinating efforts across different disciplines and institutions.

Next, we will explore an analysis of the Windows of Knowledge (WoK) structure as a digital curation tool applied to the health sector. We will detail how the WoK was designed to organise and provide reliable and expert-validated information, facilitating quick and efficient access to relevant content.

3 ANALYSIS OF THE WINDOWS OF KNOWLEDGE STRUCTURE

The Windows of Knowledge (WoK) structure aims to highlight relevant and reliable information on specific health topics. It has been designed to facilitate quick and organised access to curated content, promoting the dissemination of expert-validated information. We will detail the WoKs structure, based on the customisation and creation guide

(BIREME/PAHO/WHO, 2020), highlighting its main areas, component layout, and the importance of expert collaboration in content curation.

The WoKs comprised of two main areas (Table 3): the component area and the content area. The component area is the initial section viewed by users and aims to draw attention to the topics covered through visual elements and quick links to supplementary information.

Table 3

Component Area of the Windows of Knowledge

Element	Description	Technical details	Recommendations
1.1 title	The title is the first element to be configured in the Knowledge Window. It should be clear, objective, and representative of the central theme.	Inserted into the WordPress editing field.	- short and direct title. - attract the target audience's attention. - facilitate navigation and content access.
1.2 main image	The main image is a central visual element, inserted via the WordPress post-thumbnail function.	Minimum dimensions: 320x320 pixels. Displayed in circular format in the Knowledge Window.	- choose clear images relevant to the theme. - ensure important content is visible in the circular format.
1.3 components	The Knowledge Window allows for the inclusion of up to 8 components, which are highlight boxes arranged around the main image. Each component is configured via a form with the following fields:		
1.3.1 public content	Defines whether the component will be displayed or hidden in the public interface.	Options: on (displayed) or off (hidden).	- use the off option for components under development or not intended for public display.
1.3.2 component title	A short and descriptive title for the component.	Recommended character limit: short and direct.	- clear and objective titles. - avoid long texts to improve readability.
1.3.3 text box	Optional area to include a small explanatory text about the component.	- simple text editor. - allows basic formatting.	- short and informative texts. - avoid overloading with unnecessary information.

1.3.4 link	Allows the insertion of URLs that direct to documents, pages, or specific sections of the site.	- internal or external links. - option to open in new window.	- use reliable and relevant links. - open in new window for external links.
1.3.5 title and icon colour	Visual customisation to highlight the component.	- selection of custom colours.	- choose colours that contrast with the background to improve visibility.
1.3.6 icon	Selection of icons from the Font Awesome library or insertion of custom images.	- pre-defined icons or URLs of images uploaded to the media area.	- choose icons that clearly represent the component's theme.
1.3.7 notes	Internal field for administrator annotations, not visible to the public.	- free text for internal use.	- use for annotations about the component's development or review.

Developed by the author based on the BIREME/PAHO/WHO Windows of Knowledge construction guide.

The components are arranged circularly around the main image, creating a visually appealing and functional layout. The order of components can be adjusted according to the relevance of the information, allowing for intuitive user navigation. This circular arrangement facilitates quick access to highlights, promoting an efficient and pleasant user experience.

The second area of the WoKs the content area, which permits the inclusion of detailed information about the topic addressed (Table 4). This area is divided into sections that can be configured according to content needs, using a simplified layout or WordPress's Page Builder for greater flexibility.

Table 4

Content Area of the Windows of Knowledge

Element	Description	Technical details	Recommendations
2.1 texts	the content area allows for the insertion of explanatory texts, which can be organised into one or two columns.	- WordPress text editor. - functionalities similar to a word processor.	- use headings and subheadings to organise content. - insert images to complement the text.
		- paragraph, heading, list formatting, and image insertion.	- customise background and text colours to improve readability.

2.2 infographics, images, charts, and tables	infographics and charts are powerful visual resources for transmitting complex information clearly and accessibly.	- insertion in up to three columns. - HTML codes for interactive infographics (e.g., Tableau).	- use clear and easily understandable infographics. - check compatibility with mobile devices.
		- some resources may not be compatible with mobile devices.	- avoid overloading the page with too many visual elements.
2.3 videos	the video area is compatible with platforms such as Youtube, allowing the insertion of up to three videos per section.	- insertion of video code (obtained from the Youtube url).	- choose short and relevant videos for the theme. - complement texts and infographics with videos.
		- multimedia functionality to enrich content.	- ensure videos are from reliable sources.
2.4 links to publications, documents, and related websites	the windows of knowledge allows for the inclusion of links to publications, documents, and websites related to the topic.	- organisation in up to three columns. - internal or external links.	- use reliable and relevant links. - direct to additional knowledge sources.
		- essential functionality to expand the reach of information.	- regularly check that links are functional and up-to-date.

Developed by the author based on the BIREME/PAHO/WHO Windows of Knowledge construction guide.

The content area is highly flexible, allowing for the organisation of texts, infographics, videos, and links into columns (1 to 3), depending on the topic's requirements. The column layout facilitates reading and navigation, ensuring that users find information quickly and intuitively. The combination of different formats (text, images, videos, and links) offers a multimedia experience, enriching the content and engaging the audience.

The arrangement of components and the organisation of content within the WoK have been designed to ensure an intuitive and efficient user experience. The component area, with its circular and visually appealing layout, draws attention to the key highlights of the topic. Conversely, the content area offers a flexible structure that can be adapted to meet the specific needs of each Knowledge Window.

Content curation in the WoKs a process involving the collaboration of specialists in the subject matter. These professionals are responsible for selecting, validating, and reviewing the information to be included in the Knowledge Window, ensuring that the content is accurate, up-to-date, and relevant. The participation of experts is fundamental to ensure the reliability of information, especially in critical areas like health, where misinformation can have severe impacts. Furthermore, peer review and content validation by qualified professionals enhance the WOK 's credibility, making it a reliable source of information for researchers, healthcare professionals, and the general public (Packer et al., 2014).

The WOK 's structure, with its component and content areas, has been designed to promote quick and reliable access to relevant health information. The visually appealing arrangement of components, combined with the flexibility of the content area, facilitates navigation and comprehension of the information. Moreover, the collaboration of experts in content curation and review ensures the accuracy and reliability of the information provided. This structure not only meets the needs of health information management but also positions itself as a strategic tool in combating misinformation, promoting the dissemination of validated and accessible knowledge.

4 WINDOWS OF KNOWLEDGE: STRUCTURE, IMPLEMENTATION AND TECHNICAL CHALLENGES

Implementing the WoK requires technical knowledge of WordPress and HTML (HyperText Markup Language), as the platform is built and managed within this environment. WordPress is a powerful tool, but its configuration and customisation demand familiarity with its interface, plugins, and functionalities. Additionally, Cascading Style Sheets (CSS) adjustments are frequently necessary to ensure a consistent and appealing design for the Knowledge Window.

Difficulty for inexperienced users: Healthcare professionals or content curators unfamiliar with WordPress or HTML may encounter difficulties in configuring and updating the Knowledge Window, relying on developers for basic tasks.

Reliance on technical support: A lack of in-house technical knowledge can lead to delays in implementing new functionalities or resolving issues, increasing dependence on third parties.

Additional costs: Hiring professionals specialising in WordPress and HTML can incur additional costs, particularly for institutions with limited resources.

The WoK requires constant updating to ensure that the information provided remains relevant and reliable. This involves periodic review of texts, replacement of outdated data, and inclusion of new resources, such as infographics, videos, and links.

- **Time and resource demands:** Maintaining an up-to-date Knowledge Window necessitates a dedicated team and an organised workflow, which can be challenging for institutions with limited human resources.
- **Risk of obsolescence:** If content is not regularly reviewed, the Knowledge Window may lose credibility, especially in dynamic areas like health, where new research and discoveries are frequent.
- **Impact on reliability:** Outdated information can lead to erroneous decisions by users, particularly in critical contexts such as public health.

The WOK must be compatible with mobile devices, such as smartphones and tablets, to ensure users can access information from anywhere. However, some features, like interactive infographics generated by tools such as Tableau, may not function correctly on mobile devices.

- **Compromised user experience:** If the Knowledge Window is not responsive or if some features do not work on mobile devices, users may struggle to access and interact with the content.
- **Loss of audience:** With the increasing use of mobile devices for internet access, a lack of compatibility can result in the loss of a significant audience.
- **Need for technical adjustments:** Ensuring compatibility with mobile devices requires testing and technical adjustments, which can increase the complexity and cost of platform maintenance.
- Technical maintenance of the WOKs essential to ensure continuous operation and data security. This includes regular updates to WordPress, plugins, and themes, as well as periodic backups.
- **Risk of vulnerabilities:** Outdated platforms can be targets for cyberattacks, compromising data security and the integrity of the Knowledge Window.
- **Time and resources for maintenance:** Technical maintenance demands dedicated time and resources, which can be challenging for small teams or those with multiple responsibilities.
- **Impact on availability:** Technical failures or security issues can result in periods of Knowledge Window downtime, hindering user access to information.

The WoK must be accessible to all users, including those with visual, auditory, or motor impairments. This necessitates the implementation of accessibility guidelines, such as the Web Content Accessibility Guidelines (WCAG), and conducting usability tests.

Complexity of implementation: Ensuring accessibility can require significant technical adjustments, such as including alternative descriptions for images and guaranteeing keyboard navigation.

Additional costs: Implementing accessibility features can generate additional costs, especially if it is necessary to hire digital accessibility specialists.

Impact on user experience: A platform that is not accessible can exclude part of the target audience, particularly in health contexts, where information is crucial for everyone.

The technical issues mentioned in Table 5 represent significant challenges for the implementation and maintenance of the WoK. These challenges have direct implications for the platform's effectiveness, user experience, and the reliability of the information provided. To overcome these obstacles, it is essential to invest in training, planning, and technical resources, as well as fostering collaboration among professionals from different areas. Addressing these technical problems will not only ensure the WoK 's success but also strengthen its role as an essential tool for disseminating reliable health information.

Table 5

Challenges for the Implementation of the Windows of Knowledge

Aspect	Description	Challenges	Considerations and solutions
5.1 technical knowledge	Implementing the windows of knowledge requires knowledge of WordPress and HTML to configure and customise the platform.	Difficulty for users without experience in WordPress or HTML. Need for CSS adjustments.	Offer training for teams. Rely on support from developers or IT professionals.
5.2 constant content updates	The relevance and reliability of information depend on constant content updates.	Keeping content updated requires time and resources. Risk of outdated information.	Establish a schedule for periodic review. Designate a team responsible for updating.
5.3 collaboration between professionals	The effectiveness of the Knowledge Window depends on collaboration between information professionals,	Difficulty coordinating between different areas of expertise.	Promote regular meetings between teams. Define clear roles and responsibilities.

	health specialists, and developers.	Communication between teams.	
5.4 accessibility and usability	The platform must be accessible and usable for different audiences, including people with disabilities and users with varying levels of technological familiarity.	Ensure accessibility for people with visual or motor disabilities. Intuitive interface.	Follow accessibility guidelines (e.g., WCAG). Conduct usability tests with different audiences.
5.5 mobile device compatibility	The Knowledge Window must be compatible with mobile devices, ensuring a consistent user experience across different platforms.	Some features, such as interactive infographics, may not work well on mobile devices.	Test the Knowledge Window on different devices and browsers. Prioritise the use of responsive features.
5.6 technical maintenance	Technical maintenance of the platform is essential to ensure continuous operation and data security.	Need for regular WordPress and plugin updates. Risk of security vulnerabilities.	Implement a regular technical maintenance plan. Perform periodic data backups.

Developed by the author based on the BIREME/PAHO/WHO Windows of Knowledge construction guide.

The Windows of Knowledge plays a vital role in disseminating reliable health information; however, its implementation and maintenance present challenges that require structured approaches to ensure efficiency and sustainability over time. To address these challenges, several fundamental strategies have been established, encompassing training and capacity building, continuous updating, interdisciplinary collaboration, usability and accessibility, and technical monitoring.

Staff training is one of the primary aspects to ensure that professionals responsible for the Knowledge Window are proficient in the tools used, such as WordPress and HTML, as well as possessing knowledge of information curation. Continuous training allows for technical and editorial adjustments to be made autonomously, reducing reliance on external support and ensuring greater agility in content updates. Additionally, team training should include best practices for information organisation, ensuring that data is presented clearly and accessibly to the target audience.

Constant content updates are a critical factor for the Knowledge Window's credibility. Defining a schedule for periodic reviews enables the maintenance of information relevance, ensuring that new scientific findings are incorporated and that links and references are regularly verified. This strategy prevents content obsolescence and strengthens user trust in

the platform. The implementation of this schedule should consider the update frequency of each topic covered, prioritising areas of greater impact and dynamism.

Interdisciplinary collaboration is another essential pillar for the WoK's success. Information professionals, health specialists, and developers must work in an integrated manner, ensuring that informational needs are met with adequate technical support. Clearly defining roles and responsibilities within the team contributes to a more efficient workflow and reduces communication barriers between different areas. Holding regular meetings to align strategies and share best practices is an effective approach to enhance this collaboration.

The usability and accessibility of the Knowledge Window are fundamental aspects for expanding its reach and ensuring that all audiences can use the platform intuitively and efficiently. Adopting international guidelines, such as the Web Content Accessibility Guidelines (WCAG), ensures that people with visual, auditory, or motor impairments can access information inclusively. Regular usability and accessibility tests should be conducted to identify and correct any barriers, ensuring fluid navigation and an optimised user experience.

Finally, continuous technical monitoring of the platform is essential to ensure its stability and security. Regular updates to WordPress, plugins, and themes are necessary to prevent vulnerabilities and potential malfunctions. Additionally, performing periodic backups protects data against loss and ensures rapid information recovery in case of failures. Performance monitoring is also a crucial strategy for identifying potential loading or navigation issues, allowing for proactive adjustments that improve the user experience. Implementing these strategies strengthens the WoK's reliability and sustainability, ensuring it continues to fulfil its role of providing quality information and combating misinformation in the health sector.

BIREME's WoK plays a role in health information curation, promoting access to reliable and evidence-based content. However, like any digital tool, it presents both positive aspects and challenges that can impact its effectiveness. Table 6 below summarises the main positive aspects and challenges faced by the WoK.

Table 6

Main positive aspects and challenges faced by the WoK

Aspect	Strengths	Challenges
Quality of information	Content validated by specialists and based on scientific evidence.	Need for continuous updating to avoid misinformation.

Usability	Intuitive interface and organised navigation.	Some functionalities require technical knowledge for configuration.
Accessibility	Available online and compatible with multiple platforms.	Not all content adheres to rigorous digital accessibility standards.
Interactivity	Use of videos, infographics, and links to reliable sources.	Some interactive functionalities are not optimised for mobile devices.
Updating	Possibility of continuous review through specialised curation.	Dependence on a qualified team to keep the platform always updated.
Visibility	Resource widely disseminated within the VHL and health information networks.	Low indexing in search engines can limit its reach.
Technical infrastructure	Based on WordPress, allowing customisation and scalability.	Requires constant maintenance to ensure security and stability.

Source: Developed by the author

Digital information curation requires a set of best practices to ensure the accessibility, preservation, and dissemination of knowledge. According to Harvey (2010), digital curation should follow well-established guidelines to ensure its effectiveness. Table 7 below presents which best practices are incorporated by the WoK and which need to be improved:

Table 7

Best practices incorporated by the WoK

Curation practice (Harvey, 2010)	Present in wok	Absent or to be improved
Curation planning from content creation	Yes	
Creation of structured metadata for better information retrieval	Yes	
Digital preservation to ensure content longevity	Partially	Lacks a robust long-term preservation plan.
Use of digital accessibility standards (WCAG)	Partially	Not all content strictly follows accessibility guidelines.
Continuous updating and validation by specialists	Yes	
Enhanced indexing for efficient information retrieval	Partially	Low indexing in search engines limits content reach.
Guarantee of interoperability with other health information platforms	Yes	
Strategies for user engagement with content curation	Partially	There could be greater interaction with the public for information customisation.

Source: Developed by the author based on Harvey (2010).

The table highlights that while the WoK adheres to several best curation practices, there are significant opportunities for improvement, particularly in digital preservation, accessibility, and information indexing. Investing in these aspects can ensure greater sustainability and efficiency in knowledge dissemination.

SWOT Analysis is a strategic tool used to evaluate the main internal and external factors impacting an organisation, project, or initiative. Its name derives from the words Strengths, Weaknesses, Opportunities, and Threats. This methodology provides a structured view of organisational reality, identifying internal strengths and weaknesses, as well as external opportunities and threats.

The application process primarily involves analysing internal factors, evaluating resources, capabilities, structure, and processes that confer a competitive advantage or represent challenges. Subsequently, the external environment is considered, identifying growth opportunities, technological advancements, political and economic changes, as well as potential threats that could compromise strategic objectives. The identified elements are organised into a matrix, facilitating the visualisation of interactions between strengths,

weaknesses, opportunities, and threats (Table 8). Based on this analysis, strategies are developed to leverage strengths, mitigate weaknesses, explore opportunities, and minimise external risks. The importance of SWOT analysis lies in its ability to guide strategic decision-making, offering a comprehensive view of the organisation and allowing the alignment of actions according to the internal and external context. In the case of the WoK, this tool can be essential for improving information curation, strengthening content reliability, and expanding its impact in combating misinformation, ensuring that its potential is maximised and its challenges are managed efficiently.

Table 8

SWOT Analysis

Strengths:	Opportunities:
Reliable and evidence-based content curation. User-friendly interface and free access.	Expansion of the initiative to other health areas. Greater collaboration among specialists for continuous review.
Use of multiple formats for information presentation.	Better indexing and dissemination on external platforms.
Weaknesses:	Threats:
Dependence on technical staff for updates and maintenance.	Risk of disseminating outdated information if curation is not continuous.
Some limitations in digital accessibility.	Dependence on digital infrastructure and technical support.
Interactive resources may present issues on mobile devices.	Competition with less reliable but broader-reaching information sources.

Source: Developed by the author.

Based on the SWOT analysis, several strategies can be implemented to strengthen the WoKs and mitigate the identified challenges:

- **optimisation of indexing:** Improve visibility in search engines, ensuring that WoKs reach a larger audience.
- **Continuous training:** Offer periodic training for librarians and content curators, ensuring continuous updating of the platform.
- **Reinforcement of accessibility:** Implement rigorous guidelines to make content more accessible, following international standards such as WCAG.
- **Digital preservation plan:** Create guidelines to ensure the maintenance and longevity of stored content.
- **User engagement:** Develop strategies for interaction and content personalisation to increase public participation.

- **Regular technical monitoring:** Establish a schedule for preventive maintenance to prevent platform failures and ensure stability.
- **Institutional partnerships:** Expand the network of specialists involved in content review and validation, strengthening the platform's credibility.

Adopting these strategies can significantly enhance the efficiency of the Windows of Knowledges, consolidating them as an essential tool for health information curation and combating misinformation.

5 WINDOWS OF KNOWLEDGE IN PRACTICE: PUBLIC HEALTH USE CASES

The Windows of Knowledge on the Natural History of COVID-19, launched in September 2021, exemplifies how scientific information can be organised and made available in an accessible and reliable manner. Developed in partnership between the Latin American and Caribbean Centre on Health Sciences Information (BIREME/PAHO/WHO) and the Brazilian Ministry of Health, the WoK provides a curated collection of scientific studies and updated data on COVID-19, organised by disease phases such as transmission, incubation period, antibody production, and cytokine storm (BIREME/PAHO/WHO, 2021).

The WoK distinguishes itself by providing evidence-based content, validated by specialists, and organised clearly and accessibly. Its structure allows information to be presented objectively, minimising ambiguities and facilitating public understanding. Furthermore, the use of multiple formats, such as explanatory texts, infographics, and videos, enables greater engagement, making access to knowledge more dynamic and appealing (BIREME/PAHO/WHO, 2021).

The application of the WoK in awareness campaigns is a practical example of its relevance. During the COVID-19 pandemic, the platform was used to disseminate accurate information on preventive measures, vaccine efficacy, and combating myths and misinformation about virus contagion. This model can be replicated in other health areas, promoting education on topics such as immunisation, mental health, and nutrition (BIREME/PAHO/WHO, 2021).

Alessandra Siqueira, director of the Ministry of Health's Department of Science and Technology, highlighted the importance of facilitated access to scientific information as a means of achieving the department's mission. Rosana Leite, the extraordinary secretary for COVID-19 response, also emphasised that solid evidence bases are "indispensable" for work in the health field (BIREME/PAHO/WHO, 2021).

Beyond its use in combating COVID-19 misinformation, the WoK has been applied in various other public health areas. The Windows of Knowledge on the Commercial Dimension of Social Determinants of Health (DCDSS), launched in November 2021, addresses how commercial practices can negatively impact health, particularly regarding the consumption of unhealthy products. This Knowledge Window was developed in collaboration with over 50 specialists and aims to support public policies that reduce the consumption of health-harming products (BIREME/PAHO/WHO, 2021).

Another relevant application is Windows of Knowledge on Health Promotion, launched in December 2023. This platform brings together institutional documents from 25 countries in Latin America and the Caribbean, offering updated resources for implementing health promotion strategies within the context of the Sustainable Development Goals (SDGs). The Knowledge Window includes materials on healthy municipalities, health-promoting schools, and healthy work environments, among other topics (BIREME/PAHO/WHO, 2023).

More recently, in September 2024, the Windows of Knowledge on Mpox was updated to provide current information on the global disease outbreak, declared a Public Health Emergency of International Concern (PHEIC) by the WHO. The platform offers clinical guidelines, treatment protocols, and resources for epidemiological surveillance, aiming to support a coordinated response to the outbreak (BIREME/PAHO/WHO, 2024).

These examples demonstrate the WoKs potential in various public health areas. From the launch of the Windows of Knowledge on the Natural History of COVID-19, which provided crucial information for pandemic response, to the Knowledge Window on the Commercial Dimension of Social Determinants of Health (DCDSS), which addressed the impacts of commercial practices on health, the platform has proven versatile and adaptable to emerging needs. Furthermore, the Knowledge Window on Health Promotion and the recent update of the Knowledge Window on Mpox reinforce the WoK 's role as a dynamic and up-to-date tool, capable of responding to global health challenges with agility and precision.

The WoKs importance extends beyond merely providing information. It acts as a facilitator for building evidence syntheses, supports informed public policy formulation, and promotes health education broadly and inclusively. By offering content in multiple formats, such as texts, infographics, and videos, the WoK reaches diverse audiences, from healthcare professionals and researchers to the general population, democratising access to scientific knowledge.

Collaboration between institutions such as BIREME/PAHO/WHO, the Brazilian Ministry of Health, and specialists from various fields has been fundamental to the WoKs success. This partnership not only ensures the quality and reliability of the information provided but also strengthens the network of technical cooperation in health, promoting the exchange of knowledge and experiences among countries and regions. Therefore, the Windows of Knowledge is not merely an information platform, but a transformative tool that contributes to building a more informed, healthy, and resilient society. Its continuous development and expansion are fundamental for addressing public health challenges.

6 CONCLUDING REMARKS

This research addressed the Windows of Knowledge (WoK) created by BIREME, aiming to evaluate its capacity as a digital curation tool in the health sector. The choice of topic is justified by the growing need for effective strategies to ensure access to reliable information, particularly in an infodemic scenario. The study allowed for an analysis of how the WoK fits into this context and contributes to the organisation and dissemination of validated information, promoting qualified access to knowledge.

The main objective of this research was to understand the WoKs structure and functionality, evaluate its effectiveness in digital curation, and identify challenges and possibilities for improvement. Throughout the analysis, it was possible to demonstrate that the WoK adheres to the principles of digital curation by selecting, organising, and providing relevant information for different audiences, but challenges such as the need for continuous updates and digital accessibility require greater attention. The methodology employed in the research included a literature review and the study of BIREME's technical guidelines, which allowed for mapping the main advances and challenges of the tool according to best practices as conceptualised in the literature on digital curation. The WoK was confirmed as an important tool in information organisation and access to reliable content, as it follows a significant portion of these information curation practice guidelines.

The initial hypothesis of the research was that the WoK could be considered an efficient model for digital health information curation, capable of minimising the impacts of misinformation. The results partially confirm this hypothesis: although the WoK exhibits fundamental qualities for digital curation according to the principles of this technique, there is a need for technical and operational enhancements. The implementation of stricter guidelines for accessibility and content updating can further strengthen its performance; however, its

importance is already evident when considering practical examples of its activity, such as the Windows of Knowledges on Health Promotion, Mpox, the Commercial Dimension of Social Determinants of Health, and the Natural History of COVID-19. The cited examples demonstrate how developing strategies to increase the visibility and engagement of the scientific community with the WoK can also contribute to its consolidation as a reference in digital curation.

We conclude that the WoK, as a strategic tool of BIREME, plays an essential role in this scenario and, with the necessary adaptations, has the potential to establish itself as a model of excellence in digital health information curation.

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THE (IN)VALIDITY OF BINDING PRECEDENT Nº. 4 OF THE STF: ANALYSIS OF THE VIOLATION OF FUNDAMENTAL RIGHTS AND THE REQUIREMENT FOR CANCELLATION

A (IN)VALIDADE DA SÚMULA VINCULANTE Nº 4 DO STF: ANÁLISE DA VIOLAÇÃO AOS DIREITOS FUNDAMENTAIS E A EXIGÊNCIA DE CANCELAMENTO

LA (IN)NULIDAD DEL PRECEDENTE VINCULANTE Nº 4 DE LA CORTE SUPREMA DE BRASIL: ANÁLISIS DE LA VIOLACIÓN DE DERECHOS FUNDAMENTALES Y LA EXIGENCIA DE CANCELACIÓN

 <https://doi.org/10.56238/sevened2025.036-084>

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ABSTRACT

This article aims to analyze and demonstrate that Binding Precedent No. 4, of the Federal Supreme Court, does not meet the minimum requirements for existence, did not follow all formal procedures for creation and did not observe some of the fundamental principles and rights established in the 1988 Constitution, and should, for these reasons, be canceled from the legal system and replaced by another formally adequate statement. The methodology used will be qualitative, bibliographical and documentary.

Keywords: Binding Precedent No. 4. Minimum Wage. Fundamental Principles. Fundamental Social Principles and Rights.

RESUMO

Este artigo se propõe a analisar e a demonstrar que a Súmula Vinculante nº 4, do Supremo Tribunal Federal, não reúne os requisitos mínimos de existência, não seguiu todos os procedimentos formais de criação e não observou alguns dos princípios e direitos fundamentais estabelecidos na Constituição de 1988, devendo, por tais motivos, ser cancelada do ordenamento jurídico e substituída por outro enunciado formalmente adequado. A metodologia empregada será qualitativa, bibliográfica e documental.

Palavras-chave: Súmula Vinculante nº 4. Salário-mínimo. Princípios Fundamentais. Direitos Fundamentais Sociais.

RESUMEN

Este artículo tiene como objetivo analizar y demostrar que el Precedente Vinculante n.º 4 del Supremo Tribunal Federal no cumple con los requisitos mínimos para su existencia, no siguió todos los procedimientos formales para su creación y no respetó algunos de los principios y

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derechos fundamentales establecidos en la Constitución de 1988. Por lo tanto, debería ser cancelado del ordenamiento jurídico y reemplazado por otro que sea formalmente adecuado. La metodología empleada será cualitativa, bibliográfica y documental.

Palabras clave: Precedente Vinculante n.º 4. Salario Mínimo. Principios Fundamentales. Derechos Sociales Fundamentales.

1 INTRODUCTION

The binding precedent was introduced into the Constitution (BRASIL, 1998) by Constitutional Amendment No. 45 of 2004 (BRASIL, 2004), which became known as the "Reform of the Judiciary". It served to bring the Brazilian legal system (*civil law*³) closer to the *common law*⁴, by conferring normative force to certain judgments handed down by the Federal Supreme Court. It also changed the Constitutional arrangement of the separation of powers, to the extent that the Legislative Branch accepted to share its function of creating general and abstract norms with the Judiciary, based on the repeated creation of individual and concrete norms.

However, in order to avoid abuses and violations of the fundamental constitutional principles of the Democratic Rule of Law and, notably, of the separation of powers, it is essential that the Federal Supreme Court, when creating binding precedents, strictly remain within the formal and material limits that were established by the Constitution and by Law No. 11,417⁵ (BRASIL, 2006), which serve as a guarantee that the independence and harmony between the Powers will not be shaken, considering that binding precedents can only be approved when there is a current controversy, on certain norms, causing serious legal uncertainty and a relevant multiplication of lawsuits on the same issue.

According to article 103-A, *caput*, §§ 1 to 3, of the Constitution, inserted by Constitutional Amendment No. 45, the Federal Supreme Court may, *ex officio* or by provocation, by decision of two-thirds of its members, after repeated decisions on constitutional matters, approve a precedent that, as of its publication in the official press, will have binding effect in relation to the other organs of the Judiciary and the direct and indirect public administration. at the federal, state and municipal levels, as well as to review or cancel it. The precedent will aim at the validity, interpretation and effectiveness of certain rules, about which there is a current controversy between judicial bodies or between them and the public administration that causes serious legal uncertainty and a relevant multiplication of lawsuits on the same issue. A complaint will be filed with the Federal Supreme Court against the

³ The Brazilian legal system has traditionally been part of the *civil law* family (Roman-Germanic law), where the main source of law is written law (codes and statutes), and judicial decisions (jurisprudence) have a secondary and non-binding role for other cases.

⁴ *Common law* (Anglo-Saxon law) is characterized by the prevalence of judicial precedents (jurisprudence), following the rule of *stare decisis* (decision taken must be maintained). In this system, the decision of a higher court in a specific case is mandatory for lower courts to comply with in similar cases.

⁵ Regulates article 103-A of the Federal Constitution and amends Law No. 9,784, of January 29, 1999, regulating the edition, revision and cancellation of the statement of binding precedents by the Federal Supreme Court, and provides for other provisions.

administrative act or judicial decision that contradicts the applicable precedent or that improperly applies it.

Binding Precedent No. 4 (Brasil, STF, 2008, n.p.), unanimously approved by the Federal Supreme Court, based on the judgment of Extraordinary Appeal No. 565,714 (Brasil, STF, 2008, p. 1260.), establishes that, "Except in the cases provided for in the Constitution, the minimum wage cannot be used as an index of the basis for calculating the advantage of a public servant or employee, nor be replaced by a judicial decision".

This research is based on the following legal problem: can Binding Precedent No. 4 be considered existing, formally valid and materially compatible with the fundamental principles and rights established in the 1988 Constitution?

From this problem, three hypotheses were raised that will be addressed in the course of the work. First, Binding Precedent No. 4 does not meet the minimum requirements to exist in the legal world. Second, the approval of Binding Precedent No. 4 did not follow all the formal parameters established in the Constitution and in Law No. 11,417 of 2006. Third, Binding Precedent No. 4 ignored some of the fundamental principles and rights.

The dialectical and deductive methods will be used. The dialectic is based on the critical analysis of Binding Precedent No. 4 in relation to constitutional principles, aiming to identify conflicts and propose changes in the legal reality. The deductive will demonstrate that fundamental rights were violated by the Supreme Court's decision.

The research, with a qualitative approach, will analyze the contents, meanings and social impacts of Binding Precedent No. 4 through a bibliographic (doctrine) and documentary (legislation and jurisprudence) review.

2 THE ISSUE THAT GAVE RISE TO BINDING PRECEDENT NO. 4

The decision to approve Binding Precedent No. 4 (Brasil, STF, 2008, n.p.) occurred at the end of the judgment of Extraordinary Appeal No. 565.715 (Brasil, STF, 2008), which had been filed by military police officers against the State of São Paulo, against the Judgment that had dismissed the Appeal they handled against the judgment of dismissal, rendered in the Ordinary Action of Obligation to Do, which aimed to condemn the São Paulo Treasury to calculate the unhealthy bonus they received based on the remuneration or salaries of their positions, and not on the amount of two minimum wages, as stated in the governing legislation.

The police officers based the request on the merits of the preliminary ruling regarding the non-acceptance of article 3, paragraph 1, of Complementary Law No. 432, of 1985, of the State of São Paulo – which established that the basis for calculating the additional amount should be calculated on the amount of two minimum wages – by the rule of article 7, IV, final part, of the Constitution (BRASIL, 1988), which prohibits the indexation of the minimum wage for any purpose.

The claim was dismissed in the first instance, because the Single Judge understood that, even if the requested non-receipt was declared, it was not possible to increase salaries by means of a judicial decision, due to the principles of legality and separation of powers.

The military police officers filed an appeal with the Court of Appeals of São Paulo, which dismissed the appeal, by rejecting the preliminary question, based on a line of understanding, existing in the Federal Supreme Court, which considered that the adoption of the minimum wage as the basis for calculating the unhealthy bonus did not violate the constitutional prohibition of indexation of the minimum wage.

Dissatisfied with the decision rendered by the São Paulo Court, the military police filed the Extraordinary Appeal to the Federal Supreme Court, which was under the rapporteurship of Minister Cármen Lúcia, within the scope of the Full Body, which delivered the vote, which was accompanied by the Collegiate, obtaining a unanimous vote.

3 THE GROUNDS AND CONCLUSIONS OF EXTRAORDINARY APPEAL NO. 565,714

First, the Supreme Court recognized the General Repercussion in Extraordinary Appeal No. 565,714, generating Topic No. 25, with the title "Linking the unhealthy bonus to the minimum wage", and the following description: "Extraordinary appeal in which it discusses, in the light of article 7, IV, of the Federal Constitution (BRASIL, 1988), the revocation, or not, of article 3, sole paragraph, of São Paulo Complementary Law No. 432 (SÃO PAULO, 1985), which links the unhealthy bonus to the minimum wage, by the 1988 Constitution". (Brazil, STF, 2008, p. 1197)

Justice Cármen Lúcia began the vote by clarifying and demonstrating that, on the final part of item IV, of article 7, of the Constitution/88, numerous precedents could be presented, from the Supreme Court, in the sense of the unconstitutionality or non-reception of norms that use the minimum wage as a basis for calculating other earnings due to public and private workers.

The Magistrate cited, in this regard, several cases judged by the Court, between the years 1998 and 2008, dealing with the salary floor of professional categories, the inclusion of allowance or bonus, compensation for moral damages, the special pension, the administrative fine, the salary table of a state agency and the rates of social contributions. Upon reaching the central issue of the Appeal, referring to the calculation of the unhealthy allowance based on the minimum wage, the Rapporteur clarified that there were also numerous decisions within the scope of the Court, both for constitutionality and unconstitutionality.

From that moment on, she assumed the defense of the thesis of unconstitutionality (non-reception) of the questioned rule based on the basis extracted from Extraordinary Appeal No. 217,700 (Brasil, STF, 1999), which considered that the prohibition on indexation of the minimum wage was justified so as not to create obstacles to its increase, in view of the resulting chain of increases, which could pressure the occurrence of smaller adjustments to the minimum wage itself.

After rejecting the arguments alleged by the appellants, Justice Cármen Lúcia concluded her vote with the proposal to dismiss the Extraordinary Appeal, due to the declaration of non-reception of article 3, paragraph 1, of Complementary Law No. 432/1985, of the State of São Paulo, by the rule of article 7, IV, final part, of the Constitution/88.

This decision implied the suppression of the questioned rule (or at least in the calculation criterion) and the right of the appellants to receive the unhealthy bonus. However, the Rapporteur understood that the police officers could not lose this right and, therefore, restricted the meaning and scope of the declaratory decision to the criterion of the basis for calculating the additional payment, that is, the use of the minimum wage. As a result, the right to the unhealthy bonus would be without a basis for calculation. So, this situation forced the Court to act as a positive legislator, which would be denied through the wording of Binding Precedent No. 4. Thus, the ingenious solution that Minister Cármen Lúcia proposed, considered by her as "possible for the case", was to maintain the payment of the additional unhealthy pay in the amount of two salaries (in force at the time of the final and unappealable decision) and to link its future adjustments to the category.

The judgment was unanimous and gave rise to the following Summary of judgment for Extraordinary Appeal 565.714, which does not mention the heterodox solution that guaranteed the police officers the continuity of receiving the unhealthy bonus:

SUMMARY: CONSTITUTIONAL. ARTICLE 7, ITEM IV, OF THE CONSTITUTION OF THE REPUBLIC. NON-RECEPTION OF ARTICLE 3, § 1, OF SÃO PAULO COMPLEMENTARY LAW NO. 432/1985 BY THE 1988 CONSTITUTION. UNCONSTITUTIONALITY OF LINKING THE UNHEALTHY BONUS TO THE MINIMUM WAGE. PREVIOUS. IMPOSSIBILITY OF MODIFYING THE BASIS FOR CALCULATING THE BENEFIT BY JUDICIAL DECISION. EXTRAORDINARY APPEAL DISMISSED.

1. The meaning of the prohibition contained in the final part of item IV of article 7 of the Constitution prevents the minimum wage from being used as an indexation factor; this use would hinder a possible increase in the minimum wage by the chain of increases that would give rise to if this linkage were admitted (RE 217.700, Minister Moreira Alves). The constitutional rule aims to prevent an increase in the minimum wage from indirectly generating a greater weight than that directly related to the increase. This circumstance would pressure a lower adjustment of the minimum wage, which would mean hindering the implementation of the wage policy provided for in article 7, item IV, of the Constitution of the Republic. The use of the minimum wage to form the basis for calculating any remuneration portion or with any other pecuniary objective (indemnities, pensions, etc.) comes up against the binding prohibited by the Constitution of Brazil. History and comparative analysis of the jurisprudence of the Federal Supreme Court. Declaration of non-acceptance by the Constitution of the Republic of 1988 of Article 3, § 1, of Complementary Law No. 432/1985 of the State of São Paulo.

2. Absence of a constitutional rule authorizing the granting of unhealthy pay to public servants (art. 39, § 1, item III) or to military police officers (art. 42, § 1, c/c 142, § 3, item X).

3. Infeasibility of invoking article 7, item XXIII, of the Constitution of the Republic, because even if local legislation determines its incidence to public servants, the additional expression of remuneration contained in the constitutional rule must be interpreted as additional remuneration, namely, those who carry out painful, unhealthy or dangerous activities are entitled to additional remuneration, to compose their remuneration. If the Constitution had established workers' remuneration as the basis for calculation, it would have stated an additional amount on remuneration, which it did not do. 4. Extraordinary appeal dismissed. (Brasil, STF, 2008, p. 1189-1190).

In addition to generating Topic No. 25 of the General Repercussion and the Summary above, the judgment of Extraordinary Appeal No. 565,714 gave rise to Binding Precedent No. 4, with the following wording:

BINDING PRECEDENT No. 4: Except in the cases provided for in the Constitution, the minimum wage cannot be used as an index for calculating the advantage of a public servant or employee, nor be replaced by a judicial decision. (Brazil, STF, 2008).

Therefore, these are the grounds and conclusions adopted in the judgment of Extraordinary Appeal No. 565,714, which motivated the Federal Supreme Court to approve Binding Precedent No. 4.

4 BINDING PRECEDENT NO. 4 AND THE ABSENCE OF THE MINIMUM REQUIREMENTS FOR EXISTENCE

The term precedent, at least in the Brazilian legal context, refers to a summary of the dominant jurisprudence or the peaceful and reiterated understanding of a higher court (such as the Federal Supreme Court, or the Superior Court of Justice) on a given matter of law. Thus, when a Court repeatedly judges the same issue in the same way, it formalizes this understanding in a concise statement, which is the precedent.

For Mancuso (2013, p. 440), a precedent is the set of dominant jurisprudence of a court, covering the most varied branches of our Law, organized by numbered entries without commitment to the subject of the subject.

The jurist Lenio Luiz Streck (2010, p. 145) adopts the following concept of precedent:

In a more technical-legal sense, [precedent] means a statement that translates, concisely, the dominant jurisprudence of that court that issued it. [...] The precedent is, therefore, the production of explanatory definitions, which has prescriptive force in the daily practice of jurists.

This understanding is contained in article 103-A of the Constitution/88, which establishes that the Federal Supreme Court may approve a binding precedent "after repeated decisions" on constitutional matters, without prejudice to the other assumptions and requirements.

As seen, the issue that gave rise to Extraordinary Appeal No. 565,714, in addition to being unique, involving the control of the constitutionality of a given rule (article 3, paragraph 1, of Complementary Law No. 432, of 1985, of the State of São Paulo), was resolved by means of a singular and heterodox solution⁶, which could not and should not have been used to create a binding rule and, much less, to be extended to various issues, dealing with the basis for calculating all types of advantages received by all public servants and private workers, complemented by the prohibition of judicial action as a positive legislator, since the Supreme Court itself had acted in this way, to adapt the criterion of the calculation basis of the unhealthy bonus received by São Paulo police officers.

Thus, because there were no repeated decisions on the examination of the constitutionality of article 3, paragraph 1, of Complementary Law No. 432, of 1985, of the

⁶ There was a declaration of non-full acceptance of the rule and, even so, the appellants continued to receive the unhealthy bonus, in a judgment arrangement that was restricted to the vote rendered and was not even reproduced in the Summary of the Appeal.

State of São Paulo, the Federal Supreme Court did not have the minimum constitutional grounds necessary to produce a precedent, even more so with mandatory content, exorbitant of the singular issue, and resulting from a heterodox solution.

5 THE FORMAL ASPECTS THAT MAKE BINDING PRECEDENT NO. 4 INVALID

This section is intended to analyze and demonstrate that Binding Precedent No. 4 (Brasil, STF, 2008, n.p.) did not comply with some rules that regulate the creation of binding precedents, provided for in article 103-A of the Constitution (Brasil, 1988) and in Law No. 11,417 (Brasil, 2006), which regulates the issue.

5.1 EXTRAPOLATION OF THE OBJECTIVE LIMITS OF THE DETERMINED NORMS

Initially, it is verified that Binding Precedent No. 4 did not stick to its constitutional objective, consisting of the validity, interpretation and effectiveness of certain norms (art. 103-A, § 1, first part, of the Constitution/88), but advanced on the establishment of the meaning and scope of the effectiveness of the paradigm constitutional norm itself (art. 7, IV, final part, of the Constitution/88).

This procedure followed the doctrine of Justice Gilmar Mendes (2012, p. 1337), of the Federal Supreme Court, which gives the concept of "determined norms" an expansive meaning, in the following terms:

The constitutional rule explains that the precedent will aim to overcome the current controversy about the validity, interpretation and effectiveness of certain rules capable of generating legal uncertainty and a relevant multiplication of lawsuits. Therefore, current issues on the interpretation of constitutional norms or of these in the face of infra-constitutional norms are covered.

In view of the broad jurisdiction of the Federal Supreme Court, these [determined] norms may be federal, state or municipal. It is possible, however, that the issue involves only the interpretation of the Constitution and not its eventual contrast with other infra-constitutional norms. In these cases, generally submitted to the Court under the allegation of direct contravention of the Constitution (art. 103, III, a), the interpretation of the Constitution adopted by the courts is discussed.

However, the analysis made in this research diverges from this expansive understanding and adopts a declarative interpretation for the expression "determined norms", more compatible with the fundamental principles of the Democratic Rule of Law and the separation of powers, and with the dictate of the limitation of power.

By "determinate norms" we must understand those norms that are clear, specific, precise and identifiable in plan, and that contrast with indeterminate or undefined norms. They serve to keep the Supreme Court within the limits of its jurisdictional competence to say the law and not to produce generic, indeterminate and abstract binding precedents, which represent an invasion of the competence of the Legislative Branch.

The norms determined are not constitutional principles and rules (parameters), already considered valid, nor the principles and rules questioned (controlled), but the norm resulting from the judgment of the control of constitutionality exercised by the Supreme Court. In this case, the rule determined consisted of the following normative assertion: article 3, paragraph 1, of São Paulo Complementary Law No. 432/1985 was not accepted by article 7, IV, final part, of the Constitution/88. It was only this determined rule that, in theory, could give rise to a binding precedent, if the other constitutional assumptions and requirements were present.

However, Binding Precedent No. 4 exceeded the constitutional limits of the determined rule, resulting from the judgment of Extraordinary Appeal No. 565,714, and examined in the abstract the interpretation and effectiveness of the paradigm constitutional rule itself (article 7, IV, final part, of the FC/88), extending the meaning and scope of the prohibition contained therein to the basis for calculating any and all advantages perceived by public servants or employees, which involves an indeterminate number of infra-constitutional norms, foreign to the object of the Appeal judged, even though some have been cited in the reasoning, as a reason for deciding, but without being able to integrate the operative part.

This defect violates the so-called principle of congruence or astringency (also known as the Principle of Correlation or Conformity), which requires a strict correspondence between the claim, the cause of action and the judicial decision. The Code of Civil Procedure (Brasil, 2015) deals with the matter, mainly, in the following provisions:

Article 141: The judge shall decide on the merits within the limits proposed by the parties, and it shall be forbidden to hear issues not raised in respect of which the law requires the initiative of the party.

Article 492: It is forbidden for the judge to render a decision of a nature different from the one requested, as well as to condemn the party in a higher amount or in an object different from that which was demanded.

According to Dinamarco (2017, p. 320-321), "The extra *petita defect occurs* when the judge judges outside the limits of the demand, that is, 'if it is outside the limits [of the demand]', deciding a question not posed, granting a provision or a good of life not pleaded".

In the same sense is the understanding of Theodoro Júnior (2015, p. 814): "It is the defect that occurs when the sentence decides on an object different from what was proposed in the initial one, that is, "the judge grants a different performance from the one that was claimed from him".

Paulo and Alexandrino (2015, p. 898) reinforce the importance of the Judiciary remaining bound to the principle of the request, even in the exercise of abstract control of constitutionality, which is linked to the principle of the request, so that there is no offense to the principle of separation of powers:

The abstract control of constitutionality, in Brazil, is subject to the so-called principle of request. This means that the Judiciary can only exercise the review of the validity of laws in the abstract when provoked, not on its own initiative.

The principle of the request is typical of the judicial review of constitutionality and contributes to reducing the political character of the review of the validity of norms, as well as to preventing the Judiciary from assuming a role of supremacy in relation to the other branches.

This is not a mere formal irregularity, since the violated norms have the constitutional purpose of complying with and enforcing the fundamental principles of the separation of powers and the Democratic Rule of Law. By creating Binding Precedent No. 4, the Federal Supreme Court exceeded its jurisdictional competence to interpret legal norms and invaded the legislative competence of the National Congress, insofar as the mandatory Entry advanced on the validity, interpretation and effectiveness of indeterminate norms, incurring in the vice of absolute nullity.

5.2 THE ABSENCE OF DEMONSTRATION OF CURRENT CONTROVERSY

The approval of Binding Precedent No. 4 was also not preceded by the demonstration of the constitutional assumption regarding the current controversy between judicial bodies or between them and the public administration, which was causing serious legal uncertainty and a relevant multiplication of lawsuits on the same issue, as required by article 103-A, paragraph 1, second part, of the Constitution/88.

For Mendes and Branco (2015, p. 1337-1338), due to the need for the existence of repeated decisions, it is not possible to issue a binding precedent based on an isolated judicial decision:

Another requirement for the issuance of the binding precedent refers to the pre-existence of repeated decisions on constitutional matters.

It is required here that the matter to be addressed in the precedent has been the subject of debate and discussion in the Federal Supreme Court. It seeks to obtain the maturation of the controversial issue with the reiteration of decisions. Thus, the possibility of issuing a binding precedent based on an isolated judicial decision is prohibited. It is necessary that it reflects a jurisprudence of the Court, that is, repeated judgments in the same sense, that is, with the same interpretation.

When commenting on the assumption of the current controversy, Paulo and Alexandrino (2015, p. 833-834) clarify that it is necessary to have repeated current judgments, neither past nor future, on a relevant matter:

Therefore, for the issuance of a binding precedent by the Federal Supreme Court, the Federal Constitution requires, especially, the observance of four cumulative requirements, namely:

(...);

c) existence of current controversy between judicial bodies or between them and the

Public administration;

d) the controversy entails serious legal uncertainty and a significant multiplication of lawsuits on the same issue.

(...).

The second requirement - requirement that the constitutional matter has been the subject of repeated decisions by the Federal Supreme Court - is intended to avoid the hasty approval of a binding precedent, on a topic that is not yet consolidated in the jurisprudence of the Supreme Court. In other words, it is necessary that the binding precedent effectively reflects the jurisprudence of the Major Court, based on repeated judgments in the same sense.

Another point that should be emphasized is the requirement that the matter dealt with in the binding precedent be the subject of current constitutional controversy between judicial bodies or between them and the Public Administration. If, for example, it is a law that is already peacefully considered unconstitutional within the scope of the Judiciary and that is not being applied by the Public Administration, it will not be appropriate to issue a binding precedent. Nor is it allowed to issue a binding precedent on a matter that will presumably lead to future controversy, no matter how relevant it may be. The controversy must be current, neither future, nor already overcome.

Finally, even if the matter is the subject of current controversy between judicial bodies or between them and the public administration, it can only be dealt with in a binding precedent if this controversy is causing serious legal uncertainty and a relevant multiplication of lawsuits on the same issue. Thus, in the event that it is a controversial matter, but of reduced relevance, or concerning a few concrete cases, the issuance of a binding precedent will not be appropriate.

The constitutional issue discussed in Extraordinary Appeal No. 565,714, consisting of the examination of the constitutionality of article 3, paragraph 1, of São Paulo Complementary Law No. 432/1985, does not qualify as a current controversy, since it did not generate serious uncertainty (characterized by the existence of conflicting decisions between different judges and courts) nor the relevant multiplication of lawsuits, being restricted to a single judicial proceeding, it is certain that the cases cited as a reason for deciding also do not serve to characterize the current controversy, given that they were judged by the Federal Supreme Court from 1999 onwards.

The recognition of the General Repercussion in the judgment of Extraordinary Appeal No. 565,714, object of Topic 25⁷, also does not serve to demonstrate the existence of the current controversy, given that it constitutes one of the procedural assumptions for the admissibility of the extraordinary appeal itself (article 102, paragraph 3⁸, of the Constitution). They are different things. The general repercussion is one of the assumptions for the admissibility of the extraordinary appeal, while the current controversy, capable of causing serious legal uncertainty and the relevant multiplication of lawsuits on the same issue, is one of the specific constitutional procedural requirements for the approval of the binding precedent.

The constitutional assumption of the current controversy bears a certain similarity with the procedure for the judgment of repetitive appeals, however, its stages (selection and allocation of the representative precedent, in the suspension of the proceedings, in the judgment of the thesis and in the application of the precedent) were not followed by the Supreme Court in the judgment of the Representative Precedent, even because there were no other appeals in progress on the same issue.

Thus, Binding Precedent No. 4 should be canceled, as it does not meet the constitutional assumption of the current controversy.

5.3 THE ABSENCE OF A PRIOR STATEMENT BY THE ATTORNEY GENERAL OF THE REPUBLIC

The approval of Binding Precedent No. 4 also did not follow the obligation of prior manifestation by the Attorney General of the Republic in the proposals for editing, revising or

⁷ Title: Linking the unhealthy bonus to the minimum wage.

⁸ Paragraph 3 - In the extraordinary appeal, the appellant must demonstrate the general repercussion of the constitutional issues discussed in the case, under the terms of the law, so that the Court may examine the admission of the appeal, and may only refuse it by the manifestation of two-thirds of its members.

canceling the statement of binding precedent, provided for in article 2, paragraph 2, of Law No. 11,417, of 2006, which regulates the binding precedent.

Article 50 of the Rules of Procedure of the Federal Supreme Court establishes that the Attorney General shall have a period of fifteen (15) days to offer his procedural statements, when no other deadline has been set. (Brazil, STF, 2023).

Although the Attorney General has followed the judgment of Extraordinary Appeal No. 565,714 and the debates that led to the approval of Binding Precedent No. 4, this circumstance does not meet the fulfillment of the constitutional obligations of the Public Prosecutor's Office, as an institution essential to the jurisdictional function of the State, defender of the legal order, the democratic regime and social interests, since there was no period of reflection to issue an authoritative opinion on the issues debated.

Thus, Binding Precedent No. 4 should be canceled, for not having observed the obligation of prior manifestation of the Attorney General of the Republic in the proposal for its edition.

5.4 THE CONTRADICTION BETWEEN THE GROUNDS OF EXTRAORDINARY APPEAL NO. 565,714 AND THE TEXT OF BINDING PRECEDENT NO. 4

The Code of Civil Procedure (Brasil, 2015, art. 489, I, II and III) not only brought the essential elements of judicial decisions (report, grounds and disposition), but also established their conceptual parameters. The report will contain the names of the parties, the identification of the case, with the summary of the request and the response, and the record of the main occurrences that occurred in the course of the process. The grounds contain the judicial analysis of questions of fact and law. And the disposition is the part in which the judge will resolve the main issues that the parties submit to him.

These three parts of the judicial decision must maintain harmony and coherence, under penalty of the defect of contradiction giving rise to the motion for clarification, provided for in article 1,022, I, of the Code of Civil Procedure.

Fredie Didier Jr. and Cunha (2016, p. 251) teach that "the contradictory decision is one that has irreconcilable propositions, disharmonious statements, statements that clash, that point to opposite directions". For them, the main example is the contradiction between the reasoning (motivation) and the disposition (conclusion), as when the judge reasons that the plaintiff does not have the right claimed, but, in the operative part, upholds the request.

The precedent, consisting of a summary of the provisions of several judgments judged on a given legal matter, must also maintain the relationship of coherence with the grounds of all the decisions on which it is based, so that it does not fall into the vice of contradiction.

As Binding Precedent No. 4 (STF, 2008, n.p.) is the result of the judgment rendered in Extraordinary Appeal No. 565,714, its wording had to have been coherent, necessarily, with the reasons for deciding appeals, which did not occur in the case in question.

In fact, when analyzing whether the rule of article 192 of the Consolidation of Labor Laws (Brasil, CLT, 1943) could be applied to the appellant military police officers, Justice Cármen Lúcia identified its incompatibility with the constitutional rule that prohibits the indexation of the minimum wage (article 7, IV) and, then, stated that "[...] it will be up to the Labor Court to define the basis for calculating the unhealthy bonus due in relations governed by the CLT, taking into account labor legislation and collective bargaining agreements and conventions". (Brasil, STF, 2008, RE 565.714, p. 1217)

However, it was stated in the wording of Binding Precedent No. 4 that "the minimum wage cannot be used as an index of the basis for calculating the advantage of a public servant or employee, nor be replaced by a judicial decision" (Brasil, STF, 2008), removing from judges and labor courts the power that had been recognized in the grounds of the Extraordinary Appeal to "define the basis for calculating the unhealthy allowance due in relations governed by the CLT" (Brasil, STF, 2008, RE 565.714, 1217).

The contradiction was definitively proven when the Superior Labor Court decided to follow the guidance contained in the grounds of Extraordinary Appeal No. 565,714, and changed the wording of its Precedent No. 228 to state that "As of May 9, 2008, the date of publication of Binding Precedent No. 4 of the Federal Supreme Court, the unhealthy allowance will be calculated on the basic wage, unless a more advantageous criterion is established in a collective agreement" (Brasil, TST, 2008, n.p.). The attitude of the Labor Court was almost instantly disapproved through the granting of injunctions, which were confirmed in the judgment on the merits, issued by the Supreme Court in Complaints that were filed by agents linked to the economic market, who denounced the non-compliance with Binding Precedent No. 4.

Thus, since there is a contradiction between the reasoning used in the judgment of Extraordinary Appeal No. 565,714 and the text of Binding Precedent No. 4, the mandatory Entry should be canceled, as it does not have an autonomous existence and contradicts its own basis of existence and legal validity.

5.5 THE SELF-CONTRADICTION EXISTING IN BINDING PRECEDENT NO. 4

The normative text of Binding Precedent No. 4 is also self-contradictory, insofar as it ensures the validity and effectiveness of the fundamental constitutional right to prohibit the binding of the minimum wage for any purpose (article 7, IV, final part, of the FC/88) and, at the same time, allows this fundamental right to be violated. Here it is: "Except in the cases provided for in the Constitution, the minimum wage cannot be used as an index for the calculation basis of the advantage of a public servant or employee, nor can it be replaced by a judicial decision." (Brazil, STF, 2008).

First, the Entry prohibits "the minimum wage from being used as an index of the basis for calculating the advantage of a public servant or employee". Next, it prohibits judges and courts, who are faced with laws that provide for the minimum wage as an index of the basis for calculating the advantage of public servants or employees, from replacing the minimum wage with another index, which implies the permission of the conduct that had been prohibited in the first part of the Precedent.

In other simpler and summarized words, for Binding Precedent No. 4, the minimum wage cannot be used as an index; however, if it is being used as an indexer by any legal rule, it cannot be replaced by the Judiciary. In other words, indexation will continue to exist and produce legal effects, even though it is prohibited by Binding Precedent No. 4 itself and by the Constitution (Brasil, CRFB, 1988, art. 7, IV).

Thus, by prohibiting and, at the same time, allowing the prohibition of indexation of the minimum wage for any purpose, Binding Precedent No. 4 incurs in self-contradiction and, therefore, should be canceled.

6 THE MATERIAL ASPECTS THAT JUSTIFY THE CANCELLATION OF BINDING PRECEDENT NO. 4

In addition to not having observed all existential, formal (constitutional and legal) and logical aspects, Binding Precedent No. 4 also did not follow the legal regime that governs the judgment of the validity, interpretation and effectiveness of the issue that is the subject of Extraordinary Appeal No. 565,714, consisting of the indexation of the calculation basis of the unhealthy bonus received by São Paulo military police officers to the minimum wage.

The matters related to the issue (minimum wage and additional unhealthy wage) have the legal nature of fundamental constitutional social labor rights and are directly linked to the fundamental constitutional principles of the Democratic Rule of Law, the separation of

powers, human dignity, the social values of work and free enterprise, the construction of a free, fair and solidary society, and the prevalence of human rights, which were not observed or even cited at the time of the judgment of the Representative Precedent and the approval of the Binding Precedent.

6.1 JUDICIAL ACTIVISM

Judicial activism is a reflection of the prominent role that the Brazilian Judiciary, especially the Federal Supreme Court, assumed after the 1988 Constitution, in relation to guaranteeing the effectiveness of fundamental principles and rights.

For Barroso (2009), judicial activism is an attitude, the choice of a specific and proactive way of interpreting the Constitution, expanding its meaning and scope. It is usually installed in situations of retraction of the Legislative Branch, associated with a broader and more intense participation of the Judiciary in the realization of constitutional values and purposes, with greater interference in the space of action of the other two Branches. The activist stance is manifested through different conducts, which include: a) the direct application of the Constitution to situations not expressly contemplated in its text and regardless of the manifestation of the ordinary legislator; b) the declaration of unconstitutionality of normative acts emanating from the legislator, based on criteria less rigid than those of patent and ostensible violation of the Constitution; c) the imposition of conducts or abstentions on the Public Power, notably in matters of public policies.

On the occasion of the judgment of Extraordinary Appeal No. 565,714 (Brasil, STF, 2008), the requirements for acting through judicial activism were present, as the Justices of the Supreme Court recognized the omission of the National Congress in the regulation of the fundamental right to the unhealthy bonus. However, the claim that the Supreme Court could not act as a positive legislator prevented the application of activism.

Thus, since judicial activism is a reality in Brazil, albeit in exceptional and relatively discretionary terms, it will be taken into account in the analysis of the material aspects of Binding Precedent No. 4 and, notably, of its Representative Precedent, in order to give effect to several fundamental principles and rights that are no longer observed.

6.2 THE FUNDAMENTAL CONSTITUTIONAL PRINCIPLES THAT SHOULD GUIDE THE CREATION OF THE CALCULATION BASIS FOR THE UNHEALTHY ALLOWANCE

The 1988 Constitution conferred the stature of a fundamental right to the unhealthy bonus, however, it attributed its regulation to the ordinary legislator:

More than 37 years have passed since the promulgation of the Constitution/88, but the National Congress, markedly liberal, has not yet regulated this fundamental right, opting to maintain the obsolete and unconstitutional regulation of article 192 of the Consolidation of Labor Laws (Brasil, 1943), which originated in Law No. 185, of 1936, despite not being materially compatible with the norms of fundamental rights and human rights.

The omission of the National Congress, associated with the need to regulate and give full effect to the fundamental constitutional right to the unhealthy bonus, justified the use of judicial activism by the Justices of the Federal Supreme Court, on the occasion of the judgment of Extraordinary Appeal No. 565,714 and the approval of Binding Precedent No. 4 (Brasil, STF, 2008, n.p.).

The obsolete and unconstitutional rule that had its interpretation, validity and effectiveness implicitly crystallized by Binding Precedent No. 4, as long as the National Congress remains inert, only favors the economic interests of employers, including the State, by leveling "downwards" (based on the minimum wage) the payment of a fundamental right that aims to directly protect health, the hygiene and safety of private workers and public servants who work in activities considered unhealthy (harmful to health).

It should be noted that the 1988 Constitution prioritized the establishment of some fundamental principles that should guide the Legislative and Judiciary in the creation of rules that regulate the parameters to be used in the calculation of advantages attributed to public servants and private workers.

In fact, initially, these parameters must be extracted from the fundamental principles adopted by the Federative Republic of Brazil, namely:

First. The adoption of the constitutional principle of the Democratic Rule of Law (article 1, *caput*) requires that the calculation of the advantages attributed (fundamental rights) to civil servants and workers reflect the will and social and economic interests of the majority of the Brazilian people, which is formed precisely by the working class, which produces the national wealth.

Second. It is necessary to contemplate with special emphasis the constitutional principle of human dignity (art. 1, III), in order not to tolerate the constitutionality and legality

of payments of fundamental normative advantages that do not allow workers to have access to the existential minimum.

Third. The basis for calculating the advantage (fundamental right) must be the result of the compatibility between the social values of work and the values of free enterprise (article 1, IV), so that there is no overlap of one over the other, as occurs in the situation dealt with in the final part of Binding Precedent No. 4.

Room. The fundamental constitutional objective of building a free, fair and solidary society (article 3, I) should also guide the creation of parameters for calculating advantages, which cannot result from unfair impositions and that do not take into account solidarity at the time of distribution of the product of wealth with those who effectively contributed to its existence.

Fifth. The fundamental constitutional principle of the prevalence of human rights (article 4, II) obliges the Brazilian State to honor the international commitment to promote decent work, which must be exercised in conditions of freedom, equity, security and human dignity, under the terms of the 2030 Agenda of the United Nations, signed by Brazil. Maintaining the payment of fundamental advantages such as the unhealthy bonus in the basic standard of a minimum wage reveals, in fact, indecent working conditions, since they are imposed by the Government, are not equitable, promote insecurity and harm health and human dignity.

Although these fundamental constitutional principles should have guided the judgment of Extraordinary Appeal No. 4 and the approval of the text in Binding Precedent No. 4, it appears that they were not even mentioned in these judicial decisions.

6.3 THE FUNDAMENTAL SOCIAL CONSTITUTIONAL RIGHTS THAT SHOULD GUIDE THE CREATION OF THE CALCULATION BASIS FOR THE UNHEALTHY BONUS:

In addition to observing the fundamental principles above, due to constitutional supremacy, the establishment of legislative and judicial criteria for the calculation of the advantages of civil servants and workers also has to be guided by the fundamental constitutional social labor rights, either because they brought the standards for calculating the fundamental advantages recognized by the Constitution, or because they broke with the system of a single wage base (minimum wage), that has always existed in Brazil, and they also began to provide for the minimum wage for the different professional categories.

The fundamental constitutional social labor norms establish various standards or models for calculating the advantages of civil servants and workers, always based on the value of the salary or even the remuneration, as shown in the following cases:

- 1) Unemployment insurance (article 7, II, of the Constitution), whose calculation, according to article 5, paragraph 1, of Law No. 7,998, of 1990, which regulates the Unemployment Insurance Program, is calculated by the average of the salaries of the last three (3) months prior to the dismissal.
- 2) Guarantee Fund for Length of Service (Article 7, III, of the Constitution), whose calculation, according to Article 15, *caput*, of Law No. 8,036, of 1990, which provides for the Guarantee Fund for Length of Service, falls on the percentage corresponding to 8% (eight percent) of the remuneration paid or due, in the previous month, to each worker.
- 3) Thirteenth salary, calculated on the basis of full remuneration (article 7, VII, of the Constitution), extended to public servants (article 39, paragraph 3, of the Constitution).
- 4) Remuneration for night work higher than that for daytime work (article 7, IX, of the Constitution), whose calculation, according to article 73, *caput*, of the Consolidation of Labor Laws, must be made with an increase of at least 20% (twenty percent) on the value of the daytime hour, which, in turn, is calculated on the value of the salary. This right is extended to public servants (art. 39, § 3, of the Constitution).
- 5) Remuneration for overtime service, calculated in the percentage of at least 50% (fifty percent) of the normal hourly rate (article 7, XV, of the Constitution) which, in turn, is calculated on the value of the salary. This right is extended to public servants (art. 39, § 3, of the Constitution).
- 6) Paid annual vacation with at least one third more than the normal salary (article 7, XVII, of the Constitution), extended to public servants (article 39, paragraph 3, of the Constitution).
- 7) Leave for pregnant women (article 7, XVIII, of the Constitution), whose calculation, according to article 72, *caput*, of Law No. 8,213, of 1991, which provides for Social Security Benefit Plans, is made on a monthly income equal to the employee's full remuneration. This right is extended to public servants (art. 39, § 3, of the Constitution).
- 8) Prior notice (article 7, XXI, of the Constitution), whose calculation, according to article 487, paragraph 1, of the Consolidation of Labor Laws, must be made on the employee's remuneration.

9) Hazard pay (article 7, XXIII, of the Constitution), whose calculation, according to article 193, paragraph 3, of the Consolidation of Labor Laws, falls on the employee's salary.

Thus, as the constitutional standard is to recognize the salary and even the remuneration itself as the basis for calculating the fundamental advantages established for public and private workers, this model must guide, in a binding manner, the legal norms, public policies and judicial decisions.

By not observing the directive model of the Constitution/88, Binding Precedent No. 4 cannot maintain the validity and effectiveness of legal norms that establish the minimum wage as the sole and mandatory basis for calculating the unhealthy bonus, under penalty of violation of the fundamental constitutional principle of non-discrimination (Brasil, CRFB, art. 3, IV) and the specific human right of non-discrimination in matters of employment and profession, provided for in article 1 of Convention No. 111 (ILO, 1958), ratified by Brazil through Legislative Decree No. 104, of 1964.

In addition to the constitutional standards that recognize the salary (and not the minimum wage) and even the remuneration itself as the basis for calculating the advantages established for public and private workers, the Constitution/88 broke the constitutional system, until then existing, of setting the minimum wage as the only basis for payment of wages in Brazil (art. 157, I, of the 1946 Constitution, art. 158, I, of the 1969 Constitution, and art. 165, I, of the 1969 Constitution). In addition to the minimum wage (Brasil, CRBF, 1988, art. 7, IV), the Constitution/88 also began to provide, as a minimum threshold for the payment of wages, the minimum wage proportional to the extent and complexity of the work (Brasil, CRBF, 1988, art. 7, V), which can be set by specific federal laws (for regulated professions), by state laws (regional floor for categories that do not have a floor defined in Federal Law or collective bargaining) or by collective bargaining (collective bargaining agreements).

Thus, both due to the omission of Congress and the need to enforce a fundamental right, it can be seen that the Supreme Court failed to employ judicial activism to recognize, in the specific case of the unhealthy bonus, that the calculation of this advantage could be based on the minimum wage (for those who earn this amount) or on the minimum wage of the category, because of the guidelines taken from the Constitution itself. With this, the legislative omission would be suppressed and full effectiveness would be given to the fundamental right that was constitutionally established more than 37 years ago, however, it continues to be

regulated through obsolete, unconstitutional and unjust rules, whose validity and effectiveness were maintained through Binding Precedent No. 4.

7 CONCLUSION

Binding Precedent No. 4 (Brasil, STF, 2008) was approved at the end of the judgment of Extraordinary Appeal No. 565,715 (Brasil, STF, 2008), in which the constitutional validity of a state rule, which established the minimum wage as the basis for calculating the unhealthy bonus for public agents, was discussed.

When analyzing Binding Precedent No. 4, it was found that it did not meet the minimum requirements for existence, did not follow all the formal procedures for creation and did not observe some of the fundamental principles and rights established in the 1988 Constitution, which would lead to its cancellation.

In this regard, it was found that there were no repeated decisions on the examination of the constitutionality of the questioned rule (article 3, paragraph 1, of Complementary Law No. 432, of 1985, of the State of São Paulo) and, therefore, the Federal Supreme Court did not have the minimum constitutional grounds necessary to produce a precedent.

In addition, Binding Precedent No. 4 did not stick to its constitutional objective, consisting of the validity, interpretation and effectiveness of certain norms (art. 103-A, § 1, first part, of the Constitution/88), but advanced on the establishment of the meaning and scope of the effectiveness of the paradigm constitutional norm itself (art. 7, IV, final part, of the Constitution/88).

It was also found that the approval of Binding Precedent No. 4 was not preceded by the demonstration of the constitutional assumption regarding the current controversy between judicial bodies or between them and the public administration, which was causing serious legal uncertainty and a relevant multiplication of lawsuits, on an identical issue, as required by article 103-A, paragraph 1, second part, of the Constitution/88.

Furthermore, the procedure for approving Binding Precedent No. 4 did not observe the obligation of prior manifestation by the Attorney General of the Republic in the proposals for editing, revision or cancellation of the statement of binding precedent, provided for in article 2, paragraph 2, of Law No. 11,417, of 2006, which regulates the binding precedent.

An even more worrying fact is the contradiction between the reasoning, used in the judgment of Extraordinary Appeal No. 565,714, and the text of Binding Precedent No. 4.

The mandatory Entry also focused on self-contradiction, by prohibiting and, at the same time, allowing the constitutional prohibition of indexation of the minimum wage for any purpose.

Finally, it was found that Binding Precedent No. 4 did not take into account several fundamental constitutional principles, such as human dignity, the construction of a just and solidary society, the prevalence of human rights, etc., and did not observe the constitutional parameters that recognize the salary, and even the remuneration itself, as the basis for calculating the fundamental advantages established for public and private workers.

For these reasons, it is concluded that Binding Precedent No. 4 should be canceled or, at least, revised, in order to adapt to the Constitution/88.

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FROM OBJECT TO SUBJECT: ETHICS AND POLITICS IN CARE FOR DRUG USERS

DE OBJETO A SUJEITO: ÉTICA E POLÍTICA NA ASSISTÊNCIA AO USUÁRIO DE DROGAS

DE OBJETO A SUJETO: ÉTICA Y POLÍTICA EN LA ATENCIÓN A USUARIOS DE DROGAS

 <https://doi.org/10.56238/sevened2025.036-085>

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ABSTRACT

This article aims to analyze Brazil's care policy for users of alcohol and other drugs, articulating the ethics of psychoanalysis and Harm Reduction (HR) strategies to understand the advances and setbacks of public policies in recent decades. By revisiting the history of the Psychiatric Reform and the establishment of the Psychosocial Care Network (RAPS), it demonstrates how the rise of Therapeutic Communities (TCs)—marked by moralizing, religious, and punitive practices—represents a return to the asylum-based model, with serious human rights violations supported by prohibitionist policies and State funding. In contrast, Harm Reduction, like psychoanalysis, proposes a non-universalizing approach, guided by case-by-case analysis and by the subject's implication in their treatment, considering their choice of use, misuse, or abstinence. Thus, the article argues that any mental health, alcohol, and drug care must be guided by a commitment to listening to singularity, respecting human rights, and fostering territorial and community-based care. As a “not-all” policy, this perspective must be capable of including different modes of *jouissance* within the complexity of each subject's relationship with drugs and their uses.

Keywords: Psychoanalysis. Drug Users. Harm Reduction. Therapeutic Community.

RESUMO

O presente artigo pretende analisar a política de assistência aos usuários de álcool e outras drogas no Brasil, articulando a ética da psicanálise e as estratégias de Redução de Danos (RD) para compreender os avanços e retrocessos das políticas públicas nas últimas décadas. Ao revisitar a história da Reforma Psiquiátrica e da constituição da Rede de Atenção Psicossocial (RAPS), demonstra-se como a ascensão das Comunidades Terapêuticas (CTs) – marcadas por práticas moralizantes, religiosas e punitivas – representa um retorno ao modelo manicomial, com graves violações de direitos humanos, sustentadas por políticas proibicionistas com o financiamento do Estado. Em contraponto, a Redução de Danos, assim como a psicanálise, propõe uma abordagem não universalizante, orientada pelo caso a caso e pela implicação do sujeito em seu tratamento, considerando sua escolha pelo uso, pelo abuso ou pela abstinência. Dessa forma, o artigo defende que qualquer

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cuidado em saúde mental, álcool e outras drogas deve orientar-se pelo compromisso com a escuta da singularidade, pelo respeito aos direitos humanos e pelo cuidado territorial e comunitário. Constituindo-se como uma política não-toda, essa perspectiva deve ser capaz de incluir os distintos modos de gozo na complexidade da relação de cada sujeito com as drogas e seus usos.

Palavras-chave: Psicanálise. Usuários de Drogas. Redução de Danos. Comunidade Terapêutica.

RESUMEN

El presente artículo pretende analizar la política de atención a los usuarios de alcohol y otras drogas en Brasil, articulando la ética del psicoanálisis y las estrategias de Reducción de Daños (RD) para comprender los avances y retrocesos de las políticas públicas en las últimas décadas. Al revisar la historia de la Reforma Psiquiátrica y de la constitución de la Red de Atención Psicosocial (RAPS), se demuestra cómo el ascenso de las Comunidades Terapéuticas (CTs), caracterizadas por prácticas moralizantes, religiosas y punitivas, representa un retorno al modelo manicomial, con graves violaciones de derechos humanos, sostenidas por políticas prohibicionistas y con financiamiento estatal. En contrapunto, la Reducción de Daños, al igual que el psicoanálisis, propone un enfoque no universalizante, orientado por el caso a caso y por la implicación del sujeto en su tratamiento, considerando su elección por el uso, el abuso o la abstinencia. De este modo, el artículo sostiene que cualquier cuidado en salud mental, alcohol y otras drogas debe guiarse por el compromiso con la escucha de la singularidad, el respeto a los derechos humanos y el cuidado territorial y comunitario. Constituyéndose como una política no-toda, esta perspectiva debe ser capaz de incluir los distintos modos de goce en la complejidad de la relación de cada sujeto con las drogas y sus usos.

Palabras clave: Psicoanálisis. Usuarios de Drogas. Reducción de Daños. Comunidad Terapéutica.

1 INTRODUCTION

The existence of specific public policies on drugs is quite recent in Brazil, coinciding, almost entirely, with the history of our Republic. For many years, legislation was directed exclusively by authoritarian and hygienist models, following the North American standards that guided the practices of justice and public security, as well as the methods of health treatment. Based on war practices – inspired by the U.S. policy of the 1970s – and abstinence, such legislation and actions followed the guidelines of international treaties that, although they have their importance, never considered the singularities of each country or the complexity required by the subject.

In this way, the relationship of the Brazilian State with the drug trade has been structured based on prohibitionist and moral precepts, which sustain an unprecedented war in certain territories, targeting a specific portion of the population. Called "police operations" by the State and with the territories of favelas and peripheries as the scene of confrontations, this war victimizes black and poor populations, both through the summary execution of young people recruited by drug trafficking or criminalized by racism and through the "stray bullets" that hit residents and curtail their rights to come and go³. In the field of health, the asylum and biomedical model imposed a logic that destined people to long hospitalizations in psychiatric hospitals that for decades functioned as warehouses for individuals segregated by society, such as drug users, people with mental disorders, and even political prisoners during the military dictatorship (1964-1985).

With the political opening, the *1988 Constitution* (BRASIL, 1998) and the establishment of the SUS (BRASIL, 1990), Brazil constituted a new path based on democratic bases that inspired various movements such as the anti-asylum struggle – the foundation of the so-called Psychiatric Reform⁴ – in which the policies of assistance to drug users are inserted. Thus, advances have become possible in the construction and execution of policies that treat users from the perspective of public health, recognizing them as subjects and considering territorial differences as a guide for their work. However, recently, we have witnessed a significant setback in this field, once again leading users to long hospitalizations in asylums and religious institutions, known as Therapeutic Communities (TCs).

³ Among so many examples, the most recent and brutal of them left 122 dead in Complexo da Penha, in the North Zone of the capital of Rio de Janeiro, on October 28, 2025.

⁴ After World War II (1939-1945), a set of distinct experiences in several countries brought in common the questioning of the current asylum model, becoming known as the Psychiatric Reform Movement. For a more in-depth discussion of the issue, see: AMARANTE, P. (1995). *Crazy for life: the trajectory of psychiatric reform in Brazil*. Rio de Janeiro: SDE/ENSP.

Over many years of clinical and institutional work, listening to drug-using subjects has led us to insist on an ethical bet that goes against the grain of proposals that prescribe abstinence, isolation and that intensify tensions guided by the utopia of a drug-free world. By reducing subjects to objects of policies aimed at the control of bodies, countless practices of violence have been instituted by a State that segregates and kills, both in territories and in TCs. Our bet, guided by the ethics of psychoanalysis – ethics of desire and lack-to-be – highlights the impossibility of any universalization in the treatment of subjects who, in various ways and for various reasons, they use drugs. Because it excels in listening to singularity and considering the loss of *jouissance* as inherent, the politics of psychoanalysis is always non-all.

Therefore, from a psychoanalytic reading, this article aims to situate these facilities in the history of policies for alcohol and other drug users in Brazil and, at the same time, to raise some complaints about the seriousness of the *modus operandi* of these spaces, including the trivialization of numerous forms of violence. To this end, we will present the public policies of mental health, alcohol and other drugs in the country, with emphasis on the advances and setbacks observed in recent decades, especially from the Psychiatric Reform and the implementation of the open and territorial devices that make up the Psychosocial Care Network (RAPS). Next, we will analyze the phenomenon of Therapeutic Communities (TCs), which represent a return to the asylum model and, in this sense, a kind of anti-psychiatric reform. By discussing the tensions between public mental health policies and neoliberal practices, we will highlight the privatization of treatment as a movement that reupdates practices of violence and segregation. These first two parts of the article have as their main methodology the bibliographic review made from legislation and reports of official bodies, as will be described in the body of the text.

Subsequently, we will present the Harm Reduction (HR) policy as an alternative to the prohibitionist logic, since it promotes care based on singularity and is configured as a possible ethical proposal, similar to the bet of psychoanalysis. By sustaining the idea of a not-all politics, represented by HR, it becomes possible to include the subject and his modes of *jouissance*, enabling less segregatory models and closer to the logic of case by case, as will be pointed out in the last two parts of the text. To do so, we will make use of the bibliography on HR, as well as the contributions of theorists who think about the field of mental health, alcohol and other drugs from the perspective of public health and, especially, psychoanalysis.

In addition, we will present the report of one of the clinical and institutional studies in which we were inserted, in order to illustrate the theoretical-clinical development of this article.

2 PUBLIC POLICIES ON MENTAL HEALTH, ALCOHOL AND OTHER DRUGS IN BRAZIL: BETWEEN ADVANCES AND SETBACKS

The policy of attention and care for drug users in Brazil was built on the gains obtained with the Psychiatric Reform, consolidated in the enactment of Law 10.216 (BRASIL, 2001), after years of struggles led by users, family members and workers. The main achievement of this movement consisted of the replacement of psychiatric hospitals – an asylum and hospital-centered model, based exclusively on medical knowledge – by Psychosocial Care Centers (CAPS) which, articulated in a Psychosocial Care Network (RAPS) composed of several devices, subverted the previous model. In the new arrangement, user care takes place in open equipment, understood as integrated with the public space, the community and the territory.

Established and regulated by Ordinance 336 (BRASIL, 2002), the CAPS were organized in modalities that included the CAPS ad: an equipment intended for the care of users of alcohol and other drugs, from the perspective of a policy and a clinic based on Harm Reduction (HR) strategies, instituted with the Policy for Comprehensive Care for Users of Alcohol and Other Drugs (BRASIL, 2003). Born in Europe, HR is considered an alternative to the prohibitionist model, as it presupposes the provision of care even in the face of the subject's choice not to interrupt use. At its base, the construction of therapeutic projects with users – and not for them – aims at an approach centered on the subject and on their listening, integrating knowledge about themselves and about use – a practice that promotes autonomy and self-care – in addition to working with the community and the territory in the prevention of use and the risks arising from abuse, as we will see later.

The inclusion of a perspective in which the user came to be recognized as a subject – and not as the object of his treatment – produced effects that substantially modified the view of this population in the field of public mental health policies, which began in the last years of the Fernando Henrique Cardoso government (1995-2002) and extended during the Luiz Inácio Lula da Silva governments (2003-2010). However, this change was not enough to reach other fields that make up the issue of drug policies in the country. In relation to alcohol and tobacco – the two most used drugs in Brazil – significant changes have been implemented, such as restrictions on advertising in certain spaces, increased collection of

taxes to finance treatments for their effects and, in the case of tobacco, in particular, a significant reduction in consumption. However, with regard to the so-called illicit drugs and public security policies, progress is scarce and quite ambiguous.

In 2010, the *Integrated Plan to Combat Crack and Other Drugs* (BRASIL, 2010) introduced the proposal for the integration of public policies on social assistance, education and security. However, the word *crack*, highlighted in the title, signaled a change in focus – previously centered on alcohol – which led, a year later, to the launch of the program *Crack, é Possível Vencer* (BRASIL, 2011), during the Dilma Rousseff government (2011-2016). This initiative of the Ministry of Justice, which proposed actions in the areas of prevention, care and authority, was received with strangeness by specialists and professionals. Although the media of the time repeatedly broadcast images of the so-called *cracklands*, associating crack users with the increase in crime and depriving them of their place as subjects by representing them as "zombies", the data from the surveys pointed to another reality: alcohol and tobacco – legal drugs – continued to constitute a serious public health problem in Brazil, much more expressive than any other. In addition to this distortion, the country was preparing to host two important international events – the World Cup (2014) and the Olympic Games (2016) – which led several cities to adopt hygienist actions, such as the compulsory hospitalization of these users in public and private clinics and in shelters linked to social assistance policies.

In this regard, in 2015, the Therapeutic Communities (TCs) were regulated as entities capable of welcoming drug users and, a year later, registered to receive resources from the Unified Health System (SUS) through two ordinances: Resolution No. 01 of CONAD (BRASIL, 2015) and Ordinance No. 1,482, of the Ministry of Health (BRASIL, 2016). Although the two ordinances configure a regulatory framework for TCs, it is essential to understand that, by moving from a device recognized and regulated by the State to a device financed by it, TCs became part of the SUS, which seems much more serious to us.

Thus, advances in the destruction of public policies on mental health, alcohol and other drugs, based on the assumptions of the Psychiatric Reform, gained space and acceleration after the 2016 coup, with the insertion of the neoliberal policies of the Michel Temer government (2016-2018). With a sequence of setbacks in this field from 2016 onwards, we highlight Ordinance No. 3,588/GM/MS (BRAZIL, 2017a), CIT/SUS Resolution No. 32 (BRAZIL, 2017b) and Resolution No. 01 (BRAZIL, 2018). In them, there was a return to the centralization of the psychiatric hospital, added to the integration of TCs into the RAPS and

the disregard of HR strategies in the care policies for drug users, which began to be reoriented exclusively to abstinence.

With the government of Jair Messias Bolsonaro (2019-2022), other serious setbacks were instituted in the face of his reactionary vision, adding to an already devastated scenario. In addition to the extinction of social control bodies, such as the Councils, we highlight Technical Note No. 11 (BRASIL, 2019a) and Law 13,840 (BRASIL, 2019b) – known as the *New Drug Law*⁵ –, which instituted: 1. the purchase of new electroconvulsive therapy (ECT) devices⁶; 2. the opening of new beds and the expansion of funding for psychiatric hospitals, including the hospitalization of children and adolescents; 3. the opening of beds and new accreditations of TCs; 4. the possibility of income tax rebate for those who allocated money to this equipment; 5. the dissociation between mental health policies and those of alcohol and drugs, leaving the latter in charge of the Ministry of Citizenship; 6. the transformation of CAPS ad into a mere instrument for referring users to TCs and 7. the involuntary hospitalization of users without judicial authorization, provided that it is formalized by medical decision.

Still during the Bolsonaro Government, the country – and the world – faced the worst pandemic in recent times, COVID-19, culminating in more than 700 thousand deaths in Brazil due to the disastrous conduct by the federal government. The bleak scenario of isolation, quarantine, diseases and deaths, added to the population's disbelief, aggravated many psychosocial issues: anguish, domestic violence, abuse of psychoactive substances and other illnesses, especially for some social strata:

[...] some social groups are more susceptible due to their socioeconomic conditions and the lack of adequate public policies, making visible those who are "south of the quarantine": women, precarious or informal workers, homeless people, poor peripheries and favelas, those interned in refugee camps and prisons, the elderly, physically disabled (SANTOS, 2020, p. 1)⁷.

⁵ Legally, the law would update the 2006 Drug Law – No. 11,343 – which established the system of repression and public policies aimed at the use, trafficking and production of psychoactive substances in Brazil, distinguishing, for the first time, user from dealer, although without any mention of a quantity that objectively establishes it, leaving it up to the police officer who authorizes and the judge who approves the decision to send the subject to prison or to the devices of health for treatment. In practice, the *New Law* only reinforced stigmas and instituted TCs as priority places for the "treatment" of users.

⁶ ECTs were widely used as symbolic instruments of torture widely carried out in asylums throughout the country before the Psychiatric Reform. After the reorientation of the care model, the method still continued to be used, but as a last resort and based on many discussions in the teams of psychiatric hospitals that were still functioning.

⁷ To this list, we would add children and adolescents, especially those in a state of social vulnerability.

Undoubtedly, those most affected by the pandemic were the recurrent users of the SUS and social protection programs. Although both have proven to be absolutely necessary for their capillarity and reach, they have also been deeply overwhelmed, as well as mental health services – situations that the country is still dealing with years after the pandemic appeased, brought about by the widespread and, in some way, late vaccination.

In 2022, with the new election of Luiz Inácio Lula da Silva for his third term, there was a promise of significant change in mental health policy since the government transition process. In fact, almost three years later, we have observed some resumption of investments to strengthen RAPS, as well as the recomposition of policies for alcohol and drugs from the recreation of the Department of Mental Health in the Ministry of Health. However, the issue of TCs still persists, as also in 2023, a support department for this equipment was created within the Ministry of Social Development (MDS). In view of this, we expand the discussion on TCs, their field and method of action.

3 THE NEW TCS FOR DRUG USERS AND THE OLD ASYLUM MODEL

According to Amarante (1995), the first TCs appeared in Europe based on the same criticisms that supported the Psychiatric Reform Movement. In Birmingham, England, T. H. Main called a work he developed at the North Field Hospital, with psychoanalysts Wilfred Bion and Erich Fromm-Reichmann, for the treatment of soldiers affected by psychic suffering after World War II, the Therapeutic Community. However, the term would have been consecrated by Maxwell Jones – a South African psychiatrist based in the United Kingdom – with the theorists cited above as a basis:

[...] the term therapeutic community comes to characterize a process of institutional reforms, predominantly restricted to the psychiatric hospital and marked by the adoption of democratic, participatory and collective administrative measures, aiming at the transformation of the institutional dynamics of asylum (AMARANTE, 1995, p. 29).

With the introduction of operative groups, Jones' proposal dealt with the summoning of patients to the place of subjects in their treatments, establishing, with all those involved – from physicians to support workers – the democratization of access and institutional opportunities as the focus of work (DE LEON, 2003). Subsequently, institutions named in the same way emerged in the USA, but distanced from the original proposal, both in terms of the target audience – which began to be composed of drug users – and in terms of methodology

and work premises – restricted to the asylum model and the Twelve Step method. Popularized by Alcoholics Anonymous and Narcotics Anonymous (A.A. and N.A.), this method is guided by the strengthening of identifications among the members of the groups, called brotherhoods, who must comply with a sequence of twelve steps to control what they name, based on medical knowledge, chemical dependency.

With drugs at the center of the proposal, elevated to the category of enemy – the same *modus operandi* advocated by the American War on Drugs policies –, phrases such as "I am a recovering drug addict", "alcoholism is a chronic, incurable disease", "just for today", "avoid people and places" and "I must admit that I am powerless in the face of drugs", commonly said in meetings and outside them, they reinforce the character of bonding to illness and moral weakness. Oscillating between a sick person and a social scourge, their bodies are always taken as objects subject to intervention by knowledge such as medicine, justice, public security or religion.

Amarante (2007, p. 19) points out that there is, in the practices of mutual aid groups, an emphasis on the "loss of control of the person in relation to the substance and the surrender to a 'higher power'", which evidences a practice of "confessing oneself to others". This same point is highlighted by Fossi and Guareschi (2015, p. 94), when they situate the practices of TCs as confessional, by evidencing "the articulation between religious morality, discipline technologies and biopolitics" in the treatment of drug users. In Brazil, TCs arrived around the 1970s and were established as a model very similar to the North American one, therefore absolutely different from the European one. Based on an important survey of the first TCs in Brazil, Alberti and Bastos (2019) point out that, of the first six, only one differed from the American project, while the others remained anchored in the paradigm of religious morality that still sustains them today.

Integrating the RAPS since 2011, the TCs are defined as "points of care of the Psychosocial Network in residential care of a transitory nature" (BRASIL, 2011), despite having absolutely divergent orientations from the other devices of the same network. On the Federal Government website, we find the following definition for TCs:

[...] private, non-profit entities that provide free shelter for people with disorders resulting from the use, abuse or dependence of psychoactive substances, in a transitional residential regime and exclusively voluntary (spontaneous). The reception period varies from 3 months to 12 months, depending on the entity's therapeutic project. The main instrument used in the Therapeutic Communities during treatment is the coexistence between peers. The Therapeutic Communities are not part of the

Unified Health System (SUS) or the Unified Social Assistance System (SUAS), but they are equipment of the supplementary network of care, recovery and social reintegration of addicts of psychoactive substances, so that these entities are part of the National System of Public Policies on Drugs – SISNAD, by virtue of Decree No. 9,761/2019 and Law No. 13,840/2019 (BRAZIL, 2025, n.p.).

To demonstrate how they are inserted in Brazil, we will start from three important reports: the *Profile of Therapeutic Communities in Brazil*, carried out in 2017 by the Institute of Applied Economic Research (IPEA) and commissioned by the National Anti-Drug Secretariat (SENAD); the *National Inspection Report on Therapeutic Communities*, prepared by the Federal Council of Psychology (CFP), the National Mechanism for Preventing and Combating Torture (MNPCT) and the Federal Prosecutor's Office for Citizens' Rights of the Federal Public Ministry (PFDC/MPF); and the report *Public Financing of Brazilian Therapeutic Communities between 2017 and 2020*, produced by Conectas Human Rights and the Brazilian Center for Analysis and Planning.

With the asylum model, with long and predetermined hospitalizations, in TCs "the deprivation of liberty is the rule that sustains this model of care" (CFP, MNPCT; MPF, 2018). In all the TCs inspected by the *National Inspection*, walls, locks, bars, security guards, retention of documents, bank cards and restrictions on means of communication were found. Without the consent of users, more than 80% of hospitalizations are carried out or interrupted by family members (IPEA, 2017), depriving them of their most fundamental rights and, of course, not considering them subjects.

Reports of compulsory hospitalizations – **or of initially voluntary hospitalizations converted into involuntary ones through** dissuasive practices, retention of documents or contractual fines – are common and are added to other complaints: mechanical or chemical restraints **carried out** by the inmates themselves; internments of adolescents to comply with socio-educational measures **without any integration into the formal education** system; and the practice of medicalization without a medical prescription, **even reaching the participation of users in the dispensation of medicines**. The facilities, often **located in areas of difficult access and far from any public policy**, promote isolation and the rupture of social ties, with several users – the elderly, in particular – **living in the TCs**, some without any issue related to drug use, **but only because of their condition of vulnerability** (CFP, MNPCT, PFDC/MPF, 2018).

Spirituality is described **as directly linked** to religious institutions, especially neo-Pentecostal evangelicals, **basing** the "recovery" of inmates on the divine order and placing

religiosity as an objective criterion of access and permanence, in affront to Article 5 of the *Constitution* (BRAZIL, 1988). In addition, religious rites are often used as practices of embarrassment, punishment and torture in the face of disobedience to institutional rules and/or as forms of conversion, including the so-called "gay cure" ⁸ ⁹(CFP, MNPCT, PFDC/MPF, 2018).

Work, another of its pillars, is named as labor therapy – the use of work or some craft as a form of treatment. However, observation shows that this practice is used without any purpose of social reintegration or learning a new trade. On the contrary, the reports point to its forced and unpaid use, either as a method of punishment or to favor coordinators or owners of the institutions through profit. Labor therapy, therefore, functions as a veil that covers the practice of exploiting labor in precarious, mandatory conditions analogous to slavery.

The last pillar, discipline, is not disconnected from the previous ones, as several disciplinary practices are used for a supposed pedagogical and/or therapeutic purpose, although they are only configured as punishment and/or torture: mechanical and/or chemical restraints; isolation and confinement for long periods; sleep deprivation; suspension of alimony; physical and psychological violence. The reported practices flagrantly violate article 2, sole paragraph, item II, of Law No. 10,216/2001; article 20, item IV, of Anvisa's Resolution RDC No. 29/2011; and the Penal Code (BRASIL, 1940). All these rules prohibit the use of physical, psychological or moral punishment by institutions, even for people with disorders resulting from the use of alcohol and other drugs.

The funding of TCs usually comes from federal, state, municipal and private sources. Based on data from the Ministries of Health and Citizenship, between 2019 and 2021 there was an increase of about 65% in funding for TCs and, on the other hand, CAPS ad had a growth of only 11% in the same period. From the point of view of financing, TCs can be considered public facilities; however, a public policy needs to be based on institutional rules, target audience and clearly delimited objectives, in addition to obedience to the principles of transparency and publicity of its actions and resources, as determined by the *Constitution*

⁸ The gay cure was a terminology that became known after parliamentarians tried to pass a bill in Congress that would allow psychologists to practice sexual reversal therapies, where subjects with homosexual sexual orientation would be converted to heterosexuality.

⁹ On this, see the article shown on Fantástico – a Rede Globo program – which showed the use of work and torture mechanisms as punishment for inmates, including in TCs coordinated by Brazilian politicians, such as Pastor and Sergeant Isidório de Santana – federal deputy with the most votes for Avante da Bahia, owner of a TC – who appears with a machete in his hand, named as a "psychiatrist", uttering several homophobic insults to the inmates: Available at: <https://www.youtube.com/watch?v=JTYFhdKG-yw>

(BRASIL, 1988) and the *Fiscal Responsibility Law* (BRASIL, 2000). Furthermore, the way TCs are organized in Brazil prevents the construction of a clear typology that classifies them as health or care equipment, as they do not establish the necessary criteria for classification in any of these areas, favoring the difficulty of inspection. In their vast majority, TCs are institutions of a religious nature and, therefore, considering them as health institutions, within the scope of the SUS, is absolutely serious, as it violates the constitutional principle of secularism.

Human rights violations were found in all the institutions visited by the *National Inspection* (CFP, MNPCT, PFDC/MPF, 2018). Deregulation or weak regulation of any institution creates opportunities for illegal or criminal activities in these spaces. By being financed by the government without the proper legal criteria, TCs are left on an institutional edge: at the same time that they receive public funding, they are outside the fundamental rules that constitute a network for the promotion of care and health rights, precisely the greatest promoters of rights in the country. The government is financing private institutions without articulation with the systems that have their network spread throughout the country and obey extremely strict requirements.

We know that hospitalizing people with mental disorders and/or drug use has always yielded and still yields a lot of money to this day in Brazil, even at the expense of a lot of violence. In view of the foregoing, added to the fact that we still have more than 2,000 TCs in activity in the country, it seems clear to us that the marketing intention at stake in these institutions is clear. It is extremely serious that subjects – regardless of whether they use drugs or not – are exposed to the conditions reported in these documents so that a few people profit and enjoy them in such cruel ways.

In 2024, already in the current government of Luis Inácio Lula da Silva, the National Council of Social Assistance began not to recognize TCs as social assistance organizations, demanding their disconnection from the Unified Social Assistance System (SUAS). Thus, the TCs could no longer receive resources from the National Social Assistance Fund. As a result, it was possible to cancel the Accreditation Notice 8/2023 (BRASIL, 2023) – the main financing instrument, which already had the accreditation of 585 TCs – by Ordinance 1,104/2025 of the Ministry of Social Development (MDS). This decision responds to the demands of several anti-asylum movements and reinforces the importance of inspection and social control bodies, such as the Councils, and their actions with entities and parliamentarians, with a view

to guaranteeing care in freedom, community and territorial, as recommended by the 1988 Constitution.

4 HARM REDUCTION STRATEGIES: A BET ON THE ETHICS OF THE SUBJECT

Born in the international context, Harm Reduction (DR) strategies are widespread in several countries as part of the policy of care for drug users in the field of health. In a more comprehensive and continuous way, the beginning of HR as a policy in the 1980s, in the Netherlands, is recognized; However, some previous practices already presented their principles as a bet, even without yet receiving a formal conceptualization.

As psychoanalysts, however, it seems essential to remember that, in Freud's biographies (JONES, 1953; GAY, 1989; ROUDINESCO, 2016), we find the well-known and controversial episode involving cocaine. In 1884, still a young doctor in Vienna, Freud began studies on the substance, recently isolated at the time and considered promising for various medical applications. Motivated by scientific enthusiasm and the desire for academic projection, Freud tried the drug on himself and prescribed it to Ernst von Fleischl-Marxow, a physiologist and his former teacher. Published in the article *Über Coca*, Freud (1884/1962) defended its use to treat fatigue, chronic pain, depression and, especially, as a substitute for morphine.

Initially, cocaine allowed Fleischl to reduce his morphine use¹⁰, but it quickly led to a new dependence, accompanied by symptoms triggered by the systematic use of the substance, such as paranoia and physical deteriorations. Fleischl died in 1891 and the episode generated criticism of Freud's conduct, later being called the "cocaine scandal". Despite the negative developments, Freud's studies indirectly contributed to Karl Koller, a close colleague, discovering the use of cocaine as a local anesthetic in ophthalmology, later also used in the treatment of migraines. Freud, throughout the 1890s, gradually abandoned the use of the drug and began to avoid the topic in his later writings.

Subsequently, two specific situations deserve to be highlighted. The first, which occurred in England, concerns soldiers who had left the First World War (1914-1918) who, after having their wounds treated with morphine and other opioids, became dependent on these substances provided by the State itself. In view of this, a group of

¹⁰ Analgesic drug – from the group of opioids – used to this day for the relief of intense, acute and chronic pain, which has great potential for dependence due to the immediate sedative effects.

ex-combatants demanded the continuity of the supply, in order to avoid the damage resulting from an abrupt withdrawal or the need to resort to the illegal market. This care strategy was formalized by the Rolleston Report ¹¹ (Great Britain, 1926), which recognized the possibility of mitigating harm and reducing harmful effects associated with the use of these substances (SANTOS; SOARES; CAMPOS, 2010). The second situation refers to the emergence of methadone¹², between the 1930s and 1940s, in Germany, proposed as a strategy to replace heroin¹³.

In the 1980s, Junkiebond, a Dutch association of drug users and former users, faced with the spread of sexually transmitted infections (STIs) through the sharing of contaminated syringes, demanded that the State adopt public policies that mitigate the risks of contamination and deaths, without the interruption of use being an imposition. Faced with the concern – especially about the transmission of Hepatitis B and AIDS – the Dutch government implemented the first Syringe Exchange Program (STP).

In the following decade, the cities of Santos (SP) and Salvador (BA) managed to implement the first STPs in Brazil, with the main target being the population that used injectable cocaine and controlling the spread of STIs. This scenario gains a fundamental boost when, in 2003, HR actions are no longer just a strategy of the STD/AIDS program and start to serve as a guide for the Ministry of Health's Policy for Care for Users of Alcohol and other Drugs within the scope of the SUS. According to Passos and Souza (2011, p. 154), HR can be defined as "an alternative health production strategy to strategies based on the logic of abstinence, including the diversity of demands and expanding health offers for the population of drug users".

The field of the SUS is the condition for the existence of HR. There is no possibility of thinking of a strategy like this other than for comprehensiveness, gratuity, capillarity and the intersectionality of the articulations of the SUS with the other public policies of the State. Contrary to neoliberal projects, the SUS, in its perspective of universality as a basic right, is

¹¹ The *Rolleston Report* was a set of recommendations made by a commission chaired by the UK Health Minister, Humphrey Rolleston, which authorized British doctors to prescribe opium to addicts at risk.

¹² Analgesic drug – from the group of opioids – with effects similar to those of heroin and morphine, still used today in DR strategies as a substitute for the latter because it has less sedative effects.

¹³ In his book *High Hitler: how the use of drugs by the Führer and the Nazis dictated the course of the Third Reich*, Ohler Norman (2017) reports that there are journalistic findings narrating the emergence of Methadone in studies commissioned by Hitler, due to the abusive use of drugs by German soldiers and his own use. However, it should be noted that the Nazi regime adopted a very prohibitionist stance, executing many drug users in concentration camps.

opposed to a system that can function as a service provider that considers health to be an access only for those who can pay for it, that is, a market product.

In *The Peripatetic Clinic*, Lancetti (2012) describes HR strategies as capable of providing another way of apprehending drug users, in which many subjects could be included and recognized as inhabitants of the city in fact, even if in different ways. The creation of the figure of the harm reduction professional, a health agent that often has a close relationship with the territory, allowed the offer of care to the most segregated places: the alleys of the favelas, the streets where residents, prostitutes, transvestites, wanderers live – mostly black and poor – that is, where the scenes of use are, both people in great social vulnerability and those who, for various reasons, do not want to interrupt consumption. By this same logic, the knowledge that sustains HR is not the property of specialists. They come mainly from users, former users, family members and residents of the territories and places of consumption.

Among the various strategies that the HR clinic presupposes, we can mention the practices of disseminating information about the harms and techniques linked to the use and referrals, such as guidance on rights, prophylaxis, distribution of inputs, drug substitution therapies and assistance (BRASIL, 2005). As a practical and theoretical strategy guided by an ethics of care and by a conception of drugs as part of the human experience, HR is guided by the reduction of risks linked to this reality (TORRES; VIDAL, 2017). Thus, the bond between the user and the figure of the harm reducer is an essential part of the work of building or reconstructing a bond that allows the drug user to invest in the social bond, from which he is often precarious or separated. Therefore, although it is common to hear that HR is an "incentive to use" or mere substitution of drugs, it is essential to highlight that it can presuppose substitution, but it is not a synonym for treatment by the object. Treatment from HR necessarily involves transfer with professionals and decisions proposed and constantly rethought. As Laurent (2008, p. 15) points out:

There is also processing by object, by objects of substitution. 'You are a heroin addict, let's propose Methadone or Subutex. This substitution is less deadly, it gives you access to a legal object, to rights, there is a social status'. It is a way of rewriting the subject separated from an entire discourse, in a social bond.

Therefore, if all the definitions of objectives, goals and procedures are not imposed, but discussed, even substitution is thought of in the uniqueness of each case, as well as abstinence, which can be a goal, an end or even its beginning, never the only strategy. This

decision is up to the subject and may or may not be part of his/her therapeutic project, which, established on a case-by-case basis, aims at self-care and autonomy over treatment and use. What is at stake in a practice that, guided by the clinic, proposes to reduce harm, is precisely the implication of the subject and his responsibility and not the offer of a tutelage that fixes him in the place of object of intervention.

The construction of the singular projects, carried out in partnership with the RAPS devices, is essential for the implementation of the strategies, based on **the treatment of the case by case**. In this context, in addition to ensuring rights, it seeks to **consider the user as the protagonist** of his own treatment, bringing him, at this point, closer to psychoanalysis. It is not, obviously, a matter of equating the two fields, but of **thinking about parallels** that structure the clinical and political strategies of HR – through the subject's knowledge about its use – and psychoanalysis based on unconscious knowledge and the position that drugs occupy in their libidinal economy. The articulation between clinic and politics has been highlighted since Freud (1919 [1918]/2020) as the one that made it possible **to listen to segregated subjects**, reaffirming the analyst as the guiding thread of this process that, based on his desire, allows psychoanalytic listening to be present in any device. As Elia (2000, p. 28) points out and defends:

It is thus possible to do psychoanalysis in any social stratum, in any institutional environment. As long as there is an analyst, on the one hand, and a divided subject, on the other. The analyst should not confuse his criteria with social criteria. Thus, elitism is demonstrated here as impossible in a psychoanalytic posture.

Even when it is a demand that, initially, is configured as a request for a guarantee of rights – frequent in psychosocial care – the psychoanalyst must operate with his clinical and ethical rigor. Especially because this may be the only way in which these people can address some demand to us, since most of these subjects still do not reach private offices. Warned of its listening function, however, the bet needs to be guided by the emergence of a subject, even in the most adverse conditions. If, with the use of drugs, what is intended is the placation of the malaise, the bet of psychoanalysis needs to be to construct new possibilities that point to another way of treating this malaise: through speech and including its partialization.

As much as we can hear them in their discourses from a set that identifies them and presupposes them as equals – drug addict, addict, drug addict, pothead, drug dealer – drug abuse does not define these subjects (MARTINS, 2011). When we propose to listen to their

stories in the clinic – whether in the public or private field – we perceive the existence of an initial discourse, promoting a certain collage between the subject who uses it and the object-drug used, as if he were submerged there. Thus, they present themselves only by their uses, by a mode of *jouissance*, petrified into signifiers and linked to an identification with a name that, by itself, says nothing about the subject (ALBERTI, 2003). Therefore, it is essential to call on them to talk about their uses, but, above all, about their stories that are not limited to drugs. Starting from the singular of each case, it is the signifiers that emerge in the speech of each subject **that interest us**:

The subject is therefore always supposed. We do not find it in reality, but we suppose it. Or rather, we are forced to suppose it from the moment we recognize the incidence of the signifier in human experience, that atom of the symbolic which, because it has no meaning in itself, summons, in the living being, when it is speaking (that is, when it is inhabited by the symbolic), the response that is called the subject. We are forced to suppose the subject when we recognize the signifier because, in fact, it is the signifier (and not us) who presupposes the subject. The subject is, therefore, a supposition of the signifier, which imposes itself on us (ELIA, 2010, p. 70).

The subject is constituted by signifying marks that will be placed in a chain: "everything that is language is obtained from this alterity, and it is for this reason that the subject is always an evanescent thing, which runs under a chain of signifiers" (LACAN, 1976, p. 206). If there is no relationship between the subject and the drug-object that does not occur in the field of the symbolic, as psychoanalysts, then our work in any device needs to be an invitation to speak. Only with the sliding of the signifying chain, proposed by the free association, can the subject's ills and problems appear. In no way are they limited to drugs, but they certainly converge to their relationship with the Other and to the anguish in the face of castration.

The universalization present in groups and institutions operates by suppressing differences and subjectivity, which ends up opening space for segregation. Alberti and Figueiredo (2006) point out that perhaps the greatest lesson of psychoanalysis in a public field such as mental health is to retreat from what is daily imposed as an attempt at understanding, letting each subject, in his or her own time, conclude something about himself that brings a singular mark of *jouissance*. In this way, the exercise of psychoanalysis in the institution requires the presence of an orientation committed to its theory, its clinic and its particular ethics, "in order to underline its specificity in contributing to the support of the patient and user of the services as a subject" (ALBERTI; FIGUEIREDO, 2006, p. 14).

Thus, the ethics of psychoanalysis can never be regulated by a norm, nor according to the requirements of the ideals of the professionals or of the institution itself. By understanding symptoms as formations of the unconscious and not being guided by their immediate suppression, psychoanalysis ends up operating against what institutional mandates preach. As a challenge, there is the hole in the norms, making the case by case prevail, listening to the unconscious, pointing out the impossibility of dealing with all the issues, that is, healing as a path to normality. If we think of the offers of public policies based on the cessation of malaise, they will always be seen as failure; Therefore, our bet not only includes malaise as a possibility, but as an inherent one.

5 FROM THE MALAISE IN CULTURE TO THE MALAISE IN DRUG POLICY

For two years, we were a professor and preceptor of medical students at UFRJ – Macaé Campus – in a CAPS ad, where we heard from many students that the work in that equipment was to "dry ice", "rain on the wet", "without effectiveness". The malaise of future doctors arose in the presence of users in the institution under the influence of drugs, reporting their "relapses", missing appointments, circumventing medications – not taking them or exceeding use – that is, not remaining abstinent. In view of their mandates to heal the organic body – learned in the eight periods that preceded their "passage" through the chair of Mental Health – it was very difficult to introduce a cut that could lead them to understand that, for some subjects, seeking care during or after use, or offering them a break in this use by listening to or caring for the body – even if for a few hours – represented the possibility of building new paths *a posteriori*. In addition, as an "open-door" service, the CAPS was also a space of circulation **not restricted** only to those who interrupted drug use. On the contrary, guided by HR and, as psychoanalysts, we knew that dealing with drunkenness, intoxication, agitation, drowsiness and other effects was included. Welcoming them in this way was a gamble... And this is no small feat.

Having contact with mental health only at the end of graduation, they brought the strangeness that Paula, a student was able to express:

We spend almost five years just learning how to diagnose and treat organs and, when we get here, do you tell us that we have to listen to the subject? I'm trying, it has moved me in many ways, but many colleagues don't see the slightest use in it and I understand them.

At the time, there was a discussion at the University about the possibility of anticipating the contact of academics with mental health earlier, but, for this, it was necessary for other professors to give space, which did not happen. At that time, of the six mental health professors, there were two psychoanalysts and, at CAPS ad, two others. Therefore, the insistence on "listening to the subject" was an offer that, based on their own anxieties, caused desire in some students. The medical course is marked by the presence of knowledge that seeks, in various ways, to veil any possibility of absence. It is not by chance that the overwhelming anguish of the students was almost always followed by numerous defenses in the face of the impossibilities that the education itself imposes. In Paula's words:

I took three years of prep school to get here, it was a dream, but I saw all my ideal quickly unravel. Most teachers are happy to take us close to giving up, and this possibility is like a little voice in the back of my head. I sought analysis to remind myself weekly of why I am here. I saw up close that this is unbearable for some.

At the beginning of that semester, a classmate of Paula's died when he threw himself from the tenth floor of the student dormitory where he lived. This was already the third case since she started college. However, Paula was able to bet on her desire and, perhaps because of this, she was also able to see mental health and HR as a bet. From that same class, another student, after a class on drug policy and many questions about its "effectiveness", said: "I don't understand spending money on those who don't want to be treated. Either you can intern or do as the governor said: 'just aim at the little head and...'" . The student was referring to a speech by the former governor of the state of Rio, Wilson Witzel, in 2018¹⁴, about how the police should act in the face of any subject who was in a situation of suspicion. His words bothered part of the population, but he was acclaimed by another significant portion that brings in its bet the possibility of executing people based on the premise "a good criminal is a dead criminal". This *modus operandi* of the State is affirmed based on another Brazilian mark: that the "good citizen" is the only one who can enjoy the right to circulate in the city. The others, including drug users, the insane, the black and the poor, need to gain destinations out of their sight.

In view of such reports, we recall Foucault (1972/2004), in *History of Madness*, when he brings that, in the eighteenth century, with the beginning of the so-called industrial

¹⁴ See: BARREIRAS, G. Declarations and striking images of Wilson Witzel's government. G1, Rio de Janeiro, April 30, 2021. [www.g1.globo.com](https://g1.globo.com/rj/rio-de-janeiro/noticia/2021/04/30/declaracoes-e-imagens-marcantes-de-governo-de-wilson-witzel.ghtml). Available at: <https://g1.globo.com/rj/rio-de-janeiro/noticia/2021/04/30/declaracoes-e-imagens-marcantes-de-governo-de-wilson-witzel.ghtml>.

capitalism, work began to have an attribution of value that raised it to levels not seen before. On the other hand, poverty, which had a certain value in Christian discourse, began to be depreciated. In this way, the portion of the population that could not adapt to the world of work – the insane, beggars, prostitutes, carriers of contagious diseases, the disabled, delinquents, among others – became the target of hygienist measures. The author calls the period in which madness, before being a medical object, was treated as a moral and social problem a "major internment".

In the nineteenth century, the new parameters of modern and positivist science required medicine to undergo a reformulation, structuring methods of knowledge based on experimentation, which modified the teaching of the profession with a view to standardization. In this scenario, figures such as Philippe Pinel appeared, sustaining a psychiatry that inaugurated a field of knowledge aimed at treating madness as a mental illness, aiming at the transformation of unreason into an object of normalization. Thus, both "the great internment" and this medical and positivist science are part of a perspective of power in which submitting difference to the norm is its motto, whether by exclusion or pathologization.

Throughout his work, Foucault demonstrated a deep interest in the relations between power and knowledge, alluding to the exercise of power as something that is only possible through the use of knowledge as an instrument of justification. In other words, authoritarian practices of segregation, monitoring, and control of bodies are legitimized in the name of a single, constructed truth. Thus, Foucault (1978, p. 3) developed the concept of biopower as "the set of mechanisms by which what, in the human species, constitutes its fundamental characteristics, will be able to enter into a politics, a political strategy, a general strategy of power". The production of a knowledge-power over life, therefore, regulates it, producing discourses about what we understand as health, disease, treatments and sexuality.

Nowadays, an increasingly biologizing psychiatry moves away from clinical practice that includes listening, symptom support, and the management of anguish, in favor of a close alliance between science and contemporary capitalism, or rather, the production of a science at the service of capital. With the massive production of objects of consumption – *gadgets* – that aim to buffer any lack, capitalism produces drugs and, later, diagnoses so that drugs can be consumed or to make subjects more adequate and functional.

Returning to the Freudian text of 1930 to establish a dialogue between malaise and the so-called civilizational progress, Lacan (1967, unpublished, p. 29-30), in *A short speech to psychiatrists*, says: "the progress of universal civilization will result not only in a certain

malaise", but in a "practice, which they will see will become more and more widespread, which will not immediately show its true face, but which has a name that, transformed or not, will always mean the same thing: segregation". Then, he warns by saying that thirty or fifty years later history will demand a position from psychiatrists:

My God, the dear psychiatrists, in fact, give us a small model of what could have been done at that moment as a cogitation that could have been useful for us, but in fact they did not give it to us, because at that moment they slept, they slept, why? My God, because they never saw very clearly what was about their relationship with madness after a certain period; they did not see it, God knows why, it will be said, they did not see it precisely because they had the means to see it (LACAN, 1967, unpublished, p. 30).

Lacan states, therefore, that, instead of dealing with the effects of segregation, psychiatrists remained asleep, even though they had at their disposal the means with which they could do so, that is, psychoanalysis and its ethics. Instead of making it an instrument, they preferred to use it as a means of social ascension. More than fifty years later, what we are witnessing is psychiatry becoming more and more involved in its biologization, having diagnostic manuals as its main tool of care, leaving listening out of this process. They thus present themselves as the "gold standard" of a science that, without any constraint, joins capital with the same intention: to tame bodies and try to transform them into universals.

When referring to the relationship between psychiatrists and the madman, Lacan (1967, unpublished) says that other barriers were placed in place of isolating him, and it was no longer necessary to asylum the madman to make him docile. Psychiatry, rediscovering its purpose of being equivalent to a framework of general medicine, entered entirely into the pharmaceutical dynamism, replacing the clinical experience with the insane by its apprehension as an object of study and psychopharmacological experimentation. For a long time, science had already sought to correct the flaw that madness opened, all with the same intention: to universalize and seek the isolation of a "pure subject" (LACAN, 1967/2003, p. 28).

In *the Proposition of October 9, 1967 on the psychoanalyst of the School*, Lacan (1967a/2003) makes a new reference to an expansion of the processes of segregation as a consequence of the universalization introduced by science, taking the concentration camps as the basis for his discussion. He thus states that what we saw emerge in these places:

It represented the reaction of precursors in relation to what will develop as a consequence of the relocation of social groups by science and, nominally, of the universalization that it introduces there [...] Our future of common markets will find its balance in an increasingly harsh expansion of the processes of segregation (LACAN, 1967a/2003, p. 263).

The total institutions, named by Goffman (1987) from asylums, prisons and convents, gain new faces in Brazil with the TCs, which unite, at the same time, the moral, the religious and the medical/psychiatric discourse. We cannot fail to emphasize that the large audience of these institutions is composed of people in social vulnerability: the poor, the homeless, the unemployed – a population that, in Brazil, crosses the racial profile, a legacy of centuries of slavery, that is, of a regime that was made at the expense of the domination of a population that to this day lives its effects. Thus, the population from which a framework is most expected is also the most susceptible to drug abuse. Consequently, these people will be the priority target of totalizing policies, who will serve as slave labor in the large internments promoted by the State – in alliance with the churches and psychiatry – in the TCs. Therefore, if we can compare the TCs to the concentration camps – as some professionals committed to mental health policies and some activists have pointed out – due to the dozens of complaints exposed above, Let us not forget that there is a lot of slave ship in them.

In *Terminable and Endless Analysis*, when talking about the offices of governing, educating, and analyzing, Freud (1937/2020, p. 249) told us that they "can be given in advance the insufficiency of the result". In this way, it places them as impossible. This premise has an intrinsic relationship with the first developments of the theory of drives, when it affirmed the child as a perverse polymorph. Being always subject to the omnipotence of the pleasure principle, there is something of the drive impossible to master, expressed in the goal of the drive, that is, satisfaction. If the drive is what moves, impels the subject in one direction, it seems an impossible task to summon it to an order, to a norm and to a continuous well-being, that is, to educate it. Moreover, if satisfaction is the goal of the drive, its target – the object –, as we learned from Lacan (1964/1998), is always a void, a hollow – represented by the object *a* –, marking the partiality, the mismatch and its return. The impossible encounter institutes the compulsion to repetition, leaving a remnant that, by insisting, led Freud to the concept of the death drive.

In 1930, Freud pointed out malaise as a constant process that the subject will have to deal with throughout life as part of the instinctual renunciation necessary for the establishment of the social bond. With this, Lacan introduced the field of *jouissance* from the concept of

object **a**, and, moving forward, he was able, in *The Seminar, book 16: From an Other to the Other* (1968-69/2006), to bring discourse as a position that the subject occupies in language, situating it beyond speech. As a form of social bond, discourse contains an impossibility, through which it will introduce, once again, the object **a**, this time as the surplus-of-jouissance: "a function of renouncing jouissance under the effect of discourse" (LACAN, 1968-69/2006, p. 19). The concept of surplus-de-jouissance is brought by Lacan as a homologue to the concept of surplus-value, that is, made "of the same fabric, insofar as it is the scissor cut of discourse" (LACAN, 1968-69/2006, p. 45).

The concept of surplus value is introduced by Marx (1867/2008) as the alienated labor that the subject provides to the capitalist, that is, to those who own, accumulate capital and pay a small part to those who produce it. It is a disparity between the wages paid to the proletarian and the value of the labour he produces. Surplus value, then, is the profit of the capitalist, the profit granted by the worker to the capitalist, the extra time of work of the proletarian who increases the capital of those who own the means of production. Where there is profit as a goal, there is necessarily surplus value as an operator, an integral part of the organization of the capitalist system that aims at the production of a profit that will be infinitely reinvested, generating the accumulation of capital. Thus something of the proletarian's remuneration will always escape him, and his account will never be able to reach its true accounting. Without realizing it, the proletarian becomes the cog that sustains this system that has at its base the exploitation and delivery of capital only to the hands of those who do not produce and do not have the knowledge about production.

However, there is also a loss for the capitalist, as he will not be able to have the gear of his machine running without the labor power. A perception that the system itself seeks to cover up, creating a discourse that places the capitalist as someone who, by moving the economy, allows the creation of jobs and, consequently, guarantees the subsistence of the worker. When, in fact, this is only possible because a mass of proletarians has been created and alienated from their production. The loss is inherent, however, the capitalist system sustains a discourse that seeks to veil these holes.

The homology pointed out by Lacan (1968-69/2006) dates back to the entry of the human into language, partializing instinctual satisfaction and having as a consequence the rigging of jouissance, that is, a symbolic system that organizes jouissance by imposing a bar on it. When the law begins to organize jouissance in the social bond, it ends up delimiting what can or cannot be done, demarcating the modes of jouissance and thus producing a

deviation. It is precisely from this renunciation of part of jouissance that the surplus-de-jouissance is produced. In other words, in the illusory idea that there is something to be recovered, what is introduced for the subject is loss. If something of this jouissance is irretrievable, it also becomes impossible to be accounted for, despite being supposed to the subject.

The Freudian notes of 1920 allowed us to know that jouissance is that which escapes the pleasure principle, a principle that has as its premise the return to a previous state of tension reduced to the lowest possible homeostatic level. There is a non-taxable excess attributed to the Other that makes the account never close, leaving the subject to be infinitely indebted and articulating a relationship between jouissance and repetition, since it "is based on a return to jouissance" (LACAN, 1969-70/1992, p. 47). For Lacan, it was from this relationship that Freud found himself "in some way obliged, by the very structure of discourse, to articulate the death drive" (LACAN, 1969-70/1992, p. 47). Thus, if repetition is based on a return to jouissance, on a search for representation, "[...] it is from there that we start to give meaning to this inaugural repetition, insofar as it is repetition that aims at jouissance" (LACAN, 1969-70/1992, p. 47). In this gear, we observe the attempt to recover the lost jouissance impossible, an a-plus that cannot be symbolized by way of phallic signification. In this mathematics of jouissance, there is a mismatch that cannot be repaired, as in an exact calculation. On the contrary, in this account there will always be a remainder, an unsymbolized excess, which concerns the real, as Lacan (1968-69/2006, p. 30) points out: "In general, this is determined by the convergence towards an impossibility. That's why it's real."

When Freud, in creating psychoanalysis in an absolutely revolutionary way, brought sexuality as a drive, he showed us that, if the renunciation of a part of the satisfaction is a condition of the social bond, being in the bond will not be without discomfort, without a remainder that is precipitated and with which the subject will have to deal. It is castration itself, which, by bringing anguish as an effect, causes some subjects to resort to palliatives such as drugs, which buffer the malaise by producing sedative effects, but temporary. In view of this, in the course of listening to subjects who use drugs, it seems fundamental to us what psychoanalysis can offer by including lack – a structural and structuring loss. If the object is lost, "something else appears in the place of jouissance, that is, the trace that marks it. Nothing can be produced there without an object being lost" (LACAN, 1968-69/2006, p. 21).

Returning to the Harm Reduction proposal, Feldman (2014) reports experiences of DR in narco-rooms¹⁵ installed in treatment centers located at strategic points in some cities in Switzerland. In them, heroin applications are provided under the care of health professionals, present throughout the "wave" of the drug, at scheduled times and modes of application with safe inputs. As they are shared spaces with other users and with the presence of a team, these equipment allow a certain ordering of use by inserting it into the social bond and the offer of better quality drugs. However, some users prefer the use of the more impure heroin, bought from dealers and consumed on the streets. Experience reports that the ethics of Harm Reduction include a policy that will never be universalizing. In the same way, we cannot infer that abstinence is so, although it is proposed.

In *Television*, Lacan (1974/2003, p. 508) teaches us that the word is always a flawed instrument, since "to tell the whole truth is impossible, materially: words are missing". Truth, therefore, is always a half-truth; the other half is unspeakable. This impossible, present in language, in the impossibility of saying it in its entirety, is the real, "that which does not cease not to be written" (LACAN, 1972-73/2010, p. 55). Thus, any public policy, any offer of treatment, needs to be considered possible only to some extent, that is, it must be thought of from a non-all *jouissance*. Lacan (1974/2003) also warns us not to treat the Other *jouissance*, that which is *heteros*, as underdeveloped, imputing to it a single mode of *jouissance*. With this, he reminds us that to have the field of *jouissance* as an ethic is to sustain castration as the way to allow each one to respond, singularly, to the non-existence of sexual intercourse. There is no perfect encounter and, therefore, the measure of each one can be, for example, the substitution of drugs, of modes of use that partialize a *jouissance* that has hitherto been deadly. For others, the measure may be abstinence. The fact is that there is not a single measure and that, in addition, it is not possible to prevent the subject from cumming in any way.

In the context of deep social inequalities in Brazil, it is inadmissible to treat drug use only with a proposal to interrupt use obtained through gluing to the signifier that identifies a group, punishments, forced labor, prayers and deprivation of freedom. When they return from long hospitalizations to their territories and their ills, added to the easy availability of drugs, a favorable scenario is created for the resumption of use. Therefore, the lack of a more

¹⁵ Narco-rooms or safe use rooms are health and HR facilities where subjects use drugs assisted by health professionals who will guarantee them access to adequate supplies, assistance if they need it, food and security.

comprehensive evaluation, centering on people willing to renounce drug use altogether as their only criterion for success, makes the high public investment in this model problematic. In this way, this discourse, like any other, contains a hole, although veiled by those who propose it. There are no simple solutions to complex problems. Our proposal insists on a model that includes a range of possibilities thought out on a case-by-case basis, taking into account each subject who makes drugs a palliative resource for their malaise (FREUD, 1930/2020) and the conjuncture in which they are inserted.

In view of the above, we affirm that hospitalization in institutions that violate human rights, even with medical approval, cannot be confused with treatment. It should occur only in specific, short-term situations, decided by a multidisciplinary team and, if possible, with the participation of the patient and family members, prioritizing devices such as CAPS ad III and IV and General Hospitals, in line with the anti-asylum logic. This is the logic contained in the Psychiatric Reform and Harm Reduction: a bet that moves towards policies that consider the subject in his or her dimension of care and choice. Allied to psychoanalysis, this is a bet that calls for speech and, therefore, will come up against loss, insufficiency, limitation, partiality – but also in reformulation and change, even if arduously achieved.

6 FINAL CONSIDERATIONS

In 1913, with *Totem and Taboo*, Freud presented us with the myth of psychoanalysis through the murder of the father by a brotherhood that saw itself excluded from access to jouissance. In addition, he pointed out to us the creation of totemic systems as an affirmation of solidarity, with laws and protection mechanisms that prevent the other from being taken as an object of jouissance – that is, that prohibit because, first, they attest to and recognize the human as a being capable of killing another human. If the drive tendency aims to "treat the other as an object to be consumed: sexually and fatally" (QUINET, 2006, p. 17), the drive renunciation is the condition for the maintenance of the civilizing pact. Therefore, rethinking the laws and apparatuses that we are willing to create becomes urgent.

The call of public policies needs to be based on Eros, on the invitation to speak, on what binds and relaunches the subject in life. In this dynamic of representations that is unleashed, anything can come as a novelty, as knowledge that is not known, unconscious, even if partial, insufficient and limited, but without disregarding the insistence of the death drive, the impossibility of educating, governing and analyzing, that which escapes the significant knowledge and which, therefore, is not-all. And, once again: this is no small thing!

It is about the defense of secular, community and territorial care offers – which include the unconscious as a territory – that respect constitutional rights and promote the integrality of public policies.

With regard to mental health, alcohol and other drug policies, we already have a path that points in this direction. We need to take it up again with determination, betting on the constitutional and democratic ideals of the Psychiatric Reform in its relationship with the clinic and politics. Starting from social struggles that included users, family members and workers, listening to these actors was, for a long time, the north in the construction of psychosocial care devices. With the setbacks, we have seen that they occur precisely to the extent that one tries, once again, to exclude the subjects from this process, using, for this, discourses that objectify them. If change is only of interest to the proletarian, as pointed out by Marx, it is once again up to the same actors to fight for the reorientation of these policies. As Lacan had already said in 1967, here, psychoanalysis has much to contribute.

ACKNOWLEDGEMENTS

The authors would like to thank the institutional support of the State University of Rio de Janeiro (UERJ), especially the Graduate Program in Psychoanalysis, of the Institute of Psychology (PGPSA-IP). This study was developed with the support of the Coordination for the Improvement of Higher Education Personnel (CAPES) and the Graduate Support Program (PROAP).

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**TECHNOLOGICAL PROSPECTING OF NFTS FOR INTELLECTUAL
PROPERTY: A PATENT-BASED ANALYSIS**

**PROSPECÇÃO TECNOLÓGICA DE NFTS PARA PROPRIEDADE
INTELLECTUAL: UMA ANÁLISE BASEADA EM PATENTES**

**PROSPECCIÓN TECNOLÓGICA DE NFTS PARA LA PROPIEDAD
INTELLECTUAL: UN ANÁLISIS BASADO EN PATENTES**

 <https://doi.org/10.56238/sevened2025.036-086>

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ABSTRACT

The increasing digitization of creative assets poses significant challenges to the protection of intellectual property. In this context, blockchain and Non-Fungible Token (NFT) technologies emerge as promising solutions to ensure the authenticity, traceability, and monetization of digital assets. This study aims to explore the landscape of technological innovation at this intersection through a systematic search in patent databases. The methodology consisted of a search on the Orbit Intelligence database, followed by a rigorous dual validation process that combined manual screening and analysis by Artificial Intelligence (DeepSeek), resulting in a final portfolio of 119 patent families. The results reveal a sharp increase in the number of filings from 2018 onwards, with a peak in 2022, and a strong geographical concentration in China. The analysis of technological domains indicates that innovations are focused on "IT methods for management" and "Digital communication," highlighting the use of the technology as a governance infrastructure. The qualitative analysis of selected patents demonstrates the sophistication of the solutions, which address issues ranging from registration efficiency to rights management for AI-generated content. It is concluded that the field is rapidly maturing, moving beyond proof-of-concept to develop specialized solutions that address complex challenges in the intellectual property ecosystem, thereby redefining protection paradigms in the digital economy.

Keywords: Technological Prospecting. Intellectual Property. Non-Fungible Tokens. Blockchain. Patents.

RESUMO

A crescente digitalização de ativos criativos impõe desafios significativos à proteção da propriedade intelectual. Neste contexto, as tecnologias de blockchain e Tokens Não

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Fungíveis (NFTs) emergem como soluções promissoras para garantir autenticidade, rastreabilidade e monetização de ativos digitais. O presente estudo tem como objetivo explorar o panorama da inovação tecnológica nesta interseção, por meio de uma prospecção sistemática em bases de dados de patentes. A metodologia consistiu em uma busca na base Orbit Intelligence, seguida de um rigoroso processo de validação dupla que combinou triagem manual e análise por Inteligência Artificial (DeepSeek), resultando em um portfólio final de 119 famílias de patentes. Os resultados revelam um crescimento acentuado no número de depósitos a partir de 2018, com um pico em 2022, e uma forte concentração geográfica na China. A análise dos domínios tecnológicos indica que as inovações se concentram em "Métodos de TI para gestão" e "Comunicação digital", evidenciando o uso da tecnologia como uma infraestrutura de governança. A análise qualitativa de patentes selecionadas demonstra a sofisticação das soluções, que abordam desde a eficiência do registro até a gestão de direitos para conteúdo gerado por IA. Conclui-se que o campo está em rápido amadurecimento, transcendendo a prova de conceito para desenvolver soluções especializadas que endereçam desafios complexos do ecossistema da propriedade intelectual, redefinindo os paradigmas de proteção na economia digital.

Palavras-chave: Propriedade Intelectual. Tokens Não Fungíveis. Blockchain. Patentes.

RESUMEN

La creciente digitalización de activos creativos impone desafíos significativos a la protección de la propiedad intelectual. En este contexto, las tecnologías de blockchain y Tokens No Fungibles (NFTs) emergen como soluciones prometedoras para garantizar la autenticidad, trazabilidad y monetización de activos digitales. El presente estudio tiene como objetivo explorar el panorama de la innovación tecnológica en esta intersección, a través de una prospección sistemática en bases de datos de patentes. La metodología consistió en una búsqueda en la base de datos Orbit Intelligence, seguida de un riguroso proceso de validación doble que combinó una selección manual y un análisis por Inteligencia Artificial (DeepSeek), resultando en un portafolio final de 119 familias de patentes. Los resultados revelan un crecimiento acentuado en el número de solicitudes a partir de 2018, con un pico en 2022, y una fuerte concentración geográfica en China. El análisis de los dominios tecnológicos indica que las innovaciones se concentran en "Métodos de TI para la gestión" y "Comunicación digital", evidenciando el uso de la tecnología como una infraestructura de gobernanza. El análisis cualitativo de patentes seleccionadas demuestra la sofisticación de las soluciones, que abordan desde la eficiencia del registro hasta la gestión de derechos para contenido generado por IA. Se concluye que el campo está en rápida maduración, trascendiendo la prueba de concepto para desarrollar soluciones especializadas que abordan desafíos complejos del ecosistema de la propiedad intelectual, redefiniendo los paradigmas de protección en la economía digital.

Palabras clave: Propiedad Intelectual. Tokens No Fungibles. Blockchain. Patentes.

1 INTRODUCTION

Intellectual property rights (IPR) management faces unprecedented challenges in a digital landscape characterized by the massive production and dissemination of content by a diverse range of creators, ranging from large corporations to independent artists (Ferro et al., 2023). Traditional protection systems, designed for an analog world, often prove inadequate to keep up with the speed and complexity of digital transactions, resulting in vulnerabilities that facilitate piracy and make it difficult for rights holders to be fairly remunerated. This lag creates a demand for technological solutions that can offer more agile, secure, and transparent mechanisms for the management of intellectual assets in the digital environment.

In this context, blockchain technology emerges as a promising infrastructure, with the potential to revolutionize the protection of intellectual property (Qizi; Kamalovich, 2025). Through its distributed, transparent, and immutable ledger, blockchain offers a secure platform for tracking asset ownership and transaction history, combating fraud and strengthening proof of anteriority and authenticity. Specifically, Non-Fungible Tokens (NFTs), which are unique digital representations of assets registered on the blockchain, together with smart contracts, enable the automation of IPR enforcement, dynamic licensing, and royalty distribution in a programmatic and efficient way (Ferro et al., 2023). The combination of smart legal contracts with the operability of smart contracts on the blockchain represents an innovative approach to formalize legally binding contractual aspects while also taking care of notarization and transfer of rights.

Despite the transformative potential widely discussed in the literature, there is still no established consensus on the ability of these technologies to properly manage and transfer intellectual property rights on a large scale (Ferro et al., 2023). Most existing studies tend to focus on conceptual analyses or specific case studies, leaving a gap in terms of an empirical and comprehensive analysis of the real technological development scenario. Understanding the direction, intensity, and focus of innovation is key to anticipating trends and assessing the maturity of this field. This is where technological prospecting, as a competitive intelligence tool, plays a fundamental role.

Patent analysis is a consolidated and effective methodology for technological prospecting, allowing mapping the state of the art, identifying promising technologies, and analyzing the strategic positioning of the main actors in a given sector (Altuntas; Dereli; Kusiak, 2015). Patent documents are a direct indicator of research and development (R&D) efforts and market protection strategies of organizations, offering insight into developing

innovations. Therefore, the application of a quantitative analysis of patents is a methodological approach to empirically investigate the evolution of the intersection between NFTs and intellectual property.

In view of the above, the objective of this article is to map the global panorama of technological development at the intersection between NFTs and the protection of intellectual property, through quantitative technological prospecting based on patent data. To this end, it seeks to answer the following research question: What is the state of the art and emerging trends in the use of NFTs for the management and protection of intellectual property, as reflected in the filing of patents on a global scale? The main contribution of this study lies in offering an empirical analysis of the patenting scenario, identifying the main technological domains, the most active actors, and the geographic and temporal distribution of innovation, filling a gap in the literature on the real technological trajectory behind the discourse on NFTs and IPR.

To achieve this objective, the article is structured as follows: Section 2 details the methodology of technological prospecting used in the collection and processing of patent data. Section 3 presents the quantitative results of the analysis, including the temporal and geographical evolution of the deposits, the main technological domains and the most relevant actors. Section 4 discusses the implications of the results, contextualizing them in the broader innovation and market landscape. Finally, Section 5 presents the conclusions of the study, its limitations, and points out directions for future research.

2 METHODOLOGY

This section describes the methodological procedures adopted to carry out technological prospecting, which constitutes the core of this study. The methodology was structured to ensure the systematicity and replicability of the research, following the best practices for patent analysis as a source of technological information.

2.1 CHARACTERIZATION OF THE RESEARCH

This study is characterized as an exploratory and descriptive research, with a quantitative approach. It is exploratory because it investigates an emerging technological field that is still poorly consolidated in the empirical academic literature. It is descriptive, as it aims to describe the characteristics of the patenting scenario related to the use of NFTs for the protection of intellectual property. The quantitative approach is manifested in the collection

and analysis of patent indicators, such as number of filings, geographic distribution, and technological classification, allowing the identification of patterns and trends (Zhang; Liu, 2020).

2.2 DATA SOURCE

For the technological prospection, Questel's Orbit Intelligence patent database was used as a data source. The choice of this database is justified by its global scope, which consolidates information from more than 100 patent offices around the world, including the main ones such as the United States Patent and Trademark Office (USPTO), the European Patent Office (EPO), the Japan Patent Office (JPO) and the World Intellectual Property Organization (WIPO). In addition, the platform offers robust analytical tools for data treatment and visualization, which are essential for the proposed analysis (QUESTEL, 2023).

2.3 DATA COLLECTION PROCEDURES

The collection procedures followed a systematic protocol, divided into the definition of the search strategy and its execution and refinement, as detailed below.

- a) **Definition of the Search Sequence:** The construction of the search equation is a critical step to ensure the relevance and accuracy of the results. The process was iterative, involving the identification of keywords and their synonyms, as well as the use of Boolean operators and patent classification codes. The scope of the search was defined around two core concepts:
 - a. **Base Technology:** Covers terms related to blockchain technology and Non-Fungible Tokens (NFTs).
 - b. **Application:** Encompasses terms related to the protection and management of Intellectual Property (IP).

Table 1

Patent search strategy

Concept	Keywords and Operators
Base Technology	("non-fungible token" OR nft OR) AND (blockchain)
Application	("intellectual property" OR copyright OR patent OR trademark OR "trade secret" OR "industrial design" OR "geographical indication" OR author* OR royalty OR licensing OR piracy OR counterfeit*)

Final Operator	(Base Technology) AND (Application)
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Source: Prepared by the authors, 2025.

- b) Search Execution and Refinement: The search equation was entered into the Orbit Intelligence platform on September 10, 2025, resulting in an initial portfolio of patent documents. On this portfolio, the following refinement filters were applied:
 - a. Duplicate Removal: The platform was configured to group documents by patent family, considering only one registration per invention to avoid duplicate counting of technologies.
 - b. Time Period: The period from 2014 (the year the first NFT prototype appeared) to 2025 was considered, to ensure the coverage of the entire history of the technology's development.

After applying the filters, a final portfolio of patent families was obtained, which constituted the basis for the data analysis.

Validation and Refinement by Artificial Intelligence: to ensure the robustness and accuracy of patent selection, a double validation process has been implemented that combines manual screening and validation by Artificial Intelligence. This procedure aims to mitigate human biases and increase the scope of the analysis, following the best practices in technological prospecting studies involving large volumes of documents (CHEN et al.,).

The validation process was structured in two stages:

- a) Manual Screening: Each document in the initial portfolio was analyzed individually by the researchers, considering the established relevance criteria: (i) explicit presence of blockchain technologies or NFTs; (ii) direct or indirect application to the protection of intellectual property; (iii) technical feasibility of the proposed solution; and (iv) clarity in the description of the innovation.
- b) AI validation: The same set of documents was subjected to analysis by the DeepSeek language model, configured with specific prompts to identify relevant patents based on the same criteria used in manual screening. The model was instructed to evaluate each document considering the presence of key concepts and relevance to the scope of the research.

The use of AI as a counterproof tool offers three fundamental methodological advantages: (I) bias reduction: AI processes documents consistently, without the influence of subjective factors; (II) increased comprehensiveness: the model can identify connections and

patterns that can be overlooked in manual analysis; and (III) cross-validation: the convergence between the results of the two approaches strengthens confidence in the final data set.

The results of both analyses were compared and consolidated, prioritizing the inclusion of documents identified as relevant by either of the two approaches. This procedure resulted in the final portfolio of patents that formed the basis for all subsequent analyses

The results of both analyses were compared and consolidated, prioritizing the inclusion of documents identified as relevant by either of the two approaches. This procedure resulted in the final portfolio of patents that formed the basis for all subsequent analyses

2.4 DATA ANALYSIS AND PROCESSING

The data analysis was carried out with the support of the analytical tools of the Orbit Intelligence platform itself. The following indicators were extracted and analyzed:

- a) Temporal Evolution of Filings: Analysis of the distribution of the number of patent filings over the years, to identify the technological maturity curve.
- b) Geographical Distribution: Mapping of the main priority countries of deposits, indicating innovation centers and key markets.
- c) Top Applicants: Identification of the most active companies, research institutions, and inventors, revealing the key players in the development of the technology.
- d) Technological Classification: Analysis of the main codes of the International Patent Classification (IPC) and the Cooperative Patent Classification (CPC) assigned to the documents, to map the predominant technological domains.
- e) The results were exported in the form of graphs and tables for the elaboration of the results and discussion section, allowing a clear visualization of the technological panorama.

3 RESULTS AND DISCUSSIONS

This section presents and discusses the results obtained from the technological prospecting carried out in the Orbit Intelligence patent database. The analysis was structured to reveal the innovation landscape at the intersection between Non-Fungible Tokens (NFTs), blockchain, and intellectual property protection, addressing the characterization of the patent portfolio, temporal and geographic dynamics, the predominant technological domains, key actors, and a qualitative analysis of representative technologies.

3.1 CHARACTERIZATION AND VALIDATION OF THE PATENT PORTFOLIO

The prospecting process began with the application of three distinct search strategies, which generated a gross volume of documents. To ensure the robustness and accuracy of the analysis, this dataset was subjected to the double validation process described in the methodology section (section 2.3). Table 2 presents the consolidated result of this process, comparing the manual screening performed by the researchers with the validation performed by the DeepSeek Artificial Intelligence model.

Table 2

Comparison of relevant patents after manual filtering and AI validation

Search Keys	Manual Analysis	DeepSeek Review	Consolidated Total
((REGISTRATION) AND (INTELLECTUAL PROPERTY) AND (NFT OR BLOCKCHAIN OR SMART CONTRACTS))	65	72	72
(REGISTRATION AND PLATFORM) AND (INTELLECTUAL PROPERTY) AND (NFT OR BLOCKCHAIN OR SMART CONTRACTS)	32	34	34
(REGISTRATION AND INTERFACE) AND (INTELLECTUAL PROPERTY) AND (NFT OR BLOCKCHAIN OR SMART CONTRACTS)	13	13	13
Total	110	119	119

Source: Prepared by the authors, 2025.

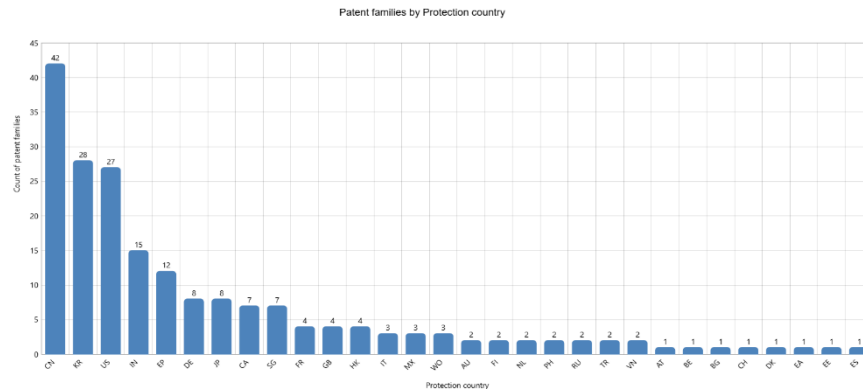
The results demonstrate a satisfactory convergence between the two validation approaches. The AI model identified 9 additional patents that proved pertinent, slightly broadening the dataset and confirming the effectiveness of the double validation process. This convergence strengthens confidence in the final portfolio of 119 patent families, which forms the basis for all subsequent analyses.

3.2 INNOVATION OVERVIEW: TEMPORAL AND GEOGRAPHICAL ANALYSIS

The analysis of the evolution of patent filings over time, presented in Figure 1, reveals a trajectory of sharp growth, characteristic of an emerging technology.

Figure 1

Annual evolution of patent families (2014-2025)



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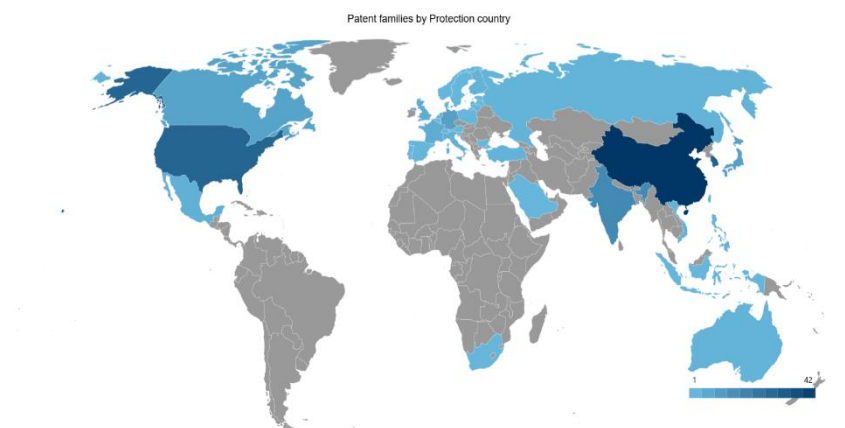
Source: Orbit, 2025

It is observed that, although the first records appear sparsely from 2014 onwards, interest in the technology gains significant traction from 2018 onwards. Growth intensifies, reaching a notable peak in 2022. This time pattern is strongly correlated with the global market's attention and investment cycle in crypto assets and NFTs, which experienced a boom between 2021 and 2022. This suggests that patented innovation in this field is largely reactive to market trends and the perception of new business opportunities, rather than being purely driven by a long-term fundamental research agenda.

Geographically, the patenting scenario is marked by a strong concentration, as illustrated in Figure 2.

Figure 2

Distribution of patent families by priority country



© Questel 2025

Source: Orbit, 2025

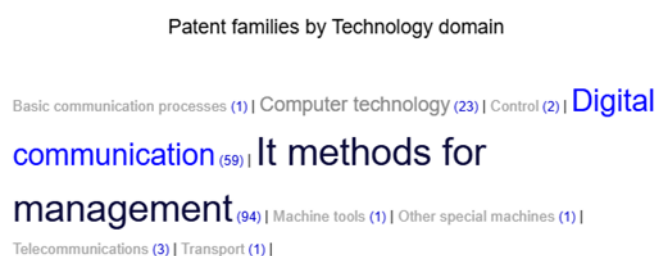
China emerges as the undisputed leader, accounting for a majority share of deposits. Next, with considerably smaller volumes, are the United States, South Korea and India. This distribution reflects the national strategies to encourage innovation and patenting, especially the Chinese policy of encouraging the registration of intellectual property in strategic technologies. The Chinese leadership indicates a deliberate effort to establish technological sovereignty in a field considered promising, while the presence of other technological hubs confirms the global relevance of the topic.

3.3 STRATEGIC TECHNOLOGY DOMAINS

The analysis of the technological domains, carried out from the classification of patents, allows mapping the priority application areas. Figure 3 shows the distribution of patent families by technological domain.

Figure 3

Distribution of patent families by technological domain



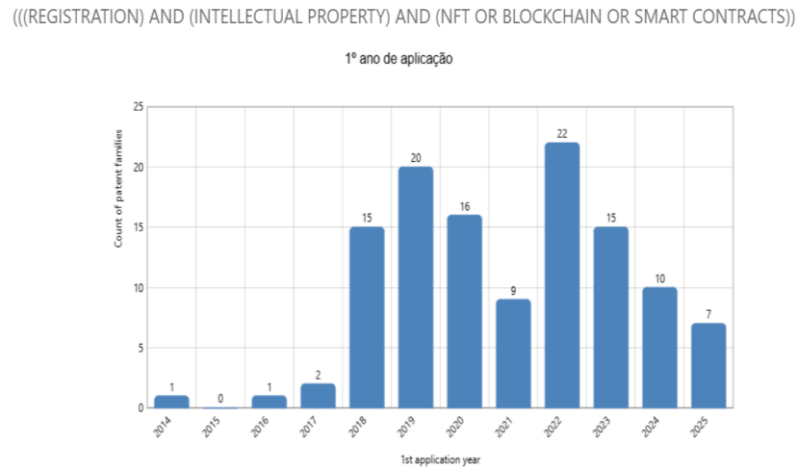
Source: Orbit (2025)

The results indicate a massive concentration of innovations in "IT methods for management" and "Digital communication". This predominance confirms that the main focus of the patented solutions is not on blockchain technology per se, but on its application as a tool for governance, administration, authentication and traceability of digital assets. The technology is seen as an infrastructure to optimize processes and ensure the security and provenance of intellectual property in the digital environment, which is in line with literature discussions about the potential of blockchain for IPR management (Ferro et al., 2023).

The temporal evolution of these domains (Figures 4, 5 and 6) corroborates this analysis, showing that the growth in the number of deposits from 2018 onwards was mainly driven by innovations in these areas of management and communication.

Figure 4

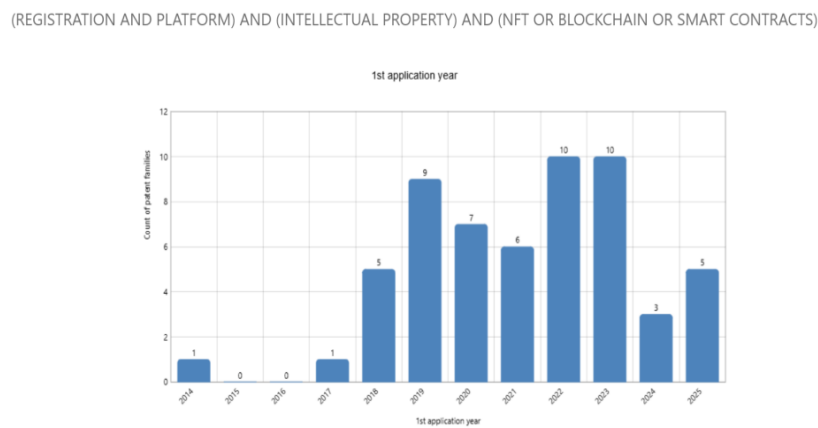
Temporal evolution of the technological areas of the patent families related to the first search key.



Source: Orbit (2025)

Figure 5

Temporal evolution of the technological areas of the patent families related to the second search key.

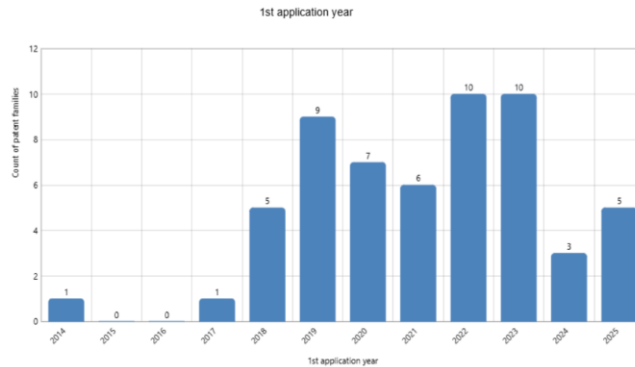


Source: Orbit (2025)

Figure 6

Temporal evolution of the technological areas of the patent families related to the third search key.

(REGISTRATION AND PLATFORM) AND (INTELLECTUAL PROPERTY) AND (NFT OR BLOCKCHAIN OR SMART CONTRACTS)



Source: Orbit (2025)

The annual evolution of patent families, illustrated by Figures 04, 05 and 06, demonstrates significant growth from 2018 onwards for the broader combination of terms (registration, intellectual property and (NFT, blockchain or smart contracts)), with notable peaks in 2019 (20 filings), 2020 (16) and, especially, in 2022 (22), evidencing the peak of interest in this technological convergence. When the term "platform" is included, the deposit curve shows a similar behavior, but on a smaller scale, with emphasis on 2019, 2022 and 2023, revealing a progressive consolidation movement.

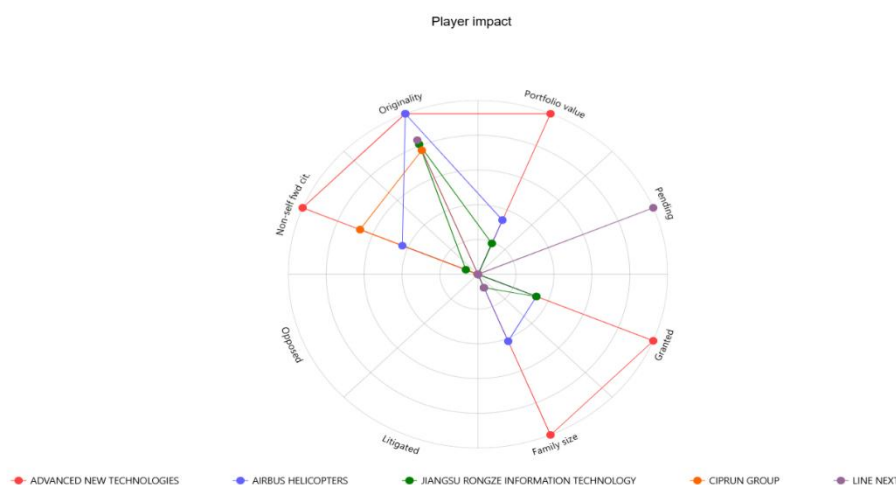
On the other hand, the inclusion of the term "interface" results in a very small number of deposits, concentrated from 2019 onwards, intermittently and with significantly lower volumes. These results suggest that the general theme of NFTs and blockchain applied to intellectual property is already in a phase of greater maturity, while more specific applications, related to platforms and, mainly, interfaces, are still in early and dispersed development. This relationship between territory and temporality reinforces the need to understand how the geography of deposits influences the evolution of applications over time.

3.4 MAPPING OF THE MAIN ACTORS

The analysis of depositors reveals a diverse innovation ecosystem. Figure 6 presents a comparison of the main actors.

Figure 7

Comparative impact of the main players



Source: Orbit (2025)

It is observed that leadership varies according to the technological niche. While more general searches are dominated by a diverse set of companies, specific searches reveal niche leaders such as Ant Group (Ant Blockchain) in "platform" solutions and the CASC Institute in "interfaces." This indicates a maturation of the sector, with specialization and market segmentation.

Two clear innovation strategies emerge: one focused on patent volume and market coverage, and the other on innovation with high scientific impact and high citation factor, as observed in players such as Airbus and Cable Television Labs. This segmentation into technological layers, from infrastructure to application, shows the maturity of the sector. A player's impact is therefore defined by its leadership in specific niches rather than a monolithic dominance of the field.

In summary, the analysis of Figures 01, 02 and 03 reveals that the scenario of patents in blockchain, NFTs and smart contracts applied to intellectual property is characterized by significant time growth and a geographical concentration in advanced technological hubs, notably China. The predominance of innovations in "IT methods for management" and "digital communication" underlines the centrality of these technologies in the management and security of digital assets, while the comparative analysis of players in Figure 04 demonstrates diversified innovation strategies, whether in volume of deposits or in originality and scientific impact. This panorama suggests a maturation of the sector, with the consolidation of specific niches and the redefinition of competitive positioning strategies.

3.5 QUALITATIVE ANALYSIS OF KEY TECHNOLOGIES

To complement the quantitative analysis, an in-depth analysis of four patents representative of different jurisdictions was performed, whose characteristics are compared in Table 3.

Table 3

Comparative analysis of selected patents

Characteristic	CN117527836 (China)	IN202541026604 (India)	US20240185191 (USA)	GB2611072 (United Kingdom)
Main Focus	Web3 Framework for Intellectual Property (IP) Registration and Transaction with Enhanced Security and Efficiency.	Copyright management for AI-generated content.	Tokenization of intellectual assets (e.g., patents, academic research).	Copyright protection for digital content using NFTs.
Problem Solved	Slow and high cost in IP registration; plagiarism detection.	Assigning rights between human creators and AI systems.	Difficulty in protecting and monetizing "illiquid" assets such as patents.	Lack of robust mechanisms to prove authorship and history.
Technological Solution	Use of the D-PBFT (Delegated Practical Byzantine Fault Tolerance) algorithm for consensus in blockchain. Detection of plagiarism during registration. Block generation for owners.	Attribution mechanism that quantifies human vs. AI contributions; unique identifiers.	Tokenization via NFTs; use of Ricardian Contracts to bind the asset to the legal contract	Distributed File System (IPFS) Registration; creation of NFTs linked to content.

Source: Prepared by the authors (2025)

The qualitative analysis reveals the sophistication and diversity of technological approaches. The Chinese patent focuses on the efficiency and security of the registry infrastructure, using an advanced consensus algorithm (D-PBFT), which aligns with the

technological domain of "IT management". The Indian patent addresses a frontier issue: the intellectual property of works created by AI, a growing debate in the field.

The U.S. patent introduces the concept of Ricardian Contracts, which seek to create a bridge between the smart contract code and the human-readable legal text, addressing one of the major criticisms of the legal validity of smart contracts. Finally, the British patent details the classic architecture of a content protection system via NFT, using IPFS for decentralized storage.

In sum, the results indicate that the field is evolving from exploring basic blockchain technology to creating complex and specialized solutions that solve specific problems of the intellectual property ecosystem. The combination of quantitative and qualitative analyses provides a robust overview of the state of the art, revealing a dynamic, geographically concentrated and rapidly maturing technological sector.

4 CONCLUSION

The main objective of this study was to explore the panorama of technological innovation at the intersection between Non-Fungible Tokens (NFTs), blockchain and the protection of intellectual property, through a systematic prospection in patent databases. The quantitative and qualitative analysis of the portfolio of 119 patent families allowed to answer the research question and achieve the proposed objectives, revealing a dynamic and rapidly maturing scenario.

The results confirm that the application of NFTs and blockchain for intellectual property management is an emerging technological field, with a significant growth in patent filings from 2018 and a peak in 2022, in line with the global market's attention cycle. Geographically, innovation is led prominently by China, followed by the United States, South Korea, and India, indicating that the technological race in this sector is concentrated in hubs with robust innovation ecosystems and policies to encourage patenting.

The analysis of the technological domains showed that the main focus of the innovations lies in "IT methods for management" and "Digital communication". This is evidence that blockchain technology is primarily being developed as a governance infrastructure to ensure the authenticity, traceability, and security of digital assets, rather than being an end in itself. The diversity of actors, with the coexistence of large corporations and niche players, suggests a growing specialization and the formation of different competitive strategies in the market.

The qualitative analysis of selected patents deepened these findings, illustrating the sophistication of the proposed solutions, ranging from the creation of efficient registration frameworks (D-PBFT) and rights management for AI-generated content, to the linking of smart contracts to traditional legal instruments (Ricardian Contracts). It is clear that the field is transcending proof-of-concept to address complex and specific challenges in the intellectual property ecosystem.

The main contribution of this work lies in the empirical mapping and detailed characterization of a technological field of high relevance and in full evolution. By providing a clear picture of trends, key players, and technology routes, this study offers valuable insights for researchers, businesses, and policymakers. As a limitation, it is recognized that the analysis is based exclusively on patent data, not covering other forms of knowledge production, such as scientific publications or open source software, which also play a role in technological development.

In short, the research demonstrates that the convergence between NFTs, blockchain, and intellectual property is not just a speculative trend, but a fertile field of technological innovation, with the potential to redefine the paradigms of asset protection and monetization in the digital economy.

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**NATURAL SWIMMING POOLS: AN NBS APPLICATION FOR WATER SAVING
IN ECOTOURISM CENTERS IN JALCOMULCO, VERACRUZ, MÉXICO**

**PISCINAS NATURAIS: UMA APLICAÇÃO DE SOLUÇÕES BASEADAS NA
NATUREZA (SBN) PARA A ECONOMIA DE ÁGUA EM CENTROS
ECOTURÍSTICOS EM JALCOMULCO, VERACRUZ, MÉXICO**

**PISCINAS NATURALES: UNA APLICACIÓN DE SBN PARA EL AHORRO DE
AGUA EN CENTROS ECOTURÍSTICOS EN JALCOMULCO, VERACRUZ,
MÉXICO**

 <https://doi.org/10.56238/sevened2025.036-087>

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ABSTRACT

Ecotourism is a practice that suggests responsible travel in natural areas, improving the well-being of local populations; However, little is discussed about the water needs of the sector. It is estimated that a tourist uses 300 liters by day (Gössling et al., 2012); for optimize the use of water resources, in Jalcomulco, Veracruz; four hotels and four ecotourism centers were characterized, estimating the water consumption of the infrastructure, especially the swimming pools. Finally, a natural swimming pool was designed and built with NbS at the La Aldea Ecotourism Center located in the town; where the treatment of water quality is based on biochemical processes carried out by aquatic plants, swamps and the microorganisms associated with them. This is one of the few works on the implementation of natural pools in Veracruz, providing useful information for future research.

Keywords: Natural Swimming Pools. Treatment. Quality.

RESUMO

O ecoturismo é uma prática que propõe viagens responsáveis a áreas naturais, promovendo o bem-estar das populações locais; entretanto, pouco se discute sobre as necessidades hídricas do setor. Estima-se que um turista utilize 300 litros por dia (Gössling et al., 2012). Para otimizar o uso dos recursos hídricos, em Jalcomulco, Veracruz, quatro hotéis e quatro centros ecoturísticos foram caracterizados, estimando-se o consumo de água da infraestrutura, especialmente das piscinas. Por fim, uma piscina natural foi projetada e construída com SbN no Centro Ecoturístico La Aldea, localizado na comunidade, onde o tratamento da qualidade da água baseia-se em processos bioquímicos realizados por plantas aquáticas, brejos e pelos microrganismos a eles associados. Este é um dos poucos trabalhos sobre a implementação de piscinas naturais em Veracruz, fornecendo informações úteis para pesquisas futuras.

Palavras-chave: Piscinas Naturais. Tratamento. Qualidade.

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RESUMEN

El ecoturismo es una práctica que sugiere el viaje responsable en zonas naturales, mejorando el bienestar de las poblaciones locales; sin embargo, poco se discute de las necesidades hídricas del sector. Se estima que un turista utiliza 300 litros por día (Gössling et al., 2012); Para optimizar el uso de recursos hídricos, en Jalcomulco, Veracruz; se caracterizaron cuatro hoteles y cuatro centros ecoturísticos, estimando el consumo de agua de la infraestructura, especialmente las albercas. Finalmente, se diseñó y construyó una biopiscina con SbN en el Centro Ecoturístico La Aldea ubicado en la localidad; en donde el tratamiento de la calidad del agua parte de procesos bioquímicos realizados por plantas acuáticas, palustres y los microorganismos asociados a ellas. Este es uno de los pocos trabajos sobre la implementación de albercas naturales en Veracruz, proporcionando información útil para futuras investigaciones.

Palabras clave: Piscinas Naturales. Tratamiento. Calidad.

1 INTRODUCTION

The practice of ecotourism represents an innovative way of enjoying nature that seeks to balance social recreation with the preservation of the environment and the well-being of local communities, as defined by Drumm and Moore (2005). This approach requires the creation of spaces that offer outdoor activities, comfort and, above all, a direct connection with nature. However, tourism is a phenomenon that involves people moving to places other than their usual environment and has a significant impact on the consumption of water resources at the local, regional, and global levels (Creative Destinations, 2023).

In this sense, tourists use water in various ways, from showering to watering gardens and golf courses, filling swimming pools or washing bedding. The tourism industry is highly dependent on the availability of water, so any scarcity can have detrimental effects on its development (Gabarda et al., 2015). It is estimated that the water consumption by an average tourist reaches 300 liters per day and swimming pools represent 15% of the total water consumption in a hotel (Gössling et al., 2012). Therefore, while ecotourism generates significant economic benefits, it can also lead to water imbalances that negatively affect the environment and, ultimately, the communities linked to this activity.

This work aims to link the amount of water destined for resting sites in order to promote the optimal use of water resources in ecotourism development. In addition, it seeks to promote the implementation and construction of nature-based solutions in the town of Jalcomulco, Veracruz.

Biopools as a nature-based solution for the treatment of water quality and its rational consumption

When we think of a swimming pool, many of us imagine a place of recreation where chlorine is an essential component. We have become accustomed to swimming in water with a characteristic smell. However, chlorine, like any chemical, can have adverse effects on our health. Its presence in water can cause eye irritation, nasal congestion, sore throat and other symptoms associated with prolonged contact with this element.

Natural pools or also called biopools, arise from the need to implement filtration and natural treatment systems to maintain optimal water quality where recreational activities are carried out, without effects due to being in direct contact with chlorine, as well as clarifying chemical compounds and pH regulation. among others, which are discharged into the water, prior to use.

Although research on natural pools is grouped in little bibliography, in 2007 Charles Durrant made a proposal for the Olympic pool of the University of Seville, where the main objective was to design a functional pool with low financing and operating costs. The design of the natural pool contemplated four heights, sand filters and two copper and silver ionization units to maintain excellent water quality in the pool, the energy from the photovoltaic solar panels was used to heat the water to about 25°C.

In 2013, the IX National Congress of Excellence in Management was held in Rio de Janeiro, where these systems are proposed to improve environmental and economic impact (Brotherhood, 2013).

In June of the same year, the event of the 7th Encontro de Educação Ambiental, Divulgação de práticas e partilha de experiências was held, where sustainable alternatives were mentioned: in the case of biological pools, they explain that the operation of these infrastructures depends on purification through vegetation in which biological processes of aquatic plants and microorganisms associated with them are carried out. these systems are an imitation of natural ecosystems, so it excludes the use of chemicals used in conventional pools (Mafra et al., 2017).

According to HCMA Architecture + Design (2016), there are more than 20,000 private and public infrastructures in Europe, more than 100 in Germany and one in Canada. The first infrastructure with these characteristics in North America was opened in Minneapolis, Minnesota in July 2015 and another in Edmonton, Alberta in 2016.

Based on the above, the operation of a natural pool consists of purifying and cleaning the water without chemical products. There are three areas: the main pool or swimming area, then the water arrives by gravity through filters that collect large particles to the regeneration area where it is filtered through layers of substrate, it is here where the bacteria decompose and function as nutrients for plant growth. Once the water is purified, it goes to the pumping area and returns to the swimming area.

Dr. Wolfram Kircher made a proposal of four designs for the construction of Biopools, analyzing the movement of water, the filtration technique, division and the type of construction in the bathing area. Filtration consists of a hydrobotanical system, where the principles of the operation of a wetland are recovered, implementing layers of substrate where the water flows slowly, or in its case a system of pipes where the water is conducted to a storage where a rapid flow filter is placed. As for the regeneration (filtration) zones, it proposes three designs, the Ein-Kammer system (one chamber), zwei-Kammer-System (two chambers) and the

Mehr-Kammer System (multi-chamber). As for the construction principles to delimit the bathing area, there is the option of building it without walls, or with the construction of boundaries with low walls. (Kircher et al., 2016).

On the other hand, Quintero et al., (2017), evaluated in the laboratory the use of vertical wetlands as a phytoremediation system, obtaining water quality values below the permitted limits. Later, Karczmarczyk (2019) studied the possibility of using three parallel mineral filters for the removal of phosphate from water in biopools. In that same year, Cedeño proposed the use of vertical flow wetlands, obtaining values below the maximum values allowed in terms of water quality (Ávila, 2022). Finally, biopools were proposed as an alternative to chlorinated pools to eliminate the need for chemical treatment and expenses in mechanical and electrical processes, minimizing pumping requirements, and reducing possible harmful health effects (Sánchez et al., 2020).

1.1 NATURE GARTEN-BADETEICH NATURAL POOLS

During the 1980s, the landscaping industry in Germany experienced an overuse of exotic plants from Asia. In response to this trend, Thöle met Martin Mikulitsch, who in 1987 designed and built the world's first natural swimming pool in the Nature Garten-Badeteich style (Biopiscinas Ameyalli, n.d.). In 1992 Robert Thöle founded the company Nature Garten-BadeTEICH, with the aim of creating gardens in harmony with nature, using local materials and endemic plants. In 1999 the Naturgarten NPO association patented the certificate "Fachbetrieb für Naturnahes Grün", which accredits a company with the reproduction and use of endemic plants to guarantee the quality of gardening services in Europe (Biopiscinas Ameyalli, n.d.).

Thus, in 1999 the first natural pool was built in Germany, implementing the Nature Garten-Badeteich style, which triggered hundreds of similar projects throughout Europe. The company joined the continent's international society of natural pools, responsible for the standardization, planning and construction of these pools. In 2009, Bioland recognized it as one of the two most important organizations in Europe in the supervision of organic producers. Bioland is a company that brings together and controls organic producers, and is one of the two most important labels in Europe for organic and biological products.

As a consequence, this concept was appropriated in 2013 in the city of Amatlán de Quetzalcoatl, Cuernavaca, with the emergence of the company Biopiscinas Ameyalli, directed by the German landscape architect Robert Thöle and Sofía Cadena Noria, who has

dedicated her life to the care, propagation and protection of aquatic plants (Biopiscinas Ameyalli, n.d.).

This idea aims to implement nature-friendly construction processes, taking into account the importance of water and the decrease in anthropic consumption in the filling of pools in the area, in addition to focusing efforts on cultivating and propagating the endemic plants of the region, since Mexican aquatic plants are mostly considered threatened species by the modifications. deterioration and disappearance of the habitats where they develop.

1.2 THE UNIT OF ANALYSIS: JALCOMULCO, VERACRUZ

One of the most representative adventure destinations in the state of Veracruz is presented as a case study. Located between parallels 19° 16' and 19° 24' north latitude and meridians 96° 41' and 96° 50' west longitude, it is located between 200 and 800 meters above sea level. The municipality of Jalcomulco is located 41.4 km from the capital of Veracruz, a journey of approximately 51 minutes. This municipality is bordered to the north by Emiliano Zapata and Apazapan; to the east by Apazapan and Tlaltetela; to the south by Tlaltetela; and to the west by Tlaltetela and Coatepec. The geographical area of Jalcomulco is 72.72 km², representing 0.1% of the state territory (SIEGVER, 2020).

The predominant climate is warm sub-humid with rainfall in summer, with average humidity (99%), and warm sub-humid with rainfall in summer and higher humidity (1%). The average temperature varies between 20°C and 26°C, while annual rainfall ranges between 1100 and 1300 mm (SIEGVER, 2020).

According to the INEGI 2020 Census, Jalcomulco has 5054 inhabitants and represents 0.06% of the state population. It has four localities, three in rural areas, Santa María Tatetla with 1707 inhabitants, Tacotalpan with 153 inhabitants and Rivera del Río with 44 inhabitants, while the municipal seat houses 3,150 inhabitants.

Ricalde (2016) comments that the most important adventure tourism destinations in Veracruz correspond to Jalcomulco and the Filobobos Natural Protected Area and its surroundings. This confirms the importance that persists in the visitor to get closer to the region. In addition to the climate, within the geoforms that are housed in the territory we can find mountain, valley, low elevations, hills and cumulative ramp, these characteristics detonate an attractive biodiversity in the region, since it is this site where the offer of services of one of the business groups in the ecotourism sector in the State of Veracruz is structured. This data is crucial since it introduces an absolutely determining variable in the configuration

of the value chain: nature, and specifically the river, a distinctive feature of this tourism segment. It is around the river that the learning capacities of the companies of the Jalcomulco cluster are built (Saldaña et al., 2012).

The hydrography that surrounds the territory belongs to the fluvial system of hydrological region No. 28, being decisive the basin of the Papaloapan river and secondarily the Actopan, La Antigua and Jamapa rivers; it occupies 41.11% of the total state territorial area (28,636 km, being 39.32% of the total of the regions), as well as the largest discharge of fresh water (44,829 million cubic meters per year, which represents 42.28% for the state); on the other hand, the La Antigua river basin covers an area of 2,827 km² (Pereyra et al., 2010); and it is made up of 27 municipalities, 22 of them belong to the State of Veracruz and 5 to the State of Puebla, partially or totally (PAMIC, 2017).

The La Antigua River rises in the Sierra Madre Oriental, with the name of Resumidero River, at an altitude of 3,350 m, east of the town of González Ortega in the state of Puebla. It flows southeast in mountainous terrain and, at the height of Rancho Calixitla, it changes its course to the ENE until the confluence with the Barranca Grande River 3 km north of the hill of the same name; at this site the general collector changes its name to Los Pescados River. It follows its southeast course and on the limits of the states of Puebla and Veracruz it changes it to the northeast; downstream from this point it receives the Cozolapa River on the left bank. At this confluence, the general collector changes its name to La Antigua River; it continues its southeast course passing through the town of Jalcomulco, Ver (Pereyra et al., 2010).

The entire territory of Jalcomulco (72.72 km²), which is located in the basin of the La Antigua River, is home to two perennial water streams: Los Pescados and Santa María; and intermittent currents of the Cascajal, Hediondo, Moyuapan and Tenexapa rivers (INEGI, 2010). It is part of the segmentation of the sub-basin identified with the code Ant24, which receives only surface water, which leads to its identification as a receiving area with a low water supply; the Los Pescados River has a Horton-Strahler order of 7, an area of 359,230 km², 16.51 km of the main river and represents 3.34 % of the total territory of the basin (PAMIC, 2017).

Of the above, in terms of tourism development, the territory of Jalcomulco has been ideal for the construction of various hotels and ecotourism centers; according to the Royal Spanish Academy, a hotel is an establishment for an inn capable of comfortably accommodating guests or travelers; on the other hand, ecotourism centers show a close

relationship with ecotourism activity, which according to the World Conservation Union, defines it as: That environmentally responsible tourism modality consisting of traveling or visiting natural areas in order to enjoy and appreciate nature (as well as any cultural manifestation of the present and the past), which promotes conservation, has a low visitation impact and fosters an active and socioeconomically beneficial involvement of local populations (Drumm et al., 2005).

In this sense, it can be said that adventure tourism companies in Jalcomulco depend on the river, and in this sense they are, if we may use the expression, dependent rivers (a play on words built from the notion of path dependence, well known to evolutionary economists) (Saldaña et al., 2012).

This study identifies a hotel offer of 25 hotels located exclusively in the urban locality. Most of these establishments are semi-open and surrounded by green areas. In addition, they have common spaces that include chlorinated water pools, with up to four facilities of this type in various sizes.

2 METHODOLOGY

To gather information about the tourist offer of Jalcomulco, tours were carried out in the community to identify lodging spaces and establish communication with the personnel who work in them, this activity involved four hotels and four ecotourism centers that provided information, since it was a voluntary decision to be part of the development of the reception work in progress. To this end, a database was designed that collected information regarding the demand for accommodation during the year 2022, as well as quantifying the amount of hydrosanitary furniture, the presence of water tanks or cisterns for water storage, and detailed measurements of the pools present in the rest sites, in order to determine the amount of water necessary for their filling; the typology of the infrastructure was also characterized, considering two variants in the analysis, in the case of hotels, those places of lodging where contact with nature is not related to the infrastructure were identified as those places of lodging where contact with nature has no relation to the infrastructure and as ecotourism centers (E.C.), those spaces where recreational practices merge with the presence of natural resources.

Subsequently, three fundamental steps were established to model water consumption in the eight tourist destinations, based on the concepts obtained from studies such as "Water

Consumption in Hotel Establishments in Mexico" by Santacruz De León et al. (2020). Listed below are the three steps to follow:

1. The first step in modelling a chain's consumption is to segment its hotels into similar groups according to their typical consumption (Escalera et al., 2014).
2. The second step consisted of detecting the water consumption that is required to meet the needs of a guest.
3. The third step consisted of calculating an estimate of water consumption derived from the hydraulic infrastructure of each hotel or ecotourism center, including the volume of water required by the pools. Consumption per use was also quantified according to site occupancy. Finally, the results were graphed.

Once we had bibliographic references and qualitative and quantitative data from the aforementioned database, comprehensive information was generated that made it possible to raise awareness and know the consumption of water in ecotourism centers and hotels, specifically the consumption of water for filling swimming pools.

During the tour of the eight tourist sites for the collection of information, the owners and managers were mentioned the purpose of investing in the construction of a natural pool, so they were invited to a talk focused on nature-based solutions for the treatment of water quality in swimming pools, which was carried out in the multipurpose room of the ejido house.

This call was attended only by the manager of the La Aldea Ecotourism Center with the possibility of making an investment, after knowing in detail the components, operation and advantages of the biopools, a visit to the facilities was formalized to make a reconnaissance of the site and to be able to choose the best location for the construction of the biopool. Once the site was defined, a topographic survey was carried out, to obtain the representation of the terrain, the information obtained from the terrain was processed in computer-aided drawing programs (AutoCAD and CivilCAD).

Two technical economic proposals were worked on and presented to the investors of the La Aldea ecotourism center. A prototype with a square shape of six meters per side was chosen. Once the design was concluded, the construction process was carried out with the necessary materials, which was documented.

The prototype was put into operation to the public. To do this, it was necessary to design an infographic with the regulations for its use, as well as an infographic that briefly explains the definition of biopools and their main elements.

As a result, in-depth research was carried out, which concluded in the design and construction of an infrastructure compatible with the three areas of Sustainable Development, economic, social and environmental. The following chapter presents the results obtained from this project.

3 RESULTS

3.1 CHARACTERIZATION OF THE HOSTING INFRASTRUCTURE

The construction of the hotels in the town of Jalcomulco includes modern buildings, as well as infrastructure with alternative sustainable materials such as bamboo, bahareque and adobe.

In relation to characterization, no lodging site has biofilters, wetlands for water treatment or dry toilets. Most have fewer than 10 rooms, a single pool, and green areas. There is a homogeneity in the construction materials in the four ecotourism centers, since they all use wood and bamboo. In the case of ecotourism center two, they also use bahareque (compacted earth walls). Only one of the hotels uses these materials; the other three are built with masonry walls and concrete slabs. A single ecotourism center has sunlight (photocell) and a system to capture rainwater. Two have a septic tank and three have a biodigester. Table 1 shows the participating sites, which provide hosting services with some of their general characteristics.

Table 1

Characterization of hotels and ecotourism centers in Jalcomulco, Ver.

Type (C.E./ Hotel)	C.E. 1	C.E 2	C.E. 3	E.C. 4	Hotel 1	Hotel 2	Hotel 3	Hotel 4
Type of building	Horizont al	Vertical	Horizont al	Horizont al	Horizont al	Vertical	Horizont al	Horizont al
Number of rooms	6	6	71	34	5	7	8	13
Total capacity	30	26	272	112	30	20	30	40
Total pools	1	3	1	1	1	1	1	1
Green Areas	Yes	Yes	Yes	Yes	Yes	No	No	No
Materials	Wood	Bamboo, wood,	Wood, adobe	Adobe, palm, canvas.	Wood, bamboo,	Concret e and	Concrete and	Concrete and

		bahareque, canvas.	walls, bamboo		masonry walls.	masonry walls,	masonry walls,	masonry walls.
Sunlight	No	Yes	No	No	No	No	No	No
Septic tank	No	No	No	Yes	Yes	No	No	No
Biodigester	Yes	Yes	Yes	No	No	No	No	No
Eco-techniques for water care								
Rainwater catchment	No	Yes	No	No	No	No	No	No
Dry toilets	No	No	No	No	No	No	No	No
Biofilters	No	No	No	No	No	No	No	No
Treatment Wetlands	No	No	No	No	No	No	No	No
Chemical Treatment	No	No	Yes	No	No	No	No	No

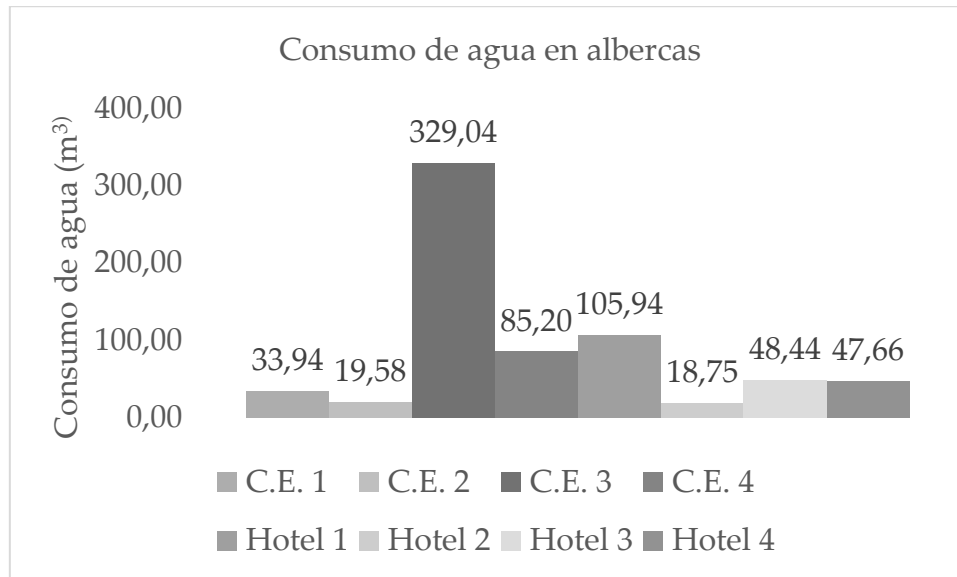
3.2 ANALYSIS AND DISCUSSION OF THE RESULTS OF WATER CONSUMPTION FOR THE FILLING OF SWIMMING POOLS IN HOTELS AND ECOTOURISM CENTERS IN JALCOMULCO

Although ecotourism centers are those spaces that are linked to natural areas, they require greater amounts of water to meet the needs of guests. In all cases, it was detected that the highest consumption corresponds to the filling of pools, since they are infrastructures that, due to their characteristics, require a permanent volume of the natural resource for their filling.

The highest consumption is reflected in Ecotourism Center 3 with 329.04 m³ of water that must be covered 365 days a year (figure 1), which seems to be related to the lodging capacity.

Figure 1

Demand for water volume in swimming pools



Source: Authors' elaboration based on the analysis of results.

As an integral part, issues related to water resource management were addressed.

In the case of Ecotourism Center 1, there is a stream from the spring that supplies drinking water to the entire community. However, from 7 am to 4 pm, the spring supplies producers directly and it is forbidden by the ejido organization to use the water for other purposes. For this reason, this Ecotourism Center begins to fill its tank and cistern during the afternoon and part of the night.

This same stream passes through Hotel 1, so it also makes use of the resource to fill its drinking water storage infrastructure, as well as the filling of the pool, in the same way, when cleaning is required, the water is discharged into the same body of water.

Ecotourism Center 2 obtains water directly from the river by pumping, in turn supplying water to other establishments. A remarkable fact about this space is that the water used to fill the pool does not use chemicals.

In the case of Ecotourism Center 3, they have a concession title from CONAGUA, so the water they extract comes from a well located within their facilities. However, the water table has decreased over time, and on some occasions they have chosen to buy water in pipes to be able to supply users. In this accommodation, they carry out a chemical treatment with a plant of minimal dimensions and, therefore, reuse the resource.

In Ecotourism Center 4, water is extracted from the river to supply the entire hydraulic infrastructure, including the swimming pool. In the case of Hotels 2, 3 and 4, being located in

the center of the town, they have the supply of drinking water from the municipal line, also the discharges are poured into the sanitary drain, however, this drainage converges to the river downstream.

As for filling the pools, in general, the water is changed every third day if there has been a lot of tourist influx. The emptied water is used to irrigate the gardens or for cleaning.

As a brief discussion, of the characterization of hotel sites, it was possible to identify the construction of ecotechniques for the care and integral management of water, such is the case of the rainwater catchment and a sedimentation plant for sewage treatment in the Ecotourism Center 3; however, those in charge of the tourist sites showed interest in training to implement actions to have water reservoirs, especially in the dry season.

Regarding the infrastructure of hotel demand, it was detected that there are lodging sites in Jalcomulco that exceed their maximum capacity by up to 300%, of the above, Gössling (2012), documented that the highest water consumption rates are found in hotels with spas and swimming pools; so it was found that the pools measured in this intervention, have 18,000 liters to 329,000 liters of water and the larger the establishment, the greater the size of the water demand, however the problem of this use does not end there, because it is water that must be renewed at least every third day, depending on its use and its emptying, it affects ecosystems by disposing of contaminated water in water veins that connect populations during its journey.

Design, construction, operation and maintenance of the Biopiscina at the La Aldea Ecotourism Center

A topographic survey was carried out to determine the unevenness of the terrain. Once the information was processed, a square area of 6 x 6 meters was allocated for the biopool. To do this, it was necessary to calculate and build a stone perimeter wall to give stability to the infrastructure. It is worth mentioning that the composition of the soil allowed the reuse of the site's material, optimizing costs and resources. Of the two technical-economic proposals raised, the one whose investment was \$170,000.00 M.N. was chosen. The area destined for planting corresponds to approximately 50% of the surface, while the remaining percentage is the swimming pool.

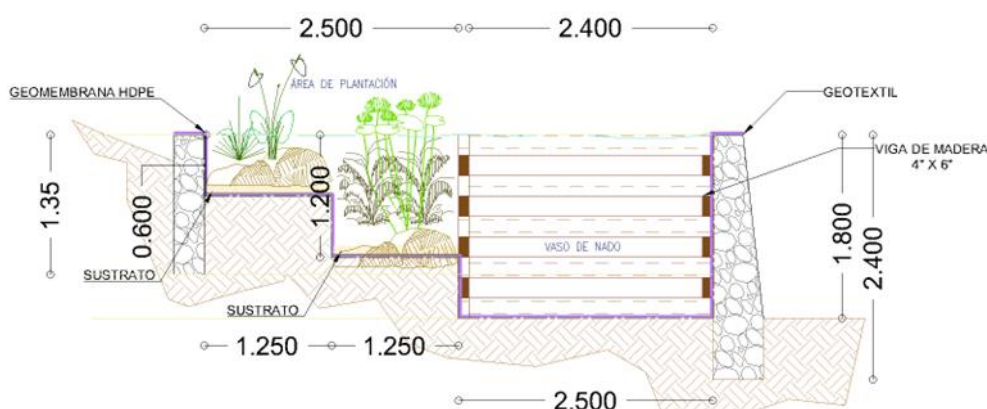
The design of the biopool considered three areas:

- 1.- Swimming pool: this area includes only the area available for swimming. Delimited by a length of 5.20 m, a width of 2.50 and a depth of 1.80 m, to receive 23.4 m³ of water.

- 2.- Submerged plant area: In this space of 1.25 x 5.20 m and a depth of 1.20 m, two types of plants are proposed, *Potamogeton coloratus* (fully submerged) and *Nymphaea colorata* (floating submerged rooted), and the area will receive 7.80 m³ of water.
- 3.- Area of emergent plants: In this space 1.25 x 5.20 m and a depth of 0.60 m are located emergent plants such as taro, horsetails, colocasias and papyrus, as shown in figure 2, this area requires 3.90 m³ of water.

Figure 2

Cross-sectional view



Source: Authored by the authors.

The planting area in a biopool should represent between 50 and 75 percent of the total area of the system. In this case, the total area intended for construction is 48 m², with a swimming area of 15 m² and a planting area of 33 m², approximately 75% of the total area, thus meeting the requirement.

The materials used for the construction included 200 gr/m² geotextile, Firestone EPDM geomembrane, pine wood beams, zeolite, earth, wooden dowels, vegetation and water.

The plants selected for the natural pool are classified as:

- Fully submerged: *Potamogeton coloratus*
- Fully Submerged Rooted Float: *Nymphaea colorata*
- Lemnaceae (free floaters): *Salvinia minima* and *Pistia stratiotes*
- Rooted submerged (edible): *Colocasia esculenta*
- Emergent rooted submerged: *Colocasia esculenta*, var. "Black Magic"; *Cyperus papyrus*; and *Equisetum arvense*.

For the construction phase, the area was delimited with the support of the total station, this topographic instrument locates georeferenced points with arbitrary coordinates; In this

case, the vertices of the area destined for the perimeter wall were located and placed in order to orient the infrastructure. Once marked, the excavation with mechanical means and the construction of the stepped stone walls began, respecting the depths of the design for the planting areas. This wall has a width of 50 cm and a height ranging from 1.35 to 2.40 meters.

Once the work that delimits the biopool area was completed, the geotextile was placed, a permeable and flexible fabric made of polypropylene or polyester, whose main function is to separate different layers of materials. Subsequently, the EPDM geomembrane was placed, whose main function is to provide the system with an impermeable layer.

Next, the swimming pool area was delimited, with wooden beams of 10 x 20 cm high and wide and a length of 5.20 m in the long direction and 2.50 m in the short direction.

For the planting area, another layer of geotextile was placed, to receive the substrate, which resulted from the combination of black soil from the site and granulated zeolite. This mineral, a product of sedimentary rocks, is used in water quality treatment systems. Being highly hydrophilic, it facilitates the absorption of nutrients by plants, since these are taken up by the roots dissolved in water (Chica Toro et al., 2006).

Simultaneously with the planting, the biopool began to be filled. Additionally, stones were placed over the area to fix roots and as ornamental elements. Once filled, the ecosystem stabilization stage was carried out (Figure 3).

After filling, the stabilization phase began that lasted from November 6 to December 18, 2023, during these six weeks, the natural pool was not used for recreational purposes, with the aim of allowing the ecosystem to adapt and begin the process of reproduction of the plants. In the case of water lilies (*Nymphaea colorata*), the growth of the petioles began from the second week, as well as the reproduction of their leaves and the first flower bud took place during the third week of May 2024.

Figure 3

Biopool finished



Source: Photograph of the authors.

In the case of papyri and reeds, emergent stems were observed. *Colocasia* var. Black Magic showed an increase in the size of its leaves and their reproduction. However, it took until the third week for the *Potamogeton* species to start breeding. During this time, it was necessary to clean up the bottom of the planting area due to the proliferation of algae, which hindered leaf growth. Once the cleaning was complete, the reproduction of the *Potamogeton* leaves continued steadily. As for the fauna of the ecosystem, dragonflies were observed in the larval and adult stages, as well as snails, ladybugs and bees. Water turbidity was also monitored to prevent eutrophication in the ecosystem.

After the weeks of stabilization, a maintenance session was held to train the personnel who work in the ecotourism center. During this activity, the team carried out various tasks such as cleaning and removing leaf litter from the bottom, untangling petioles in the water lily area, and removing dead vegetation. Finally, the infrastructure was opened to the public during the month of March 2024.

Figure 4

General view of the biopool



Source: Photograph of the authors.

To improve the landscape and protect the geomembrane in place, planters were built using leftover materials and recycled wooden pallets. These planters were placed around the planting area to collect leaf litter and organic matter derived from the pruning of the plants responsible for phytoremediation. In addition, various species of ornamental plants were planted and a wooden corridor was built to walk through the swimming area and bamboo railings were placed to improve the safety of visitors (figure 4).

In this same sense, and in order to inform tourists about the operation of natural pools and the regulations to make use of these infrastructures, the design of two infographics was carried out, which are shown below in Figure 5. It should be noted that the QR codes attached to them link information that was collected during the execution of the reception work.

Figure 5

Supporting infographics



Source: Authored by the authors.

4 CONCLUSION

Based on the results obtained, it is concluded that the design, construction, operation and maintenance of the natural biopool has been a meticulous, carefully planned and comprehensive process. From the beginning with the topographic survey to determine the unevenness of the terrain, to the selection and efficient use of materials such as EPDM geomembrane and geotextile, each step has been key to ensure the stability and functionality of the system. The stabilization phase has been fundamental, allowing the natural ecosystem to adapt and begin to thrive, evidenced by the growth and reproduction of various plant species, as well as the presence of a variety of aquatic fauna.

In addition, post-stabilization maintenance and improvement measures, such as the construction of planters with recycled materials, the planting of ornamental plants, and the installation of safe infrastructure for visitors, have contributed not only to the protection of the

landscape, but also to the continued well-being of the ecosystem. The integration of sustainable practices and the reuse of resources have been fundamental pillars throughout the process, highlighting a commitment to environmental conservation and efficiency in the use of natural resources.

This project stands out for effectively addressing local water management through innovative solutions such as natural pools, also serving as a model of collaboration between various social actors. The active participation of the tourism business sector and the local community have been instrumental in its success, underscoring a shared commitment to environmental conservation and sustainable development.

The La Aldea Ecotourism Center has played a central role in investing in innovative infrastructure and promoting sustainable practices within its tourist destination. This has not only added economic and environmental value to the place, but has also contributed to strengthening the identity of Jalcomulco as a destination committed to the care of its natural resources.

Overall, the biopool not only meets the expected technical and aesthetic standards, but also stands as an example of how ecotourism can coexist harmoniously with environmental conservation, offering visitors a unique and educational experience in a restored and cared for natural environment.

In addition, the dissemination of this project has the potential to positively influence the adoption of similar solutions in other localities and sectors. By promoting eco-techniques and integrated water management, a culture of environmental responsibility is fostered that can be replicated in future academic and business initiatives.

It is essential to continue sharing knowledge and raising awareness about the importance of taking care of water resources. This study lays the groundwork for future research and improvements in ecotourism biopools, as well as advocating for the integration of nature-based solutions as an effective response to global water stress.

In summary, the natural biopool in Jalcomulco represents a remarkable example of how innovation, collaboration, and community engagement can converge to promote sustainable and resilient practices in the face of current environmental challenges.

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**THE ESSENCE OF PROJECT-BASED LEARNING INVOLVES USING
TECHNOLOGY IN LEARNING FINANCIAL MANAGEMENT**

**A ESSÊNCIA DA APRENDIZAGEM BASEADA EM PROJETOS ENVOLVE O
USO DE TECNOLOGIA PARA APOIAR O APRENDIZADO DE GESTÃO
FINANCEIRA**

**LA ESENCIA DEL APRENDIZAJE BASADO EN PROYECTOS CONSISTE EN
UTILIZAR LA TECNOLOGÍA PARA APOYAR EL APRENDIZAJE DE LA
GESTIÓN FINANCIERA**

 <https://doi.org/10.56238/sevened2025.036-088>

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ABSTRACT

Project-Based Learning (PBL) is one of the recommended methods to improve students' practical problem-solving skills. It is hoped that students can acquire critical thinking skills and a deep understanding of the material. Deep learning is an approach used in the national learning system. This study aims to assess students' perceptions regarding PjBL learning in the MSME financial management course. This study uses a qualitative approach. Data collection techniques use open-ended questionnaires, conducting observations during the learning process, and documentation related to learning files during the method used. Data analysis techniques use the Miles and Huberman model, consisting of data collection, data reduction, data presentation, and drawing conclusions. The results of the study indicate that by implementing PjBL steps in the financial statement analysis project of MSMEs in the production sector, it can facilitate understanding of the calculation components of Cost of Goods Sold (COGS), the difference between business income and other income, analysis of business operating expenses and other expenses, components of current and non-current liabilities, analysis of depreciation expense calculations and overall improve students' competence in preparing financial reports correctly in accordance with SAK EMKM. During the project, the analysis of MSME financial reports was carried out using the assistance of Ms. Excel.

Keywords: Project-Based Learning. Financial Management. Teaching and Learning. Msmes.

RESUMO

A Aprendizagem Baseada em Projetos (PBL) é um dos métodos recomendados para melhorar as habilidades práticas de resolução de problemas dos estudantes. Espera-se que os estudantes desenvolvam pensamento crítico e uma compreensão profunda do conteúdo. A aprendizagem profunda é uma abordagem utilizada no sistema nacional de ensino. Este

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estudo tem como objetivo avaliar as percepções dos estudantes em relação ao aprendizado por meio de PjBL na disciplina de gestão financeira de MPEs. Este estudo utiliza uma abordagem qualitativa. As técnicas de coleta de dados incluem questionários abertos, observações durante o processo de ensino-aprendizagem e documentação relacionada aos materiais utilizados durante a aplicação do método. A análise dos dados segue o modelo de Miles e Huberman, composto por coleta de dados, redução de dados, apresentação dos dados e elaboração de conclusões. Os resultados do estudo indicam que, ao implementar as etapas de PjBL no projeto de análise das demonstrações financeiras de MPEs do setor produtivo, é possível facilitar a compreensão dos componentes de cálculo do Custo das Mercadorias Vendidas (CMV), da diferença entre receita operacional e outras receitas, da análise das despesas operacionais e demais despesas, dos componentes de passivos circulantes e não circulantes, da análise do cálculo da despesa de depreciação e, de forma geral, melhorar a competência dos estudantes na elaboração correta de relatórios financeiros de acordo com o SAK EMKM. Durante o projeto, a análise dos relatórios financeiros das MPEs foi realizada com o auxílio do Microsoft Excel.

Palavras-chave: Aprendizagem Baseada em Projetos. Gestão Financeira. Ensino e Aprendizagem. MPEs.

RESUMEN

El Aprendizaje Basado en Proyectos (PBL) es uno de los métodos recomendados para mejorar las habilidades prácticas de resolución de problemas de los estudiantes. Se espera que los estudiantes desarrollen pensamiento crítico y una comprensión profunda del contenido. El aprendizaje profundo es un enfoque utilizado en el sistema educativo nacional. Este estudio tiene como objetivo evaluar las percepciones de los estudiantes sobre el aprendizaje mediante PjBL en el curso de gestión financiera de MIPYMES. Este estudio utiliza un enfoque cualitativo. Las técnicas de recolección de datos incluyen cuestionarios abiertos, observaciones durante el proceso de enseñanza-aprendizaje y documentación relacionada con los materiales utilizados durante la aplicación del método. El análisis de datos sigue el modelo de Miles y Huberman, que consiste en la recolección de datos, reducción de datos, presentación de datos y elaboración de conclusiones. Los resultados del estudio indican que, al implementar los pasos de PjBL en el proyecto de análisis de los estados financieros de MIPYMES del sector productivo, se puede facilitar la comprensión de los componentes de cálculo del Costo de los Bienes Vendidos (CBV), la diferencia entre ingresos operativos y otros ingresos, el análisis de los gastos operativos y otros gastos, los componentes de pasivos corrientes y no corrientes, el análisis del cálculo del gasto por depreciación y, en general, mejorar la competencia de los estudiantes en la elaboración correcta de informes financieros de acuerdo con el SAK EMKM. Durante el proyecto, el análisis de los informes financieros de las MIPYMES se realizó con la ayuda de Microsoft Excel.

Palabras clave: Aprendizaje Basado en Proyectos. Gestión Financiera. Enseñanza y Aprendizaje. MIPYMES.

1 INTRODUCTION

Combining financial management with other disciplines such as marketing, operations and strategic management can provide a holistic learning experience and prepare students for the complex challenges of managing MSMEs (Delgado and Ayala 2019; Poponi et al. 2019). Working with local MSMEs provides practical experience for students while helping businesses gain new perspectives and innovative solutions (Garrido-Lopez et al. 2018). Through PBL, students develop important skills in financial management, including budgeting, financial planning and resource management, which are critical for MSMEs (Suharsono et al. 2025; Shahiwala 2017).

PBL allows students to engage directly with real financial challenges faced by MSMEs, thus developing practical problem-solving skills (Delgado and Ayala 2019; Garrido-Lopez et al. 2018). PBL emphasizes the active role of learners, requiring them to apply knowledge rather than just passively absorb it. This approach helps students develop practical financial management skills through real-world application (Yulianti 2024; Abinzano et al. 2022). PBL projects often require students to communicate effectively with business owners and stakeholders, thus improving their interpersonal and professional communication skills (Garrido-Lopez et al. 2018).

Successful PBL requires adequate resource support, including access to financial data, mentorship from industry professionals, and institutional support (Shahiwala 2017; Liang et al. 2016). By engaging in projects that mimic real business scenarios, students gain hands-on experience in financial planning, budgeting, and resource management, which are critical for MSMEs (Shahiwala 2017; Reid, Muenzen, and Rezvanian 2020). PBL needs to be integrated into the financial management curriculum, so that students can work on projects related to real financial problems in MSMEs. This integration helps students apply theoretical knowledge to practical scenarios (Delgado and Ayala 2019; Shahiwala 2017).

Some of the benefits of PBL applications include encouraging critical and creative thinking, which are essential for effective financial decision-making and problem-solving in MSMEs (Yulianti 2024; Sugeng and Suryani 2019). Projects often require teamwork and communication, thus enhancing these skills which are critical in managing financial operations and working with stakeholders (Yulianti 2024; Harb et al. 2025). Studies show that students who participate in PBL perform better compared to those who learn through traditional methods, particularly in the understanding and application of financial management concepts. This is reflected in higher exam scores as well as better overall

academic performance (Abinzano et al. 2022; Liu and Chen 2020). PBL encourages self-regulated learning, allowing students to take charge of their learning process (Sugeng and Suryani 2019).

Through PBL, students learn to prepare and manage budgets, conduct financial analysis, and develop financial strategies, which are directly applicable to MSMEs (Shahiwala 2017; Iyamuremye et al. 2025). PBL projects often involve effectively managing limited resources, a common challenge for MSMEs. This experience helps students develop the ability to optimize resource use in real business situations (Suharsono et al. 2025). PBL enables iterative learning, where students can receive feedback, reflect on their performance and make improvements. This process is similar to the continuous improvement efforts needed in MSME financial management (Garrido-Lopez et al. 2018; Blazevic and Lievens 2004).

The use of PBL on an ongoing basis can shape the professional abilities needed in the world of work in the digital era. These professional abilities include Ethical Skills, Business Skills, and Soft Skills including Critical thinking, communication, leadership, and emotional intelligence (Tsiligiris and Bowyer 2021; Sebele-Mpofu 2024; Zainuddin et al. 2023).

By capturing students' perceptions about the implementation of PBL in MSME financial management courses, it is expected to directly influence their motivation and level of engagement. Meaningful learning, emotional environment, and interaction between students are all associated with better academic performance. For example, an increase in these perceptions can result in higher scores on standardized tests (Wayne et al. 2013). Knowing how important it is to improve the accounting curriculum in technology-based higher education institutions can increase students' desire to learn. Involving students in the assessment process helps them take responsibility for what they learn. As a result, students' intrinsic motivation and accountability increases (Woytek 2005).

So, from the results of the screening of student perceptions in PBL learning in the MSME financial management course, it is hoped that it can be used as a study in improving the overall quality of accounting learning through the application of this PBL learning model. In this accounting learning, the application of PBL is carried out by integrating technology for MSMEs, so that it can provide learning for MSMEs and students through the use of technology in making MSME financial reports.

2 METHODOLOGY

The research approach used is qualitative. The data collection technique uses an open questionnaire which gives students the freedom to provide opinions regarding the application of project-based learning in the MSME financial management course. Research sources are students who have taken the course in the accounting education study program. Thus, the sampling technique is purposive sampling. The data analysis technique uses the Miles & Huberman model, consisting of data reduction, data presentation, and conclusion drawing/verification. Data validity uses method triangulation techniques, namely filling out an open questionnaire, observation, and documentation.

The learning components in project-based learning that have been taken in the MSME financial management course are as follows:

- a. Involves collaborative efforts, where students work in teams to complete projects, thus developing communication and cooperation skills (Missingham et al. 2009; Wood and Pranjol 2024). The project in this case is to analyze the financial statements of MSMEs whether they are in accordance with SAK EMKM standards. SAR EMKM is the Financial Accounting Standards for Micro, Small and Medium Entities, an accounting standard that stands alone and is specifically designed to prepare financial reports for MSMEs in Indonesia. If it is found that something is not appropriate, students will provide correct advice according to the rules in SAK EMKM.
- b. Working on real problems, students gain practical experience that prepares them for professional challenges. This approach is in line with the needs of employers who want graduates with hands-on experience (Yen, Orley, and Drinka 2014). In this project, students are asked to analyze the financial statements of MSMEs in the production sector.
- c. PBL fosters critical thinking skills by requiring students to analyze complex problems, make decisions, and develop solutions. This is particularly important in accounting, where professionals often face unstructured problems (Stanley and Marsden 2012). This is related to providing solutions faced by MSMEs in implementing SAK EMKM. So students will conduct a complex analysis of the causes of MSME problems starting from recording financial transactions to preparing financial reports. To then find a solution.
- d. Technology integration in PBL enhances the learning experience. Tools such as learning management systems, e-learning platforms, and virtual simulations can make

the learning process more interesting and effective (Srinivasa and J 2016). The integration of technology in this project is the use of Ms. Excel to simplify recording transactions.

3 RESULTS

Based on the questionnaire that we distributed online, students' impressions after taking the MSME financial management course using the Project Based Learning (PBL) strategy include that they think they understand MSME finance better because they are directly involved in obtaining information and processing the data. As quoted from the results of one student's questionnaire, as follows:

"I understand more about Umkm financial material because I directly get information and process the data. And the application of PBL will be very useful for those of us who want to become MSME actors."

So there are students who say that:

"“If I have a business, it is easier to prepare the financial statements.”"

There are also those who argue as in the following quote:

"After digging up data directly from MSME actors in the use of project-based learning (PBL) strategies, in my opinion, I can think more critically in analyzing and preparing business financial reports to make them more organized and make it easier to see the income, profits and losses of a business run"

So from this statement PBL is proven to train students' critical thinking. As well as providing more real understanding of the cases faced by MSMEs. As the following quote.

"PBL is very useful for me as a student who is just learning and also has many benefits because with the application of PBL we become more knowledgeable about the characteristics of MSMEs. And also understand better how to manage their finances. After seeing what MSME actors do

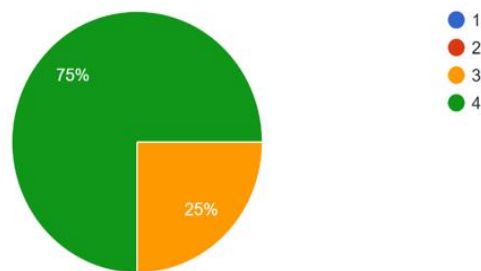
There are even students who provide detailed benefits in terms of developing their competencies, such as the following quote.

"This course is very beneficial for our study program, the competencies that develop include (1) Training students to use reasoning in solving business problems; (2) Training participants in making hypotheses in problem solving based on simple business concepts; (3) training critical and contextual thinking skills"

The following are student perceptions of technical skills that have improved after carrying out the assigned project:

Figure 1

PBL can increase the accuracy of the analysis of cost components or expenses incurred by MSMEs when creating Profit and Loss reports



There are 75% of students strongly agree that the application of PBL learning can make it easier for them to analyze accounts that include the cost component in the income statement. The remaining 25% are in the agree category.

This shows that they are not confused in sorting out the cost components, among others

1. Cost of Goods Sold

This expense reflects the direct costs related to the acquisition of merchandise or the production process of goods/services sold.

Examples: purchase of raw materials, direct labor, and other production costs.

2. Selling Expenses

These are costs incurred due to promotional activities, marketing, and distribution of products or services.

Examples: advertising, promotion, transportation/expedition costs, and marketing staff salaries.

3. Administrative and General Expenses

These are costs related to managerial activities, control, and general company operations.

Examples: salaries of office employees, electricity and telephone bills, office supplies, and depreciation of office buildings.

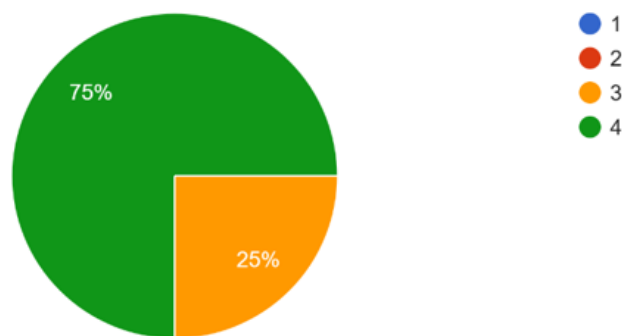
4. Financial Expenses

Expenses that arise from financing activities or the use of company resources.

Examples: interest on loans and bank administration fees.

Figure 2

The PBL model can improve the analysis of the income component in the MSME income statement

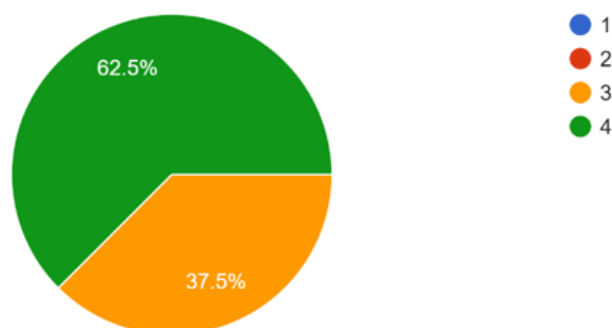


There are 75% of students who strongly agree that the application of PBL learning can make it easier for them to analyze the accounts included in the income component in the income statement. The remaining 25% are in the agree category.

This shows that they are not confused in sorting out the components of income.

Figure 3

The PBL model can improve the analysis of the calculation of Cost of Goods Sold (COGS) in the process of making MSME profit and loss statements



There are 62.5% of students who strongly agree that the application of PBL learning can make it easier for them to analyze the accounts included in the calculation of COGS (cost of goods sold) in the income statement. The remaining 37.5% are in the agree category.

Then analyze the COGS, among others:

The calculation of COGS for a trading company consists of the following elements: Beginning inventory of trade goods; net purchases; ending inventory of trade goods.

Description:

Beginning inventory is the amount of goods available for sale at the beginning of the accounting period or a certain period in a company. This inventory value is the value of goods remaining from the previous period and is ready to be sold or used during the current period.

Net purchases Is the total cost incurred by the company to purchase merchandise, after deducting returns, purchase discounts (also known as discounts), and shipping costs, if any. In other words, it is the amount that the company actually paid for the purchased goods, regardless of returns and discounts. Ending goods inventory Is the total value of goods still available for sale at the end of the accounting period.

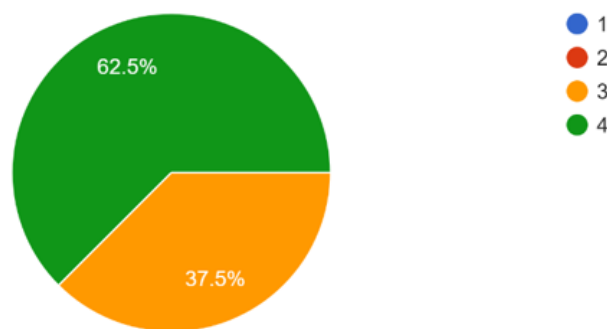
Calculate the direct costs associated with producing goods or providing services, such as raw materials, direct labor, and factory overhead costs.

The three elements can be formulated as follows:

$\text{COGS} = \text{Beginning inventory of merchandise} + \text{Net purchases} - \text{Ending inventory}$

Figure 4

Students' perceptions of the PjBl model can improve the analysis of the current and non-current asset components of SMEs



There are 62.5% of students who strongly agree that the application of PBL learning can make it easier for them to analyze current and non-current asset accounts in the balance sheet report. The remaining 37.5% are in the agree category.

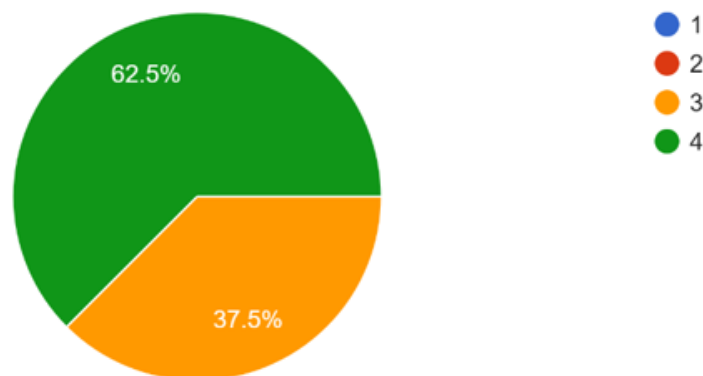
Then analyze the assets, among others:

Assets are resources that are owned or controlled by the entity as a result of past transactions or events and are expected to provide economic benefits in the future. In SAK EMKM, assets are grouped into:

- Current Assets: cash, cash equivalents, accounts receivable, inventory, and other assets that are expected to be realized within 12 months.
- Non-Current Assets: include fixed assets (such as land, buildings, equipment), intangible assets, and long-term investments.

Figure 5

The PBL model can improve the analysis of current and non-current liability components of MSMEs



There are 62.5% of students who strongly agree that the application of PBL learning can make it easier for them to analyze current and non-current debt accounts in the balance sheet report. The remaining 37.5% are in the agree category.

Then analyze the debt, among others:

Liabilities are obligations that the entity currently has, which arise from past events and their settlement will result in the expenditure of economic resources.

In SAK EMKM, short-term liabilities are defined as debts or obligations of the entity that must be settled within a maximum period of 12 months from the reporting date, or within the entity's normal operating cycle, whichever is longer.

The main categories of short-term liabilities in MSMEs include:

1. Accounts Payable

This is a liability arising from the purchase of goods or services on credit in the ordinary course of business.

Examples: debts to raw material suppliers or trade payables to distributors.

2. Short-term Bank Loans

Namely loans obtained from banks with a maximum repayment period of 12 months.

This includes overdrafts and loans for working capital.

3. Accrued Expenses

Expenses that have become liabilities but have not been paid until the end of the reporting period.

Examples: unpaid employee salaries, outstanding electricity or telephone charges.

4. Unearned Revenue

Funds that have been received from customers, but the goods or services for which they are obligated have not yet been provided.

Example: advances on orders for products or services.

5. Other Current Liabilities

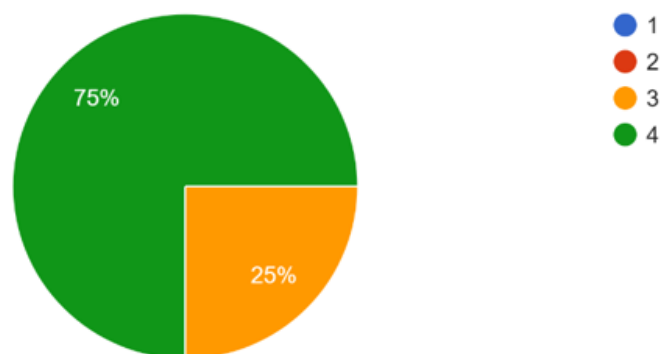
Includes other liabilities that must be repaid within a short period of time.

Examples: taxes payable, dividends payable, or other current liabilities arising from business activities.

Entities classify all other liabilities as long-term liabilities.

Figure 6

The PBL model can increase student competence in making correct financial reports for MSMEs, especially those engaged in production MSMEs



There are 75% of students who strongly agree that the application of PBL learning can improve student competence in making correct financial reports for MSMEs, especially those engaged in MSME production. The remaining 25% are in the agree category.

The stages of making financial statements include collecting transaction data, making general journals, moving to the ledger, compiling a balance sheet, making adjusting journals, compiling a balance sheet, making financial statements (profit and loss, balance sheet, cash flow, and changes in capital),

4 DISCUSSION

PBL promotes self-directed learning, encouraging students to independently search for solutions and make sound financial decisions, which are key success factors for MSMEs (Abinzano et al. 2024). PBL enables iterative learning, where students can receive feedback, reflect on their performance, and make improvements. This process is similar to the continuous improvement efforts needed in MSME financial management (Garrido-Lopez et al. 2018; Blazevic and Lievens 2004). Successful completion of PBL projects increases students' confidence in their financial management skills, making them better prepared for financial responsibilities in MSMEs (Yulianti 2024; Shahiwala 2017).

PBL involves addressing real problems faced by MSMEs, such as financial planning, risk management and investment decision-making (Delgado and Ayala 2019; Abinzano et al. 2024, 2022). This ensures that learning can be directly applied in the business environment. Engage MSMEs and industry partners directly in the development of projects that respond to their specific challenges (Delgado and Ayala 2019; Ott and Liesaputra 2020). This collaboration increases the relevance and impact of the learning experience.

PBL emphasizes hands-on activities where learners are actively involved in projects, such as preparing consultancy reports or business plans (Abinzano et al. 2024; Shahiwala 2017; Liang et al. 2016). This method promotes deeper understanding and retention of financial concepts.

Effective PBL models cover various aspects of business management, including resource management, financial structure, marketing and business development (Delgado and Ayala 2019; Suharsono et al. 2025). This holistic approach helps MSME managers understand the interconnectedness of business functions. PBL emphasizes hands-on activities where learners are actively involved in projects, such as preparing consulting reports or business plans (Abinzano et al. 2024; Shahiwala 2017; Liang et al. 2016). This method promotes deeper understanding and retention of financial concepts. It encourages collaboration between students to solve problems and complete projects, reflecting the collaborative nature of business management in MSMEs (Abinzano et al. 2024; Browning,

Anderson, and Galway 2024). It also helps develop soft skills such as communication and teamwork.

Projects should also focus on improving technological infrastructure, which is critical for MSMEs to thrive in the digital economy. This includes training in the use of digital tools and platforms that can simplify operations and reduce costs (Harnida et al. 2024). PBL should focus on solving real financial problems that MSMEs face. This includes developing business models, financial plans and strategies that are directly applicable to the MSME context (Kabilan 2024). Involving students from different disciplines in PBL projects can provide MSMEs with diverse perspectives and innovative solutions to financial challenges. This approach helps MSMEs develop comprehensive strategies that cover various aspects of the business (Favaloro et al. 2018; Sabnis, Kulkarni, and Gurav 2020).

PBL encourages students to engage deeply with the material through large-scale project work that provides context for technical learning (Sleezer, Leung, and Bates 2018). PBL supports the development of essential skills such as critical thinking, problem solving, teamwork, and self-directed learning (Colim et al. 2022). These skills are essential for mastering deep learning techniques and applying them effectively in real situations. By engaging students in projects relevant to their lives and future careers, PBL increases motivation while deepening understanding of theoretical concepts (Mutanga 2024).

Students may face difficulties in adapting to PBL, especially when switching from traditional teaching methods. Consistent attendance and repeated assessments are critical to mastering concepts (Mutanga 2024). Effective lecturer intervention and timely feedback are important components to improve group performance and deepen learning (Kim et al. 2011). The iterative assessment process helps students refine their understanding and application of deep learning concepts.

PBL encourages collaboration among students, which is essential in dealing with complex deep learning problems. Group projects and case studies mimic real challenges, thus enhancing teamwork and collective problem solving (Martínez-Monés et al. 2005). The utilization of digital technologies and AI can support PBL by providing reliable assessment methods and enhancing collaboration (Divjak, Svetec, and Aničić 2025). Integrating generative AI in PBL can bring innovation to the learning process while ensuring equitable practices.

5 CONCLUSIONS

The application of PBL in the MSME financial management course based on student perceptions provides the following benefits:

- a. train students' critical thinking
- b. better understand MSME finance because they are directly involved in obtaining information and processing the data
- c. develop competence in using reasoning in solving business problems;
- d. Train students in making hypotheses in problem solving based on simple business concepts;
- e. train critical and contextual thinking skills"
- f. As well as making it easier for students to understand the components of the income statement and balance sheet.

Therefore, the suggestion for further researchers is to conduct an assessment in the implementation of PBL in the framework of industrial internships. Given that based on student perceptions, direct field work makes a positive contribution to the development of skills, both hard and soft skills.

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RELIGION, SPIRITUALITY, AND RATIONALIZATION: MEANINGS OF SOCIAL ACTION FROM THE WEBERIAN PERSPECTIVE

RELIGIÃO, ESPIRITUALIDADE E RACIONALIZAÇÃO: SENTIDOS DA AÇÃO SOCIAL NA PERSPECTIVA WEBERIANA

RELIGIÓN, ESPIRITUALIDAD Y RACIONALIZACIÓN: SENTIDOS DE LA ACCIÓN SOCIAL DESDE LA PERSPECTIVA WEBERIANA

 <https://doi.org/10.56238/sevened2025.036-089>

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ABSTRACT

This chapter discusses religion, theodicy, and spirituality from a Weberian perspective, highlighting their implications for social action in modern and disenchanted societies. Based on Max Weber's sociology of religion, religion is addressed as a form of rationalized social action, linked to different modes of religious domination and to the process of the disenchantment of the world, in which rationalization and bureaucracy weaken the institutional centrality of the sacred. The chapter then explores the concept of theodicy as a set of religious explanations for suffering, evil, fortune, and misfortune, emphasizing its role in moral and social legitimation. Drawing on the comparison among traditions such as Protestantism, Catholicism, Confucianism, Hinduism, and Buddhism, it analyzes how distinct religious ethics produce specific rationalizations of economic and social life. Finally, it examines the emergence of spirituality as a contemporary, less institutionalized and more subjective category that engages with central questions formulated by Weber, especially the search for meaning, the experience of suffering, and the orientation of social action. It is argued that even in highly rationalized contexts, religion and spirituality continue to act as decisive dimensions in the construction of meaning and in the legitimation of forms of life.

Keywords: Disenchantment of the World. Rationalization. Bureaucracy. Comparative Religious Ethics. Search for Meaning.

RESUMO

Este capítulo discute religião, teodiceia e espiritualidade na perspectiva weberiana, destacando suas implicações para a ação social em sociedades modernas e desencantadas. Com base na sociologia da religião de Max Weber, a religião é abordada como forma de ação social racionalizada, vinculada a diferentes modos de dominação religiosa e ao processo de desencantamento do mundo, no qual a racionalização e a burocracia enfraquecem a centralidade institucional do sagrado. Em seguida, explora-se o conceito de teodiceia como conjunto de explicações religiosas sobre sofrimento, mal, fortuna e infortúnio,

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ressaltando seu papel na legitimação moral e social. A partir da comparação entre tradições como protestantismo, catolicismo, confucionismo, hinduísmo e budismo, analisa-se como distintas éticas religiosas produzem racionalizações específicas da vida econômica e social. Por fim, examina-se a emergência da espiritualidade como categoria contemporânea, menos institucionalizada e mais subjetiva, que dialoga com questões centrais formuladas por Weber, especialmente a busca de sentido, a experiência do sofrimento e a orientação da ação social. Argumenta-se que, mesmo em contextos altamente racionalizados, religião e espiritualidade seguem atuando como dimensões decisivas na construção de significados e na legitimação das formas de vida.

Palavras-chave: Desencantamento do Mundo. Racionalização. Burocracia. Ética Religiosa Comparada. Busca de Sentido.

RESUMEN

Este capítulo analiza la religión, la teodicea y la espiritualidad desde la perspectiva weberiana, destacando sus implicaciones para la acción social en sociedades modernas y desencantadas. Basándose en la sociología de la religión de Max Weber, la religión se aborda como una forma de acción social racionalizada, vinculada a distintos modos de dominación religiosa y al proceso de desencantamiento del mundo, en el cual la racionalización y la burocracia debilitan la centralidad institucional de lo sagrado. A continuación, se explora el concepto de teodicea como un conjunto de explicaciones religiosas sobre el sufrimiento, el mal, la fortuna y el infortunio, resaltando su papel en la legitimación moral y social. A partir de la comparación entre tradiciones como el protestantismo, el catolicismo, el confucianismo, el hinduismo y el budismo, se analiza cómo diferentes éticas religiosas producen racionalizaciones específicas de la vida económica y social. Por último, se examina la aparición de la espiritualidad como una categoría contemporánea, menos institucionalizada y más subjetiva, que dialoga con cuestiones centrales formuladas por Weber, especialmente la búsqueda de sentido, la experiencia del sufrimiento y la orientación de la acción social. Se argumenta que, incluso en contextos altamente racionalizados, la religión y la espiritualidad siguen actuando como dimensiones decisivas en la construcción de significados y en la legitimación de las formas de vida.

Palabras clave: Desencantamiento del Mundo. Racionalización. Burocracia. Ética Religiosa Comparada. Búsqueda de Sentido.

1 INTRODUCTION

Religion occupies a privileged place in classical sociology, as it is understood not only as a set of beliefs, but as a force that structures social relations, moral practices, and forms of domination. Among the authors who contributed most to this understanding is Max Weber, whose analysis of the religious phenomenon allows us to understand how symbolic systems are articulated with the economy, politics, ethics, and rationalization processes characteristic of modernity, especially in his works published in 1996 and 2004. Unlike approaches that treat religion as something merely collective or irrational, Weber (1996; 2004) conceives it as a form of rationalized social action, endowed with internal coherence and capable of guiding human conduct and legitimizing the social order.

In investigating the role of religion in traditional and modern societies, Weber (1996; 2004) describes different types of religious authority — the priest, the sorcerer, and the prophet — and shows how each of them can contribute both to the consolidation of bureaucratic structures and to movements of spiritual renewal and rupture with tradition. With the advance of rationalization, bureaucracy and secularization, however, the disenchantment of the world emerges: religious explanations cease to occupy a hegemonic position and begin to dispute meanings with other autonomous spheres, such as science, economics and politics. Thus, a constitutive tension of modernity is intensified: religion loses institutional power, but continues to offer answers to fundamental existential questions, such as suffering, fate and morality, as highlighted by Pierucci (2003) and Gigante (2013).

This permanence is expressed in a particular way in theodicy, a central concept in Weber's thought, which designates religious explanations elaborated to justify the existence of evil, pain and inequalities (WEBER, 1996; 2004). The theodicies of fortune and misfortune, analyzed by Weber and deepened by authors such as Gigante (2013), show how religious beliefs function as mechanisms of moral and social stabilization, legitimizing class positions and guiding individual conduct. The comparison between religious traditions — such as Protestantism, Catholicism, Confucianism, Hinduism and Buddhism — shows, according to Weber (1996; 2004), different ways of ordering the world, interpreting morality and organizing economic life, producing different rationalities.

At the same time, the weakening of institutional religion in modernity opens space for a phenomenon that goes beyond confessional boundaries: spirituality. Although Weber (2004) does not use this concept in the contemporary sense, his work offers bases for understanding it as a subjective experience of meaning, linked to the search for

understanding life, suffering, evil, and finitude, as Gerone (2015; 2022) also indicates. Contemporary authors such as Gerone (2015; 2022), Nietzsche (2024), Frankl (1989), Kohlberg (1981) and Sponville (2001; 2007) allow us to deepen this dimension, understanding spirituality as a movement that can both dialogue with religious traditions and distance itself from them, opening up to theistic, pantheistic and even atheistic forms.

Finally, in Weber (1996), the articulation between spirituality and social action makes it possible to analyze how experiences of meaning influence the ways in which individuals guide their conduct — whether by values, ends, tradition or emotion. This relationship allows us to revisit the tension between the ethics of conviction and the ethics of responsibility, showing that spirituality can operate both as a critical element in the face of excessive rationalization and as a mechanism for reinforcing dogmatic postures, according to the interpretations of Weber (1996; 2004) and Gigante (2013). In view of this scenario, this chapter aims to analyze religion, theodicy and spirituality from the Weberian perspective, evidencing their implications for social action in modern and disenchanted societies. To this end, it articulates Weber's classic concepts with contributions from contemporary authors, seeking to understand how, between tradition and modernity, human beings continue to construct meanings for their own existence and for their relationship with the world.

2 RELIGION, DOMINATION AND DISENCHANTMENT OF THE WORLD IN WEBER'S SOCIOLOGY

In the Weberian perspective, religion can be understood as a specific way of acting in community. Unlike Durkheim, who defines it above all as a collective social fact, Weber (1996) does not oppose religion and rationality: it operates its own modes of rationality through religious and magical acts, endowed with internal logic and practical function in contexts of power. He distinguishes three types of religious domination: the priest, linked to institutional and bureaucratic authority (priests, rabbis); the sorcerer, whose authority is based on tradition and recognized spiritual powers (shamans, healers); and the prophet, based on revelation and charisma, capable of breaking with traditions (Moses, Mohammed, Luther). This typology helps to understand why some religions become centralized structures, while others remain forces of disruption and renewal. With modernity, however, religion loses its position of domination over the other spheres (economic, scientific, political, etc.), because it is recognized as a human construction and its legitimacy is no longer taken as absolute. In this sense, Weber (2004), like Marx, denounces dominating religion as a form of alienation and

defends that it should be understood as a human product, in order to limit its power to legitimize domination. However, according to Pierucci (2003) this does not imply atheism, but criticism of religion that suffocates autonomy and overlaps with other spheres.

In addition, according to Pierucci (2003), religion, in the Weberian perspective, also functions as an instance of justification and perpetuation of inequalities. In the Indian caste system, for example, religious doctrines legitimize stratification by attributing sacred meanings to social positions. Religion presents norms and hierarchies as natural and unquestionable, contributing to the maintenance of order. Thus, for Weber, religion is decisive in social structuring, but when it acts in a domineering way, it conceals its own human nature and places its values as absolutes above the autonomy of the subjects.

A central notion to understand this process is the disenchantment of the world. It is through it that religion, as an instance of absolute explanation of the meaning of existence, loses strength. Weber (2004) argues that in modernity, economic and bureaucratic rationality and the secular mentality begin to organize social life, replacing the old religious references. Social spheres begin to operate according to their own norms, and there is no longer a universality based on a single religious interpretation. This does not mean the disappearance of religion, but its transformation and resignification in new institutional and personal forms.

Bureaucracy is another key theme to understand religion in modernity. Weber (2004) states that bureaucracy is structured in rational norms, hierarchies and impersonal procedures, it seeks predictability and efficiency. Unlike religion, which acts on the symbolic and subjective plane, bureaucracy establishes universal rules applicable to everyone, regardless of belief. Politics, economics, science and culture began to function with relative autonomy, marking the passage from theocratic societies to secular societies. The meaning of life is no longer sought exclusively in religion, but also in other forms of rationality and expression of faith, based on reason and experience. Secularization, however, is not a simple linear departure from religion, but a transformation of beliefs and practices, making them compatible with new social and moral realities.

In this scenario, in which religion transforms and disputes meanings with other spheres, a central question remains: how does it continue to offer answers to suffering, evil, inequality, and human destiny in a disenchanted world? Even in rationalized and plural societies, people continue to seek explanations for pain, misfortune and prosperity, and these answers guide ethical conduct and legitimize social positions. It is here that Weber introduces the concept of theodicy, understood as the set of religious explanations that seek to make

sense of human experience, justify social order, and stabilize the relationship between individual destiny and collective structure. Theodicy becomes a decisive link between religion, morality and social organization, by showing how different traditions elaborate different responses to fortune, suffering and inequality. Next, this concept and its sociological implications will be deepened.

3 THEODICY, MORAL VALUES AND SOCIAL LEGITIMATION IN RELIGIONS

According to Gigante (2013), the sociology of religion in Weber highlights the role of religious beliefs in the formation of moral values that guide human conduct and legitimize the social order. The author presents the idea of *sanctification of life*, that is, the internalization of religious values as a guide to behavior and as a form of social legitimation, in which groups and classes adopt religious systems aligned with their material and symbolic interests. According to Weber (2004), in Calvinism, for example, the doctrine of predestination leads the faithful to seek signs of divine election in work and action in the world: work effort is a moral and religious duty, and prosperity is interpreted as a blessing.

In a life marked by effort and the search for divine blessing, questions about suffering and evil inevitably arise. In the Weberian perspective, theodicy designates the explanations that religions offer for these issues and that different social classes use to justify their material situation. Gigante (2013) when describing the theodicies stated that the theodicies of fortune, common among elites, interpret prosperity as divine favor; On the other hand, the theodicies of misfortune, frequent among disadvantaged classes, see adversity as a trial or test of faith, with a reward postponed to the afterlife, which reduces conflicts and questions. In both cases, they function as mechanisms of moral and social legitimation. In Protestantism, for example, economic failure tends to be seen as a sign of moral deviation, and success, as a divine reward, influencing laws, political, economic, and social systems in contexts of strong religious presence.

Comparing religions, Weber notes that Catholicism, especially in Latin American societies, values material renunciation and does not directly encourage the accumulation of wealth. Weber (2004) points out that salvation is linked to the sacraments and obedience to the Church, emphasizing community values, charity and solidarity. Thus, the Catholic ethic differs from the Protestant one: Catholics would tend to pursue careers linked to the humanities and public service, while Protestants would be more involved in commercial and industrial activities.

Another case is Confucianism, the normative system that structured the social and bureaucratic order of imperial China. Unlike Western religions centered on the individual-God relationship, Confucianism organizes an ethic focused on social harmony, respect for hierarchies, and adaptation to the existing order, without requiring a strictly religious foundation. According to Weber (1996), the search for wealth is not condemned, but must respect the established hierarchies. This configuration, while guaranteeing significant kinship networks and social support, limits social mobility and prevents the emergence of an autonomous bourgeoisie, as in Europe, restricting the development of a fully rationalized modern capitalism.

According to Weber (1996), in Hinduism, asceticism assumes a passive and extramundane character, reinforcing the caste structure and the acceptance of the social order as an expression of the cosmic order. The belief in karma and dharma makes social position the result of previous lives, legitimizing conformism and discouraging structural change. Ascension is not the effect of individual effort, but of the fulfillment of a pre-assigned role. The division between castes – such as Brahmins (religion) and vaishyas (economy) – separates religious and economic functions, unlike the Protestant ethic, which values economic work as a divine calling. The absence of a spirit focused on the rational transformation of the world makes it difficult to form a modern capitalism in India, keeping the economy in traditional patterns.

Weber (1996) also analyzes Buddhism, one of the first missionary religions, widespread in China, Japan and Tibet. Buddhism deepens the distance from the material world, proposing the renunciation of desires and attachment as the path to enlightenment. This limits economic and political engagement, although the absence of a rigid caste system allows different social groups to adopt its teachings, facilitating cultural adaptation. In contrast to Protestantism, which associates vocation with work and the accumulation of wealth, Buddhism does not encourage economic rationalization and entrepreneurship.

Thus, by analyzing the sanctification of life, the theodicies of fortune and misfortune, and the various religious ethics, Weber shows that religion has a double function: it morally guides action and gives meaning to suffering, but it also legitimizes the social order and inequalities. With the advance of modernity and the autonomization of social spheres, the power of institutional religion to define the ultimate meaning of existence weakens. A space then opens up for more subjective experiences of meaning, which do not depend exclusively on traditional religious doctrines or structures. It is in this scenario of disenchantment and

transformation of the forms of the sacred that the contemporary notion of spirituality emerges with force – more fluid and less institutionalized, but still deeply linked to the existential questions that Weber identified in his analysis of human action and the rationalization of the world.

4 SPIRITUALITY IN THE WEBERIAN PERSPECTIVE

Spirituality in the Weberian perspective is related to his sociology of religion. Although Weber (2004) does not treat spirituality as an autonomous concept, he analyzes religion in depth not in theological terms, but by comparing religious beliefs, social structures and behaviors, especially in the development of Western capitalism. As Gerone (2022) points out, the distinction between spirituality, religion, and religiosity is recent, non-existent as a category of its own in Weber. Even so, his analysis of the religious phenomenon encompasses a subjective dimension of the state of mind, a rational posture towards life, marked by the search for meaning and personal and collective ethical behaviors, beyond Christian doctrines. Thus, by treating religion as an organized system of beliefs – close to the notion of religiosity –, Weber opens space for readings that touch on the idea of spirituality, which justifies its importance as a theoretical reference in this study.

Weber (2004) indicates that, although religious values have been central to social organization, scientific, political and moral modernity promotes a move away from absolute religious explanations, making room for rational and secular forms of social ordering. For Gerone (2022), this is articulated with the contemporary emergence of spirituality as a distinct notion from institutional religion, multifaceted and linked to existential experience. The loss of traditional religious legitimacy contributes to a field in which spirituality involves the possibility of adhering or not to a religion, shifting the focus from the mere acceptance of beliefs to the construction of meaning, personal norms and position in life. In plural societies, faith becomes choice, no longer an unquestioned social obligation.

According to Gigante (2013), in the "Zwischenbetrachtung" Weber analyzes forms of religious rejection of the world, highlighting intramundane and extramundane asceticism. The first implies living religious discipline within the world, seeing work and daily activities as a divine vocation, as in Protestantism. The second emphasizes withdrawal from the world and renunciation of pleasures. Added to this is mysticism, aimed at a subjective and immediate experience with the transcendent. Although formulated in a religious context, Gerone (2022) argues that these concepts allow us to understand spirituality as an essence common to

traditions: rites, norms, and values are crossed by a search for meaning that may or may not take on a religious form.

In addition, the notion of religion in Weber (2004) is guided by Gerone (2015; 2022), who highlighted how a way of acting in community, mediated by a system of beliefs that guides practices and social organization, is compatible with current conceptions of religion and religiosity. Spirituality, on the other hand, can be seen as an underlying dimension of central themes such as the "disenchantment of the world": religion loses the monopoly of social organization, but does not disappear; it is transformed and reinterpreted in a secular, cosmic and subjective key. Associated with spirituality, this condition points to a search for meaning that integrates religious and human values (solidarity, humanism), aiming at a more integral view of the person. For Gerone (2015; 2022), in a world governed by technical and impersonal norms, spirituality rescues the subjective and emotional dimension, functioning as a human differential and offering meaning even in the face of death and suffering.

This proposal to give meaning to life's impasses can be read in the light of Weber's theodicy. Despite the persistence of currents that instrumentalize pain and suffering as a spiritual bargaining chip, Gerone (2015; 2022) highlights the emergence of emerging theologies that reject the theology of prosperity and suffering and conceive spirituality as something that goes beyond religion, not reduced to the good/evil binomial. The response to suffering becomes the result of an experiential construction between the subject and what is cosmic, moving away from rigid schemes of punishment and reward. In this horizon, Nietzsche (2024) proposes a divinity beyond good and evil, symbolized by Dionysus, in which joy and pain are integrated into the fullness of existence. Inspired by Nietzsche, Frankl (1989) sees the search for meaning as a fundamental need: attributing meaning to suffering allows one to endure and transcend it. Kohlberg (1981) admits that theistic or pantheistic perspectives respond to uncertainty in the face of evil and death, while Sponville (2001; 2007) argues for an atheistic spirituality as the "life of the spirit" that thinks, feels, and loves beyond doctrines, including experiences such as agape love.

Thus, understanding spirituality from a Weberian perspective means recognizing it as an essential dimension of human experience and as a form of relationship with the world, the sacred (or the cosmic) and others. It gives meaning to experiences and promotes values that permeate the interior of the person and their external actions, and can both transform and sustain social structures. Spirituality, therefore, influences the types of social action, guiding

not only how people behave in the world, but also how they legitimize their choices and perceive their place in society.

4.1 SPIRITUALITY AND TYPES OF SOCIAL AND ETHICAL ACTION

Social actions, according to Weber (1996), can be articulated with spirituality in its four ideal types. In rational action with respect to ends, the subject chooses effective means to achieve an end, and spirituality can act as a criterion for judging whether the end is worthy and which means are morally acceptable (e.g., refusing fraud or violence). Thus, it functions as an ethical limit and a form of rationalization. However, when faith is instrumentalized only for practical purposes, there is a risk of emptying its existential dimension and producing forms of fundamentalism, approaching the metaphor of the "iron cage": an extremely rationalized life, without the spirit that gave it meaning.

In traditional action, guided by culturally transmitted customs and habits, spirituality is expressed in religion as a social phenomenon that preserves rites, festivities and doctrines. Religion can function both as a resistance to change and as a critical space, in which to ponder whether or not certain changes threaten the essential values of a tradition.

In affective action, moved by immediate emotional states, spirituality appears in experiences of ecstasy, epiphany, conversion, and belonging, which transform personal and collective life. Examples are communities of religious fervor (such as Pentecostalism), charismatic leaders such as Gandhi and Martin Luther King Jr., or humanitarian actions and alternative communities motivated by spiritual ideals and empathy.

In rational action in relation to values, the subject acts by principles that he considers valid in themselves, regardless of the consequences. In the religious field, this is expressed in the Puritan who works as the fulfillment of a sacred duty; outside of it, in humanist, pacifist or environmentalist militancy, with strong ethical convictions and a sense of personal transcendence, often in confrontation with the established order.

In the light of spirituality, the types of action help to balance the ethics of conviction (absolute and transcendent principles, resistance to excessive rationalization) and the ethics of responsibility (attention to consequences and the common good, not always linked to dogmas). The same spirituality can underlie both rigid and dogmatic religiosities and pragmatic and instrumental forms of faith. When rationalization completely dominates this field, the "iron cage" also applies to spirituality, imprisoning it in rigid structures that stifle its living and critical dimension.

4.2 CONTEMPORARY DIALOGUES: THE SPIRITUALITY OF THE "PILGRIM" AND "BELIEVING WITHOUT BELONGING"

In Weber's work, the analysis of the disenchantment of the world and the consequent subjectivation of the search for meaning finds an echo and detail in important works of the sociology of contemporary religion. Two authors, in particular, offer concepts that can be seen as empirical manifestations of the processes that Weber described: Grace Davie and Danièle Hervieu-Léger.

Grace Davie, in her influential work, coined the phrase "believing without belonging" to describe the religious landscape of modern Europe. According to Davie (2000), the process of secularization did not result in a disappearance of belief, but rather in a dissociation between individual faith and belonging to a religious institution. People continue to have spiritual beliefs, but they no longer feel obligated to actively participate in the life of a church or religious community. This notion aligns perfectly with Weber's thesis on the loss of centrality of institutional religion. "Believing without belonging" is in many ways a direct consequence of disenchantment: in a world where no institution has a monopoly on meaning, belief becomes a matter of private choice, and belonging optional.

In a complementary way, French sociologist Danièle Hervieu-Léger defines religion as a "chain of memory", a system that connects the present to the past through the continuous transmission of a tradition and a lineage of belief. For her, modernity is characterized precisely by the rupture of this chain. In this scenario of religious amnesia, the figure of the "pilgrim" emerges: a type of believer who builds his own spiritual journey autonomously, selecting and combining elements from different traditions, without fixating on any of them. Hervieu-Léger's (2008) "pilgrim" can be understood as the personification of the individual in Weber's disenchanted world. Having lost the certainties of tradition, he is forced to use rationality and subjective experience to assemble his own mosaic of meaning, navigating freely among the various spiritual offerings available.

Thus, the concepts of Davie and Hervieu-Léger do not contradict Weber's analysis, but deepen and update it, providing the conceptual tools to observe, at the empirical level, the consequences of the great process of rationalization and individualization that Weber identified as the mark of modernity. Contemporary spirituality, fluid and deinstitutionalized, is the field where the modern "pilgrim" exercises his "believing without belonging", in an incessant search for meaning that continues to be one of the main engines of social action. This convergence between Weberian theory and the contemporary analyses of Davie and

Hervieu-Léger reinforces the conclusion that religion and spirituality, although transformed, remain fundamental dimensions of human experience in modernity.

5 FINAL CONSIDERATIONS

The analysis developed throughout this study shows that Weber's contribution to the understanding of the religious phenomenon goes beyond the mere description of beliefs or devotional practices. In Weber, religion appears as a structuring force of social action, capable both of morally orienting human life and of legitimizing inequalities and preserving forms of domination. The typology of religious authorities, the process of disenchantment of the world and the emergence of bureaucracy allow us to understand why religion, although it has lost institutional centrality in modernity, remains influential as a system of meaning, albeit in new configurations.

The study of theodicy reveals that religious explanations about suffering, fortune and destiny are not only symbolic responses to existential concerns, but function as mechanisms of social stabilization and legitimization of class positions. The distinction between theodicies of fortune and misfortune, as well as the comparison between traditions such as Protestantism, Catholicism, Confucianism, Hinduism, and Buddhism, shows how different religious systems produce specific ethics and particular rationalizations of economic, political, and moral life. In these dynamics, the "sanctification of life" appears as a central axis in the constitution of conduct and in the sustenance of the social order.

However, the advance of rationalization, the pluralization of social spheres and the disenchantment of the world weaken the power of institutional religion to define, in an exclusive way, the ultimate meaning of existence. Thus, an expanded space is opened for subjective experiences of meaning that do not necessarily depend on dogmas or traditional religious structures. It is in this context that the contemporary notion of spirituality gains relevance, and can be understood, in the light of Weber and later authors, as a more fluid, less institutionalized form strongly marked by the autonomy of the person in the search for meaning, especially in the face of suffering, evil and finitude. This new religious landscape is well described by concepts such as Grace Davie's "believing without belonging" and Danièle Hervieu-Léger's figure of the "pilgrim," which empirically illustrate the dissociation between individual faith and institutional belonging.

By relating spirituality, theodicy and types of social action, it is also possible to reread the Weberian tension between the ethics of conviction and the ethics of responsibility.

Spirituality can sustain both postures rigidly based on absolute principles — when it becomes dogmatic religiosity or fundamentalism — and more reflective attitudes, sensitive to the consequences of actions and committed to the common good. In this sense, spirituality can act simultaneously as a force of criticism of excessively rationalized forms of life and as an element of reinforcement of structures of domination, depending on the way it is appropriated and lived.

Finally, it is important to recognize that this study has clear limits: it is a theoretical-bibliographical approach that focuses on Weber's work and on some contemporary commentators and interlocutors, without empirically entering into specific contexts of spirituality or religion. Future research can deepen how the categories discussed here — religious domination, disenchantment, theodicy, spirituality, and types of social action — manifest themselves in concrete practices, whether religious, parareligious, or non-religious, illuminating the ambiguities, tensions, and possibilities of resistance present in everyday life. Still, Weber's intuition remains current that, between tradition and modernity, between religion and secularization, human beings continue to make senses of pain, evil, destiny, and purpose—and it is precisely in this search that spirituality finds its place.

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**ARTIFICIAL INTELLIGENCE IN MARKETING CAMPAIGNS: A WAY TO ADAPT
MARKETING TO NEW TECHNOLOGIES**

**INTEGENCIA ARTIFICIAL NAS CAMPANHAS DE MARKETING: UMA FORMA
DE ADAPTAÇÃO DO MARKETING ÀS NOVAS TECNOLOGIAS**

**INTEGENCIA ARTIFICIAL EN LAS CAMPAÑAS DE MARKETING: UNA
FORMA DE ADAPTAR EL MARKETING A LAS NUEVAS TECNOLOGÍAS**

 <https://doi.org/10.56238/sevened2025.036-090>

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ABSTRACT

The contemporary landscape of Digital Marketing is marked by the incessant demand for personalized and optimized content, which poses a critical challenge to teams: the inefficiency in the manual analysis of information and the subsequent slowness in writing campaigns, limiting the scalability of corporate communication. The aim is to mitigate this limitation through the development of SocialGen-AI, a generative Artificial Intelligence system designed for end-to-end automation of the creation of promotional texts for social media, starting from the structural and semantic analysis of web pages. The implementation methodology is based on Agile Software Engineering, culminating in a solution implemented in Python and structured via API, which integrates with the Ollama framework for the optimized execution of the DeepSeek large language model. The process includes data extraction, contextualized semantic analysis, and the generation of copy with tone and style

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adjustments. Thus, SocialGen- AI allows for a substantial reduction in content time-to-market, in addition to ensuring high consistency and personalization at scale. In conclusion, an architecture based on local LLMs and dedicated APIs represents a viable and scalable technological solution for optimizing marketing productivity, paving the way for future research focused on native integration with social media platforms and the continuous improvement of AI's contextual accuracy.

Keywords: Artificial Intelligence. Digital Marketing. Content Automation. LLMs. FastAPI.

RESUMO

O cenário contemporâneo do Marketing Digital é marcado pela demanda incessante por conteúdo personalizado e otimizado, o que impõe um desafio crítico às equipes: a ineficiência na análise manual de informações e a subsequente morosidade na redação de campanhas, limitando a escalabilidade da comunicação corporativa. Objetiva-se mitigar essa limitação por meio do desenvolvimento do SocialGen-AI, um sistema de Inteligência Artificial generativa concebido para a automação end-to-end da criação de textos promocionais para mídias sociais, partindo da análise estrutural e semântica de páginas web. A metodologia de implementação baseia-se na Engenharia de Software Ágil, culminando em uma solução implementada em Python e estruturada via API, que se integra ao framework Ollama para a execução otimizada do modelo de large language DeepSeek. O processo compreende a extração de dados, a análise semântica contextualizada e a geração de copy com ajuste de tom e estilo. Desse modo, observa-se que o SocialGen-AI permite uma redução substancial no time-to-market do conteúdo, além de garantir alta consistência e personalização em escala. Conclui-se que a arquitetura baseada em LLMs locais e APIs dedicadas representa uma solução tecnológica viável e escalável para a otimização da produtividade em Marketing, pavimentando o caminho para futuras pesquisas focadas na integração nativa com plataformas de redes sociais e no aprimoramento contínuo da precisão contextual da IA.

Palavras-chave: Inteligência Artificial. Marketing Digital. Automação de Conteúdo. LLMs. FastAPI.

RESUMEN

El panorama actual del marketing digital se caracteriza por la demanda constante de contenido personalizado y optimizado, lo que supone un desafío crucial para los equipos: la ineficiencia del análisis manual de la información y la consiguiente lentitud en la creación de campañas, limitando la escalabilidad de la comunicación corporativa. El objetivo es mitigar esta limitación mediante el desarrollo de SocialGen-AI, un sistema de Inteligencia Artificial generativa diseñado para la automatización integral de la creación de textos promocionales para redes sociales, a partir del análisis estructural y semántico de páginas web. La metodología de implementación se basa en la Ingeniería de Software Ágil, culminando en una solución implementada en Python y estructurada mediante API, que se integra con el framework Ollama para la ejecución optimizada del modelo de lenguaje DeepSeek. El proceso incluye la extracción de datos, el análisis semántico contextualizado y la generación de textos con ajustes de tono y estilo. De este modo, SocialGen-AI permite una reducción sustancial del tiempo de lanzamiento del contenido, además de garantizar una alta coherencia y personalización a gran escala. En conclusión, una arquitectura basada en LLM locales y API dedicadas representa una solución tecnológica viable y escalable para optimizar la productividad del marketing, allanando el camino para futuras investigaciones centradas en la integración nativa con las plataformas de redes sociales y la mejora continua de la precisión contextual de la IA.



Palabras clave: Inteligencia Artificial. Marketing Digital. Automatización de Contenido. LLM. FastAPI.

1 INTRODUCTION

In recent years, social media has consolidated itself as one of the main communication channels between brands and consumers. In an increasingly competitive digital environment, maintaining an active, relevant, and coherent online presence has become essential for the strategic positioning of organizations. However, the traditional process of creating content for these platforms requires continuous effort from marketing teams, who need to analyze products, study trends, write texts, and adjust the tone of each publication to the audience of different networks. According to a study applied to the banking sector, sentiment analysis on social networks is essential to monitor public perceptions and guide strategic decisions, since these platforms have become essential sources for capturing opinions and trends in real time (DOS SANTOS; FERREIRA; BOENTE, 2025).

This process, while critical, is labor-intensive and time-consuming, which limits the agility and scalability of communication strategies. In addition, the speed with which new trends and information emerge makes exclusively human monitoring unfeasible. Faced with this challenge, Artificial Intelligence (AI) emerges as a powerful tool to automate content generation steps, reducing manual effort and increasing team efficiency. According to Goodfellow, Bengio, and Courville (2016), advances in deep learning have revolutionized the way machines process natural language, allowing neural models to generate text that is increasingly similar to human-written text.

Additionally, the automation provided by AI allows repetitive and operational activities to be performed more quickly and accurately, freeing up professionals to dedicate themselves to strategic tasks. This logic is widely recognized in Software Engineering, where automation "significantly reduces the human effort required in routine and repetitive tasks, increasing productivity and the quality of the development process" (SOMMERVILLE, 2019, p. 25). Applying this premise to marketing, the SocialGen-AI system was conceived in this context, seeking to transform a repetitive process into an automated and intelligent practice.

2 THEORETICAL FRAMEWORK

The theoretical framework in this study comprises a critical and organized analysis of the literature that underlies the development of the SocialGen-AI system, providing a technological and market contextualization. The analysis focuses on the pillars of Generative Artificial Intelligence, the application of these tools in Digital Marketing and the Software Architecture concepts that make the solution viable.

2.1 GENERATIVE ARTIFICIAL INTELLIGENCE AND DEEP LEARNING

Advances in deep learning models play a key role in the implementation of intelligent systems capable of understanding and generating language with a high level of coherence. This capability has become the basis for Large Language Models (LLMs), which are the heart of generative AI systems.

According to Goodfellow, Bengio and Courville (2016), deep learning has revolutionized natural language processing by enabling models to understand semantic and syntactic patterns in a hierarchical way, making systems more capable of performing tasks previously restricted to the human intellect (GOODFELLOW; BENGIO; COURVILLE, 2016). This capacity for contextual representation and semantic adaptation is what enables the practical application of generative models, such as the DeepSeek used in SocialGen-AI, in creative tasks, such as the automated production of advertising campaigns.

2.2 AUTOMATION, AI, AND DIGITAL MARKETING STRATEGIES

The contemporary Digital Marketing landscape requires organizations to maintain an active and relevant online presence, but the process of manual content creation is labor-intensive, time-consuming, and limits the scalability of communication. The manual production of posts consumes significant time and limits the frequency and relevance of publications, justifying the need for an automated solution (DOS SANTOS; FERREIRA; BOENTE, 2025).

Artificial intelligence emerges as the key technology to mitigate these challenges, playing an essential role in automating processes and generating strategic insights, allowing organizations to optimize resources and increase their operational efficiency (SILVA, 2023).

Additionally, the automation provided by AI allows repetitive and operational activities to be performed more quickly and accurately, freeing up professionals to dedicate themselves to strategic tasks. SocialGen-AI adopts this principle, using AI to automate content creation steps, improving the efficiency of marketing work.

2.3 RESTFUL SYSTEMS ARCHITECTURE AND APIS

The technical feasibility of SocialGen-AI lies in its modular architecture. The system was designed in the RESTful API format, which is a fundamental software architecture style for building scalable web services, where communication between client and server systems occurs in a standardized way, usually using the HTTP protocol (GUPTA, 2025). SocialGen-

AI's API endpoints are capable of receiving and returning data in JSON, favoring scalability and integration with other services (TIANGOLO, 2025).

The API was developed using the FastAPI framework, chosen for its high performance and simplicity in building modern web services. This architecture is essential for integration with Ollama, which acts as a local intermediary, functioning as a layer that manages the execution, loading, and processing of the DeepSeek model directly in the local environment (OLLAMA, 2025). Local processing eliminates dependence on cloud services, ensuring greater control over data flow and ensuring privacy, as well as reducing costs (DEEPSEEK API, 2025).

3 METHODOLOGY AND SYSTEM ARCHITECTURE

The development of SocialGen-AI followed a structured methodological approach, divided into stages of conception, implementation and testing. The main objective was to create a system capable of automatically processing web pages and generating, from them, personalized marketing campaigns.

The methodology adopted for the development is based on a systematic approach, divided into interdependent steps that aim to ensure the efficiency of the process of collecting, processing and generating automated content. Initially, a requirements survey was carried out to identify the main needs of the target audience and define the criteria for selecting information sources.

Next, the architecture of the system was established, contemplating the definition of the operating flow, from data capture to the generation and storage of draft posts. At this stage, the technologies to be used were also selected, such as the Python language and specific libraries for web scraping and feed reading.

With the architecture defined, the data collection and extraction stage was carried out. The collected material was subjected to a generative artificial intelligence API, responsible for processing and transforming the raw data into draft posts. Finally, the methodology included the validation stage of the system with real users, through practical tests and feedback collection. The process was completed with the preparation of technical and use documentation.

The methodology of an article outlines the procedures employed to conduct the research, including the type of study, sample selection, methods of data collection and analysis, ethical considerations, and limitations of the study. Its detailed and transparent

description is essential to ensure the replicability and reliability of the results, in addition to providing a solid basis for the interpretation and generalization of the findings.

3.1 DESIGN AND DEFINITION OF REQUIREMENTS

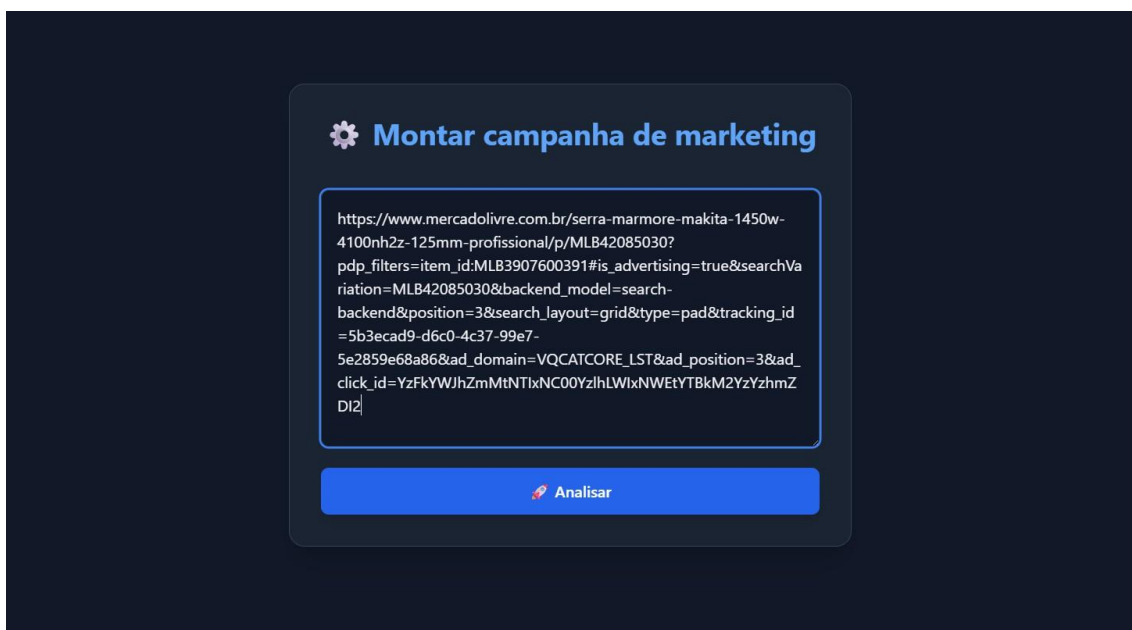
In the initial phase, a requirements analysis determined the essential functionalities of the system. Among the demands identified were:

1. Receive a link from a website as input;
2. Automatically collect and process the textual content of the page;
3. Send the processed text to an advanced language model (DeepSeek) executed locally via Ollama;
4. Generate a marketing campaign adapted to the product or service present in the link;
5. Return the result in a structured format, allowing future integration with other applications.

Based on these requirements, the use of Python as the main language was defined. The system was designed in the RESTful API format, with endpoints capable of receiving and returning data in JSON, favoring scalability and integration with other services.

Figure 1

Input from the site to be analyzed



Montar campanha de marketing

`https://www.mercadolibre.com.br/serra-marmore-makita-1450w-4100nh2z-125mm-profissional/p/MLB42085030?pdp_filters=item_id:MLB3907600391#is_advertising=true&searchVariation=MLB42085030&backend_model=search-backend&position=3&search_layout=grid&type=pad&tracking_id=5b3ecad9-d6c0-4c37-99e7-5e2859e68a86&ad_domain=VQCATCORE_LST&ad_position=3&ad_click_id=YzFkYWJhZmMtdNTIxNC00YzlhLWlxNWUeYTBkM2YzYzhmZDI2`

Analisar

Source: Prepared by the authors themselves (2025).

3.2 GENERAL SYSTEM ARCHITECTURE

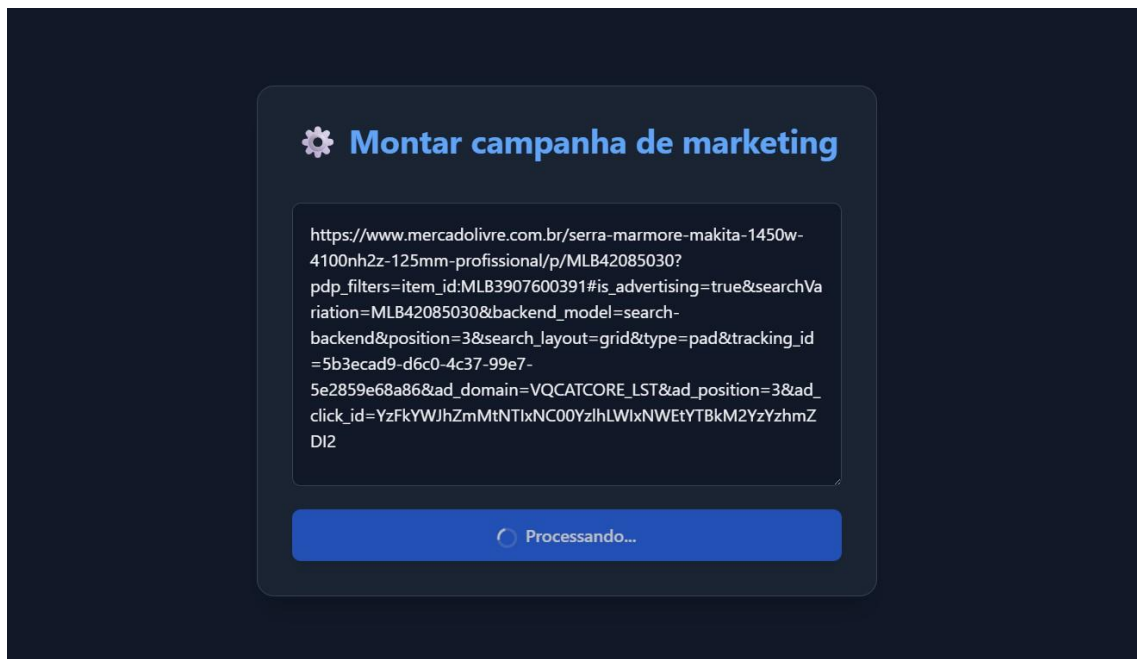
The architecture of SocialGen-AI is designed based on three main layers:

- Input Layer: Receives the link sent by the user or client system.
- Processing Layer: In charge of extracting the textual content from the website, sending the text to the AI model via Ollama and handling the response received.
- Output Layer: Responsible for structuring and making available the final result of the generated campaign text in a standardized format.

This modular structure allows each component to work independently, ensuring greater maintainability, scalability, and clarity in data flow.

Figure 2

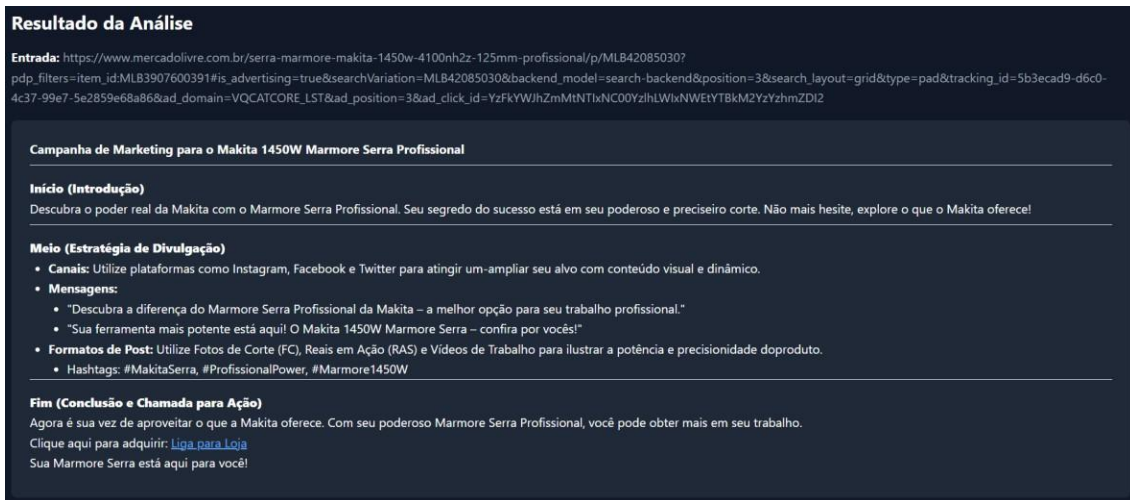
Processing of the embedded website



Source: Prepared by the authors themselves (2025).

Figure 3

Data returned after search



Source: Prepared by the authors themselves (2025).

3.3 PYTHON API IMPLEMENTATION

The API was developed using the FastAPI framework, chosen for its performance and simplicity. The main endpoint (/parse) receives the link, extracts the content, and triggers the DeepSeek model to generate the final text.

The simplified deployment flow includes:

1. You submit a POST request with the product link.
2. The API uses libraries (Requests and BeautifulSoup4) for scraping and extracting relevant content.
3. The clean text is passed to Ollama, specifying the DeepSeek template for generation.
4. The response is handled and converted to a structured format (JSON).
5. The result is returned to the API client.

3.4 INTEGRATION WITH OLLAMA AND THE DEEPSEEK MODEL

Ollama acts as a local intermediary, managing the execution of the DeepSeek model. This approach eliminates dependence on cloud services, ensuring greater control over the flow of data, ensuring privacy, and reducing costs and latency. The DeepSeek model was selected for its robust performance in textual comprehension, semantic analysis, and creative content generation tasks, making it ideal for turning product descriptions into engaging campaigns.

The API is responsible for putting together a carefully structured prompt, guiding the model to analyze the content and produce a campaign that highlights the product's

differentials. The quality of the prompt is key to ensuring consistency in style and alignment with the communication proposal.

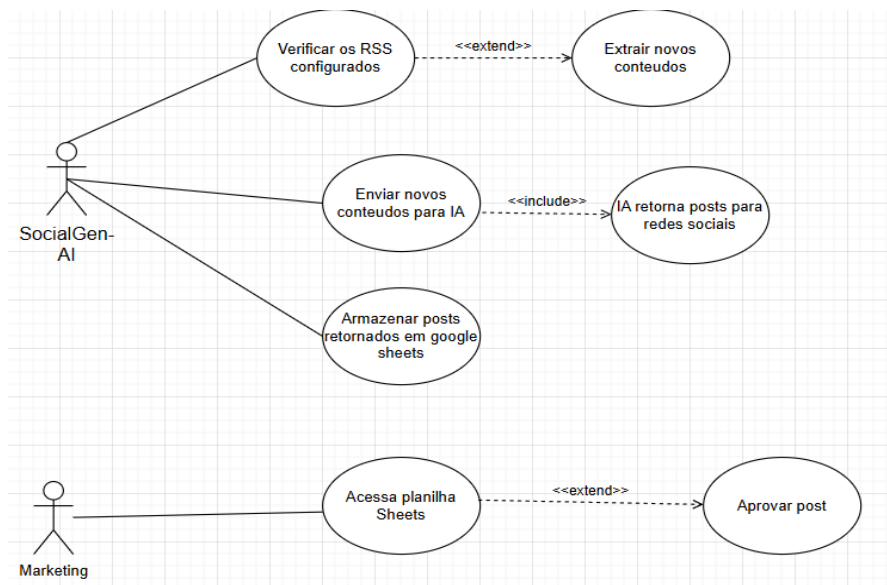
3.5 DATA FLOW AND OPERATION

The flow of SocialGen-AI is organized into five main steps:

1. Input: Receipt and validation of the link by the API.
2. Data Collection: Automatic extraction of textual content, including request, interpretation of HTML and filtering of irrelevant elements.
3. Interpretation: Sending the text to the DeepSeek model via Ollama, using a defined prompt to guide the analysis and style of the response.
4. Generation: The model produces a complete marketing campaign, highlighting differentials and aspects relevant to the target audience.
5. Output: Return of the final text formatted and ready for publication via the API.

Figure 4

Produced by the author



Source: Prepared by the authors themselves (2025).

4 RESULTS AND DISCUSSIONS

4.1 IMPLEMENTATION RESULTS AND CONTENT GENERATION

The results of this study focus on demonstrating the feasibility and effectiveness of SocialGen-AI as a technological solution for automating the creation of digital marketing campaigns. The implementation of the RESTful API architecture (Section 3.3) in Python and

the integration with Ollama, running the DeepSeek model, proved to be efficient in capturing and processing web information in real time.

The most significant result is the system's ability to turn a product link into a full-fledged marketing campaign draft, which includes:

- Introduction and Hook: Initial messages to capture attention.
- Dissemination Strategy: Suggestions for channels and post formats.
- Key Messages (Copy): Creative and persuasive texts, focusing on the product's differentials.
- Conclusion and Call to Action (CTA): Finalization and targeting the consumer.

The detailed output example in Figure 3 (Section 3.2) demonstrates that the system is capable of generating content with a professional and sales-oriented tone, fulfilling the requirement of producing creative ad suggestions from the interpretation of the text on the page.

4.1.1 Performance and Safety

The local execution of the DeepSeek model via Ollama showed favorable results in terms of operational efficiency. Local processing eliminates the latency associated with external API calls, resulting in faster and more consistent responses, allowing full campaigns to be generated in seconds.

In terms of security, the local approach mitigates the risk of data leakage or interception, since no sensitive information is transmitted to external servers. This is a crucial outcome for the applicability of SocialGen-AI in enterprise environments that require confidentiality and compliance.

4.2 DISCUSSION AND IMPLICATIONS OF THE STUDY

The implementation of SocialGen-AI corroborates the Generative Artificial Intelligence literature (Section 2.1), demonstrating in practice how the advancement of deep learning and LLMs allows neural models to "understand and generate text in an increasingly human-like way" (GOODFELLOW; BENGIO; COURVILLE, 2016). The system's ability to generate multiple content formats for different digital platforms (LinkedIn, Twitter/X, Facebook) from a single source supports the thesis that AI is a powerful tool for automating content creation, reducing manual effort and increasing efficiency.

4.2.1 Solving the Research Question

The main result directly addresses the research question of the study: The system is able to automate the analysis of web content and generate texts for digital marketing campaigns in a coherent and personalized way, optimizing the workflow of the teams.

- **Coherence and Personalization:** The generation of messages focused on differentials and with specific call-to-actions validates the model's ability to reinterpret content strategically, adopting advertising language and elements that arouse interest.
- **Workflow Optimization:** The proposed methodology (Section 3.5), which culminates in the storage of drafts in Google Sheets with approval status, transforms the marketing team's work from manual writing to only final review and validation. This aligns SocialGen-AI with the Software Engineering principle of reducing human effort on routine tasks, increasing productivity (SOMMERVILLE, 2019).

4.2.2 Limitations and Future Research

Despite the promising results, the study has limitations inherent to an initial development project. Hands-on validation of the system was performed in a controlled production environment (shown in Figures 1, 2, and 3). As future researches, the following stand out:

1. The practical implementation of the tool in a real production environment.
2. Direct integration with social media platforms for automated scheduling.
3. Continuous improvement of the AI model to increase accuracy and personalization, addressing more complex linguistic nuances.

5 CONCLUSION

The present study presented the design and architecture of SocialGen-AI, an Artificial Intelligence-based system designed to automate the generation of content for social media from information collected from web pages or news feeds. The analysis of the problem demonstrated that the manual production of posts consumes significant time and limits the frequency and relevance of publications, justifying the need for an automated solution.

The proposed methodology, which included stages of requirements gathering, data collection and extraction, processing with generative AI, storage, and review, evidenced the technical feasibility of the tool. The system demonstrates potential to generate content adapted to different platforms, promoting greater operational efficiency and supporting

strategic decision-making in marketing.

The development of SocialGen-AI, with its RESTful API architecture and the local execution of the DeepSeek model via Ollama, contributes significantly to the field by offering a scalable and secure model for optimizing the workflow of marketing teams.

As future perspectives, the following stand out:

- The practical implementation and testing with real users of the tool.
- Integration with multiple social platforms for scheduling.
- The continuous improvement of the AI model to increase the relevance, accuracy, and personalization of the generated content.

In this way, SocialGen-AI presents itself as a promising contribution to the automation of digital marketing and the advancement of technological solutions based on artificial intelligence.

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**TOURISM, INCLUDING AND SOCIAL RESPONSIBILITY: THE ROLE OF
AMESNE MUNICIPALITIES**

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MUNICÍPIOS DA AMESNE**

**TURISMO, INCLUSIÓN Y RESPONSABILIDAD SOCIAL: EL PAPEL DE LOS
MUNICIPIOS DE AMESNE**

 <https://doi.org/10.56238/sevened2025.036-091>

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ABSTRACT

This article investigates how the municipalities of the Association of Municipalities of the Upper Northeast Slope (AMESNE) can articulate tourism and social assistance to reduce territorial inequalities and promote productive inclusion. The central research question seeks to understand how tourism can be structured as a tool for social transformation, going beyond the economic aspect to consolidate itself as an intersectoral public policy. The general objective is to analyze the role of the AMESNE municipalities in the integration between tourism, social responsibility, and assistance policies, aiming at sustainable and inclusive regional development. The specific objectives involve: (i) outlining a socioeconomic panorama of the municipalities in the region; (ii) mapping the structure of the Unified Social Assistance System (SUAS) and its interaction with tourism policies; (iii) identifying local initiatives in social and community-based tourism; and (iv) proposing strategies to strengthen productive inclusion through tourism. The methodology adopted is applied in nature, with a qualitative approach, of an exploratory and descriptive character. Documentary analysis and statistical survey techniques were used, based on secondary data from the Brazilian Institute of Geography and Statistics (IBGE), the Single Registry (CadÚnico), the Bolsa Família Program, official reports from AMESNE and SUAS, as well as national and state normative documents. Data processing involved content analysis (BARDIN, 2016) applied to plans and legislation, descriptive statistics to highlight social inequalities, and spatial analysis through georeferencing (QGIS and ArcGIS) to map vulnerable families and social protection structures. Methodological triangulation (FLICK, 2018) was employed to integrate qualitative and quantitative data, providing greater reliability to the results. The literature review consisted of an analysis of public policies on tourism and social assistance. The results show that, despite the high tourism and economic potential of the region, significant inequalities persist, highlighted by the concentration of vulnerable families. The inequalities became evident through high GDP indicators coexisting with significant social vulnerabilities, highlighted by the number of families registered in the Unified Registry and beneficiaries of the Bolsa Família Program. The structure of the Unified Social Assistance System (SUAS),

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composed of 49 CRAS units and 13 CREAS units, is presented as a basis for territorial social protection actions. Corroborating this evidence, it was observed that the structured presence of SUAS, associated with community-based tourism practices, professional qualification, and cultural appreciation, strengthens the social dimension of ESG, potentially reducing dependence on income transfers, generating job and income opportunities, and strengthening social cohesion. The study concludes that integrated tourism and social assistance policies have the potential to transform AMESNE into a benchmark for fair, sustainable, and inclusive regional development.

Keywords: Tourism. Social Assistance. ESG. Public Policies. AMESNE.

RESUMO

O artigo investiga de que forma os municípios da Associação dos Municípios da Encosta Superior do Nordeste (AMESNE) podem articular o turismo e a assistência social para reduzir desigualdades territoriais e promover a inclusão produtiva. A questão-problema central busca compreender como o turismo pode ser estruturado como ferramenta de transformação social, indo além do viés econômico para consolidar-se como política pública intersetorial. O objetivo geral é analisar o papel dos municípios da AMESNE na integração entre turismo, responsabilidade social e políticas de assistência, visando o desenvolvimento regional sustentável e inclusivo. Os objetivos específicos envolvem: (i) traçar um panorama socioeconômico dos municípios da região; (ii) mapear a estrutura do Sistema Único de Assistência Social (SUAS) e sua interação com políticas turísticas; (iii) identificar iniciativas locais de turismo social e de base comunitária; e (iv) propor estratégias para fortalecer a inclusão produtiva via turismo. A metodologia adotada é de natureza aplicada, com abordagem qualitativa, de caráter exploratório e descritivo. Foram utilizadas técnicas de análise documental e levantamento estatístico, com base em dados secundários provenientes do Instituto Brasileiro de Geografia e Estatística (IBGE), Cadastro Único (CadÚnico), Programa Bolsa Família, relatórios oficiais da AMESNE e do SUAS, além de documentos normativos nacionais e estaduais. O tratamento dos dados envolveu análise de conteúdo (BARDIN, 2016) aplicada a planos e legislações, estatística descritiva para evidenciar desigualdades sociais e análise espacial por meio de georreferenciamento (QGIS e ArcGIS) para mapear famílias vulneráveis e estruturas de proteção social. A triangulação metodológica (FLICK, 2018) foi empregada para integrar dados qualitativos e quantitativos, conferindo maior confiabilidade aos resultados. A revisão bibliográfica consistiu em análise das políticas públicas de turismo e assistência social. Os resultados evidenciam que, apesar do elevado potencial turístico e econômico da região, persistem desigualdades expressivas, destacadas pela concentração de famílias vulneráveis. As desigualdades ficaram evidentes pelos altos indicadores de PIB convivendo com vulnerabilidades sociais expressivas, destacadas pelo número de famílias inscritas no Cadastro Único e beneficiárias do Programa Bolsa Família. A estrutura do Sistema Único de Assistência Social (SUAS), composta por 49 unidades do CRAS e 13 do CREAS, é apresentada como base para ações territoriais de proteção social. Corroborando essa evidência percebeu-se que a presença estruturada do SUAS, associada a práticas de turismo de base comunitária, qualificação profissional e valorização cultural, fortalece a dimensão social do ESG, podendo reduzir dependências de transferências de renda, gerar oportunidades de trabalho e renda e fortalecer a coesão social. O estudo conclui que políticas integradas de turismo e assistência social têm potencial para transformar a AMESNE em referência de desenvolvimento regional justo, sustentável e inclusivo.

Palavras-chave: Turismo. Assistência Social. ESG. Políticas Públicas. AMESNE.

RESUMEN

Este artículo investiga cómo los municipios de la Asociación de Municipios de la Alta Vertiente Noreste (AMESNE) pueden articular el turismo y la asistencia social para reducir las desigualdades territoriales y promover la inclusión productiva. La pregunta central de la investigación busca comprender cómo el turismo puede estructurarse como una herramienta de transformación social, trascendiendo el aspecto económico para consolidarse como una política pública intersectorial. El objetivo general es analizar el papel de los municipios de la AMESNE en la integración de las políticas de turismo, responsabilidad social y asistencia, con miras al desarrollo regional sostenible e inclusivo. Los objetivos específicos incluyen: (i) delinear un panorama socioeconómico de los municipios de la región; (ii) mapear la estructura del Sistema Único de Asistencia Social (SUAS) y su interacción con las políticas turísticas; (iii) identificar iniciativas locales de turismo social y comunitario; y (iv) proponer estrategias para fortalecer la inclusión productiva a través del turismo. La metodología adoptada es de naturaleza aplicada, con un enfoque cualitativo, de carácter exploratorio y descriptivo. Se emplearon técnicas de análisis documental y de levantamiento estadístico, con base en datos secundarios del Instituto Brasileño de Geografía y Estadística (IBGE), el Registro Único (CadÚnico), el Programa Bolsa Família, informes oficiales de AMESNE y SUAS, así como documentos normativos nacionales y estatales. El procesamiento de datos implicó análisis de contenido (BARDIN, 2016) aplicado a planes y legislación, estadística descriptiva para resaltar desigualdades sociales y análisis espacial mediante georreferenciación (QGIS y ArcGIS) para mapear familias vulnerables y estructuras de protección social. Se empleó triangulación metodológica (FLICK, 2018) para integrar datos cualitativos y cuantitativos, brindando mayor confiabilidad a los resultados. La revisión bibliográfica consistió en un análisis de políticas públicas en turismo y asistencia social. Los resultados muestran que, a pesar del alto potencial turístico y económico de la región, persisten desigualdades significativas, resaltadas por la concentración de familias vulnerables. Las desigualdades se hicieron evidentes a través de altos indicadores de PIB que coexisten con importantes vulnerabilidades sociales, resaltadas por el número de familias registradas en el Registro Único y beneficiarias del Programa Bolsa Família. La estructura del Sistema Único de Asistencia Social (SUAS), compuesto por 49 unidades CRAS y 13 unidades CREAS, se presenta como base para las acciones territoriales de protección social. Corroborando esta evidencia, se observó que la presencia estructurada del SUAS, asociada a prácticas de turismo comunitario, cualificación profesional y valoración cultural, fortalece la dimensión social de los ASG, reduciendo potencialmente la dependencia de las transferencias de ingresos, generando oportunidades de empleo e ingresos, y fortaleciendo la cohesión social. El estudio concluye que las políticas integradas de turismo y asistencia social tienen el potencial de convertir a AMESNE en un referente para el desarrollo regional justo, sostenible e inclusivo.

Palabras clave: Turismo. Asistencia Social. ASG. Políticas Públicas. AMESNE.

1 INTRODUCTION

The region of AMESNE (Association of Municipalities of the Upper Slope of the Northeast) represents one of the most important poles of Rio Grande do Sul in economic, cultural and tourist terms. Composed of 37 municipalities, this region has tourism as one of its main economic activities. However, behind the enchanting landscapes and industrial strength, there are social challenges that require an integrated approach between economic development and social institutional responsibility (AMESNE, 2025).

Figure 1

The AMESNE region



Source: Prepared by the authors (2025).

Such challenges require an intersectoral and integrated approach, which articulates economic development with social inclusion, equity and territorial justice, based on the strengthening of Social Institutional Responsibility (BRASIL, 2025).

Culturally, the region reflects the rich diversity of southern Brazilian culture, marked by the influence of European immigrants — mainly Italians, Germans and Azoreans — as well as by the contributions of indigenous and African peoples, whose presence, although historically marginalized, is fundamental for the formation of regional identity. Typical festivals, gastronomic knowledge, religiosity, architecture and artistic expressions are constitutive elements of local daily life and are consolidated as important tourist and identity assets. This

cultural multiplicity, in addition to attracting visitors, strengthens community bonds and can be mobilized as an instrument of territorial development based on valuing roots and promoting cultural citizenship (AMESNE, 2025).

However, despite the economic advances and the prominence in macroeconomic indicators, the region still faces significant internal inequalities. Municipalities with high *GDP per capita* and a high human development index coexist with localities that face severe restrictions on access to basic rights, such as housing, income, sanitation, health, and education (IBGE, 2025).

In urban centers considered centers of wealth, such as Caxias do Sul and Bento Gonçalves, the realities of vulnerable peripheries coexist, with populations exposed to situations of poverty, food insecurity, domestic violence, and structural discrimination. This contrast reveals the importance of building a development model that goes beyond economic growth and is committed to social justice, territorial cohesion, and respect for diversity.

In this sense, public policies that integrate the economic, social, environmental, and cultural dimensions are indispensable to ensure a more balanced and inclusive future. The strengthening of the social protection network, through the Unified Social Assistance System (SUAS), and the articulation with tourism as a tool for productive inclusion and appreciation of cultural territories are convergent strategies.

The implementation of the Rio Grande Plan, for example, with a focus on structuring investments and qualification of human capital, points to a long-term vision that recognizes the impacts of climate change, regional inequalities and the need for intergovernmental integration. Joint action between municipal and state governments, academic institutions and civil society is crucial for the proposed transformations to be effective and legitimate.

In addition, the State Social Assistance Plan of Rio Grande do Sul (2020–2023) highlights the urgency of ensuring the rights of the population in situations of vulnerability, emphasizing the role of the State in ensuring access to basic and special social protection, income, work, and community life. This guideline dialogues directly with the challenges faced by the municipalities of AMESNE, where the social protection of the territory, combined with endogenous development strategies — such as community-based tourism, rural tourism and cultural tourism — can be decisive for the promotion of equity and social autonomy.

The strengthening of Social IR as a public management tool based on data, evidence, and intersectoral agreement expands the possibilities of decision-making that is more sensitive to inequalities. It makes it possible to map vulnerabilities, plan policies in an

articulated way, and value territories not only as spaces for tourist consumption, but as places of life, memory, and belonging (BRASIL, 2025).

In this direction, tourism, as an economic and social activity, has been consolidated as an important vector for the promotion of social inclusion and sustainable territorial development.

The expansion of social tourism, which goes beyond leisure and consumption, seeks to democratize access to tourist experiences, ensuring that vulnerable segments of the population can actively participate in this sector and enjoy its benefits. This perspective reaffirms tourism as a social right, capable of strengthening community bonds, valuing cultural identities and fostering the local economy.

In Brazil, recent public policies, such as the National Tourism Plan (2024-2027), reinforce the commitment to the democratization of access, professional qualification, and the productive insertion of people in situations of social vulnerability. The strengthening of integrated networks between tourism and social assistance is essential for the sector to effectively contribute to the reduction of regional inequalities and the promotion of social justice.

In addition, the articulation between tourism and social protection policies enables the construction of inclusive tourist environments, which respect the cultural, ethnic, generational and gender diversity of local communities. This integration enhances the development of tourist itineraries and activities that value traditional knowledge and promote community participation, expanding economic opportunities and the feeling of belonging.

Therefore, when thinking about tourism as an instrument of productive and social inclusion, it is necessary to overcome the fragmented view of public policies, building integrated and intersectoral strategies. This expanded focus contributes to tourism moving from being just a mechanism for generating revenue to becoming a space for the realization of rights, citizenship and human development.

In summary, the AMESNE region is a multifaceted territory, of great economic and cultural relevance, whose tourism potential must be understood as part of a broader strategy of sustainable development. For this development to reach all segments of the population, especially the most vulnerable, it is essential to adopt an integrated approach that unites economic growth, social responsibility, cultural appreciation and territorial inclusion.

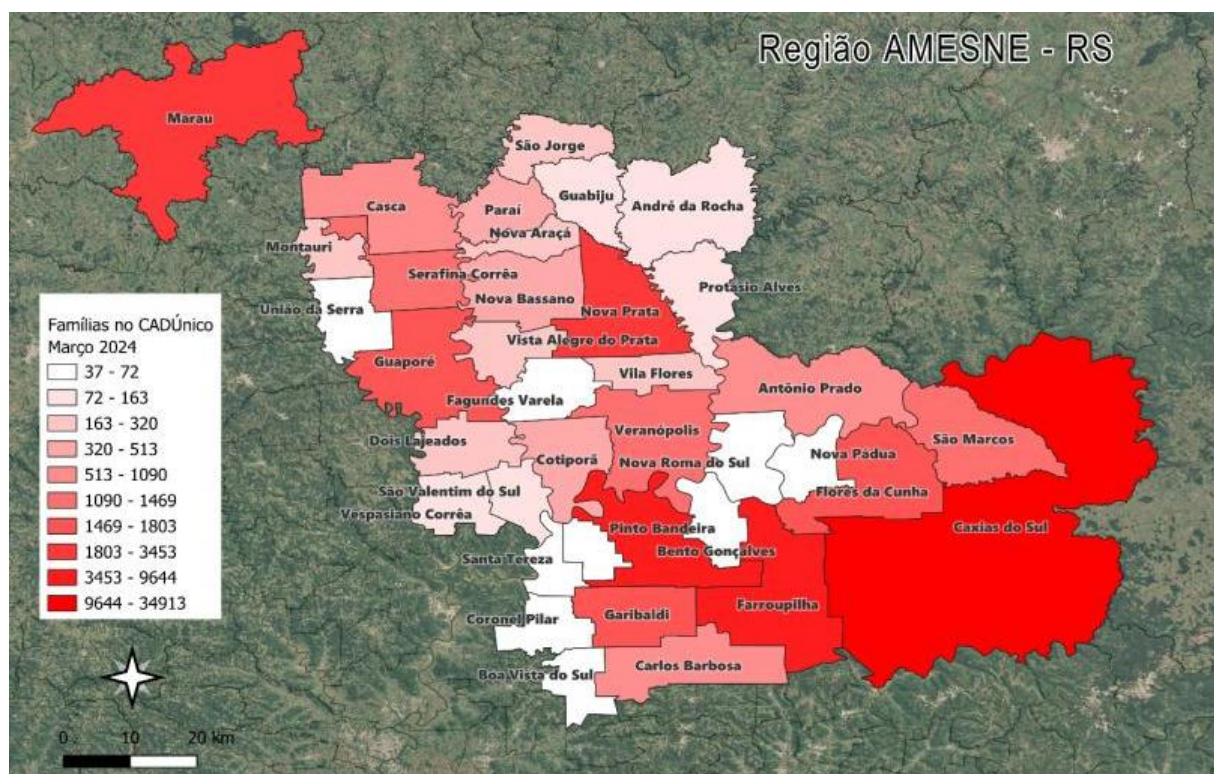
Thus, the challenge is to build public policies that not only boost the economy, but also strengthen citizenship, equity and collective well-being, making AMESNE a reference not only for prosperity, but for social justice and regional cohesion.

2 SOCIOECONOMIC OVERVIEW OF AMESNE

Although the region has high development indicators, many of its municipalities have a significant portion of the population enrolled in the Unified Registry for Social Programs (CadÚnico), and beneficiaries of the Bolsa Família Program, reflecting internal territorial inequalities (BRASIL, 2025).

Figure 2

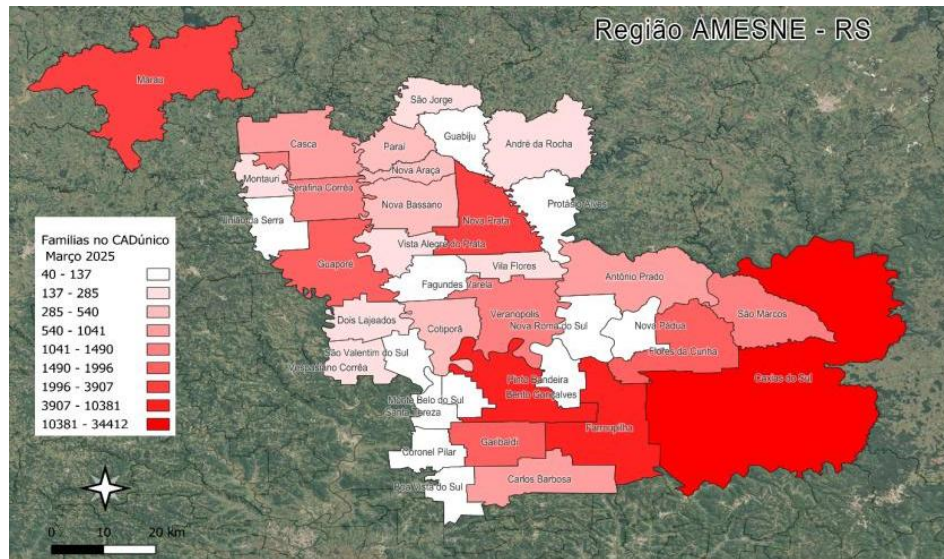
Distribution of families enrolled in CadÚnico in AMESNE municipalities in 2024



Source: prepared by the authors (2025).

Figure 3

Distribution of families enrolled in CadÚnico in the municipalities of AMESNE in 2025



Source: Prepared by the authors (2025).

In the period between March 2024 and March 2025, the AMESNE region presented, in general, an increase in the number of families enrolled in the Unified Registry. This growth reflects both the expansion of the reach of public policies and a possible increase in socioeconomic vulnerability in several municipalities.

Municipalities such as André da Rocha and Bento Gonçalves recorded significant increases in registered families, from 147 to 215 and from 9,644 to 10,381, respectively. This increase indicates a greater demand for social inclusion and access to government programs that serve families in poverty or extreme poverty. Other municipalities, such as Farroupilha and Marau, also showed relevant growth, with Farroupilha going from 6,250 to 6,798 registered families and Marau from 3,453 to 3,907. This movement suggests that these localities may be expanding the coverage of social policies or facing economic challenges that drive the enrollment of families in the system (Brasil, 2025).

On the other hand, there are municipalities that presented small variations or even a slight reduction in the number of families enrolled, which may be related to registration update processes, improvement in socioeconomic conditions or other local factors.

In the region as a whole, the increase in the number of people enrolled in the Unified Registry points to a growing demand for social programs and the importance of maintaining and expanding these policies to ensure inclusion and support for families in vulnerable situations.

3 INSTITUTIONAL/SOCIAL RESPONSIBILITY AND TERRITORIAL INCLUSION

The Bolsa Família Program represents an important mechanism of the Social RI for the promotion of territorial inclusion and the fight against poverty in the AMESNE region. Between March 2024 and March 2025, there is a general downward trend in the number of benefited families in several municipalities, which may reflect both socioeconomic advances and registration adjustments in the program.

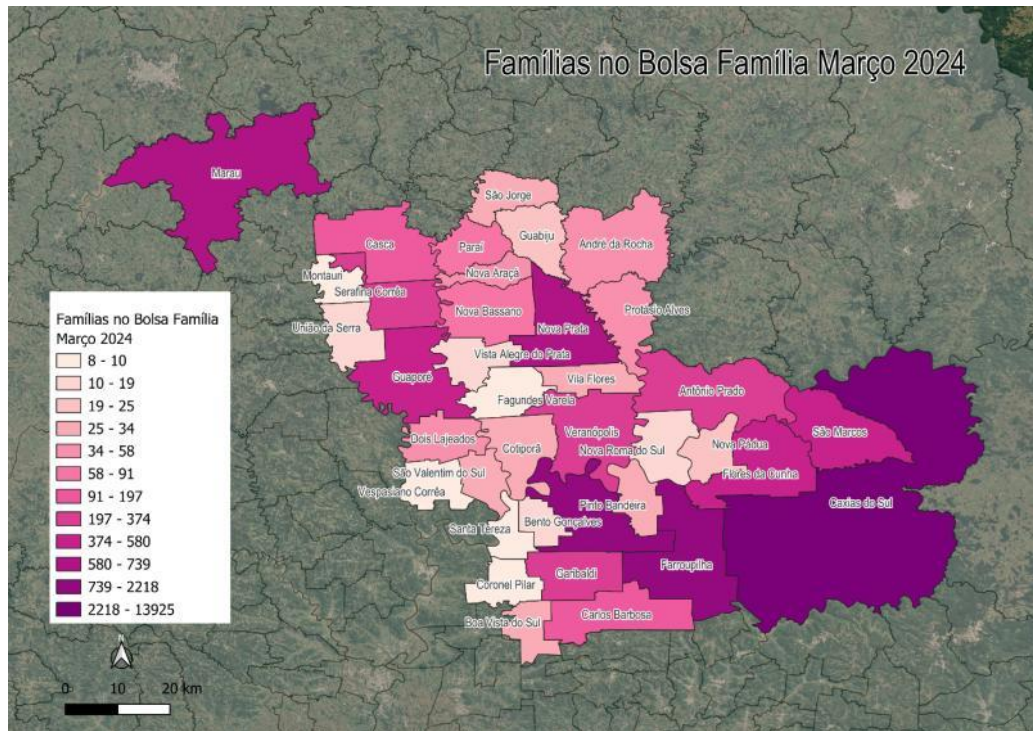
For example, in the municipality of Bento Gonçalves, the number of families in the Bolsa Família reduced from 1,913 to 1,738, and in Farroupilha, the decrease was from 2,315 to 2,218 families. This drop was also accompanied by a reduction in the total number of people benefited — Bento Gonçalves went from 5,344 to 4,829 people and Farroupilha from 6,248 to 5,902 people (IBGE, 2025).

However, there are relevant exceptions, such as the municipality of Marau, which showed a significant growth in the number of benefited families, from 650 to 1,118, and an increase in the number of people served from 2,670 to 3,109, reflecting an expansion of the program's coverage in this location. Guaporé also registered growth in the number of benefited families, from 580 to 654, and people assisted, from 1,588 to 1,722. In financial terms, the monthly amount transferred by Bolsa Família followed the variations in beneficiaries, with a general reduction in most municipalities, but with occasional increases where there was growth in coverage, such as in Marau (from R\$626,958 to R\$729,592) and Guaporé (from R\$382,894 to R\$424,940) (IBGE, 2025).

As we can see in the figures below:

Figure 4

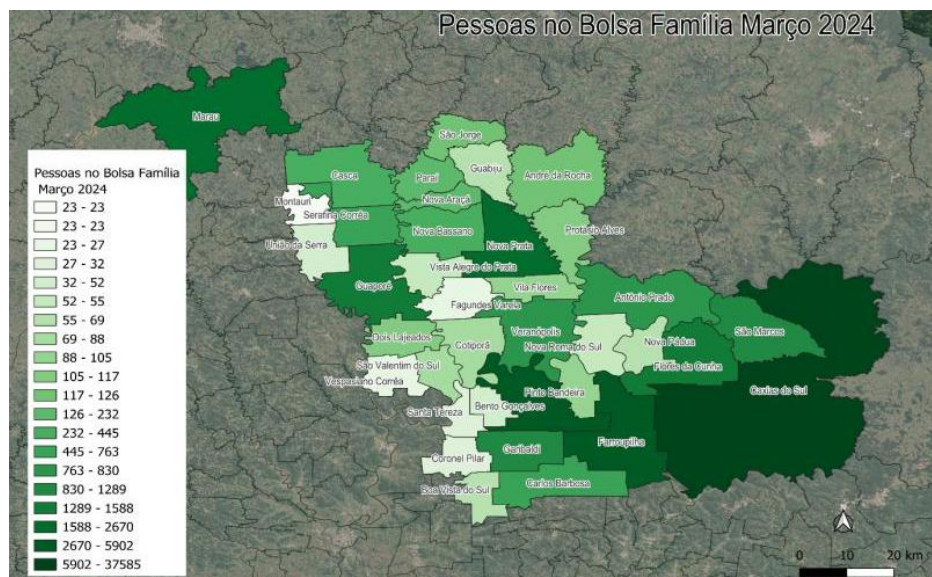
Distribution of families in the Bolsa Família in the municipalities of AMESNE in 2024



Source: Prepared by the authors (2025).

Figure 5

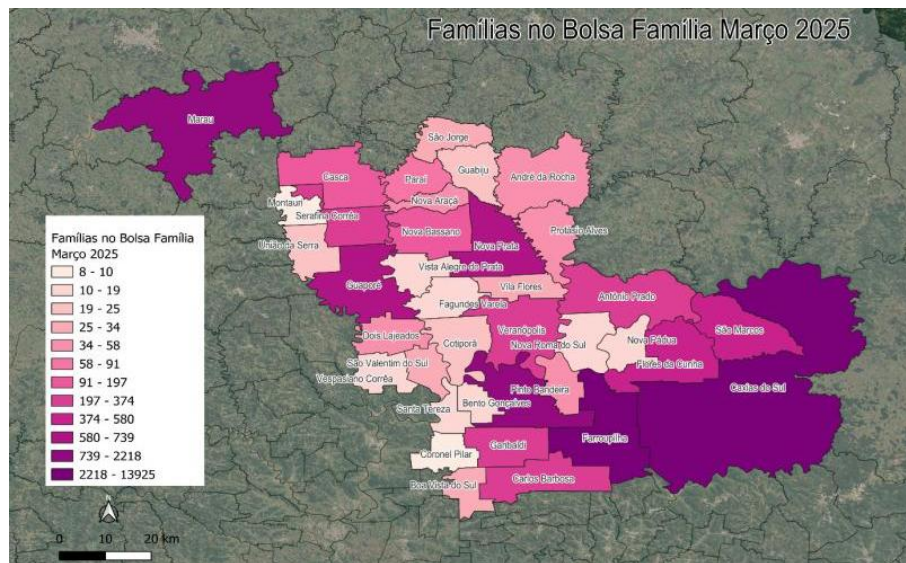
Distribution of people in the Bolsa Família in the municipalities of AMESNE in 2024



Source: Prepared by the authors (2025).

Figure 6

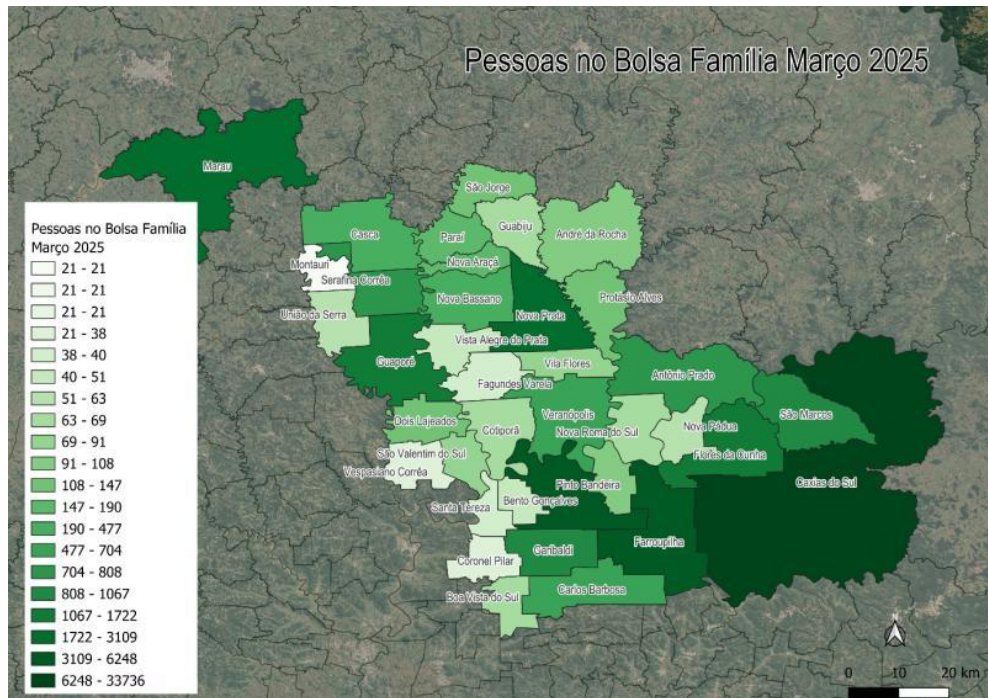
Distribution of families in the Bolsa Família in the municipalities of AMESNE in 2025



Source: Prepared by the authors (2025).

Figure 7

Distribution of people in the Bolsa Família in the municipalities of AMESNE in 2025



Source: Prepared by the authors (2025).

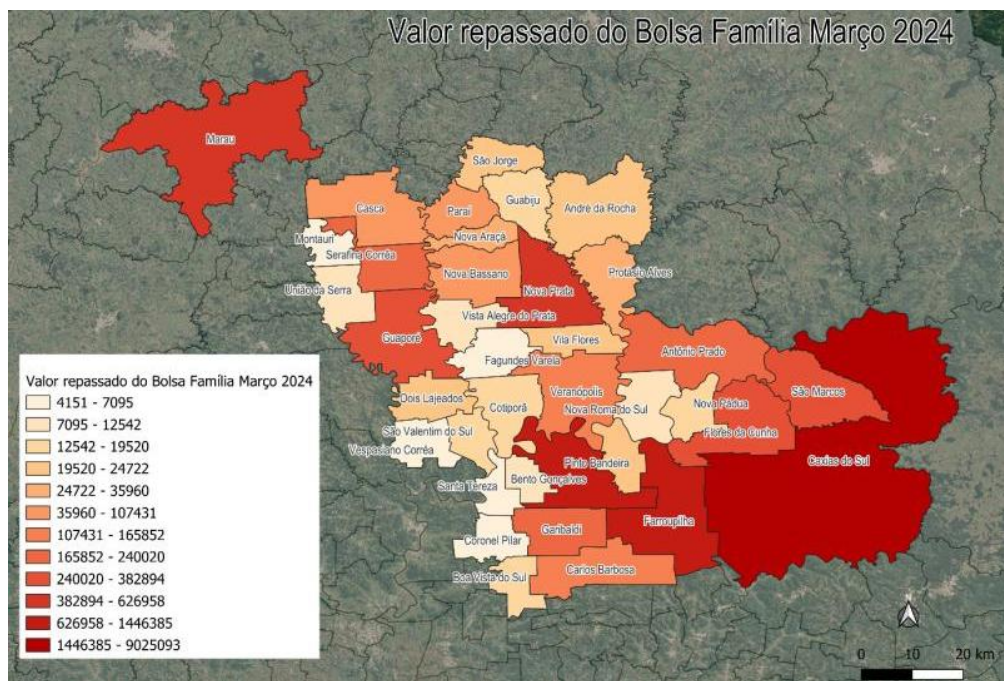
These movements reflect the dynamics of Social IR in the region, which seeks to adjust benefits according to the local socioeconomic reality, promoting territorial inclusion by

ensuring that families in vulnerable situations have continuous access to essential resources for their subsistence and development.

Thus, the analysis of the monthly amounts transferred by the Bolsa Família Program in the AMESNE region between March 2024 and March 2025 reveals a downward trend in the total volume of resources allocated to the program in most municipalities. This reduction accompanies, in many cases, the decrease in the number of families and people benefited, which may be linked to registration revisions, improvement in the income conditions of part of the population or changes in eligibility criteria (BRASIL, 2025).

Figure 8

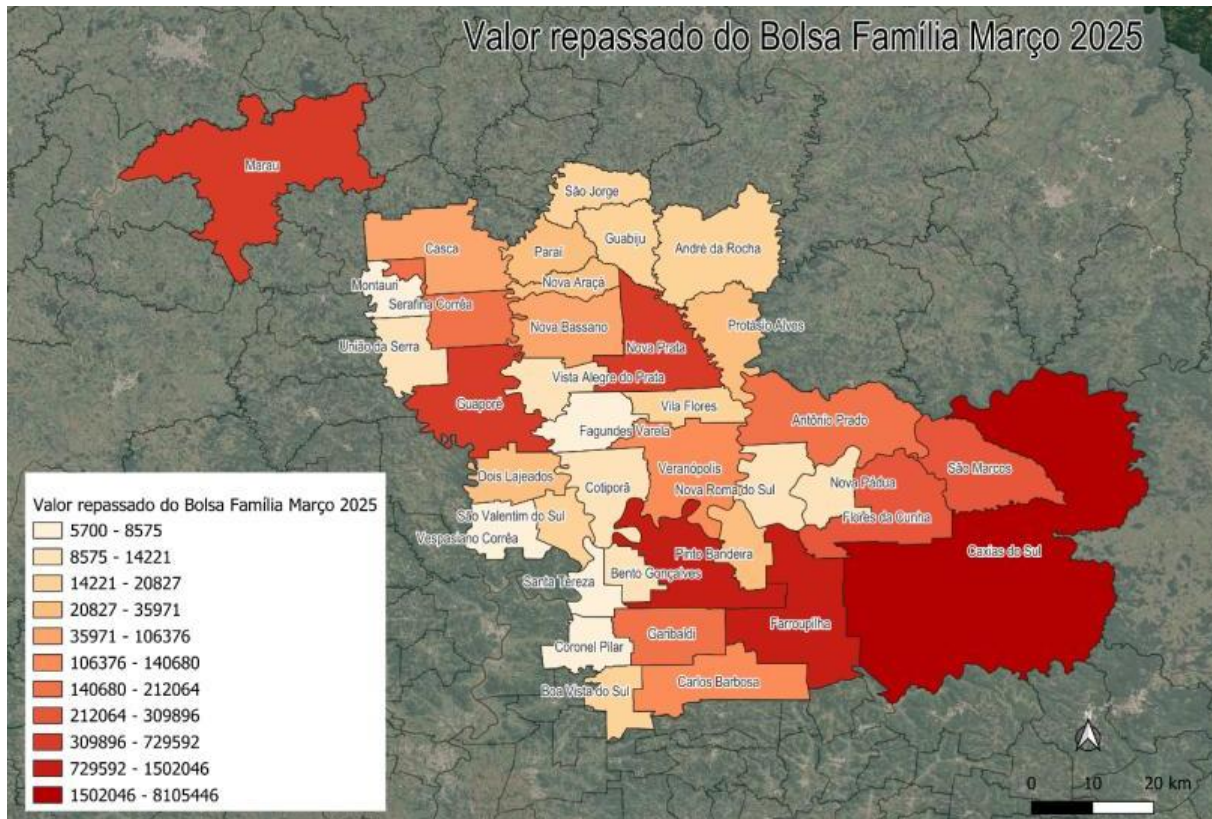
Amounts transferred from the Bolsa Família in the municipalities of AMESNE in 2024



Source: Prepared by the authors (2025).

Figure 9

Amounts transferred from the Bolsa Família in the municipalities of AMESNE in 2025



Source: Prepared by the authors (2025).

We can see that the municipality of Caxias do Sul, for example, showed a significant drop in the amount transferred, from R\$ 9,025,093.00 in March 2024 to R\$ 8,105,446.00 in March 2025. A similar situation occurred in Bento Gonçalves, with a reduction from R\$ 1,221,695.00 to R\$ 1,067,796.00, and in Veranópolis, which went from R\$ 165,852.00 to R\$ 140,680.00.

On the other hand, some municipalities recorded an increase in the transfer of resources, especially Marau, which received R\$ 729,592.00 in 2025, compared to R\$ 626,958.00 in 2024 — a direct reflection of the increase in the number of families and people served in the municipality. Guaporé also had an increase, with a transfer of R\$ 424,940.00 in 2025, compared to R\$ 382,894.00 in the previous year. In smaller cases, the growth was more slight, such as in Cotiporã (from R\$ 17,751.00 to R\$ 13,420.00), or Protásio Alves (from R\$ 28,018.00 to R\$ 29,124.00). Such variations indicate specific and localized movements in the profile of the benefited families, as well as in the territorial coverage of the program (Brasil, 2025).

These data reinforce the role of Bolsa Família as a dynamic and adaptable public policy, adjusting to the socioeconomic realities of the territories. In addition, they show how regionalized monitoring of financial transfers allows Social RI to identify trends, correct distortions, and ensure that resources efficiently reach the families that need it most.

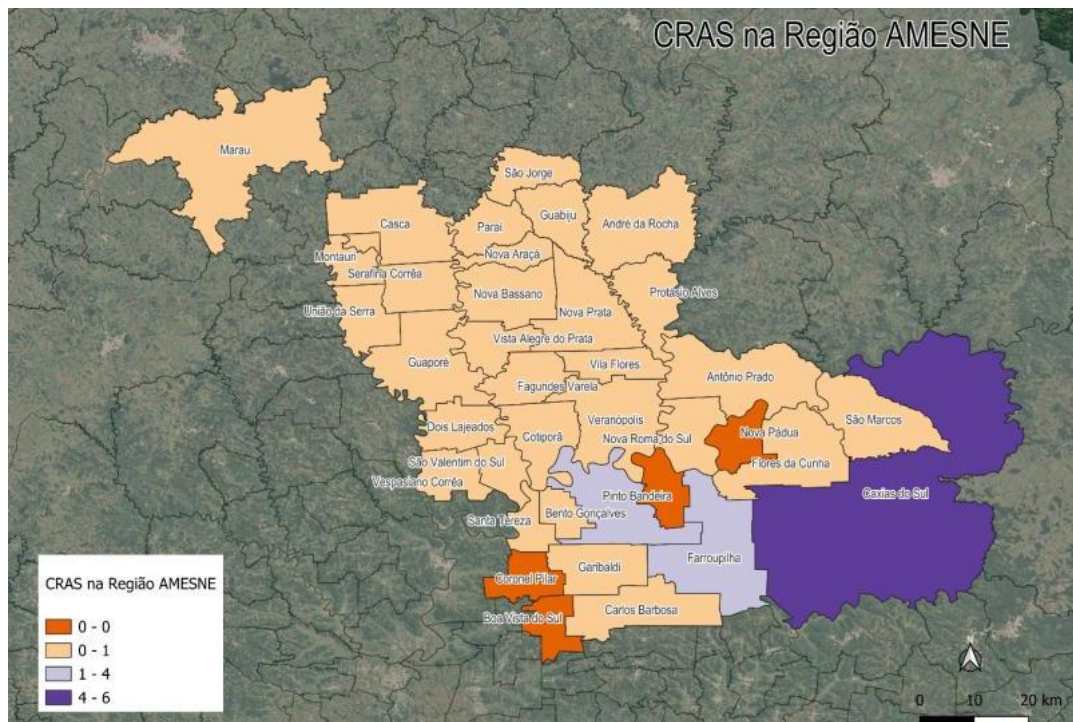
The implementation of Social Institutional Responsibility practices in the municipalities of AMESNE involves recognizing these inequalities and acting with local strategies that articulate public policies, tourism and social inclusion. Encouraging community entrepreneurship, locally-based tourism and the use of traditional knowledge are possible paths.

In 2025, the AMESNE region has a total of 49 CRAS (Social Assistance Reference Centers) units distributed among the municipalities, in addition to 13 CREAS (Specialized Social Assistance Reference Centers) units. These facilities represent the fundamental structure of the social assistance policy, being responsible for ensuring the access of vulnerable populations to services, programs and social benefits.

The presence of CRAS in all municipalities in the region demonstrates the commitment to basic social protection and the capillarization of care. Municipalities with larger populations, such as Caxias do Sul, have up to 6 units, which reinforces the articulation between the volume of demand and the installed structure. Smaller municipalities, such as André da Rocha, Boa Vista do Sul, Coronel Pilar, Santa Tereza and others, have 1 unit, ensuring minimum territorial coverage.

Figure 10

Number of CRAS in the municipalities of AMESNE

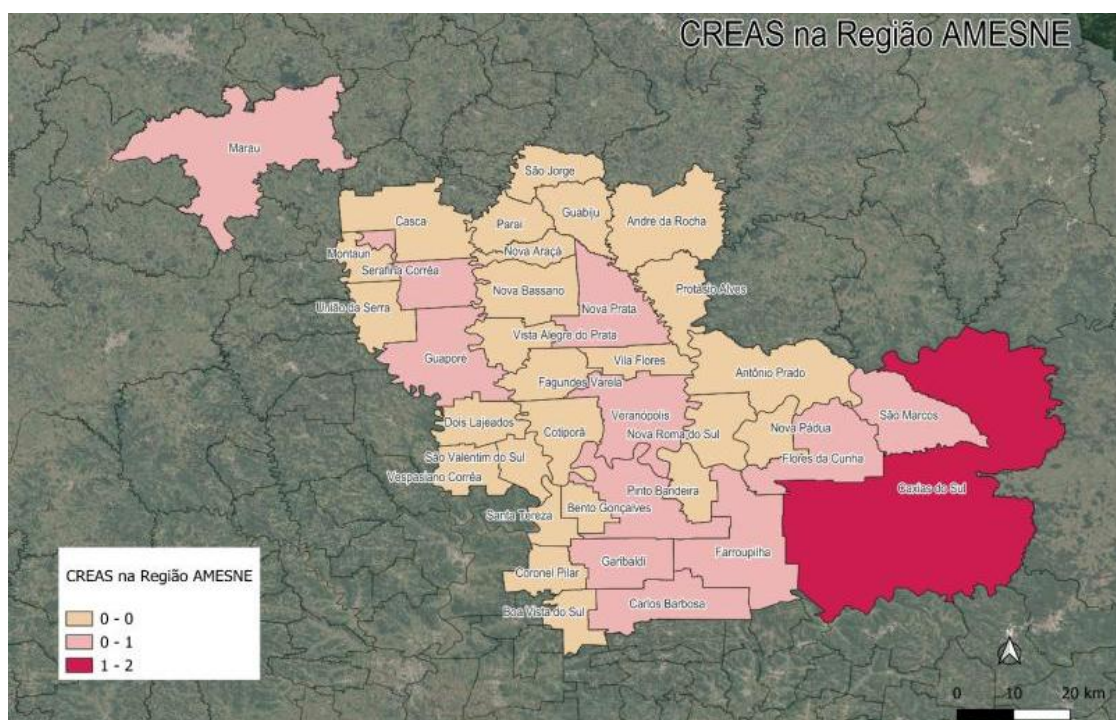


Source: Prepared by the authors (2025).

CREAS, in turn, is present in 13 municipalities, all of larger size or regional relevance, such as Bento Gonçalves, Caxias do Sul, Carlos Barbosa, Farroupilha, Flores da Cunha, Guaporé, Marau, Nova Prata, São Marcos, Serafina Corrêa, Veranópolis and other urban centers. The function of CREAS is focused on special social protection, focusing on cases of rights violations, such as domestic violence, abuse and neglect, requiring specialized technical teams.

Figure 11

Number of CREAS in the municipalities of AMESNE



Source: Prepared by the authors (2025).

The available structure allows the strengthening of the Unified Social Assistance System (SUAS) in the region, ensuring that families in vulnerable situations have where to seek support, guidance and access to the benefits network. The data show that, despite the population and economic differences between municipalities, there is a coordinated regional effort to maintain an active and territorialized social protection network, strengthening the role of Social IR as an instrument of social inclusion and development (RIBEIRO, 2024).

Thus, the 2025 data show that the AMESNE region has a consolidated structure of social assistance service, with the presence of CRAS in all municipalities and CREAS in 13 of them. This distribution demonstrates the regional commitment to ensuring access to public social assistance policies, respecting the different local realities. The articulation between the municipalities and the maintenance of this equipment strengthen the SUAS and reaffirm the Social IR as an effective instrument of inclusion and territorial organization in the promotion of social rights (RIBEIRO, 2024).

More than an institutional apparatus, this network represents a concrete commitment to social justice and the democratization of access to basic rights, such as health, education, work and leisure. The capillary presence of CRAS and CREAS contributes to the service being carried out in a decentralized way and close to the reality of the communities,

respecting the principles of equity, citizen participation and intersectoriality. This territorialized logic of action is aligned with the SUAS model, which organizes services by levels of social protection (basic, medium and high complexity), with the family and the territory being the structuring axes of the actions.

In addition, the strengthening of SUAS at AMESNE also allows us to think about inclusion from a broader perspective, which goes beyond emergency assistance and encompasses human development actions, strengthening community bonds and promoting family autonomy. An example of this is the services offered within the scope of the PAIF (Protection and Integral Care to the Family) and the SCFV (Service of Coexistence and Strengthening of Bonds), which not only provide care, but create concrete opportunities for individuals in situations of social vulnerability to become protagonists of their life projects.

In this context, it is necessary to highlight the role of tourism as a public policy that can dialogue with social assistance and expand its inclusion effects. The articulation between SUAS and tourism, although still incipient in many territories, represents a strategic opportunity to strengthen local capacities, generate income and promote cultural belonging. Social tourism — understood as a practice of accessible leisure, appreciation of local culture and community mobilization — emerges as a powerful tool for integrating economic development and social justice.

Experiences such as those developed in the municipality of Antônio Prado – RS, for example, demonstrate that it is possible to articulate professional training actions with the demands of the tourism sector, such as maid, waiter, gastronomy and service courses, promoted through partnerships between social assistance, the S system and the state government. These initiatives, while fostering the qualification of local labor, contribute to reducing dependence on income transfer programs, promoting the autonomy of subjects and their productive insertion in the territory.

However, it is necessary to advance in the construction of a public tourism policy that goes beyond the instrumental logic of preparing the workforce for the market. Social inclusion through tourism should not be restricted to the economic dimension, but rather encompass the right to tourist experience, mobility, leisure, access to natural and cultural heritage, and community participation in decisions about the use and development of territories.

To this end, it is essential to invest in tourism education with a social focus, promoting training actions in schools, CRAS and communities on social rights, the role of tourism and the role of local populations in the construction of the region's tourist identity. Tourism should

be understood as an intersectoral public policy, capable of dialoguing with policies of assistance, culture, youth, solidarity economy and the environment.

Also, practices such as community-based tourism and solidarity tourism can be stimulated as strategies for local protagonism and productive inclusion. These modalities value traditional knowledge, strengthen community bonds, and promote the circulation of the economy within their own territories, with respect for ethnic, generational, cultural, and gender diversity.

Finally, the strengthening of the social assistance network in AMESNE, combined with an expanded conception of social inclusion that integrates tourism, reaffirms the region's commitment to a model of integral human development, in which people are recognized in their dignity, diversity and creative potential. Social RI, in this sense, is no longer just a registration system and becomes an instrument of territorial organization, social justice, and regional strategic planning, which can — and should — incorporate cultural, tourist, and community dimensions into its actions.

4 TOURISM AS A TOOL FOR TRANSFORMATION

Tourism can consolidate itself as an important vector of productive inclusion in the AMESNE region by valuing the local identity, cultural heritage and territorial diversity of the municipalities. By integrating practices such as handicrafts, family farming, rural tourism and ethnic-cultural tourism, the sector contributes to boosting local economies and generating income opportunities for families in situations of social vulnerability. According to Font and Lynes (2018), responsible social practices are fundamental in the context of sustainable tourism, with the inclusion and well-being of local communities being decisive factors for its lasting success. The authors argue that it is necessary for companies in the tourism sector to get involved with the communities where they operate, providing jobs, fostering economic development and valuing local culture. Complementing, Steiner (2024) mentions that this type of action contributes both to raising the quality of life in the communities involved and to strengthening the brand image and increasing public loyalty.

The analysis of the region's data demonstrates the coexistence of diverse socioeconomic realities. Municipalities with a strong rural predominance, such as Boa Vista do Sul (83% rural), Coronel Pilar (88%), Pinto Bandeira (70%), Monte Belo do Sul (69%) and Vista Alegre do Prata (66%), have great potential for the development of community- and

existing public policies, tourism can cease to be just an activity focused on consumption and leisure to assume the role of a tool for social transformation, community strengthening and economic dynamism of the territories.

The strengthening of tourist itineraries that integrate artisanal production, typical cuisine, visits to rural properties, memory tourism and the appreciation of local cultural manifestations represents a concrete opportunity to generate decentralized and sustainable income, respecting the socio-cultural singularities of the region. These itineraries not only attract visitors, but also stimulate the local population's sense of belonging, rescuing and valuing historically invisible identities (SALAMON; SOTTORIVA, 2025).

In this process, the social assistance protection network existing in the AMESNE region — with its 49 CRAS and 13 CREAS — becomes a fundamental ally in the construction of tourism with social responsibility. The infrastructure already installed, based on a territorialized and participatory logic, can be mobilized to offer support to families, foster professional qualification, promote tourism education workshops and encourage solidarity and cooperative entrepreneurship practices. SUAS, by focusing on the family and the territory, shares with social tourism the concern with equity, dignity and social justice.

The articulation between social assistance equipment and tourism initiatives also favors the inclusion of audiences historically excluded from tourist experiences — such as the elderly, people with disabilities, women in situations of violence and young people in situations of vulnerability — promoting access to the right to leisure, mobility and cultural enjoyment. Through actions such as the Service of Coexistence and Strengthening of Bonds (SCFV), it is possible to develop workshops on handicrafts, gastronomy and oral history, which become products and tourist experiences with local identity.

In addition, training programs — such as those already carried out in municipalities such as Antônio Prado, with courses aimed at the hospitality, gastronomy and cultural tourism sectors — demonstrate that productive inclusion can be planned in a way that is sensitive to the territory and its demands, promoting real job opportunities and income based on local potential. This approach avoids the simple instrumentalization of the vulnerable population to fill gaps in the market, placing it at the center of decisions and the collective construction of development projects (SALAMON; SOTTORIVA, 2025).

Thus, by articulating public policies, cultural identity, territorial belonging and economic dynamism, tourism in AMESNE can consolidate itself as a concrete and transformative strategy, capable of strengthening the local economy, expanding social inclusion, stimulating

community organization and contributing to regional development with justice, sustainability and dignity. To this end, it is essential to understand tourism not only as an economic sector, but as a right, an intersectoral public policy and an instrument of citizen construction (VILELA; COSTA, 2020).

More than an activity aimed at visitors, tourism can — and should — be an experience lived by those who live in the territories. Tourism that promotes cultural exchanges, strengthens family and community bonds, encourages intergenerational coexistence and values traditional knowledge, is configured as a true policy of inclusion and human development. In short, tourism, when articulated with SUAS and committed to the principles of equity, participation and co-responsibility, can be a fundamental vector in the construction of a fairer, more inclusive and resilient AMESNE.

5 METHODOLOGY

5.1 EPISTEMOLOGICAL FRAMEWORK

This study is part of the qualitative-interpretative paradigm, with a phenomenological approach, considering that it seeks to understand the articulation between tourism, social assistance policies and productive inclusion from social perceptions and institutional data. The perspective adopted is dialectical, allowing us to examine contradictions between economic development and territorial inequalities (MINAYO, 2017).

The research is anchored in the conception of public policies as dynamic and intersectoral processes, influenced by multiple actors and socioeconomic factors (BALI et.al., 2021). The Social Responsibility and ESG framework serves as a theoretical matrix for analyzing the integration between tourism and social assistance, considering its environmental, social, and governance dimensions (STEINER, 2024).

5.2 NATURE AND TYPE OF RESEARCH

The research is of an applied nature, aimed at producing knowledge aimed at solving practical problems in the municipalities of AMESNE. As for the objectives, it is exploratory and descriptive, as it seeks to map phenomena that have been little investigated and characterize the interactions between tourism, SUAS and social inclusion.

The approach is qualitative, privileging the understanding of the meanings attributed to social programs and tourism by the public agents and communities involved.

In addition, a documentary and statistical survey is used to quantify aspects of social vulnerability, ensuring data triangulation (YIN, 2021).

5.3 SPATIAL AND TEMPORAL DELIMITATION

The study includes the 37 municipalities that are part of the Association of Municipalities of the Upper Slope of the Northeast (AMESNE), in Rio Grande do Sul. The documentary analysis covers the period from March 2024 to March 2025, compatible with the last update of data from the Unified Registry, the Bolsa Família Program and the municipal GDP per capita.

5.4 DATA SOURCES

The information was collected from:

- Secondary bases:
 - Brazilian Institute of Geography and Statistics (IBGE, 2025);
 - Unified Registry for Social Programs (CadÚnico);
 - Bolsa Família Program (Ministry of Development and Social Assistance, 2025);
 - AMESNE reports (2025);
 - Unified Social Assistance System (SUAS) – data from CRAS and CREAS.
- Normative documents and plans:
 - National Tourism Plan 2024–2027;
 - MTur Ordinance No. 10/2025;
 - State Social Assistance Plan (2020–2023);
 - Social IR (regional instrument of social management).
- Scientific literature:
 - Articles and books that deal with public policies for tourism, ESG and social inclusion (VILELA & COSTA, 2020; STEINER, 2024; FONT & LYNES, 2019).

5.5 DATA COLLECTION TECHNIQUES

The collection took place in three stages:

1. **Documentary analysis** of federal, state and municipal plans and legislation, identifying guidelines for tourism and social assistance.
2. **Statistical survey** of socioeconomic data (GDP, CadÚnico, Bolsa Família) to characterize territorial inequalities and map social vulnerability.

3. **Territorial mapping** through georeferencing (QGIS and ArcGIS software), evidencing the distribution of vulnerable families, the presence of CRAS/CREAS and potential tourism integration axes.

5.6 ANALYSIS PROCEDURES

The data were processed through:

- **Content analysis** (BARDIN, 2016) applied to documents and public policies, identifying thematic categories: (i) social tourism; (ii) productive inclusion; (iii) intersectoral governance.
- **Descriptive statistical analysis**, with calculation of frequencies, means and percentage variations, seeking to evidence relationships between social vulnerability and tourist potential.
- **Spatial analysis**, allowing the visualization of territorial inequalities through thematic maps (CadÚnico, Bolsa Família, GDP per capita).

The triangulation between documentary, statistical, and theoretical data ensured greater validity and reliability of the results (FLICK, 2018).

5.7 RESEARCH LIMITATIONS

Among the limitations are: (i) dependence on secondary data subject to underreporting; (ii) absence of interviews with municipal managers and beneficiaries, which could deepen local perceptions; (iii) time restriction of the analysis to a period of 12 months, which may not capture long-term structural variations.

6 RESULTS AND DISCUSSION

The results and discussion are interspersed with the text, below each map.

7 CONCLUSION

The performance of the municipalities of AMESNE must be guided by a systemic vision that articulates economic development with the overcoming of social inequalities, recognizing tourism as a strategic vector for productive inclusion and strengthening of local identity. The data presented show a region marked by deep territorial, economic and social diversities, which require calibrated and integrated political responses, built from the recognition of local realities and active listening to the communities involved.

The socioeconomic panorama reveals municipalities with high levels of GDP per capita, such as André da Rocha, which registers R\$ 142,922.95, alongside locations with significantly lower per capita income, such as Pinto Bandeira (R\$ 24,212.76) and Santa Tereza (R\$ 28,949.13). This economic disparity points to different realities that coexist in the region, imposing the need for public policies adapted to each context, whether predominantly rural or urban. Regional inequality, if not addressed with redistributive policies, tends to accentuate social exclusion and limit the possibilities of sustainable and equitable development.

In addition, the presence of vulnerable populations is evidenced by the numbers of families enrolled in the Unified Registry and beneficiaries of the Bolsa Família. Municipalities such as Guaporé, with 1,996 registered families and 654 beneficiaries of the program, and Marau, with 3,907 families enrolled and 1,118 covered by the Bolsa Família, exemplify the concentration of significant social demands.

These data indicate the relevance of the role of income transfer policies and social monitoring for poverty alleviation in the region, as well as the need for productive inclusion strategies that break the cycle of dependence and promote autonomy for families.

In this context, the structure of the Unified Social Assistance System (SUAS) stands out as an essential foundation for the consolidation of territorial, participatory and humanized public policies.

The existence of 49 CRAS units, present in all AMESNE municipalities, and 13 CREAS units, located primarily in urban centers, ensures a capillary network of reception, guidance and monitoring of families in vulnerable situations. This infrastructure not only meets immediate needs, but also functions as a platform for capacity building, strengthening family and community bonds, and promoting strategies to overcome structural inequalities.

By providing guidelines for territorial planning and the integration of social policies with economic initiatives, the Social IR emerges as an indispensable instrument for modern and effective public management.

By mapping and understanding the local reality in depth, public managers can formulate more precise actions, oriented towards the creation of real, permanent and sustainable opportunities. In this sense, tourism, as an economic, cultural and social activity, can be enhanced beyond its traditional function, assuming a transformative role in the promotion of social inclusion and the dynamization of territories.

The valorization of local identity, handicrafts, family farming, rural tourism and ethnic-cultural tourism are elements that can boost regional development with respect to diversity and sustainability. Integrated with tourism, these sectors promote income generation for the most vulnerable families, while preserving traditional knowledge, strengthening the sense of belonging and rescuing the collective memory of the territories. It is in this scenario that tourism is configured as a transversal instrument capable of connecting culture, economy and citizenship, contributing to the construction of a new model of regional development.

This articulation between tourism and productive inclusion not only contributes to the economic diversification of municipalities and to the reduction of dependence on traditional sectors, but also promotes the strengthening of the social and cultural capital of communities.

The involvement of families, especially those inserted in SUAS services, reinforces the importance of public policies that are planned and executed based on values such as social justice, equity, popular participation and co-responsibility. Tourism, in this context, is no longer just a destination or a consumption activity, and becomes an experience of social transformation.

In addition, by thinking of tourism as a right and not a privilege, its reach and social function are expanded, effectively integrating it into human development strategies.

The implementation of social tourism policies, the promotion of education for and through tourism, and the creation of accessible and inclusive tourist itineraries represent promising ways to ensure that vulnerable populations can also enjoy the symbolic, cultural and natural assets of their own territories. This is especially relevant in a region like AMESNE, where the cultural, historical and landscape heritage is vast, but not always accessible to the resident population itself.

Finally, the implementation of a public policy that combines tourism development with the overcoming of poverty reaffirms AMESNE's commitment to the promotion of human and social development. Steiner (2024) corroborates by stating that the tourism sector has a unique opportunity to take the lead in this transformation, by establishing a new model of excellence in business management that integrates economic success with environmental and social responsibility.

The consolidation of SUAS and Social IR as instruments of integrated and humanized management strengthens the construction of fairer and more sustainable public policies, capable of ensuring that the benefits of economic growth reach all layers of the population,

especially the most vulnerable. In this process, tourism takes on a new dimension — not only as an economic engine, but as an expression of citizenship, participation, and justice.

In this way, the AMESNE region finds in tourism and social assistance strategic allies for the promotion of inclusion, equity and regional development. When thought of in synergy, these two fields expand their reach, strengthen the social fabric and lay the foundations for a more prosperous, egalitarian and sustainable future for all its municipalities, reaffirming the role of people and communities in building their own paths of transformation.

ACKNOWLEDGEMENTS

The authors would like to thank the National Council for Scientific and Technological Development (CNPq) for the financial support granted for this research. This work is the result of encouraging scientific production and strengthening sustainable tourism and social inclusion policies in Brazil, made possible by the promotion of research and innovation provided by CNPq.



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**EFFECTS OF SGLT2 INHIBITORS ON GLYCEMIC CONTROL AND THE
REDUCTION OF CARDIOVASCULAR AND RENAL OUTCOMES IN PATIENTS
WITH TYPE 2 DIABETES: A BIBLIOGRAPHIC REVIEW**

**EFEITOS DOS INIBIDORES DE SGLT2 NO CONTROLE GLICÊMICO E NA
REDUÇÃO DE DESFECHOS CARDIOVASCULARES E RENAIIS EM
PACIENTES COM DIABETES TIPO 2: UMA REVISÃO BIBLIOGRÁFICA**

**EFFECTOS DE LOS INHIBIDORES DE SGLT2 EN EL CONTROL GLUCÉMICO Y
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RENALES EN PACIENTES CON DIABETES TIPO 2: UNA REVISIÓN
BIBLIOGRAFICO**

 <https://doi.org/10.56238/sevened2025.036-092>

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ABSTRACT

The objective of this study was to identify the real effects of SGLT2 inhibitors and their efficacy on glycemic control and the impact of medication on the prevention of cardiovascular events and progression of diabetic kidney disease. To develop this research, a guiding question was developed: "What are the effects of SGLT2 inhibitors on glycemic control and cardiovascular and renal outcomes in patients with type 2 diabetes?". The searches were performed in the PubMed Central (PMC) database. Four descriptors were used in combination with the Boolean term "AND": SGLT2 inhibitors, Diabetes Mellitus Type 2, Cardiovascular Outcomes, Renal Protection. Thus, it is observed that SGLT2 inhibitors promote glycosuria, increase insulin sensitivity, in addition to reducing arterial stiffness, improving endothelial function, slowing the rate of decline in eGFR in diabetic patients, which allows us to conclude the effectiveness of their glycemic control effects, and reduction of cardiovascular and renal events in patients with type 2 diabetes mellitus.

Keywords: SGLT2 Inhibitors. Type 2 Diabetes Mellitus. Glycemic Control. Cardioprotection. Nephroprotection.

RESUMO

O objetivo deste estudo foi reconhecer os efeitos dos inibidores do SGLT2 e sua eficácia no controle glicêmico e o impacto da medicação na prevenção de eventos cardiovasculares e na progressão da doença renal diabética. Para o desenvolvimento dessa pesquisa foi elaborada uma questão norteadora: "Quais são os efeitos dos inibidores de SGLT2 no controle glicêmico e nos desfechos cardiovasculares e renais em pacientes com diabetes tipo 2?". As buscas foram realizadas na base de dados PubMed Central (PMC). Foram utilizados 4 descritores em combinação com o termo booleano "AND": SGLT2 inhibitors, Diabetes Mellitus Type 2, Cardiovascular Outcomes, Renal Protection. Desse modo, observa-se que os inibidores de SGLT2 promovem glicosúria, aumenta sensibilidade à

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insulina, além de reduzir a rigidez arterial, melhorar a função endotelial, lentificam a taxa de declínio da TFG_e de pacientes diabéticos, o que permite concluir a eficácia de seus efeitos de controle glicêmico, e redução de eventos cardiovasculares e renais em pacientes com diabetes mellitus tipo 2.

Palavras-chave: Inibidores de SGLT2. Diabetes Mellitus Tipo 2. Controle Glicêmico. Cardioproteção. Nefroproteção.

RESUMEN

El objetivo de esta revisión bibliográfica fue reconocer los efectos reales de los inhibidores de SGLT2 y su eficacia en el control glucémico, así como el impacto del medicamento en la prevención de eventos cardiovasculares y en la progresión de la enfermedad renal diabética. Para el desarrollo de esta investigación se elaboró una pregunta orientadora: “¿Cuáles son los efectos de los inhibidores de SGLT2 en el control glucémico y en los desenlaces cardiovasculares y renales en pacientes con diabetes tipo 2?”. Las búsquedas se realizaron en la base de datos PubMed Central (PMC). Se utilizaron cuatro descriptores en combinación con el término booleano “AND”: **SGLT2 inhibitors, Diabetes Mellitus Type 2, Cardiovascular Outcomes, Renal Protection**. De este modo, se observa que los inhibidores de SGLT2 promueven glucosuria, aumentan la sensibilidad a la insulina, además de reducir la rigidez arterial, mejorar la función endotelial y ralentizar la tasa de disminución del FG estimado (TFG_e) en pacientes diabéticos, lo que permite concluir la eficacia de sus efectos en el control glucémico y en la reducción de eventos cardiovasculares y renales en pacientes con diabetes mellitus tipo 2.

Palabras clave: Inhibidores de SGLT2. Diabetes Mellitus Tipo 2. Control Glucémico. Cardioprotección. Nefroprotección.

1 INTRODUCTION

Type 2 diabetes mellitus (DM2) is a chronic metabolic disease characterized by insulin resistance and pancreatic beta cell failure, which leads to chronic hyperglycemia. This condition, when not managed correctly, is associated with cardiovascular and renal complications.

Chronic hyperglycemia results in damage to the vasculature, leading to microvascular and macrovascular diseases. Microvascular complications are mainly diabetic retinopathy and nephropathy, while macrovascular complications are related to accelerated atherosclerosis in different areas, such as cerebrovascular atherosclerotic disease that manifests as cerebrovascular accident (CVA), coronary artery disease (CAD) and peripheral arterial disease (PAD). Other macrovascular complications are cardiac dysfunctions, including cardiomyopathy and heart failure (SPINETTI et al., 2023).

Sodium-glucose cotransporter-2 (SGLT2) inhibitors are oral antidiabetic drugs, and were initially used to aid glycemic control in diabetic patients in order to avoid complications. This effect is due to glycosuria, from the inhibition of SGLT2, decreasing renal glucose reabsorption. However, currently, this class of antidiabetic drugs has come to be considered as pleotropic drugs, due to their beneficial results in cardiovascular diseases and chronic kidney disease (CKD). (SANTULLI et al., 2023) Evidence suggests that there is an improvement in renal and cardiovascular outcomes in patients with T2DM, especially those with previous cardiovascular events, chronic kidney disease (CKD), or HF (XU et al., 2022).

Four SGLT2 inhibitors were approved by the FDA (Food and Drug Administration), the first was Canagliflozin in 2013, followed by Empagliflozin and Dapagliflozin in 2014 and Ertugliflozin in 2017, all of which have an effect of controlling hyperglycemia and also improving cardiovascular and renal outcomes. In clinical trials involving the use of SGLT2 inhibitors in diabetic patients, adverse reactions, such as genital infections, diabetic ketoacidosis, fractures, and amputations, were shown relative to placebo. (XU et al., 2022). However, the results of the various trials of cardiovascular outcomes with these drugs showed the benefits in reducing adverse cardiovascular events by 11%, reducing the risk of cardiovascular death or hospitalization for heart failure by 23%, and reducing the progression of kidney disease by 45%. (ROWN et al., 2021).

The objective of this literature review was to evaluate the most recent findings on the effects of SGLT2 inhibitors on glycemic control, in addition to detailing their mechanism of action and their proven efficacy in the prevention of cardiovascular and renal outcomes. By

consolidating these findings, we seek to provide a comprehensive and updated view that contributes to the optimization of disease control and also reduces associated complications, thus improving the quality of life and clinical outcomes of this patient.

2 METHODOLOGY

This is a literature review that seeks to understand the effects of glucose-sodium-2 cotransporter inhibitors, and their actions in reducing hyperglycemia and reducing complications resulting from chronic hyperglycemia. For the development of this research, a guiding question was developed through the PVO (population, variable and objective) strategy: "What are the effects of SGLT2 inhibitors on glycemic control and cardiovascular and renal outcomes in patients with type 2 diabetes?".

The searches were carried out based on searches in the PubMedCentral (PMC) database. 4 descriptors were used in combination with the Boolean term "AND": SGLT2 inhibitors, Diabetes Mellitus Type 2, Cardiovascular Outcomes, Renal Protection. The search strategy used in the PMC database was: SGLT2 inhibitors AND Diabetes Mellitus Type 2, SGLTS inhibitors AND Cardiovascular Outcomes, SGLT2 inhibitors AND Renal protection. From this combination, articles were found that were later submitted to the selection criteria. The inclusion criteria were: randomized clinical trials, meta-analyses examining SGLT2 inhibitors and in patients with type 2 diabetes; articles in English, Portuguese published in the last 10 years that address the theme proposed by this research. The exclusion criteria were: studies that exclusively involve patients without diabetes; narrative reviews, case studies; and studies with no relevant clinical outcomes or very small sample sizes.

After applying the inclusion and exclusion criteria listed above, 10 articles were selected to compose the collection.

3 RESULTS AND DISCUSSIONS

The kidneys contribute to glucose homeostasis through its filtration and reabsorption. With glomerular filtration the kidney filters about 162g of glucose daily, the amount of glucose filtered increases linearly with the increase in its plasma concentration. Glucose is absorbed in the proximal renal tubules. The threshold for reabsorption is plasma glucose concentration = 8.3 mmol/L, above this value, there is glycosuria. When the plasma glucose concentration is > 13.3 mmol/L, the maximum glucose reabsorption capacity is exceeded, and therefore the

degree of glycosuria increases linearly with increasing plasma concentrations (BROWN et al., 2021).

The transport of glucose across cell membranes in the kidney depends on two families of transporters: the facilitated glucose transporters (GLUTs) and the sodium-glucose cotransporters (SGLTs). GLUTs are responsible for passive transport, whereas SGLTs do active transport across a concentration gradient. There are two forms of sodium-glucose cotransporters: SGLT1 and SGLT2. SGLT1 is found in the small intestine and segment 3 of the proximal tubule. SGLT2 is found in the luminal membranes of the epithelial cells of segment 1 and 2 of the renal proximal tubules (BROWN et al., 2021).

In individuals with T2DM, in order to avoid glycosuria, there is a compensatory upregulation of SGLT2 expression, which leads to increased glucose reabsorption (SANTULLI et al., 2023).

Thus, based on the knowledge of the role of the kidney in glucose homeostasis, sodium-glucose cotransporter 2 inhibitors were developed, which are direct inhibitors of the SGLT2 protein, which prevents glucose from binding to the cotransporters, leading to reduced reabsorption by the proximal tubules, and results in increased excretion of sodium, glucose and water in the urine. The mechanism of action of these oral hypoglycemic agents is independent of insulin secretion by pancreatic cells, so there is a low incidence of hypoglycemia in patients, which has a higher occurrence when associated with the use of sulfoniruleia or insulin therapy (DAI et al., 2023). β

4 GLYCEMIC CONTROL

Glycemic control by SGLT2 inhibitors occurs in two mechanisms. The first is due to its effects on modulating renal glucose excretion, reducing the glucose reabsorption capacity and the threshold for glycosuria, promoting a glycosuria of 60-80g/day. The second occurs due to the improvement of glucotoxicity, due to the reduction of glucose concentration secondary to glycosuria, leading to greater insulin sensitivity in peripheral tissues (adipose tissue and skeletal muscle) and improvement in the function of β cells, with an improvement in insulin secretion. (BROWN et al., 2021) Meta-analyses of HbA1c reduction with SGLT2 inhibitors in type 2 diabetes have observed reductions of 0.5-1% of the value (BAILEY; DAY; BELLARY, 2022).

Another beneficial factor in relation to the use of SGLT2 is the weight reduction of patients, in several meta-analyses it has been noted a reduction of 2-3kg in weight after 6

months of treatment. The mechanism of weight loss is associated with glycosuria, natriuresis and aquaresis, in addition, there are changes in the use of substrates so that there is a change from glucose oxidation to increased lipolysis, fat oxidation and formation of ketone bodies. Weight loss with SGLT2 inhibitor therapy was calculated based on urinary glucose excretion of 60-80g/day, which is equivalent to a caloric loss of 240-320 calories/day (BROWN et al., 2021).

5 CARDIOPROTECTION

Patients with type 2 diabetes have an important risk factor for cardiovascular disease, conferring a two- to three-fold increased risk of coronary artery disease, including angina, myocardial infarction, stroke, and heart failure (HF) (BROWN et al., 2021). Thus, the cardioprotective effects of SGLT2 inhibitors can be attributed to: blood pressure control, increased plasma erythrocyte levels, decreased inflammation and oxidative stress, decreased uric acid, prevention of ischemia injury, and improved cardiac and vascular function (XU et al., 2022).

Studies indicate that the reduction in blood pressure by SGLT2 is due to the mechanism of volume reduction secondary to diuresis and natriuresis, in addition, other effects, such as loss of calories and decrease in fat mass, resulting from the increase in diuresis and glycosuria, also contribute to the reduction of blood pressure. The reduction in blood pressure does not accompany the increase in heart rate, which indicates that there is no activation of the sympathetic nervous system, demonstrating that this class of antidiabetics has a beneficial effect on HF patients (ZENG et al., 2021).

The efficiency of reducing arterial stiffness, it was demonstrated in an observational study the ability of SGLT2 inhibitors, especially dapagliflozin, empagliflozin and canagliflozin, to reduce PWV (pulse wave velocity), which is the main parameter of arterial stiffness. In addition, in other studies, improved endothelial function has been observed, which may be mediated by increased nitric oxide, reduced oxidative stress, or activation of voltage-gated potassium channels and protein kinase G (ZENG et al., 2021).

In addition, there is an inhibition of NHE1 and NHE3 which are sodium-hydrogen exchangers, and transfer sodium (Na⁺) to the cell in exchange for the export of protons. NHE1 is present in cardiomyocytes and its activation can lead to increased intracellular ions and calcium, and this effect is involved in abnormal myocardial hypertrophy and ischemia-perfusion injury. NHE3 is expressed in the proximal tubule and contributes to the tubular

reuptake of these receptors. Thus, although there is no expression of SGLT2 in the heart, SGLT2 inhibitors from NHE1 blockade can reduce intracellular concentrations of and protect the heart from intracellular overload. Similarly, they can inhibit NHE3 that improves natriuresis, restores sodium homeostasis throughout the body, and improves heart function (ZENG et al., 2021). $Na^+Na^+Ca^{2+}Na^+.Na^+Ca^{2+}Ca^{2+}$

In some studies, it has been shown to be an increase in hematocrit after treatment with SGLT2, and has been associated with increased plasma volume and increased production of erythropoietin (ZENG et al., 2021), which increases oxygen delivery to tissues, especially the kidney, reducing renal hypoxia (GIORGINO et al., 2020).

Three large clinical trials were conducted to evaluate the effects of SGLT2 inhibitors on cardiovascular outcomes, EMPA-REG, CANVAS and DECLARE-TIMI, which respectively evaluated Empagliflozin, Canagliflozin and Dapagliflozin, and showed that there is a significant reduction in cardiovascular events, especially in patients with established atherosclerotic cardiovascular diseases. Not showing as much benefit in patients who had multiple risk factors but no established cardiovascular disease. In addition, it was seen in these studies, a benefit in reducing hospitalization in heart failure, in patients with and without type 2 diabetes mellitus and both in HFrEF and HFpEF (BROWN et al., 2021).

The pathogenesis of HF involves activation of the immune system, with the Toll-Like (TLR) receptor expressed predominantly in the heart, TLR 4, is closely associated with myocardial inflammation. Thus, with its activation, there is the expression of pro-inflammatory cytokines, such as IL-6, IL-1 and TNF- α , which in the long term leads to cardiac remodeling and deterioration of function. Thus, some studies have shown that SGLT2 inhibitors have an anti-inflammatory effect by reducing the formation of pro-inflammatory cytokines. This can be explained by different signaling pathways, such as the kappa factor B (NF- κ B) signaling pathway, the mitogen-activated protein kinase (MAPK) pathway, and the TLR4 pathway (ZENG et al., 2021).

Based on these findings, SGLT2 is being introduced as standard therapy for heart failure with reduced ejection fraction (HFrEF), is indicated as add-on therapy to RAAS inhibitors and beta-blockers in patients with New York Heart Association (NYHA) grades YHA II-IV in the current update of the American Board of Cardiology (ACC) consensus. Meta-analyses have described a reduction in mortality and an even greater reduction in hospitalization for HF (KOLESNIK et al., 2022).

However, in acute HF, limitations in studies such as sample size and study method have failed to determine whether SGLT2 inhibitors can be safely applied in these patients (ZENG et al., 2021).

Currently, a number of studies have researched the antiarrhythmic properties of SGLT2 inhibitors. Its effectiveness in reducing hospitalization in cases of heart failure, due to improved cardiac function, is leading to a reduction in the number of ventricular arrhythmias. In addition, from evidence in clinical trials, a lower incidence of atrial fibrillation and other atrial arrhythmias was revealed in diabetic patients treated with SGLT2 inhibitors, when compared to other glucose-lowering drugs. Despite these results, no pathways or molecular mechanisms have been identified for these antiarrhythmic properties (KOLESNIK et al., 2022).

A randomized, double-blind, placebo-controlled clinical study, the EMPA-ICD, was launched to demonstrate the antiarrhythmic effects of empagliflozin in patients with type 2 diabetes and using an implantable cardioverter defibrillator (ICD) or resynchronizer defibrillator (CRT-D), the SGLT2 inhibitor group had a significant reduction in the number of ventricular arrhythmias compared to the placebo group. These effects have been associated with increased blood ketone levels, improved myocardial energy metabolism, increased hematocrit, decreased B-type natriuretic peptide, and reduced body weight.

6 NEPHROPROTECTION

Kidney disorders are common complications in T2DM. Many people with the disease already have some degree of kidney dysfunction at the time of diagnosis, and it can evolve over time, leading to the development of chronic kidney disease and end-stage renal disease (ESRD). Some observational studies have identified the duration of diabetes as an independent risk factor for the progression of kidney failure (GIORGINO et al., 2020).

Diabetic kidney disease is recognized to be a progressive chronic kidney disease (CKD) with an estimated glomerular filtration rate (eGFR) $< 60 \text{ ml/min/1.73}$, may be accompanied by micro- or macroalbuminuria, with an underlying glomerulopathy of thickened basal capillary membranes, diffuse mesangial sclerosis, and nodular sclerosis. The normal rate of age-related decline in eGFR ($\sim 1 \text{ ml/min/1.73}$ when eGFR is $> 60 \text{ ml/min/1.73}$) is doubled in DM2 with CKD (BAILEY; DAY; BELLARY, 2022).

The action of SGLT2 in nephroprotection occurs due to numerous factors, one of them is a reduction in glomerular hyperfiltration, this occurs due to the increase in the dense

macula, through the tubuloglomerular feedback that stimulates the relaxation of the efferent arterioles and the constriction of the afferent arterioles. This reduces intraglomerular pressure and reduces glomerular hyperfiltration, which are critical to preserving kidney function. Thus, there is an acute reduction in the glomerular filtration rate (GFR), but it is a reversible effect (SANTULLI et al., 2023). This drop in GFR is initially about 5ml/min/1.73, reaches its lowest point in 1-2 weeks, and returns to pre-treatment values over the next 3-9 months. Evidence from long-term trials indicated that eGFR declined at a slower rate with the use of SGLT2 inhibitors than in placebo-treated patients and that albuminuria was lower (BAILEY; DAY; BELLARY, 2022).

In addition, the class of antidiabetics reduces the consumption of renal oxygen, by inhibiting the reabsorption of Na^+ , decreases the amount of sodium that enters the cells and therefore decreases the expenditure of ATP, by ATPase, responsible for pumping it out of the cells. This effect becomes more significant in diabetes, when hyperperfusion increases the amount of ultrafiltered knot (SANTULLI et al., 2023).

In addition, other factors of these antidiabetic drugs that corroborate nephroprotection are: anti-inflammatory, anti-oxidative and antifibrotic effects. In a study in diabetic rats by Ojima et al., the effect of empaglifozin in reducing the expression of advanced glycosylation products (AGEs), receptors of advanced glycosylation products (RAGE), which results in the inhibition of oxidative stress secondary to hyperglycemia (DAI et al., 2023), was observed.

Another important factor of SGLT2 is the ability to reduce the progression of chronic kidney disease in diabetic patients, which occurs through the reduction of chronic hyperurekaemia. They act by eliminating glucose, which competes with glucose transporter protein 9 (GLUT9) present in the renal tubules and which are responsible for the reabsorption and excretion of urate. In this way, there is a reduction in urate reabsorption and an increase in uric acid excretion (DAI et al., 2023).

The increase in glycosuria secondary to the effects of SGLT2 inhibitors leads to a state of relative glucose deficiency, triggering lipolysis in adipose tissue, fatty acid oxidation, and ketone body formations. Ketone bodies are more efficient for energy production in renal tubular cells than glucose, so oxygen consumption is reduced in the presence of mild ketosis. Thus, studies suggest the use of ketone bodies as an energy substrate as a form of renoprotection (GIORGINO et al., 2020).

The nephroprotective effects of SGLT2 inhibitors in patients with type 2 diabetes mellitus were evaluated in five large cardiovascular outcome trials: EMPA-REG OUTCOME

(empagliflozin), CANVAS and CANVAS-R (canagliflozin), DECLARE-TIMI 58 (dapagliflozin), and VERTIS CV (ertugliflozin).

In the EMPA-REG OUTCOME study, the effects of empagliflozin treatment on rates of acute renal failure and AKI were greater in patients with baseline GFR < 60 ml/min/1.73. In the CANVAS program, canagliflozin showed the ability to reduce renal outcomes constantly at different levels of baseline albuminuria, but with absolute benefits in those with macroalbuminuria. DECLARE-TIMI 58 demonstrated that dapagliflozin reduced the increase in urinary albumin-creatinine ratio (UACR), which is an important indicator of kidney disease progression, especially in patients with T2DM (GIORGINO et al., 2020).^{m2}

These studies have proven the efficacy of SGLT2 inhibitors in the treatment of patients with type 2 DM and mild to moderate renal impairment (eGFR >30 ml/min/1.73). However, efficacy and safety in patients with stage G4 and G5 diabetic kidney disease remained uncertain until the release of the results of the DAPA-CKD and EMPA-KIDNEY studies. ^{m2}

In the DAPA-CKD study, it was evidenced that the use of dapagliflozin is effective in reducing the risk of sustained decline in eGFR > 50%, CKD and death from kidney disease, there was also a significant reduction in proteinuria. In EMPA-KIDNEY showed that groups that were treated with empagliflozin reduced risks of cardiovascular and renal events, hospitalization, and progression of kidney disease in patients with chronic diabetic disease and stage 4 CKD (DAI et al., 2023).

Furthermore, the CREDENCE study, which was limited to patients with diabetic kidney disease (DKD), highlighted that canagliflozin was effective in reducing cardiovascular and renal events, as well as showing results in delaying the progression of kidney disease in patients with DKD, including stage 4 (DAI et al., 2023).

7 CONCLUSION

It is concluded that the use of SGLT2 inhibitors in patients with type 2 diabetes mellitus, in addition to their hypoglycemic effects, has benefits in reducing the risk of cardiovascular and renal complications. SGLT2 are effective in reducing renal glucose reabsorption, leading to glycosuria and, consequently, improved insulin sensitivity and glycemic control. In addition, its ability to reduce blood pressure and weight loss secondary to glycosuria, promote a better quality of life for patients.

Cardioprotection is related to multifactorial mechanisms, resulting from the effects of SGLT2, such as the reduction of arterial stiffness and the improvement of endothelial function,

which reduce the risk of cardiovascular death, atherosclerotic events, hospitalization for heart failure, and antiarrhythmic properties. Regarding renal function, antidiabetic drugs have demonstrated a favorable impact on the progression of chronic kidney disease, with evidence of a slower decline in the eGFR rate of diabetic patients and also on the reduction of albuminuria, being considered an excellent therapeutic option in patients with mild to moderate renal impairment, delaying the need for renal replacement therapy.

In addition, recent studies have shown that medications such as empagliflozin, dapagliflozin, and canagliflozin have been found to be effective options for patients with advanced stage chronic kidney disease (stages 4 and 5).

Thus, SGLT2 inhibitors are fundamental in the management of patients with type 2 diabetes, who are at increased risk for cardiovascular events and chronic kidney disease. The results of the studies reinforce the need to incorporate these drugs into the treatment of these patients, for better survival and reduced risk of complications.

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REGIONALIZATION MODELS IN MUNICIPAL PLANNING, LIMITS, INTER-CAPITAL COMPARISONS AND PROPOSED CRITERIA FOR MACEIÓ

MODELOS DE REGIONALIZAÇÃO NO PLANEJAMENTO MUNICIPAL, LIMITES, COMPARAÇÕES INTERCAPITAIS E PROPOSIÇÃO DE CRITÉRIOS PARA MACEIÓ

MODELOS DE REGIONALIZACIÓN EN LA PLANIFICACIÓN MUNICIPAL, LÍMITES, COMPARACIONES ENTRE CAPITALES Y PROPUESTA DE CRITERIOS PARA MACEIÓ

 <https://doi.org/10.56238/sevened2025.036-093>

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ABSTRACT

The study critically examines the regionalization models adopted in Brazilian municipal planning, with a specific focus on the case of Maceió. It assumes that regionalization is a structuring element of territorial state capacity and of the effectiveness of planning instruments such as the Multi-Year Plan, the Budget Guidelines Law and the Annual Budget Law. This qualitative research employs document analysis, literature review and inter-capital comparison to assess the technical, institutional and functional criteria guiding territorial delimitation in Brazilian capitals. Maceió's model, based on neighborhood subdivision and consolidated since 1988, is contrasted with benchmark experiences and with capitals of similar characteristics. The analysis adopts as methodological reference the Regionalization Model for State Planning of Alagoas, grounded on the principles of polarization and socioeconomic flows. The findings show that Maceió's current regionalization lacks technical criteria, which compromises diagnostics, prioritization and the territorial allocation of public expenditure. The study concludes that it is necessary to advance toward a standardized municipal regionalization model, articulated with indicators, data and participatory processes, capable of supporting more efficient planning oriented toward territorial inequalities.

Keywords: Regionalization. Municipal Planning. Territory. Multi-Year Plan. Territorial Governance. Maceió.

RESUMO

O estudo analisa de forma crítica os modelos de regionalização adotados no planejamento municipal brasileiro, com ênfase no caso de Maceió. Parte-se do pressuposto de que a regionalização constitui elemento estruturante da capacidade estatal territorial e da efetividade dos instrumentos de planejamento, como o Plano Plurianual, a Lei de Diretrizes Orçamentárias e a Lei Orçamentária Anual. A pesquisa, de natureza qualitativa, utiliza análise documental, revisão bibliográfica e comparação intercapitais para avaliar os critérios técnicos, institucionais e funcionais que orientam a delimitação territorial nas capitais brasileiras. O modelo de Maceió, baseado em abairramento e consolidado desde 1988, é

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confrontado com experiências referenciais e com capitais de características semelhantes. Adota-se como parâmetro metodológico o Modelo de Regionalização para o Planejamento Estadual de Alagoas, fundamentado nos princípios de polarização e fluxos socioeconômicos. Os resultados demonstram que a regionalização vigente em Maceió carece de critérios técnicos, comprometendo diagnósticos, priorização e territorialização do gasto público. Conclui-se que é necessário avançar na construção de um modelo normatizado de regionalização municipal, articulado a indicadores, dados e processos participativos, capaz de apoiar um planejamento mais eficiente e orientado às desigualdades territoriais.

Palavras-chave: Regionalização. Planejamento Municipal. Território. PPA. Governança Territorial. Maceió.

RESUMEN

El estudio analiza críticamente los modelos de regionalización adoptados en la planificación municipal brasileña, con énfasis en el caso de Maceió. Se parte del supuesto de que la regionalización constituye un elemento estructurante de la capacidad estatal territorial y de la efectividad de instrumentos de planificación, como el Plan Plurianual, la Ley de Directrices Presupuestarias y la Ley de Presupuesto Anual. La investigación, de naturaleza cualitativa, emplea análisis documental, revisión bibliográfica y comparación entre capitales para evaluar los criterios técnicos, institucionales y funcionales que orientan la delimitación territorial en las capitales brasileñas. El modelo de Maceió, basado en el abairramiento y consolidado desde 1988, se contrasta con experiencias de referencia y con capitales de características similares. Se adopta como parámetro metodológico el Modelo de Regionalización para la Planificación Estatal de Alagoas, fundamentado en los principios de polarización y flujos socioeconómicos. Los resultados muestran que la regionalización vigente en Maceió carece de criterios técnicos, lo que compromete diagnósticos, priorización y territorialización del gasto público. Se concluye que es necesario avanzar en la construcción de un modelo normativo de regionalización municipal, articulado con indicadores, datos y procesos participativos, capaz de apoyar una planificación más eficiente y orientada a las desigualdades territoriales.

Palabras clave: Regionalización. Planificación Municipal. Territorio. Plan Plurianual. Gobernanza Territorial. Maceió.

1 INTRODUCTION

Regionalization is a structuring element of government planning and contemporary territorial governance. At the municipal level, its function goes beyond the mere administrative division and assumes a strategic role in the production of diagnoses, in the identification of intra-urban inequalities, in the formulation of territorialized policies and in the efficient allocation of public resources. Despite this, the regionalization used by most Brazilian capitals remains anchored in historical, political, and administrative criteria, revealing a low connection with socioeconomic flows, mobility patterns, service networks, and functional dynamics of the territory. As a result, the state's capacity to understand, prioritize and intervene in different areas of the city is reduced, which limits the effectiveness of the Multi-Year Plan, the Budget Guidelines Law and the Annual Budget Law.

This picture is more clearly evident in Maceió. The regionalization originally instituted by Law No. 4,687 of 1988, preserved in subsequent amendments, is based on the *aairramento* and physical contiguity between neighborhoods. Although it has fulfilled a relevant administrative function, especially in supporting the decentralization of services, the model was not designed with technical criteria of regionalization aimed at planning. It does not incorporate indicators of social vulnerability, does not dialogue with mobility patterns, does not distinguish urban functions, nor does it establish relations of influence or polarization between territorial units. This produces a structural disconnection between territory and planning, with inaccurate diagnoses, low territorialization of public policies, and weaknesses in the prioritization of investments.

The literature indicates that regionalization models based on technical criteria, such as polarization, functionality, service networks, and socio-spatial integration, increase the internal coherence of planning and strengthen territorial state capacity, according to Haesbaert, Contel, and Saldanha. In Brazil, few capitals have advanced in this direction. Curitiba is the main national reference in articulating territorial planning, mobility, land use and socioeconomic indicators. Belo Horizonte, with its nine technical-administrative regions, also presents methodological coherence. Porto Alegre structured a model of participatory regionalization that influenced the budget and the territorial distribution of investments. On the other hand, most Brazilian capitals, such as Aracaju, João Pessoa, Natal and São Luís, use essentially administrative models similar to that of Maceió, with low technical foundations.

In this scenario, the Regionalization Model for the State Planning of Alagoas, prepared by SEPLANDE and IBAM in 2014, emerges as a relevant methodological reference. It

combines two structuring movements: the definition of hub municipalities based on their socioeconomic and functional influence, and the delimitation of planning regions derived from territorial flows and interdependencies. Although conceived for the state scale, its logic offers parameters applicable to the municipal level and makes it possible to critically evaluate the regionalization of Maceió, as well as to propose technically consistent alternatives.

From this perspective, the article seeks to answer the following question: to what extent does the absence of a standardized model of regionalization affect the planning capacity of the Municipality of Maceió and how can the experiences of other Brazilian capitals, articulated with the state model of Alagoas, guide its reformulation? To answer this question, an analysis based on three axes is developed: theoretical review of territory, region and regionalization; comparison between models adopted by Brazilian capitals, with emphasis on cities of similar size and characteristics; and a critical examination of the case of Maceió in the light of the state model of Alagoas.

The research is qualitative, of a documentary and comparative nature, based on municipal and state legislation, technical reports, official data and specialized literature. The analysis articulates theoretical foundations, normative requirements and empirical evidence, with the purpose of sustaining concrete guidelines for a technically oriented regionalization model, capable of strengthening municipal planning, promoting greater territorial equity and qualifying the distribution of public resources.

Next, the theoretical foundation explores the concepts of territory, region, regionality and regionalization, as well as the bases of government planning. Next, the methodology is presented. Subsequently, a comparative analysis is carried out between Maceió, reference capitals and capitals with similar characteristics. Finally, the conclusions are discussed and the guidelines for a standardized model of municipal regionalization are presented.

2 THEORETICAL FRAMEWORK

Understanding the regionalization models used in municipal planning requires a conceptual basis that articulates government planning, territory, and territorial governance. These three axes structure the state's capacity to formulate diagnoses, define priorities, and distribute resources in a way that is consistent with inequalities and urban dynamics. Thus, before examining the experiences of Brazilian capitals and the case of Maceió, it is necessary to present the theoretical foundations that guide the analysis, with emphasis on government planning as a structuring function of the State and regionalization as an essential instrument

for the territorialization of public policies.

2.1 GOVERNMENT PLANNING AS A STRUCTURING FUNCTION OF THE STATE

Planning is the first and most relevant administrative function of the State, guiding the definition of objectives, the coordination of public actions and the rationalization of the allocation of resources, according to Saldanha. In Brazil, its foundation is constitutionalized. The Federal Constitution of 1988 instituted an integrated planning system composed of the Multi-Year Plan, the Budget Guidelines Law and the Annual Budget Law. These instruments express the government project and the strategy of socioeconomic development, organizing priorities, goals and financial commitments, as Andrade observes.

For this author, planning is an indispensable condition for the responsible use of public resources and the prevention of improvised, short-sighted or fragmented practices, traits that are still recurrent in the Brazilian public administration. In the field of public policies, Schmitter has already emphasized that well-planned policies configure institutionalized arrangements capable of reducing distributive conflicts by rationally organizing the allocation of public goods and services.

In this context, regionalization plays a decisive role. Planning only becomes effective to the extent that the territory is properly understood, analyzed and structured. Planning without regionalization corresponds to planning in a vacuum, that is, setting goals without knowing precisely where they should focus.

2.2 THE TERRITORY AS AN OPERATIONAL BASIS FOR PLANNING

Territory is not a neutral category. It expresses power relations, inequalities, flows, uses, disputes, and identities, as discussed by Santos, Raffestin, and Haesbaert. For government planning, the territory is simultaneously:

- unit of analysis, where demands and inequalities are identified;
- intervention unit, where policies and investments are applied;
- coordination unit, where actions and actors are articulated.

Without understanding the territory in its characteristics, functions, dynamics and hierarchies, there is no planning capable of producing consistent results.

Territorial planning depends on a regionalization capable of:

- identify intra-urban inequalities;

- capture mobility patterns and flows;
- reveal areas of socioeconomic vulnerability;
- consider polarization and centralities;
- guide the prioritization of investments.

This set of elements sustains the territorialization of public spending, a critical dimension of contemporary planning.

2.3 REGIONALIZATION AND TERRITORIALIZATION OF PUBLIC SPENDING

The territorialization of spending refers to the distribution of resources and investments based on territorial diagnoses and the specific demands of each region. It connects four structuring dimensions:

- Planning, which defines priorities;
- Territory, which reveals needs;
- Budget, which allocates resources;
- Public policy, which executes actions in space.

When regionalization is merely administrative or based only on *abairramento*, as occurs in Maceió, this connection is broken. The result is a set of recurring problems:

- public policies that do not dialogue with territorial inequalities;
- asymmetric distribution of investments;
- sectors acting in a disconnected way, such as education, health and mobility;
- difficulty in establishing territorial priorities in the PPA;
- inability to measure regional impacts of policies.

For this reason, the contemporary literature emphasizes that regionalization must be functional, and not just administrative, as Contel and the OECD argue.

2.4 WHY TECHNICAL REGIONALIZATION IS INDISPENSABLE TO THE PPA, LDO AND LOA

2.4.1 In the Multiannual Plan

The PPA requires a prior diagnosis of the socioeconomic reality, definition of guidelines and territorialization of medium-term policies. Without data-based regionalization, the

diagnosis becomes inaccurate.

2.4.2 In the Budget Guidelines Law

The LDO defines annual goals and priorities and, for this, it needs:

- identify priority regions;
- measure inequalities and demands;
- project territorial impacts of fiscal and budgetary targets.

Without technical regionalization, generic priorities are produced, without defined territorial location.

2.4.3 In the Annual Budget Law

The LOA requires territorial precision to:

- allocate resources;
- distribute investments;
- specify regionalized actions;
- monitor physical and financial execution.

When the regions are not technically structured, the LOA loses its ability to guide public spending in the territory.

Brazilian planning instruments require regionalization, but most municipalities, including Maceió, still operate with inadequate models, generating misalignment between priorities, needs, and execution.

2.5 THE CONTEMPORARY AGENDA FOR TERRITORIAL GOVERNANCE (2012–2024)

Recent research highlights that state capacity depends on the territorial coherence of planning, as Abrucio, Lotta, Pires and Gomide point out. The OECD reinforces that countries with consistent territorial models have:

- greater allocative efficiency;
- stronger intersectoral coordination;
- lower spatial inequality;
- greater transparency in the use of resources.

This agenda incorporates:

- multilevel planning;
- metropolitan governance;
- use of indicators and territorial information systems;
- functional regionalization;
- strengthening of administrative capacities.

Thus, regionalizing well is not only a technical decision, but a condition for the State to operate with true capacity for planning and territorial intervention.

3 METHODOLOGY

The research adopts a qualitative approach, based on documentary analysis, literature review and inter-capital comparison. According to Gil, qualitative research is indicated for studies that seek to understand phenomena in depth, exploring meanings, relationships and contexts that cannot be reduced to numerical measurements. Creswell points out that this type of approach mobilizes multiple sources of evidence and allows interpreting social phenomena in an integrated and contextualized way. From this perspective, it is based on the understanding that regionalization for planning purposes involves territorial, political and administrative dimensions whose study demands interpretation, analysis and conceptual reconstruction.

The documentary analysis follows the understanding of Lakatos and Marconi, according to which official and normative documents are indispensable primary sources for identifying institutional structures, public policies and organizational processes. The first set of sources corresponds to the municipal laws of Maceió, especially Law No. 4,687 of 1988, its subsequent amendments, the Master Plan of 2005 and the provisions related to the territorial organization of the municipality. The second set comprises the Regionalization Model for the State Planning of Alagoas, prepared by SEPLANDE with technical support from IBAM, whose methodology based on poles, flows and areas of influence offers analytical parameters particularly useful to the study.

For comparative purposes, Brazilian capitals with urban and structural characteristics similar to those of Maceió were selected, such as Aracaju, João Pessoa, Natal and São Luís. This selection follows the methodological orientation highlighted by Prodanov and Freitas, who indicate that the inter-case comparison allows the identification of patterns, divergences

and convergences relevant to the problem investigated. At the same time, capitals considered national reference in regionalization models were analyzed, such as Curitiba, Belo Horizonte and Porto Alegre, which allowed the construction of contrastive patterns between administrative, hybrid and functional models.

The analytical procedure was developed in three stages. The first consisted of the systematization and analysis of the legal bases, territorial divisions and criteria used in each city. The second stage corresponded to the comparison of the models, classifying them according to categories derived from the literature and the methodology applied in the state model of Alagoas. The third stage focused on the interpretation of the effects of each model on government planning, relating territorial diagnosis, prioritization of policies and territorialization of public spending.

The combination of documentary analysis, theoretical review and intercapital comparison allowed the construction of a comprehensive interpretation of the limits of the regionalization model of Maceió, in addition to supporting the identification of essential elements for its future review. The methodology adopted thus ensures coherence between the research problem, the objectives and the analytical procedures employed.

4 RESULTS AND DISCUSSIONS

The analysis developed below presents the main findings of the research, organized from the interpretation of the regionalization models adopted by Maceió, the capitals of similar size and the reference capitals in the national scenario. The results allow us to understand how different territorial criteria influence diagnoses, prioritization of public policies and state capacity. The discussion is structured in sub-items that detail characteristics, limits and implications of each model, relating them to the contemporary requirements of government planning.

4.1 THE REGIONALIZATION MODEL OF MACEIÓ, CHARACTERISTICS, LIMITS AND IMPLICATIONS

The regionalization in force in Maceió has its origin in Law No. 4,687 of 1988, which divided the urban area into seven Administrative Regions using as the main criterion the physical contiguity between neighborhoods. This logic was preserved by Laws No. 4,952 of 2000 and No. 5,217 of 2001 and reaffirmed in the Master Plan of 2005, when the eighth

administrative region was established without, however, changing the methodological foundation of the model.

The most recent data from the IBGE and the Socioeconomic Profile of Maceió show that the city has marked territorial heterogeneity, marked by a strong population and economic concentration in the coastal strip and persistent vulnerabilities in the high areas. This reality highlights the central limitation of the current model, which fails to capture contemporary socio-spatial dynamics. Administrative regions do not reflect patterns of mobility, service networks, emerging centralities, or socioeconomic inequalities already documented in official public databases.

The second limitation refers to the fragile integration between regionalization and planning. The diagnoses used in the PPA, LDO and LOA reproduce territorial divisions that have little dialogue with urban complexity, which restricts the ability to identify territorial priorities and guide the balanced distribution of investments.

The third limitation lies in the inability to reveal intra-urban inequalities, since the current model does not incorporate indicators of income, schooling, sanitation, density or accessibility, essential elements for any consistent territorial reading. As a result, the territorialization of public spending becomes uncertain and sectoral policies are implemented without reference to functional planning cuts.

The specialized literature reinforces that administrative regionalizations, when not anchored in technical criteria, tend to reproduce inequalities and reduce the effectiveness of government action. In Maceió, this phenomenon is expressed by the fragmentation of policies, the overlapping of initiatives, the low intersectoral articulation and the weak adherence between territory, budget and strategic programs.

4.2 THE STATE MODEL OF ALAGOAS AS A METHODOLOGICAL REFERENCE

The Regionalization Model for the State Planning of Alagoas, prepared by IBAM and published in 2014, presents a methodological arrangement that contrasts strongly with the municipal model of Maceió. His logic combines two complementary movements. The first consists of the definition of hub municipalities, identified according to their socioeconomic importance, the supply and density of services, and the capacity for polarization. The second movement corresponds to the delimitation of the areas of influence of these poles, resulting in planning regions that incorporate flows, functional interdependencies, equipment networks and mobility patterns.

It is a model anchored in measurable and replicable criteria, structured to translate urban functions and territorial articulations. The use of socioeconomic indicators, associated with the interpretation of commuting and consumption flows, the analysis of the location of public services and the identification of centralities and subcentralities, constitutes its backbone. These elements allow the construction of excerpts that represent the real dynamics of the territory, strengthening diagnoses, increasing the precision in the allocation of resources and guiding programs and actions of a territorial nature.

When used as a reference to evaluate Maceió, the state model shows the distance between an administrative regionalization, based on historical cuts, and a functional regionalization guided by technical criteria. While the state model incorporates territorial articulations and identifies effective centralities, the municipal model remains stuck in divisions that are not very responsive to urban transformations, incapable of consistently guiding the planning and management of the territory.

4.3 COMPARISON WITH SIMILAR CAPITALS: ARACAJU, JOÃO PESSOA, NATAL AND SÃO LUÍS

The comparative analysis with capitals of similar size and characteristics confirms that Maceió is not an isolated case. Aracaju (with about 670 thousand inhabitants), João Pessoa (approximately 830 thousand), Natal (almost 900 thousand) and São Luís (about 1.1 million) structure their administrative regions based on predominantly historical cuts, linked to the division of neighborhoods, physical contiguity and administrative practices consolidated over time. In general, these models do not incorporate socioeconomic indicators, do not represent urban flows, nor do they systematically guide the budget cycle, reflecting the persistence of an essentially administrative regionalization in the northeastern capitals.

Although they share limitations, these cities have particularities that help to contextualize the case of Maceió. Aracaju is organized into 9 administrative regions, articulated with urban planning, still without explicit functional criteria. João Pessoa uses excerpts that partially dialogue with community dynamics, but lack a methodological framework capable of translating socio-spatial inequalities into planning criteria. Natal, divided into four administrative zones since the mid-twentieth century, maintains similar weaknesses due to the lack of integration between regionalization and planning instruments. São Luís, with five major administrative regions, faces similar challenges, mainly due to the absence of analytical criteria and the low incorporation of territorial indicators.

The socioeconomic data from the IBGE and the indices from the Brazil Atlas reinforce this picture, evidencing intense patterns of vulnerability and intra-urban inequalities in these capitals — elements that, as in Maceió, are not incorporated into the administrative cutouts or used to guide the goals of the PPA or the execution of the LOA. The result is a budget cycle that is poorly articulated with the territory, marked by generic diagnoses, low precision in identifying priorities, and less capacity for territorial evaluation of the impacts of public policies.

Thus, the common point between these capitals is the disconnection between territory and budget, which limits the effectiveness of government actions, reinforces patterns of exclusion, and makes it difficult to confront intra-urban inequalities. The comparison shows that Maceió is part of a national pattern of capitals that adopt administrative models of regionalization. However, it is distinguished by having a functional state model already consolidated, which can serve as a technical reference for a consistent territorial reform aligned with the socio-spatial demands of the city.

To qualify the comparative analysis and highlight the territorial characteristics of capitals of similar size, the official maps of Aracaju, João Pessoa, Natal and Maceió are presented below. These representations illustrate the administrative structure adopted by these municipalities, predominantly anchored in historical cuts, physical contiguities and traditional divisions of neighborhoods. The visualization of these maps helps to understand the methodological limitations identified in the regionalization of these capitals, reinforcing the arguments developed in this subsection.

Figure 1

Administrative Regionalization of Aracaju



Source: Prefeitura Municipal de Aracaju.

Figure 2

Administrative Regionalization of Natal



Source: Prefeitura Municipal de Natal.

Figure 3

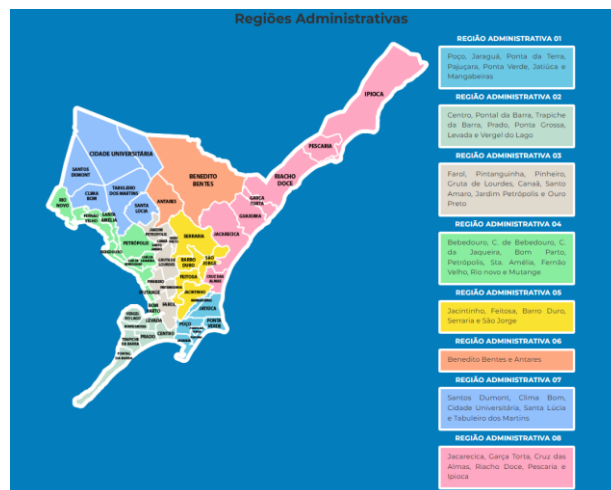
Administrative Regionalization of João Pessoa



Source: Prefeitura Municipal de João Pessoa.

Figure 4

Administrative Regionalization of Maceió



Source: Prefeitura Municipal de Maceió.

The integrated reading of the maps confirms that Aracaju, João Pessoa and Natal adopt regionalization models of an essentially administrative nature, without functional criteria, without articulation with urban flows and without consistent integration with the budget cycle. Such visual evidence corroborates the findings presented in the textual analysis and empirically substantiates the classification of these capitals as "similar models" in Chart 1.

4.4 COMPARISON WITH REFERENCE CAPITALS: CURITIBA, PORTO ALEGRE AND BELO HORIZONTE

Curitiba, Porto Alegre and Belo Horizonte are national references for adopting more structured and methodologically consistent functional regionalization models. Curitiba integrates its regionalization with land use policies, mobility and urban structuring, articulating transport axes, urban centralities and socioeconomic data. Porto Alegre has developed a territorialized model associated with Participatory Budgeting, allowing the identification of regional inequalities, territorializing investments and strengthening the relationship between planning, budgeting and social participation. Belo Horizonte has structured nine regional offices based on population, socioeconomic and functional criteria, which enables territorialized diagnoses and continuous monitoring of goals.

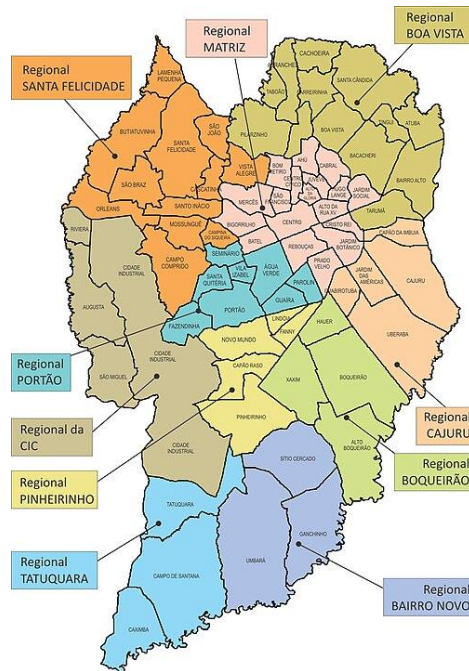
These experiences offer relevant lessons. In Curitiba, regionalization guides structuring decisions on mobility, zoning and service networks. In Porto Alegre, territorialization qualifies the distribution of resources and reinforces democratic legitimacy. In Belo Horizonte, regionalization is the basis for territorial indicators, monitoring of goals and intersectoral coordination.

The contrast with Maceió highlights the importance of functional cuts to strengthen state capacity. Detailed diagnoses, territorial prioritization, articulation between sectors and efficient allocation of resources depend on regions defined by technical criteria that express the socio-spatial dynamics of the city.

Next, the maps of the reference capitals — Belo Horizonte, Curitiba and Porto Alegre — are presented with the objective of illustrating the territorial organization based on functional criteria, urban centralities, mobility networks and intersectoral articulation. These representations show regionalization arrangements aligned with urban and budgetary planning, offering a direct contrast with the administrative models observed in the northeastern capitals previously analyzed.

Figure 5

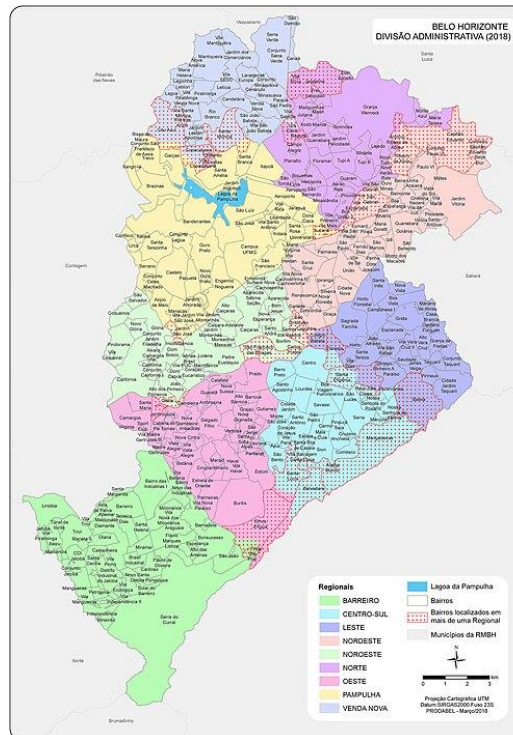
Administrative Regionalization of Curitiba



Source: Prefeitura Municipal de Curitiba.

Figure 6

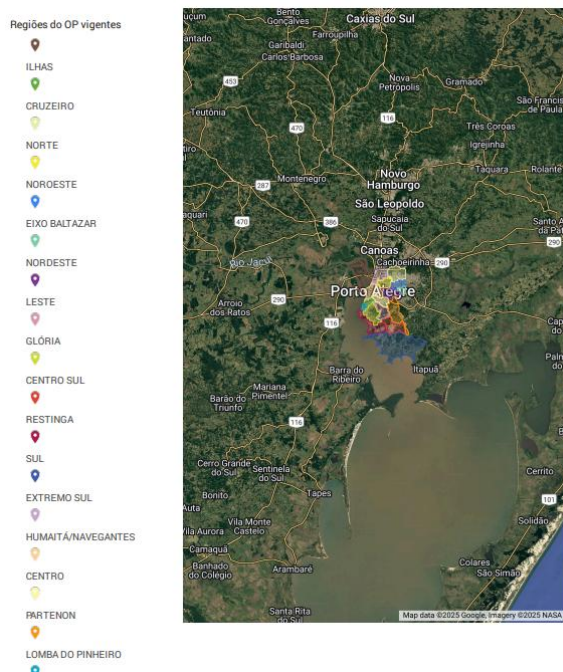
Administrative Regionalization of Belo Horizonte



Source: Prefeitura Municipal de Belo Horizonte

Figure 7

Territorial Regionalization of Porto Alegre (Participatory Budget)



Source: Prefeitura Municipal de Porto Alegre / ObservaPOA.

The comparative observation of the regional offices of Belo Horizonte, Curitiba and Porto Alegre confirms the presence of functional criteria, delimitations consistent with the urban dynamics and systematic use of indicators for planning purposes. Unlike administrative models, such regionalizations structure territorial diagnoses, guide sectoral policies and facilitate the territorialization of the budget. This visual evidence reinforces the privileged position of these capitals in Chart 1, as well as the importance of technically grounded territorial cutouts for strengthening state capacity.

4.5 COMPARATIVE TABLE OF REGIONALIZATION MODELS

The following is an analytical table that summarizes the main differences between the models:

Table 1

Criterion	Maceió	Similar capitals ² (Aracaju, João Pessoa, Natal, São Luís)	Reference Capitals ³ (Curitiba, Belo Horizonte, Porto Alegre)	State Model of Alagoas ⁴ (IBAM/SEPLANDE, 2014)
Territorial base	Abairramento; Historic division of neighborhoods	Administrative sections based on neighborhoods or sectors	Functional cutouts structured by centralities and land use	Territorial polarization: poles and areas of influence
Methodological criterion	Not defined; Absence of technical criteria	Partially defined; still predominantly administrative	Methodologically defined; Data-driven and urban functions	Highly defined; Two-step method
Socioeconomic indicators	Unused	Little used; Limited Application	Used systematically	Fully utilized
Consideration of urban flows	Not considered	Considered partially	Considered in full	Considered in full
Centralities and subcentralities	Unidentified	Little explored	Identified and used as a territorial base	Identified from the poles
PPA Integration	Low	Low to moderate	High	High
Integration with LOA	Reduced	Reduced	High	High
Use for territorial diagnosis	Weak	Weak to moderate	Strong	Strong
Territorial coherence	Low	Low to medium	Discharge	Discharge
Intersectoral articulation	Limited	Limited	High	High
Territorial social participation	Unstructured	Partial	Partial to strong (e.g., Porto Alegre)	Partial
Model-derived state capacity	Reduced	Reduced	Strengthened	Strengthened

Source: Prepared by the authors based on the municipal legislation of Maceió (Laws No. 4,687/1988, 4,952/2000, 5,217/2001 and Master Plan 2005), the Regionalization Model for the State Planning of Alagoas (SEPLANDE/IBAM, 2012–2014) and official documents from the capitals Aracaju, João Pessoa, Natal, São Luís, Curitiba, Belo Horizonte and Porto Alegre.

² Population, demographic and territorial data for the capitals Aracaju, João Pessoa, Natal and São Luís were consulted on the "Panorama of Municipalities" and "Cities and States" platforms of the Brazilian Institute of Geography and Statistics (IBGE).

³ Information related to territorial organization, centralities, urban mobility and functional criteria adopted by Curitiba, Porto Alegre and Belo Horizonte were obtained from official urban planning documents, municipal statistical databases and complementary IBGE panels.

⁴ The Regionalization Model for the State Planning of Alagoas was prepared by the Brazilian Institute of Municipal Administration (IBAM) in partnership with SEPLANDE (2012–2014), defining poles, areas of influence and socioeconomic and functional criteria.

⁴ Socioeconomic indicators used for comparative purposes — MHDl, income, education and social vulnerability — were obtained from Atlas Brasil (PUND/IPEA/FJP).

⁵ The data referring to intra-urban inequalities in Maceió were extracted from the Socioeconomic Profile of Maceió (SEPLAG/AL), complemented by IBGE and Atlas Brasil.

The differences between municipal and metropolitan scales, as well as the demographic and institutional particularities of the capitals analyzed, were considered in the elaboration of the table, ensuring comparative coherence and avoiding interpretative distortions.

The picture shows that Maceió shares weaknesses typical of northeastern capitals, especially the absence of functional criteria and the low integration between regionalization and planning. At the same time, it is noteworthy that the municipality has a relevant comparative advantage: the existence of an already consolidated state model, which incorporates technical guidelines necessary to guide a functional regionalization. This model can serve as a basis for the construction of a new municipal territorial framework, more coherent with contemporary socio-spatial dynamics and with the requirements of government planning.

The analysis confirms that regionalization is a decisive element for the quality of municipal planning. In Maceió, as in several northeastern capitals, the absence of a standardized and technically based model compromises the territorialization of public spending, reduces the accuracy of diagnoses, and limits the state's capacity to address persistent intra-urban inequalities.

The comparison with reference capitals shows that functional models strengthen the integration between policy, territory and budget, allowing detailed diagnoses, intersectoral coordination and better distribution of resources. On the other hand, the comparison with similar capitals shows that administrative models tend to reproduce structural weaknesses and maintain the distance between territory and budgetary decisions.

In this context, the state model of Alagoas emerges as a robust methodological reference and able to guide a new territorial framework for Maceió. Its use would allow for greater territorial coherence, more accurate diagnoses and strengthening of state capacity, indispensable elements to address inequalities and qualify municipal public planning.

5 CONCLUSION

The analyses presented demonstrate that Maceió operates with an essentially administrative regionalization, historically defined by the *abairramento* and the traditional division of neighborhoods, without technical criteria capable of reflecting flows, socio-spatial inequalities, land uses and urban centralities. This configuration compromises central processes of government planning, such as the preparation of the Multi-Year Plan, the

identification of LDO priorities and the territorialization of the expenses provided for in the LOA.

The comparison with similar capitals reveals that Maceió is part of a set of municipalities with fragile territorial cuts, predominantly administrative and poorly articulated with planning. At the same time, the reference capitals, such as Curitiba, Belo Horizonte and Porto Alegre, demonstrate that functional regionalization is capable of expanding state capacity, strengthening territorial diagnoses and guiding investments in a more equitable way.

The Regionalization Model for the State Planning of Alagoas shows that the construction of territorial divisions guided by indicators, centralities, urban flows and areas of influence offers more solid bases for diagnoses and strategic decisions. This methodological reference suggests ways for a broad review of the regionalization of Maceió, including mechanisms of social participation, integration between budget planning and urban planning, and articulation between different scales of governance.

It is concluded that the construction of a standardized model of municipal regionalization is a fundamental step to strengthen the planning of Maceió, support the balanced distribution of public investments and face historical inequalities in the territory. A model that considers centralities, flows, vulnerabilities and functional articulations will allow the city to move towards a more coherent, democratic planning that adheres to the real needs of the population.

ACKNOWLEDGEMENTS

To God, because "in everything we ought to give thanks, for this is the will of God in Christ Jesus for you" (Thessalonians 5:18) – and a grateful heart pleases God!

I thank my wife, Elda Nicácio, for her companionship and support at all times of our life journey.

I thank my sons, Vinicius and Matheus, for understanding my absence in the hours dedicated to research, studies and work.

I also thank my friend Marielza, for her academic complicity, for the hours of debates and for the contributions that greatly enriched our journey.

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**THE DIALECTIC OF MELANCHOLY: A MODEL FOR UNDERSTANDING THE
PRODUCTION OF ADAPTED SUBJECTIVITIES**

**A DIALÉTICA DA MELANCOLIA: UM MODELO DE ENTENDIMENTO DA
PRODUÇÃO DE SUBJETIVIDADES ADAPTADAS**

**LA DIALÉCTICA DE LA MELANCOLÍA: UN MODELO DE COMPRENSIÓN DE
LA PRODUCCIÓN DE SUBJETIVIDADES ADAPTADAS**

 <https://doi.org/10.56238/sevened2025.036-094>

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ABSTRACT

Based on the problem of the impossibility of forming the individual in a social organization based on barbarism, the constitution of melancholy is analyzed, whose characteristic of maintaining the memory of the pain experienced questions survival in a state of inversion of means and ends, which mutilates the individual while summoning them to participate in a reality that is alien to their realization as such. Contrary to what is demanded by neoliberal culture, the melancholic state, while manifesting the impediments inflicted on the individual, indicates the possibility of resisting these conditions by renouncing the untruth of the imposed meaning and can also signal an ethical-political orientation of present action because its movement brings traces of non-forgetfulness, a fundamental condition for critical reflection on the contemporary imposition of the social process of adaptation.

Keywords: Forgetfulness. Formation. Critical Theory. Freud. Education.

RESUMO

A partir da problemática da impossibilidade de formação do indivíduo em uma organização social pautada pela barbárie, se analisa a constituição da melancolia, cuja característica de mantenedora da lembrança da dor vivida questiona a sobrevivência em um estado de inversão de meios de fins, que mutila o indivíduo enquanto o convoca a participar de uma realidade alheia à sua realização enquanto tal. Na contramão do que é exigido pela cultura neoliberal, o estado melancólico ao mesmo tempo que manifesta os impedimentos infligidos ao indivíduo, indica a possibilidade de se resistir a essas condições pela renúncia da inverdade do sentido imposto e pode assinalar ainda uma orientação ética-política da ação presente por seu movimento trazer rastros do não-esquecimento, condição fundamental para a reflexão crítica sobre a imposição contemporânea do processo social de adaptação.

Palavras-chave: Esquecimento. Formação. Teoria Crítica. Freud. Educação.

RESUMEN

A partir del problema de la imposibilidad de formación del individuo en una organización social regida por la barbarie, se analiza la constitución de la melancolía, cuya característica de mantener el recuerdo del dolor experimentado cuestiona la supervivencia en un estado de inversión de medios y fines, que mutila al individuo al tiempo que lo convoca a participar

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de una realidad ajena a su realización como tal. Al contrario de lo que exige la cultura neoliberal, el estado melancólico, al tiempo que manifiesta los impedimentos infligidos al individuo, indica la posibilidad de resistir a estas condiciones renunciando a la falsedad del sentido impuesto y puede señalar también una orientación ético-política de la acción presente, porque su movimiento aporta huellas de no-olvido, condición fundamental para la reflexión crítica sobre la imposición contemporánea del proceso social de adaptación.

Palabras clave: Olvido. Formación. Teoría Crítica. Freud. Educación.

1 INTRODUCTION

Based on Theodor W. Adorno's (1995) propositions about the need for a rationality capable of thinking about itself in the forms of violence it perpetuates, the concept of melancholy is investigated here from the author's formulation about the project of enlightenment, which organizes modern societies, in dialogue with the constitution of the melancholic state according to Freud's (1974) proposition. In the understanding that is intended to be constructed here, it is considered that, as a condition for overcoming the social determinants that historically inflict suffering on the individual, another relationship with the pain suffered should be considered, which goes beyond an individualized approach.

It seeks to consider psychic suffering extrapolating the strict space of clinical psychology, meeting areas such as education, which lends itself to the elaboration of the formative dimension. In this way, contemporary rationality and its effects on the subject are questioned, in a position that meets the characterization of melancholy.

As Horkheimer and Adorno (1973) point out, the understanding of the individual is not dissociated from the understanding of society, founding the understanding that the form and content that constitute the individual, whose substance is historical and material, is determined by the way society orders itself and determines the configuration of the concrete social relations in which the individual is inserted. Identifying the bases on which humanity is founded allows – and can be said to be the condition for – the location and understanding of the phenomena that are identified in the constitution and manifestations of subjectivity.

In a split reality where particular interests are announced as universal and sustain the rational system, the rationality that should serve as an instrument for the organization of human existence is structured as a representative of hegemony, bringing within itself a contradiction (ADORNO, 1996). From this understanding, it is considered that the social totality is guided by ends contrary to those necessary for the existence of the individual, who, therefore, needs to annul himself in order for the collectivity to be maintained.

Thus, the contradiction present in the social reality, in which the educational processes are situated, is observed in the manifestations of individual suffering. From a sociological perspective, it is understood the way in which the individual experiences his symptom in relation to the way in which this individual is socially situated, being mediated by the institutions that order the formative process (FRANCISCATTI, 2002). The refusal present in melancholy can thus be understood, not as an incapacity, but as a response of the individual to the process of dehumanization that is set in motion by the contemporary social structure.

Going through the concepts of semi-formation and rationality, from which the concept of melancholy is analyzed as resistance to the imposition of a damaged formation, the theoretical framework of the present investigation is composed of the dialogue between Theodor Adorno's sociological approach and Freudian psychoanalysis. Thus, the historical constitution of the individual is considered in its intertwining with culture, which is understood by the concept of formation, constructing the characterization of melancholy not as a symptom to be overcome, but as a model of analysis. By safeguarding traces of memory of the unrealized, such a model can allow the elaboration of reason in the face of domination and the preservation of the possibility of realizing culture as a place for the formation of the individual.

2 THE DAMAGED FORMATION

For Adorno (2010), cultural formation refers to the process of subjective appropriation of culture, which inserts the individual in what is proper to him: his humanity. The formed individual is the one capable of asserting himself as a rational and free being, which is not dissociated, since it is its source, from a society that is also rational and free. Within a tradition of critical theory in dialogue with psychoanalysis, the subject is a formation focused on the possibility of differentiation, which implies a constitution capable of sustaining a position of autonomy.

This points to the fact that education is not a process that happens in an isolated and individual way, but rather in the construction of the space between subject and object, in which the former perceives itself as mediated. The formative experience is composed of the movement by which the subject is confronted with his limitation, in a process determined by a negative dialectic, as indicated by Adorno (2009). The understanding of negative dialectics indicates that formation does not occur in a merely positive movement of constitution, but is permeated by elements that do not fully fit into the constituted form. In this sense, the movement necessary for the structuring of a unit, which is recognized as I, starts from the contact with that which is different from it, making the identity always refer to that which escapes it.

In a world where standardization and immediacy prevail, driven by technological advances that are guided precisely by the planning of social dynamics, what results is the imposition of a commodification logic on all domains of life. When there is no space for the constitution of the diverse, education becomes semi-formation, a "false experience that

obscures, but at the same time convinces" (MAAR, 1995, p. 23), putting in place of experience, consumer relations, which come to compose the psychic structure of the subjects subjected to such logic.

It is precisely because it composes the internal life of the individual that this condition, although false, remains active in a generalized way (ADORNO, 1995). If Marx (2013) shows that human material forces were appropriated for the maintenance of class society, it is Freud (1974) who points out how this external state of affairs determines the constitution and dynamics of subjectivity, indicating how this reality is also maintained by the work of the individual psyche, which is sustained by the sacrifice imposed by repression, acts blindly in relation to his own interests (MATOS, 1989).

According to Adorno (2010), since semi-formation is a failure of the formative movement, it is also characterized as "a weakness in relation to time" (p. 406) because it breaks with the consciousness that preserves what education was in other times, making it difficult to understand what its advancement or deterioration would be. Deprived of access to his own constitution, the individual yields the conformation and confirmation of the reality that presents itself to him. The repetition of the same past time represents a compulsion that demands of individuals the constant response to the order of progress. Prevented from reaching reality and understanding it, but without the possibility of ceasing the movement of the 'always forward', consciousness, which serves conservation, realizes the justification of the unjustifiable, and the individual becomes an active and conscious reproducer of his own suffering.

For Adorno (2009), the negative moment is fundamental to dialectical thinking. It represents everything that resists synthesis, and thus, adaptation to the dominant normativity. In other words, the negative moment is the one that insists and does not fit into the system, but that, precisely for this reason, reveals its contradictions. Instrumental rationality, dominant in capitalist modernity, tries to suppress negativity: suffering, pause, error and difference. Thus, society tends to model adjusted and adapted subjects. Everything that escapes this form is considered unproductive and dysfunctional.

This picture of the causes and motives contained in the concept of semi-formation indicate that it is not possible to change the objective situation in isolation, since it is entangled with profound effects on subjectivity and is circumvented by ambivalence, requiring an understanding that reaches the character of multiple determination of reality, in its objective and subjective aspects.

3 MELANCHOLY AS A HISTORICAL RECORD

In *Mourning and Melancholia* (1947), Freud describes melancholy as a mourning that is not concluded. There is a loss of object (real or symbolic) that the subject is unable to name or elaborate, and because of this, he locates the psychic record of this loss in his own self, generating affects of self-devaluation, inhibition and suffering without a defined object. The melancholic constitution represents on the psychic plane an affect that loses its place and returns in a pathological way, due both to the imposition of the object's loss and to the subject's predisposition to deal with identifications with the object.

Considering the process of subjective formation, which is determined by the subject's relationship with the influences of the environment, one should think about the constitution of melancholy from a social dynamic, inserting the understanding of subjective predisposition in this relational understanding. In this way, it is understood that social phenomena are in a relationship of mutual determination with states of thought. By identifying in society the presence of an intense process of reification, it is clear that its correlate is the thought that is constituted by hiding its limits and forgetting its trace. This means that the hegemonic social form paralyzes the unfolding of alternative tendencies that would be proper to the living character of culture.

From what is indicated by Adorno (1995) it is clear that the nature of the relationship of the contemporary individual with the past, his own and social, is understood in two ways: first, this past is not the conservation of the strict event, as it happened, since it is originally already mediated by experience and preserves what happened in a transformed way in the relationship with the subject's aptitudes and wills; second, supported by this understanding, it is the relationship with the past as an experience and conservation of what has been lived, preserved in consciousness as a promise and as a mark, which imposes the need to be in contact with it, since its presence, conscious or not, imposes itself either by giving form to need and will, or by erasing them in the name of adaptation to order.

As seen, the logic of the administered world is to engender all its processes in the oblivion of what is human, electing the reproduction of technique, progressively refined, to take the place of truth and the work of reason. The tension of the conditions that produce the impotence of the individual provokes reactions of dissatisfaction, bringing out the contradiction of this way of life. In the disenchantment of the world promoted by the interests of the bourgeoisie, the loss of tradition, of the memory of the historical determinants present

in the conditions of man's formation, causes the abandonment of the individual to himself, without him being able to count on a constituted individuality (ADORNO, 1995).

According to Adorno (1993, p. 51), Freud "[...] investigated conscious action from a materialistic point of view, descending to the unconscious instinctual foundation of the latter [...]", describing from these terms the dynamics of loss and oblivion articulated with the concept of melancholy. As presented by Kehl (2010), the word melancholy was used by the author to analyze a mental illness called manic-depressive psychosis by psychiatry. His understanding of the phenomenon was fundamental for the understanding of the depressive melancholic complex in the field of psychoanalysis, in an understanding that broadens the conception of melancholy treated by the tradition of Western thought, which related it to culture and artistic creation. It is in the articulation between the psychological and the traditional approach that the understanding elaborated here is located.

Matos (1989), following this articulation, says that melancholy is the preservation of the memory of an issue whose oblivion is radicalized in technological rationality, which, by making it impossible for the individual to realize it with the minimum of sacrifices, liquidates him along with his memory. What is preserved is the promise that the social totality must offer the conditions for emancipation to be possible. Separated from the dimension of time and external space, the melancholic, in its refusal to be forgotten, bears the mark of the suffering experienced and the regression of the drive movement in the face of exacerbated fear, but also preserves the traces of what was denied to it.

For Freud (1974), mourning is a painful process in the face of the suspension of contact with that which becomes irremediably inaccessible and, in melancholy, the drive resulting from this suspension refuses to seek new external objects in a more lasting way, in a regression of the work of the libido to the self. This is due to the refusal of the self to abandon the relationship with the object, identified as the representative of satisfaction within the subject's reach. In this understanding, in melancholy the loss of the object translates as the loss of aspects of one's own self, which triggers a reaction of opposition to what cannot take the place of the lost object.

Freud (1974) prepares this idea in his text "On Transience", which reflects on the different emotional dispositions in the face of the ephemerality of what is beautiful. Faced with the threat of death that condemns to decay what one loves, feelings of discouragement or rebellion can be manifested. The awareness of the transience of the enjoyment of an object leads to a painful process of detachment of the libido that can intensify the damage that has

fallen on life and, according to the dictates of the drive economy, can either make one give in to this damage or safeguard the claim of the continuity of beauty and its fruition. Such a feeling contains the recognition that something precious to life has been lost in the confrontation with the obstacles imposed on the movement of the drive (FRANCISCATTI, 2005).

Crochík (2000) also indicates that melancholy is marked by what has been lost in the process of individuation and self-preservation, in the memory of forgotten and constantly postponed *jouissance*. As in the memory movement, melancholy is the individual's experience of perplexity in the face of an issue that cannot be resolved. It is the confrontation of consciousness with an absence that is based on the erasure of its possibilities of existence and leaves as a remainder the emptying of this existence converted into an object of the social totality.

The melancholic is the one who, in the confrontation with an impoverished and threatening reality, finds in himself the marks of this situation and turns to it in a recollection that recognizes in the imperative of the 'always forward', demanded by the pace of capitalist production, the distancing from a truth capable of pointing to barbarism. It is not the melancholic state that drags the individual into an impoverished existence, it is the social totality that imposes his impoverishment, the recognition of which is particularized in melancholy. This is because, according to Matos (2006), the project of rationalization that liquidates individual and collective references is not a process that takes place integrally, but rather leaves traces, in which memory is inserted, where melancholy is fixed.

Matos (1989) takes up Adorno to indicate that the melancholic state is the one that, in a kind of negative dialectic, denies the given by pointing to what it is not from experience with what can be. The individual turns to melancholy after the imposition of a loss that is not repaired with the available objects, since what is lost is of the order of the maintenance of his individuality. By denying the replacement of the lost object, remaining withdrawn from contact with aspects of the external world, it resists the annulment of itself in a totality that asks for sacrifice without reparation.

4 THE SYMPTOM BEYOND PSYCHOPATHOLOGY

If education is carried out through contact with historically constituted objects capable of realizing the human form, and therefore is not separated from tradition and the dimension of ancestry (MATOS, 1989), it is characteristic of the ordering rationality of the bourgeois

world to dissociate progress from its historical element and to see as an advance the constant superimposition of a false differentiated that separates itself from what preceded it. The relationship with tradition should not be one of hardening of manners and facts, but of contact with the existing for the updating of what deserves to be preserved, since it maintains the possibility of human satisfaction.

The formation that is sustained by continuity is effective when the new is particularized, which is why it is dynamic: between the maintenance and contact with what is continuous and equal and the rupture of this continuity by the establishment of another (ADORNO, 1996). On the other hand, the ordering of the administered world makes the movement of history unidirectional, standardizing it by inserting a logic that replaces the past and imposes that which must be repeated without having contact with this repetition.

Since there is no life that takes place outside of historical time and space, which has been constituted based on the principle of domination of nature, man's violence against other men and against himself (internal nature) also leaves its mark (HORKHEIMER; ADORNO, 1973). If the individual, in the current conditions described here, has been deprived of his active role in the transformation of reality, Adorno (1995) argues that the only thing that can still recognize injustice is the memory, the record of the marks left by the impeded formation. The thinker emphasizes that the forgetfulness of phenomena that recall the persistence of barbarism is not explained from psychopathology, but from the general social situation.

In contemporary society, especially under the neoliberal logic, there is a growing imposition of an ideal of the hyperpositive, permanently productive, efficient, adaptable and focused subject. In this context, a culture of high performance prevails, in which there is no legitimate space for the expression of subjective negativity. Feelings such as boredom, anguish, frustration, tiredness, dispersion and dissatisfaction are disqualified, becoming undesirable experiences, pathologized or quickly medicalized.

This refusal of negativity is not just an individual trait, but reveals an ideological operation that shifts the structural contradictions of society into the realm of personal responsibility. Thus, what could be recognized as a social symptom, being a sign of the tensions, symbolic violence and exhaustive demands of the neoliberal model, comes to be interpreted as individual failure, personal deficit or inability to adapt. This mechanism not only produces psychic suffering, but also reinforces the devices of control and self-demand, making it difficult to critically elaborate one's own condition of existence.

The psychological mechanism of refusing unpleasant memories is mobilized in order to serve practical goals. In order for the image of progress proclaimed by society to be sustained in order to maintain a certain social cohesion with the intended ends, the memory of past barbarism must be blurred, so "erasing the memory would be much more a result of vigilant consciousness than a result of the weakness of consciousness in the face of the superiority of unconscious processes" (ADORNO, 1995, p. 34).

According to Matos (1989), also in dialogue with Adorno, if history is a massacre, because it is kept in a flow of time that carries oblivion and imposes violence on life, memory is the possibility of redemption, in the preservation of what should not be forgiven without first being overcome. Remembering, not forgetting, are a pause in the course of compulsive time and make room for the possibility of elaboration.

It is in this sense that Adorno (1996) indicates that the rhythm of production and reproduction of an alienating reality is maintained by the domination of memory, a process in which the constant response to the new is requested, only recognized as new by forgetting what has already been. Social forms already experienced as tragic are repeated under the appearance of circumstantiality, acting as repetitions of oppressive orders against the manifestations of still resistant individualities.

The call to adapt to a reality that in no way innovates its oppressive structure is operated by the mechanism of maintaining oblivion, ensuring that every manifestation of malaise or dissatisfaction is co-opted into the effort to remain competitive, waiting for a moment of recognition and fulfillment. This is due to the fact that, as Horkheimer and Adorno (1973) indicate, the logic of the culture industry anesthetizes desire, a component that drives the movement of transformation of reality to satisfy human interests, repeatedly exposing objects destined to the satisfaction of pleasure, already mutilated by the renunciation imposed by society, to mechanical reproduction.

The desire that resists repression is mobilized, framing it with the possibility of satisfaction that does not threaten the reproduction of the social whole. The search for pleasure, which could lead to the production of the new by guiding the paths of reason, as indicated by Adorno (2015), is brought back to the starting point, to the need for progression of value. Subjectivity is standardized, thus keeping individuals under the same controlling hand.

The need to remain referred to the past is imposed as long as the conditions that produce dehumanization still persist and, therefore, remain active (ADORNO, 1996). This

understanding resizes the relationship that must be established between the foundation and what results from it and what is the place of memory in the vital process of production and reproduction of human reality.

5 THE CRITICAL POTENTIAL OF NON-FORGETTING

The repression of negativity is not limited to a theoretical abstraction, but materializes in a forceful way in the social and institutional practices that cross childhood, mental health, education and the construction of subjectivity. Contemporary culture, instead of recognizing negativity as a constitutive dimension of human experience, seeks to neutralize it, pathologize it, or convert it into a commodity, offering quick, productive, and consumable solutions. The individual survives himself. But in its residue, in what is condemned by history, there is still something that resists false identity. Its function lies in the absence of functionality: it is the spirit that, contradicting the general, represents it.

The truth capable of clarifying the problem of semi-formation is glimpsed through the sufferings inflicted on the individual by the totalitarian system to which he belongs, but without being completely integrated and still being able to distance himself, even if by dysfunction. If the movement of the social whole is ordered to the progress of the forces that have taken the centrality of the process, and that are sustained by that erasure of what indicates its untruth, it is that which does not fit into the entire utility, so totalitarianly calculated by the scientific progress represented in the positivist strands, that preserves the idea, materially oriented, of the individual who wants to be realized.

The memory of pain and the refusal of forgetting, which configure the melancholic state, offers the critical reference in relation to the existent and prevents attempts to anesthetize consciousness by a system that wants to cover its irrational functioning with meaning. Because there is no intrinsic end to the movement of history, it is necessary to constantly exercise criticism and to base this movement on what is capable of unfolding in the affirmation of freedom, choosing as an orientation the overcoming of unnecessary violence, against its appropriation by tendencies to barbarism.

As Adorno (1993) indicates, thought is nourished by impulses and the rational ordering of existence is nourished by the individual's instinctual satisfaction. This is negated by a rationality that excludes the drive as a guide of the human historical path, an exclusion declared as an act of cunning and that hides a trail of domination that has not yet been overcome. The body, a historical representative in the place of the individual, brings in its

limitations to pleasure and consciousness, the marks of this process (TIBURI, 2004). Melancholy, as a look at this marked body, presents itself as a denial of a rationality that is not able to realize human freedom, resisting as a knowledge that recognizes the contradiction in which the individual finds himself.

In a direction contrary to what is imposed by the cultural industry, which operates by confining the spirit and the senses, it is the possibility of sensitizing thought, putting it in contact with its limits, that allows the truth to manifest itself, announcing the falsity of reality and its moments of contradiction, in which the potential for social transformation is found.

6 FINAL CONSIDERATIONS

From the above, what we have is that in the process of historical constitution of human reality, external and internal, possibilities of differentiation and expansion of this reality are objectified at the same time that the undifferentiated is maintained, the imposition of the always same, which is not surpassed, is updated as a determinant in the progress of historical forces, guided by the maintenance of particular interests opposed to the truly universal. And since truth is what is contained in happiness, truth is what is directed towards overcoming suffering (HORKHEIMER; ADORNO, 1985).

If for the process of formation of the human constitution to be effective it is necessary that human action in the world and the organization of this world be guided by the principles of freedom and human autonomy, the rational ordering of reality for the satisfaction of truly human needs remains historically as a promise not yet fulfilled, as what humanity still has to accomplish.

It is the tendency to weaken the consciousness of historical continuity that is one of the main elements that contribute to the maintenance of humanity in a state of barbarism (ADORNO, 1995). These tendencies are dictated by a social organization that values economic development and submits the existing to the laws of exchange which, emptied of its historical and human content, serves to calculate the equivalent and the attribution of value as a commodity. This emptying erases the human historical form, naturalizing suffering and distancing humanity from the possibility of achieving emancipation.

According to Adorno (1996), due to the predominance of technique and its reproducibility, it operates in the destruction of memory, which takes with it the accumulated experience that would serve the training. The experience, which is also a movement of transformation of the subject in contact with the object, is replaced by access to punctual,

disconnected and ephemeral information, maintaining the fragmentation of the individual that is only constituted as a unit in the dialectic of differentiation and continuity between whole and part. And as Benjamin (2012) reminds us, the remembrance of the past takes place from the identification of the present danger, which seeks in the ruins traces of a diversity that could be elevated in the movement of progress. Gagnebin (2006), in dialogue with Benjamin and Adorno, emphasizes that it is the non-forgetting in its relationship with the presence of what no longer exists that can illuminate what sustains the semi-formation of the individual and the possibility of elaborating the conditionings that fall on the instances of social mediation.

Historically articulating the past is due less to an attempt to describe facts, intended by positivist science, than to thinking about the bases on which present facts are founded, in an ethical-political pretension to oppose the tendency to forget and to justify objective violence in the face of the call to adaptation and productivity. The evocation of memory occurs from the tension between the presence of a fragile present and the absence of a vanished past, which weakens the continuity and transmission of human tradition and its possibility of transformation by generations (GAGNEBIN, 2006). Non-forgetfulness keeps present what still needs to be elaborated and, once the one who looks at the past can clarify it with the marks of present pain, the suffering that drags on and must be overcome is illuminated, overcoming the conditions that sustain it in an effort to understand and clarify.

As indicated by Adorno (1996), the possibilities of facing the conditions that maintain barbarism are found in the recognition of a social whole and of particularities, of objective and subjective traits, which have historically been constituted by non-human ends – since, "[...] the only possibility of survival left to culture is critical self-reflection on the semi-formation that it has necessarily become" (p. 410). To this end, it is understood that the effort to bring to light the falsification of the relationship between individual and society is what guides the work of critical reflection, which thinks about the individual and his subjectivity in an effort to reach the determination of the whole, an instance in which the problem to be overcome is truly found.

Rescuing the tension between a movement of oppression and the movement of a life that is not completely paralyzed and identified as all inhuman, at the same time that the melancholic state manifests the impediments imposed on the individual, due to the paralysis of the drive, resistance is situated in looking at the trail left by the progress of domination that leaves behind a certain idea of humanity. In this way, the non-forgetfulness assumed in

melancholy keeps present what still needs to be elaborated, since it is still a cause of suffering. The suffering that drags on and that must be overcome by the transformation of the conditions that sustain it is illuminated, reaffirming the historical character of reality in an ethical-political commitment to oppose the justification of the various forms of violence in the name of the force of the call to adaptation and productivity that maintains the inversion of means and ends and the predominance of economic development that does not correspond to the achievement of human freedom.

It is from this critical model that the criticism of a reality distant from the possibility of offering the conditions for the formation of the individual is built, and the main point of these elaborations is the issue that, since the process of formation is oriented and carried out historically, it is necessary to know the conditions in which humanity finds itself and what sustains them, so that some overcoming is achievable. Given that it is only possible to elaborate the past that caused violence and suffering when the conditions that led to a certain event have been overcome, and one no longer has to experience the return of old threats, it is necessary, then, a certain amount of fixation to what has not yet been overcome, resistance that finds some of its traces in melancholy.

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**BETWEEN ESG DISCOURSE AND ACCOUNTING PRACTICE: DIVERGENCES
IN THE MEASUREMENT OF CARBON CREDITS IN THE BRAZILIAN ENERGY
SECTOR**

**ENTRE O DISCURSO ESG E A PRÁTICA CONTÁBIL: DIVERGÊNCIAS NA
MENSURAÇÃO DE CRÉDITOS DE CARBONO NO SETOR ENERGÉTICO
BRASILEIRO**

**ENTRE EL DISCURSO ESG Y LA PRÁCTICA CONTABLE: DIVERGENCIAS EN
LA MEDICIÓN DE CRÉDITOS DE CARBONO EN EL SECTOR ENERGÉTICO
BRASILEÑO**

 <https://doi.org/10.56238/sevened2025.036-095>

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ABSTRACT

The rapid institutionalization of ESG (Environmental, Social and Governance) discourse has reshaped corporate narratives worldwide. *This investigation is justified by the increasing discrepancy between publicly declared climate commitments and the effectiveness of the accounting metrics that should substantiate them, especially in sectors with high socio-environmental materiality.* However, its widespread adoption has been accompanied by critiques pointing to symbolic practices disconnected from effective environmental measurement and accountability. This article investigates the divergences between discourse and practice in the accounting of carbon credits by energy companies listed on Brazil's B3 stock exchange. Using a qualitative and documentary approach, the study analyzed financial statements, explanatory notes and ESG reports from 18 firms in the oil, gas and biofuels sectors. Only four of them (Raízen S.A., Refinaria de Petróleo Riograndense S.A., Ultrapar Participações S.A. and Vibra Energia S.A.) effectively recognize and disclose carbon credits, mostly as intangible assets and regulatory provisions linked to RenovaBio, in partial compliance with OCPC 10, CVM 223/2024 and CTG 10. The findings reveal substantial gaps between ESG commitments and actual accounting transparency, evidencing a pattern of performative ESG and reinforcing greenwashing risks. The article contributes by highlighting governance weaknesses in Brazil's energy sector and discussing the potential and limitations of environmental accounting as an instrument of climate accountability amid global crisis.

Keywords: ESG. Environmental Accounting. Carbon Credits. Governance. Brazil.

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RESUMO

A crescente institucionalização do discurso ESG (Environmental, Social and Governance) consolidou um novo regime narrativo nas corporações contemporâneas. *Justifica-se esta investigação diante da crescente discrepância entre compromissos climáticos declarados e a efetividade das métricas contábeis que deveriam sustentá-los, sobretudo em setores de alta materialidade socioambiental.* Contudo, sua adoção massiva tem sido acompanhada por críticas que apontam a predominância de práticas simbólicas, desconectadas de processos efetivos de mensuração e responsabilização ambiental. Este artigo investiga as divergências entre narrativa e prática no contexto da contabilização dos créditos de carbono por empresas do setor energético brasileiro listadas na B3. A pesquisa, de abordagem qualitativa e documental, analisou demonstrações financeiras, notas explicativas e relatórios ESG de 18 companhias dos segmentos de petróleo, gás e biocombustíveis. Observou-se que apenas quatro delas (Raízen S.A., Refinaria de Petróleo Riograndense S.A., Ultrapar Participações S.A. e Vibra Energia S.A.) reconhecem e divulgam contabilmente seus créditos de carbono, majoritariamente como ativos intangíveis e provisões regulatórias derivadas do RenovaBio, em conformidade parcial com a OCPC 10, CVM 223/2024 e CTG 10. A análise revela discrepâncias significativas entre compromissos ESG declarados e transparência contábil efetiva, caracterizando um padrão de ESG performativo e reforçando riscos de greenwashing. O estudo contribui ao evidenciar fragilidades de governança climática no setor energético brasileiro e discutir os limites e possibilidades da contabilidade ambiental como instrumento de accountability em cenários de crise climática.

Palavras-chave: ESG. Contabilidade Ambiental. Créditos de Carbono. Governança. Brasil.

RESUMEN

La creciente institucionalización del discurso ESG (Environmental, Social and Governance) ha consolidado un nuevo régimen narrativo en las corporaciones contemporáneas. *Esta investigación se justifica debido a la creciente discrepancia entre los compromisos climáticos declarados y la efectividad de las métricas contables que deberían sustentarlos, particularmente en sectores de alta materialidad socioambiental.* Sin embargo, su adopción masiva ha venido acompañada de críticas que señalan la predominancia de prácticas simbólicas, desconectadas de procesos efectivos de medición y de responsabilización ambiental. Este artículo investiga las divergencias entre narrativa y práctica en el contexto de la contabilización de los créditos de carbono por parte de empresas del sector energético brasileño listadas en la B3. La investigación, de enfoque cualitativo y documental, analizó estados financieros, notas explicativas e informes ESG de 18 compañías de los segmentos de petróleo, gas y biocombustibles. Se observó que solo cuatro de ellas (Raízen S.A., Refinaria de Petróleo Riograndense S.A., Ultrapar Participações S.A. y Vibra Energia S.A.) reconocen y divulgan contablemente sus créditos de carbono, en su mayoría como activos intangibles y provisiones regulatorias derivadas del RenovaBio, en conformidad parcial con la OCPC 10, la Resolución CVM 223/2024 y la CTG 10. El análisis revela discrepancias significativas entre los compromisos ESG declarados y la transparencia contable efectiva, caracterizando un patrón de ESG performativo y reforzando riesgos de greenwashing. El estudio contribuye al evidenciar fragilidades en la gobernanza climática del sector energético brasileño y a discutir los límites y posibilidades de la contabilidad ambiental como instrumento de accountability en escenarios de crisis climática.

Palabras clave: ESG. Contabilidad Ambiental. Créditos de Carbono. Gobernanza. Brasil.

1 INTRODUCTION

The global climate agenda has irreversibly reconfigured the expectations of transparency and socio-environmental responsibility on the part of organizations. Based on the reports of the Intergovernmental Panel on Climate Change (IPCC, 2023), the expansion of climate disclosure instruments, understood as the process of structured, transparent, and standardized disclosure of relevant information, especially those related to environmental risks, impacts, and strategies (TCFD, 2017), and the consolidation of international sustainability standards (ISSB/IFRS S1–S2), corporate practices began to be analyzed by multiple based on criteria that go beyond the economic and financial dimension.

In this scenario, accounting is no longer just the "language of business", in the terms of Ludícibus (2021), to become the language of socio-environmental legitimacy, operating as an instrument of mediation between environmental impacts and public accountability. Such a transformation reflects the thesis of Gray, Bebbington and Larrinaga (2009), according to which accounting is simultaneously technical and political, as it organizes symbols, produces narratives and selects what will be visible and invisible in the public sphere.

The ESG discourse has become hegemonic, being adopted by corporations as an indispensable communication strategy to attract investors, access markets, and signal climate compliance (Kotsantonis, Pinney, & Serafeim, 2016). However, Tariq Fancy (2021), former director of sustainability at BlackRock, argues that most ESG practices do not substantially change the environmental behavior of companies, operating as a "financial placebo" that masks the maintenance of destructive economic models.

In Brazil, the energy sector, especially oil, gas and biofuels, occupies a central position in national greenhouse gas (GHG) emissions, having the technical and financial capacity to mitigate impacts, but also strong reputational exposure. The country has recently structured essential regulatory frameworks, such as CVM Resolution 223/2024, CTG 10, and OCPC 10, which finally standardize the accounting treatment of carbon credits. Still, a gap persists between the ESG narrative and effective accounting measurement, indicating low adherence to transparency requirements. The question that guides this article is: How do companies in the Brazilian energy sector measure, record and disclose carbon credits, and what divergences emerge between ESG discourse and accounting practice?

The general objective is to critically analyze the methodologies, evidence, and accounting omissions related to carbon credits in energy companies listed on B3. The specific objectives involve: identifying companies that effectively evidence carbon credits; assess

their adherence to newly established standards; investigate the relationship between ESG discourse and accounting practice; and discuss implications for governance and greenwashing risks.

The relevance of the study lies in the climate urgency, regulatory pressures, and the need for robust accountability mechanisms. Environmental accounting plays a strategic role in making environmental externalities visible, contributing to reducing informational asymmetries and strengthening climate governance.

2 THEORETICAL FRAMEWORK

The theoretical framework that underlies this study articulates contributions from environmental accounting, ESG critical literature, debates on climate governance, and recent discussions about the integrity of carbon markets. These perspectives provide a solid foundation for understanding how measurement, recognition, and disclosure practices relate to institutional pressures, reputational risks, and regulatory frameworks. The main conceptual axes that support the analysis are presented below.

2.1 ENVIRONMENTAL ACCOUNTING AND IMPACT VISIBILITY

Environmental accounting emerges as an attempt to incorporate information into accounting systems that, for long periods, have been treated as invisible externalities. Gray, Owen and Adams (2014) observe that traditional financial accounting tends to prioritize monetary indicators, relegating relevant socio-environmental impacts to the background and thus contributing to the maintenance of unsustainable economic structures.

This limitation is partially mitigated by the expansion of environmental accounting, which, according to Ribeiro (2021), expands the ability of organizations to measure environmental costs, investments, liabilities, and revenues, offering instruments capable of making their interactions with the environment more transparent. Along these lines, Tinoco and Kraemer (2011) emphasize the need for rigor in the recognition of environmental obligations. The authors state that,

With reference to the recording, recognition and disclosure of environmental provisions in the financial statements, it should be mentioned that the vast majority of legislation [...] only allow the corresponding recording when compensation resulting from damage caused to the environment is paid, or when there is strong evidence of damage that will have to be compensated or indemnified (Tinoco; Kraemer, 2011, p. 145).

Such a perspective highlights the mismatch between the social demand for transparency and the normative requirements for accounting recognition, making it difficult to timely socio-environmental information. The consolidation of instruments such as Integrated Reporting, TCFD and the new IFRS S1/S2 standards reinforces the global trend of integrating financial and non-financial performance, expanding the importance of social and environmental disclosure as a governance instrument.

2.2 ESG, CLIMATE GOVERNANCE AND THE CRITIQUE OF THE PERFORMATIVE

The rise of ESG has consolidated a global language of corporate governance, incorporated by companies, investors, and multilateral organizations. Kotsantonis, Pinney, and Serafeim (2016) highlight that ESG factors influence long-term performance, affecting risk, return, and cost of capital, which justifies its growing institutionalization.

However, recent literature points out that a large part of these practices are made up of performative mechanisms, more associated with strategic communication than with material changes in the productive structure. Tariq Fancy (2021), a former BlackRock executive, criticizes the superficiality of corporate climate initiatives, stating that they often behave as symbolic instruments that do little to alter emissions-intensive business models.

Larcker and Watts (2020) reinforce this argument by highlighting methodological inconsistencies and the absence of solid metrics for ESG assessment, which increases the margin for arbitrariness. This critique echoes the notion of climate governance presented by Schaltegger and Burritt (2017), for whom measurement, verification, and accountability processes should be integrated into the decision-making process and not just used as reputational tools.

2.3 CARBON MARKET, CBIOS AND INTEGRITY ISSUES

The global carbon market is worth billions of dollars, but faces criticism about its structural integrity, especially in the voluntary market, where problems of additionality, double counting, and methodological fragility are recurrent (ICVCM, 2023).

The *Integrity Council for the Voluntary Carbon Market* (ICVCM) is an independent international body created to establish minimum quality standards in this market. In 2023, the Council published the *Core Carbon Principles* (CCPs), a set of criteria that determines that voluntary credits must represent real, additional, and verifiable reductions or removals of greenhouse gases, ensuring traceability, independent verification, and socio-environmental

safeguards. The ICVCM's work seeks to correct historical failures in the voluntary market, increasing its credibility and mitigating *greenwashing risks*.

In Brazil, RenovaBio is the main regulatory framework for issuing and trading Decarbonization Credits (CBIOs), which are linked to energy efficiency and the carbon intensity of biofuels. Law No. 15,042/2024 and CVM Resolution 223/2024 established mandatory criteria for accounting for these assets, operationalized by OCPC 10 and CTG 10, which classify agents as originators, intermediaries or end users.

Despite regulatory advances, sectoral adoption remains heterogeneous. Companies in the energy sector differ in terms of the level of methodological detail, the internalization of standards, and the degree of maturity in the measurement and disclosure of carbon credits, revealing governance weaknesses and inconsistencies in the quality of *disclosure*.

2.4 BRAZILIAN ENERGY SECTOR: LEGITIMACY, RISK AND SOCIAL PRESSURE

Companies in the energy sector, especially oil companies, occupy a strategic position in greenhouse gas emissions and face growing pressure from regulatory bodies, investors and civil society. Lins (2015) points out that organizations with high environmental impact tend to use socio-environmental communications as legitimization strategies in the face of public questioning. According to the author, "companies with high environmental impact resort to socio-environmental communication as a mechanism of symbolic legitimation in the face of growing external pressures" (Lins, 2015, p. 7).

This process reveals a tension between discourse and practice, especially in Brazil, where energy companies are simultaneously protagonists of climate discussions and as agents with heterogeneous standards of governance and transparency. Thus, they become central elements in the analysis of disclosure quality, reputational risks, environmental performance, and *climate accountability*.

3 METHODOLOGY

The research adopts a qualitative approach, of exploratory nature and critical-interpretative orientation. The documentary method was chosen because it allows the analysis of materials produced by the companies themselves, such as financial statements, explanatory notes, reference forms and ESG reports.

18 companies in the energy sector listed on B3 were examined, covering the oil, gas and biofuels segments. The time frame considered the fiscal years 2023 and 2024, a period

marked by the consolidation of new regulatory frameworks for the accounting of carbon credits in Brazil.

The content analysis was structured in five categories: (i) existence of accounting records of carbon credits or CBIOS; (ii) the account classification adopted; (iii) adherence to applicable rules (OCPC 10, CTG 10 and CVM Resolution 223/2024); (iv) consistency between environmental information disclosed in ESG reports and that evidenced in the financial statements; and (v) evidence of performative ESG or practices potentially characterized as *greenwashing*.

The main limitation of the study stems from the unavailability of the internal assumptions used by companies to measure and value carbon credits, which requires interpretations based only on the *available public* disclosures.

4 RESULTS AND DISCUSSIONS

The analysis of the collected data allowed us to identify patterns, asymmetries and inconsistencies in the way companies in the Brazilian energy sector recognize, measure and disclose carbon credits. The results show a significant mismatch between declared climate commitments and accounting practices effectively adopted, revealing governance weaknesses, *greenwashing* risks, and low regulatory maturity. The main findings of the study are presented below.

4.1 OVERVIEW OF THE 18 COMPANIES ANALYZED

Among the 18 companies analyzed, 14 do not have any accounting records of carbon credits, despite many disclosing climate goals and decarbonization commitments. This discrepancy reinforces Gray's (2006) thesis on "accounting silences", according to which the absence of registration also communicates, and communicates risk, opacity and discursive inconsistency. To summarize this scenario, chart 1 is presented below with the distribution of the results found.

Table 1

Disclosure of Carbon Credits by Companies in the Energy Sector (B3 – 2023/2024)

Category analyzed	Companies (n=18)	Percentage	Observations
Companies that recognize carbon credits	4	22%	Partial registration, with methodological weaknesses.

Companies that do not register at all	14	78%	Strong inconsistency between ESG discourse and accounting practice.
Most Used Account Assignment	Intangible	–	Mainly CBIOs linked to RenovaBio.
Full adherence to standards (OCPC 10, CTG 10, CVM 223/2024)	0	0%	No company fully meets all the requirements.
Inconsistencies between ESG and DF reporting	7	39%	Gaps between narratives and accounting evidence.
Evidence of performative ESG/greenwashing	12	67%	Companies declare commitments, but do not record environmental credits, liabilities or provisions.

Source: Prepared by the authors (2025).

The table reinforces that the absence of accounting recognition is the dominant pattern, and not the exception. Such a scenario suggests low integration between disclosed climate strategies and the formal systems of measurement, registration and *disclosure*.

4.2 THE FOUR COMPANIES THAT REGISTER CARBON CREDITS

Of the 18 companies analyzed, only four recognize carbon credits in their statements. The **Raízen S.A.** has the most consistent disclosure, with registration of CBIOs as intangible assets and provisions associated with RenovaBio. The **Riograndense Refinery** acknowledges credits, but with excessively synthetic explanatory notes, which compromises the verifiability of the information. The **Ultrapar** it highlights climate credits and obligations, but presents inconsistencies between the ESG report and the financial statements. The **Vibra Energy** partially complies with the applicable standards, but does not detail the criteria used for measurement or the assumptions of fair value (*Fair value*), defined by IAS 46/IFRS 13 as the price that would be received for the sale of an asset or paid for the transfer of a liability in an orderly transaction between market participants. The absence of this information compromises transparency and prevents the evaluation of the adequacy of the measurement carried out. Even among the companies that perform accounting records, methodological weaknesses and low standardization are observed.

4.3 DIVERGENCES BETWEEN DISCOURSE AND PRACTICE: PERFORMATIVE ESG

The most evident contradiction emerges when companies affirm climate neutrality, emission reduction targets, and broad commitments, but do not record environmental credits, provisions, or liabilities. Such a scenario is close to the concept of **performative ESG**, in which institutional communication becomes more relevant than materially implemented practices. Chart 2 is presented below with a comparison that summarizes these divergences.

Table 2

Main Divergences between ESG Discourse and Accounting Practice (Energy Sector - B3)

Dimension	Evidence in the ESG discourse	Evidence in Financial Statements	Interpretation
Climate neutrality	Widely stated <i>net-zero</i> targets	Absence of accruals and recorded credits	Risk of <i>greenwashing</i>
Reducing emissions	Strategic plans and public commitments	There is no auditable measurement methodology	Performative ESG
Carbon market	Declared voluntary participation	Lack of registration, measurement and fair value	Low accounting maturity
Climate governance	Committees, policies, and comprehensive reporting	Inconsistency between DF and ESG reporting	Governance integration failures
Transparency	Extensive annual reports	Significant accounting gaps	Informational asymmetry

Source: Prepared by the authors (2025).

4.4 IMPLICATIONS FOR GOVERNANCE, RISK AND PUBLIC POLICIES

The *identified disclosure* gaps compromise:

- comparability between companies;
- the efficient functioning of the regulated carbon market;
- the reliability of climate risk analyses;
- the verification of future environmental obligations;
- the integrity of neutrality commitments;
- the relationship of transparency with stakeholders.

The energy sector, given its strategic position in the national emissions inventory, should lead the adoption of consistent accounting measurement and climate disclosure practices. However, the results point to regulatory delay, low standardization, and weaknesses in climate governance.

5 CONCLUSION

The analysis shows that the ESG narrative in the Brazilian energy sector remains far from effectively consistent accounting practices. Among the 18 companies analyzed, only four recognize carbon credits in their statements, and even these have methodological limitations, insufficient detail, and absence of clear measurement assumptions. The scenario confirms the persistence of accounting silences, informational opacities, and evident tensions between discourse and practice, configuring an environment conducive to performative ESG and the risk of structural *greenwashing*.

The regulatory progress represented by CVM Resolution 223/2024, CTG 10 and OCPC 10 is an important milestone, but still insufficient to consolidate robust standards for climate measurement and disclosure. Without effective enforcement, compulsory standardization, methodological transparency, and integration between corporate governance and environmental accounting, a superficial adoption of ESG tends to prevail, used as a reputational tool rather than as an instrument of social and environmental accountability (*accountability*).

The contributions of this study focus on demonstrating:

- (i) the gaps in environmental disclosure in the energy sector;
- (ii) the inconsistencies between ESG narratives and accounting records;
- (iii) the need to improve the practices of measurement and recognition of carbon credits;
- (iv) the urgency of more coercive public policies and regulations to avoid arbitrariness and informational asymmetries.

Future research can deepen longitudinal analyses, assess the financial impacts of climate disclosure, investigate correlations between disclosure and socio-environmental risk, and promote international comparisons that allow us to understand Brazil's position in the face of the best global practices in climate governance.

In summary, strengthening environmental accounting as an instrument of visibility, control, and *accountability* is an indispensable condition for ESG to go beyond the discursive field and achieve effectiveness in the transition to sustainable production models.

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**STUDY OF THE FREQUENCY RESPONSE OF CONCRETE SPECIMENS IN
DIFFERENT STRENGTH CLASSES****ESTUDO DA RESPOSTA EM FREQUÊNCIA DE CORPOS DE PROVA DE
CONCRETO EM DIFERENTES CLASSES DE RESISTÊNCIA****ESTUDIO DE LA RESPUESTA EN FRECUENCIA DE MUESTRAS DE
HORMIGÓN EN DIFERENTES CLASES DE RESISTENCIA** <https://doi.org/10.56238/sevened2025.036-096>**Cássio Humberto Lima¹****ABSTRACT**

Concrete, being a heterogeneous composite material sensitive to the proportions of its constituents, exhibits significant variations in its mechanical and dynamic behavior. This study analyzed the vibrational behavior of concrete specimens with four compressive strength classes (15, 20, 25, and 30 MPa) through experimental modal analysis and determination of Frequency Response Functions (FRF). For each class, 10 specimens were molded in plywood forms using Portland cement CP II, quartz sand, granite aggregate, and water in specific volumetric proportions, followed by curing for 28 days. Impulsive excitation was applied with an instrumented hammer, and acceleration responses were acquired using a dedicated acquisition system in the 0 to 2560 Hz range, with evaluation of the coherence between excitation and response for FRF validation. The curves obtained showed a systematic shift of resonance peaks to higher frequencies as compressive strength increases, in addition to more stable spectral responses in the higher classes, highlighting the strong correlation between dynamic stiffness and mechanical strength. The methodology employed confirmed the potential of modal analysis as a sensitive non-destructive technique for characterizing the vibrational response of concrete, providing relevant information for applications in quality control and evaluation of structures subjected to dynamic actions.

Keywords: Frequency Response. Experimental Modal Analysis. Concrete. Dynamic Properties. Strength Classes.

RESUMO

O concreto, por ser um material compósito heterogêneo e sensível às proporções de seus constituintes, apresenta variações significativas em seu comportamento mecânico e dinâmico. Este estudo analisou o comportamento vibracional de corpos de prova de concreto com quatro classes de resistência à compressão (15, 20, 25 e 30 MPa) por meio de análise modal experimental e determinação das Funções de Resposta em Frequência (FRF). Para cada classe foram moldados 10 corpos de prova em formas de madeirite, utilizando cimento Portland CP II, areia quartzosa, brita granítica e água em proporções volumétricas específicas, seguidos de cura por 28 dias. A excitação impulsiva foi aplicada com martelo instrumentado, e as respostas de aceleração foram adquiridas em sistema de aquisição dedicado, na faixa de 0 a 2560 Hz, com avaliação da coerência entre excitação e resposta para validação das FRF. As curvas obtidas mostraram deslocamento sistemático dos picos

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de ressonância para frequências mais elevadas à medida que a resistência à compressão aumenta, além de respostas espectrais mais estáveis nas classes superiores, evidenciando a forte correlação entre rigidez dinâmica e resistência mecânica. A metodologia empregada confirmou o potencial da análise modal como técnica não destrutiva sensível para caracterização da resposta vibracional do concreto, fornecendo subsídios relevantes para aplicações em controle de qualidade e avaliação de estruturas sujeitas a ações dinâmicas.

Palavras-chave: Resposta em Frequência. Análise Modal Experimental. Concreto. Propriedades Dinâmicas. Classes de Resistência.

RESUMEN

El hormigón, al ser un material compuesto heterogéneo sensible a las proporciones de sus componentes, presenta variaciones significativas en su comportamiento mecánico y dinámico. Este estudio analizó el comportamiento vibracional de probetas de hormigón con cuatro clases de resistencia a la compresión (15, 20, 25 y 30 MPa) mediante análisis modal experimental y la determinación de las Funciones de Respuesta en Frecuencia (FRF). Para cada clase, se moldearon 10 probetas en encofrados de madera contrachapada utilizando cemento Portland CP II, arena de cuarzo, árido granítico y agua en proporciones volumétricas específicas, tras lo cual se dejó curar durante 28 días. Se aplicó excitación impulsiva con un martillo instrumentado y se adquirieron las respuestas de aceleración mediante un sistema de adquisición específico en el rango de 0 a 2560 Hz, evaluando la coherencia entre la excitación y la respuesta para la validación de la FRF. Las curvas obtenidas mostraron un desplazamiento sistemático de los picos de resonancia a frecuencias más altas a medida que aumenta la resistencia a la compresión, además de respuestas espectrales más estables en las clases más altas, lo que destaca la fuerte correlación entre la rigidez dinámica y la resistencia mecánica. La metodología empleada confirmó el potencial del análisis modal como técnica sensible y no destructiva para caracterizar la respuesta vibracional del hormigón, proporcionando información relevante para aplicaciones en el control de calidad y la evaluación de estructuras sometidas a acciones dinámicas.

Palabras clave: Respuesta en Frecuencia. Análisis Modal Experimental. Hormigón. Propiedades Dinámicas. Clases de Resistencia.

1 INTRODUCTION

Concrete is one of the most widely used structural materials in the world due to its versatility, durability, and ease of molding. Its application is widely disseminated in infrastructure works, buildings, paving and precast elements. However, as it is a heterogeneous composite material, its mechanical and dynamic response depends directly on the composition, the proportion of the aggregates, the quality of the cement pulp, and the curing process (SEGALIN et al., 2020). Among its fundamental properties, compressive strength is the most used for structural classification and design, serving as a reference for the overall performance of the material (NEGRI et al., 2024). However, properties related to dynamic behavior, such as natural frequencies, vibration modes, and damping, also play a significant role in situations where concrete is subject to dynamic actions, such as traffic, wind, industrial vibrations, and impacts.

Experimental modal analysis (AME) is a well-established technique for the characterization of the dynamic properties of materials and structural systems. It allows the determination of natural frequencies, vibration modes, and damping factors from data obtained through mechanical excitation and response measured by appropriate sensors (Rosa et al., 2016). The Frequency Response Function (FRF), which relates the structural response to an applied excitation, is one of the main tools in the identification of these properties. For cementitious materials, FRF has been used to assess structural integrity, identify damage, investigate stiffness differentiations, and understand how variations in concrete composition influence its dynamic behavior (MAGALHÃES et al., 2024).

The heterogeneity of concrete implies that small changes in the proportion of aggregates, water content, type of cement or additives can significantly modify its overall stiffness, directly reflecting on the vibrational response. Studies show that lower strength concretes have lower natural frequencies due to their lower stiffness, while higher strength concretes tend to exhibit vibration modes in higher ranges (ALMEIDA et al., 2012). This relationship between mechanical strength and dynamic behavior is fundamental, especially in non-destructive techniques, where the frequency response allows inferring internal properties without causing damage to the material.

In addition, the application of dynamic methods for the evaluation of cementitious materials has gained relevance in the context of *Structural Health Monitoring* (SHM). Techniques based on modal analysis allow the identification of subtle variations in the internal structure of materials, being able to detect early damage, microcracking, or progressive

degradation (HU et al., 2018). Within this scope, the study of FRFs of specimens with different resistance classes provides important subsidies to understand how dynamic properties are affected by variations in the dosing process and how such information can be used in the monitoring of real structural elements.

The use of dynamic testing is also encouraged by its non-destructive nature and high sensitivity to stiffness variations. While destructive tests evaluate the final properties of the material, such as compressive strength, modal analysis allows the observation of changes from the initial states of damage, making it a promising technique for monitoring throughout the useful life of the structure. Thus, understanding how different strength classes respond in dynamic terms contributes not only to academic purposes, but to practical applications in technological control, structural inspections, and the development of concretes with specific dynamic performance.

In the experimental context, obtaining FRF from impulsive excitation has significant advantages, such as operational simplicity, speed of execution, and good repeatability for small specimens. Allied to this, the advancement of computational tools such as MATLAB facilitates the processing, visualization and interpretation of vibrational data. The generation of three-dimensional graphs (frequency $\times$ magnitude $\times$ sample) allows you to identify consistent patterns between resistance classes, facilitating the visualization of typical differences in stiffness and dynamic behavior.

Given this scenario, it is relevant to understand how different resistance classes influence the frequency response of concrete. Systematic analysis of these responses provides valuable insights into the relationship between mechanical and vibrational properties, allowing for a more comprehensive characterization of the material. Thus, this study contributes to the understanding of the dynamic behavior of concrete as a function of its strength, offering a robust experimental approach that can serve as a basis for future research in structural engineering, integrity monitoring and non-destructive methods applied to cementitious materials.

2 METHODOLOGY

The methodology adopted in this study was structured to allow the dynamic characterization of concrete specimens with different classes of compressive strength, using experimental methods of modal analysis and computational processing of the signals obtained. The procedure ranged from the molding and curing of the samples to the acquisition

of data by impulsive excitation and the analysis of the FRF. The steps were performed in a standardized manner to ensure reproducibility and comparability between classes.

2.1 MOLDING OF THE SPECIMENS

The production of the specimens followed a strict protocol of molding and material control, with the objective of ensuring experimental repeatability and reducing external variables that could influence the dynamic behavior. The samples were molded in previously sanded plywood molds, cleaned and covered with commercial release agent (Vedacit®), ensuring adequate surface finish conditions and facilitating the demolding process.

Specimens belonging to the four strength classes conventionally used in structural concrete works were manufactured: 15 MPa, 20 MPa, 25 MPa and 30 MPa, totaling 10 specimens for each class, which provides sufficient statistical basis for dynamic behavior analysis.

The concrete was prepared using Portland cement composite CP II, of the CAUÊ® brand, whose chemical composition, provided by the manufacturer and presented in Table 1, consists essentially of tricalcium silicate, dicalcium silicate, calcium aluminates and ferro-aluminates, gypsum and standardized mineral additions. This characterization is fundamental, because cement mineralogy is directly related to hydration processes, the development of stiffness and, consequently, the vibrational properties of the material.

Table 1

Chemical composition of the Portland cement of class CPII used in the samples

Component	Concentration Range (%)
Tricalcium silicate	20-70
Dicalcium silicate	10-60
Calcium ferroaluminate	5-15
Calcium Sulfate	2-8
Tricalcium Aluminate	1-15
Calcium carbonate	0-10
Magnesium oxide (free)	0-6
Calcium oxide (free)	0-3

Source: From the author (2025)

The volumetric proportions of cement, quartz sand, granitic gravel and water were defined as shown in Table 2, adjusted to meet the expected resistance classes. The homogenization of the materials was carried out manually in a rigid container of 0.001 m³,

starting with the mixing of the dry components, followed by the gradual addition of water to obtain a consistency suitable for molding.

Table 2

Proportions of concrete components for compressive strength classes equivalent to 15, 20, 25 and 30MPa

Resistance Class (MPa)	Cement (m ³)	Sand (m ³)	Crushed stone (m ³)	Water (m ³)
15 MPa	0,0010	0,0025	0,0040	0,0020
20 MPa	0,0010	0,0028	0,0035	0,0023
25 MPa	0,0015	0,0023	0,0025	0,0020
30 MPa	0,0015	0,0020	0,0020	0,0020

Source: From the author (2025)

After mixing, the concrete was placed in the forms in two successive layers, each submitted to 12 blows of compaction with a metal rod, according to the classic recommendation for eliminating bubbles and obtaining good density. The final dimensions of the specimens were standardized at 0.03 m × 0.06 m × 0.40 m, which reduces variability in the moment of inertia and ensures comparability between samples.

The curing process was conducted in a protected environment for 28 days, respecting the conventional criteria for stabilization of mechanical resistance. After this period, the specimens were demolded, identified and visually inspected to confirm their physical integrity.

2.2 EXPERIMENTAL SETUP AND INSTRUMENTATION

The dynamic characterization was performed by experimental modal analysis with impulsive excitation, a widely used technique to identify the vibrational properties of systems with simple geometry and heterogeneous materials. To minimize support interference and allow the specimen to vibrate freely, each specimen was suspended by nylon wires fixed near the ends—a configuration equivalent to the "free–free" boundary conditions often employed for determining natural frequencies in test elements.

Mechanical excitation was performed with a PCB *Piezotronics* instrumented hammer model 086C03, equipped with a metal tip (sensitivity 2.417 mV/N). Vibration response was measured by a Piezotronics PCB piezoelectric accelerometer model 352C33, with a sensitivity of 98.5 mV/g, fixed at 0.06 m from the end for efficient capture of longitudinal and flexional modes.

The choice of excitation position (0.06 m from the end) and accelerometer position was set in such a way as to maximize the energy transferred to the system and allow clear identification of resonance peaks, reducing nodal effects that could impair the reading of certain modes. For each specimen, five successive impacts were performed, allowing the average of the signals to reduce random noise and increase the robustness of the obtained spectra. Between each impact, the vibration was fully dampened, avoiding overlapping transients.

2.3 SIGNAL ACQUISITION AND DIGITAL PROCESSING

The excitation and response signals were recorded by a *National Instruments* (NI) acquisition system consisting of: NI cDAQ-9174 chassis, NI 9234 dynamic acquisition modules (8 channels), and LabVIEW software, with the *Sound and Vibration library*.

The system was configured to acquire the signal in the range of 0–2560 Hz, with spectral resolution of 0.5 Hz, sufficient value to identify dominant modes and characterize the dynamics of small elements.

During the tests, the coherence between the force and acceleration signals was continuously analyzed. Assays with coherence less than 0.95 were discarded and repeated, ensuring the reliability of the spectra and the representativeness of the FRF. The determination of FRFs was performed directly in *LabVIEW* by means of the ratio between the response and excitation Fourier spectra. The processed data were exported for complementary analysis and graphical organization.

2.4 DETERMINATION AND ANALYSIS OF FREQUENCY RESPONSE FUNCTIONS (FRF)

The identification of FRF was the central step in the dynamic characterization of the specimens, allowing to quantify the relationship between the applied force and the resulting vibratory response. The FRF was obtained directly from the signals acquired by the instrumentation system, using the spectral ratio between the Fast Fourier Transform (FFT) of the acceleration and the FFT of the impact force, a procedure widely consolidated in the literature of experimental modal analysis.

The *free–free* configuration, achieved by suspending the specimens by nylon wires, provided virtually free boundary conditions, eliminating rigid constraints that could mask or displace the material's intrinsic natural frequencies. This condition favors the excitation of a

broad spectrum of vibratory modes, allowing the FRF to reveal both longitudinal and flexional modes, depending on the intensity and location of the impact.

The acquired signals were previously filtered and inspected for spectral coherence, a parameter that expresses the quality of the relationship between excitation and response. Only FRFs from impacts with coherence values close to 1.0 were considered valid, ensuring that the spectrum faithfully represented the dynamic behavior of the sample. Impacts with reduced coherence, potentially associated with environmental noise, clamping slippage or off-axis excitations, were automatically ruled out and repeated.

Once validated, the FRFs exhibited well-defined magnitude peaks, associated with the dominant natural frequencies of each specimen. These peaks represent resonance conditions, in which the energy introduced by the impact coincides with the vibration frequencies of the concrete element. The clarity of these peaks, observed even in the lower resistance classes, reflects the appropriate combination of instrumentation, repetition of the tests and geometric uniformity of the specimens.

In addition to the direct identification of natural frequencies, FRF allowed the observation of complementary characteristics of vibratory behavior, such as:

- relative amplitude of responses, associated with the dissipation capacity and rigidity of the system;
- spectral separation between classes, indicating differences in global stiffness induced by variation in mechanical strength;
- presence of secondary modes, which appear more intensely in less rigid materials;
- stability of the peaks between replications, evidencing reproducibility and sensitivity of the methodology.

The use of five consecutive impacts and subsequent spectral mean was fundamental to eliminate specific irregularities and highlight only the systematic dynamic components. This procedure resulted in smooth spectral curves, with a high signal-to-noise ratio and excellent definition of the resonance regions.

The consolidated FRFs unequivocally demonstrated that the concrete grades exhibit distinct vibrational signatures. Concretes of higher strength showed displacement of the main peaks to higher frequency ranges, reflecting greater dynamic stiffness, while concretes of lower resistance showed lower peaks and, in general, a greater number of modes within the analyzed range.

In summary, the FRF determination process adopted in this study:

- ensured high accuracy in identifying natural frequencies,
- showed robustness in the face of the intrinsic variabilities of the material,
- allowed direct comparison between classes,
- and provided solid bases for the interpretation of the vibrational differences between the types of concrete analyzed.

The final result is a set of sTable, consistent and adequate FRFs for comparative analyses between resistance classes, an essential condition for the objectives of this study.

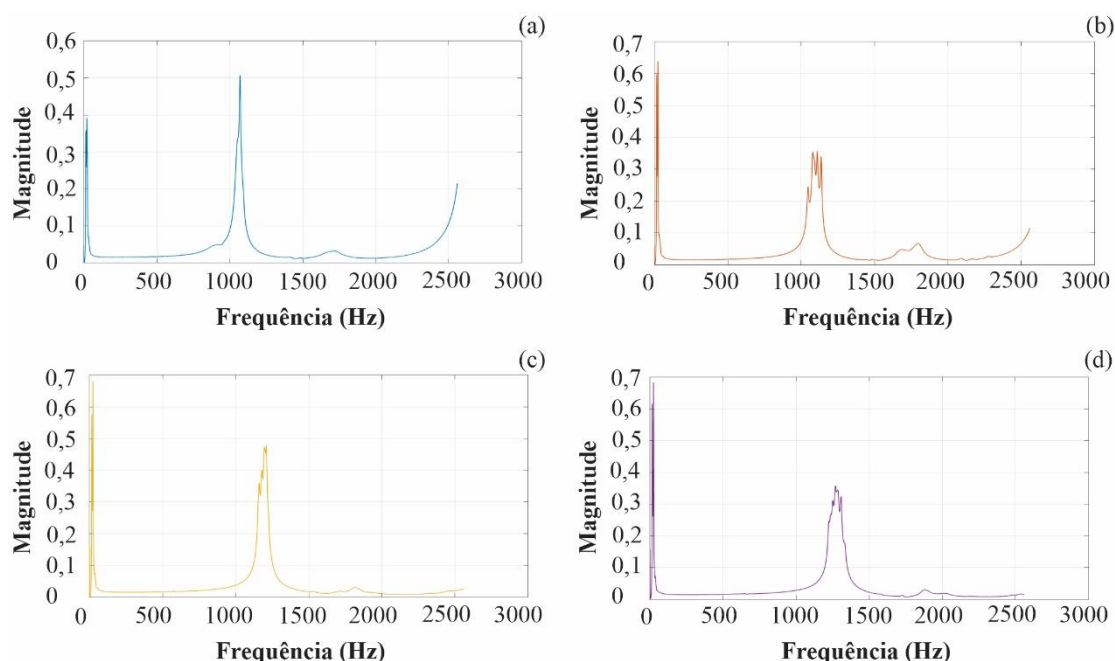
3 RESULTS AND DISCUSSION

The modal analysis performed by means of impulsive excitation allowed to obtain the Frequency Response Functions (FRF) of the concrete specimens referring to the four strength classes studied (15, 20, 25 and 30 MPa). The extracted FRFs directly reflect the vibrational behavior of each sample and make it possible to identify the predominant natural frequencies. As the experimental procedure has been standardized for all specimens, the observed differences in natural frequencies can be attributed to the intrinsic properties of each grade of concrete.

From the average of the signals obtained in five consecutive impacts, it was possible to reduce any occasional fluctuations and ensure statistical stability to the results. This procedure ensured that the FRF curves faithfully represented the dynamic behavior of the samples, highlighting the resonance frequencies clearly and consistently. The frequency by magnitude graphs, shown in Figure 1, show the curves of the four classes of concrete, showing clear differences between the materials.

Figure 1

Frequency graphs by magnitude of the dynamic responses of the specimens: (a) 15MPa (b) 20MPa (c) 25MPa (d) 30MPa



Source: From the author (2025)

In the 15 MPa samples (Figure 1a), the presence of two well-defined peaks is observed, one around 1,000 Hz and the other close to 1,500 Hz, both with high magnitudes, indicating lower rigidity and greater dynamic mobility. As the resistance class increases, FRFs start to show shifted peaks to higher frequencies and, in general, with greater sharpness and lower spectral dispersion. The 20 MPa (Figure 1b) and 25 MPa (Figure 1c) concretes show this progressive displacement, with the first peak remaining in lower ranges, but the main peak migrating to higher regions of the analyzed range. In 30 MPa concrete (Figure 1d), this trend is even more evident, with the dominant peak concentrated in a higher frequency region compared to 15 MPa concrete. This behavior confirms the direct relationship between material stiffness and increased compressive strength, reflected in the upward shift of natural frequencies.

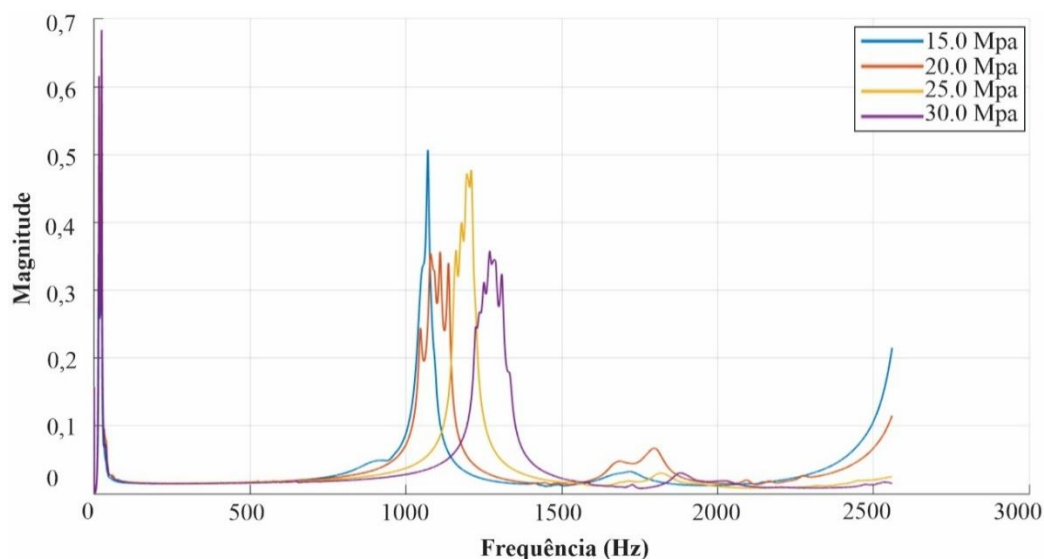
Another relevant aspect identified in the FRFs obtained is the variation in the number and definition of the vibratory modes along the analyzed range. The 15 MPa concrete presents a more "spread" response, with multiple undulations before and after the main peaks, evidencing greater flexibility and the presence of several modes of lower energy. In the higher classes, especially 25 MPa and 30 MPa, the curves become more concentrated and clean, with fewer secondary peaks and modes distributed predominantly in higher

ranges. This suggests that, in addition to increasing overall rigidity, increasing resistance reduces excitation from lower modes, resulting in more rigid vibrational behavior and more stable spectra. These patterns corroborate the direct influence of mechanical strength on the dynamics of concrete.

The superimposition of the curves in a single graph, presented in Figure 2, allows us to directly visualize the spectral separation between the resistance classes. A progressive shift of the main peaks to higher frequency regions is observed as the resistance increases, in addition to a reduction in secondary undulations and greater definition of the peaks in the higher classes. This integrated visualization clearly shows the correlation between dynamic stiffness and compressive strength, reinforcing the consistency of the results obtained.

Figure 2

Frequency graphs by magnitude of the dynamic responses of the specimens: (a) 15MPa (b) 20MPa (c) 25MPa (d) 30MPa



Source: From the author (2025)

The trend observed in this study is in line with recent findings in the literature in modal analysis applied to cementitious materials. Research such as that of Silva et al. (2025) demonstrates that variations in the composition of concrete, whether in the cementitious matrix, aggregates or additives, result in significant differences in natural frequencies and damping. These studies reinforce that the vibrational behavior is highly sensitive to the overall stiffness of the sample, corresponding to what was observed in the specimens tested in this work.

Other authors also highlight the potential of modal analysis for dynamic characterization of concrete structural elements. Beskhyroun et al., (2020), for example, applied similar techniques to evaluate the dynamic behavior of a reinforced concrete building, verifying that the identification of natural frequencies is capable of evidencing differences related to geometric variations, stiffness, or the presence of damage. These studies corroborate the use of frequency response as a reliable tool to investigate the dynamic performance of cementitious systems.

Modal analysis has also been used to identify subtle structural changes, even in apparently intact elements. Recent studies, such as those by Sartorti et al. (2024), show that small modifications in the state of the structure, such as initial cracking or changes in boundary conditions, can result in detectable changes in natural frequencies or modal shapes. These findings reinforce the sensitivity of the method, which could also be observed in this study, where modest differences between resistance classes were sufficient to generate very distinct FRF curves.

The results obtained demonstrate the potential of modal analysis to differentiate concretes with distinct mechanical properties. The clear separation between the classes, observed from the FRFs, suggests that the dynamic parameters can serve as reliable indicators of the stiffness and, consequently, the mechanical strength of the specimens. This behavior reinforces the applicability of dynamic tests as a non-destructive alternative for concrete characterization.

In summary, the results show that:

- lower strength concretes have lower natural frequencies and a greater number of modes in the analyzed range;
- stronger concretes exhibit concentrated response at higher frequencies, reflecting greater stiffness;
- the FRF curves allow clear and visual distinction between the classes studied;
- Modal analysis is adequate and sensitive to evaluate the mechanical properties of concrete without destructive testing.

These results validate the effectiveness of the methodology employed and reinforce the potential of the study for future applications related to both structural monitoring and technological control of cementitious materials.

4 CONCLUSION

The experimental modal analysis performed in this study allowed to consistently characterize the dynamic behavior of concrete specimens belonging to four distinct classes of compressive strength. From the FRF, it was possible to clearly identify the natural frequencies of each sample and understand how these responses change as a function of the stiffness and mechanical properties associated with the resistance class.

The results showed that concretes of lower strength, such as those of 15 MPa, have natural frequencies located in lower ranges and greater sensitivity to spectral variations, reflecting reduced structural stiffness. With the increase in compressive strength, a systematic displacement of the main peaks to higher frequency regions was observed, accompanied by more stable and well-defined FRF curves, a typical behavior of materials with higher dynamic stiffness. This trend was consistently verified among the classes, evidencing the ability of modal analysis to distinguish concretes with different levels of resistance.

The methodology adopted, encompassing standardized production of the specimens, controlled curing, impulsive excitation and judicious processing of the FRFs, proved to be efficient and reproducible, allowing the identification of subtle differences in the vibrational behavior of the samples. In addition to being a non-destructive method, modal analysis proved to be a sensitive and technically adequate approach to evaluate properties related to the stiffness of concrete, and can complement traditional tests used in technological control.

It is concluded, therefore, that experimental modal analysis is a robust tool for dynamic characterization of concrete, enabling the differentiation between resistance classes through the identification of their natural frequencies and the shape of their spectral responses. The results obtained reinforce the potential of this technique for applications in quality control, structural monitoring and advanced studies on the dynamic performance of cementitious materials.

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DIGITAL TRANSFORMATION AND ADVERTISING STRATEGIES ON SPANISH RADIO: A COMPARATIVE ANALYSIS OF CADENA SER, COPE, AND ONDA CERO

TRANSFORMAÇÃO DIGITAL E ESTRATÉGIAS PUBLICITARIAS NO RÁDIO ESPANHOL: UMA ANÁLISE COMPARATIVA DE CADENA SER, COPE E ONDA CERO

TRANSFORMACIÓN DIGITAL Y ESTRATEGIAS PUBLICITARIAS EN LA RADIO ESPAÑOLA: UN ANÁLISIS COMPARATIVO DE LA CADENA SER, LA COPE Y ONDA CERO

 <https://doi.org/10.56238/sevened2025.036-097>

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ABSTRACT

This study examines the evolution of digital and advertising strategies of Cadena SER, Onda Cero and COPE, audience leaders according to the EGM (2024). Using a qualitative-descriptive method based on content analysis (Krippendorff, 1990; Bardin, 1986), we compare the structure, user interactivity and advertising strategies of their websites. Key aspects such as accessibility, live radio, on-demand content, digital native audio, interactivity and content personalisation are examined. The findings reveal notable differences in organisation, engagement and personalisation. The study concludes that Spanish online radio is migrating to a multiplatform model, facilitating audience expansion and diversification of the advertising business, although challenges remain in personalisation and digital advertising integration.

Keywords: Radio. Media Convergence. Online Monetization. Interactivity. Audio on Demand.

RESUMO

Este estudo examina a evolução das estratégias digitais e publicitárias da Cadena SER, Onda Cero e COPE, líderes em audiência segundo a EGM (2024). Utilizando um método qualitativo-descritivo baseado em análise de conteúdo, (Krippendorff, 1990; Bardin, 1986), a estrutura, interatividade com o usuário e estratégias publicitárias de seus sites são comparadas. Aspectos-chave como acessibilidade, rádio ao vivo, conteúdo sob demanda, áudio nativo digital, interatividade e personalização do conteúdo são examinados. Os resultados revelam diferenças notáveis em organização, participação e personalização. O estudo conclui que a rádio online em espanhol está migrando para um modelo multiplataforma, facilitando a expansão do público e a diversificação do negócio da publicidade, embora persistam desafios na personalização e integração da publicidade digital.

Palavras-chave: Rádio. Convergência de Mídia. Monetização Online. Interatividade. Áudio Sob Demanda.

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RESUMEN

Este estudio examina la evolución de estrategias digitales y publicitarias de Cadena SER, Onda Cero y COPE, líderes en audiencia según el EGM (2024). Empleando un método cualitativo-descriptivo basado en análisis de contenido, (Krippendorff, 1990; Bardin, 1986), se comparan la estructura, interactividad con el usuario y estrategias publicitarias de sus sitios web. Se examinan aspecto clave como accesibilidad, radio en directo, contenidos a la carta, audio nativo digital, interactividad y personalización de contenido. Los hallazgos revelan diferencias notables en organización, participación y personalización. El estudio concluye que la radio online española migra a un modelo multiplataforma, facilitando expansión de audiencia y diversificación del negocio publicitario, aunque persisten desafíos en personalización e integración publicitaria digital.

Palabras clave: Radio. Convergencia Mediática. Monetización Online. Interactividad. Audio a la Carta.

1 INTRODUCTION

The digitalization of the media ecosystem has profoundly transformed the modes of production, circulation and consumption of sound content at a global level. In the last two decades, radio — traditionally considered a medium of great social capillarity and associated with instantaneity and orality — has undergone a continuous process of technological reconversion marked by the convergence of platforms, the multiplication of formats and the emergence of new patterns of interaction between audiences and broadcasters. Far from signifying the decline of the medium, this transformation has highlighted its historical capacity for adaptation, innovation, and social resignification, as highlighted by several studies on radio in Spain and Europe (Toural & Sánchez, 2021; González & Toural, 2017; Roderó & Sánchez, 2007).

In the Spanish context, this reconfiguration is driven by the incorporation of digital services — such as multimedia websites, mobile apps, native podcasts, geolocation tools, and personalization spaces — that expand the reach of broadcasters and diversify their business models. Radio no longer depends exclusively on the linear logic of transmission to adopt a hybrid paradigm in which live radio, on-demand content, digital native audio products, and new interactive formats coexist (Bonet & Sellas, 2019; Benson & Powers, 2011; Tandoc et al., 2018). Thus, sound consumption expands to multiplatform environments, breaking temporal and geographical barriers and enabling more immersive and customizable experiences (Losifidis & Wheeler, 2018; Chen & Han, 2020).

This digital transition also has a decisive impact on the advertising strategies of broadcasters. The implementation of dynamic banners, pre-roll spots, branded content, "Brand Day" formats, and programmatic advertising has redefined the economic role of web portals, which now function as fundamental extensions of the traditional monetization of analog broadcasting (Piñeiro-Otero, 2015; Legorburu et al., 2019). It is, therefore, a transformation that involves both the renewal of the content offer and the restructuring of revenue models.

In the Spanish market, Cadena SER, Cadena COPE and Onda Cero constitute the three main private generalist radio groups, historically leading the audience measured by the General Media Study (EGM). These broadcasters operate as references in the adoption of digital strategies that seek to capture new audiences, retain traditional audiences, and explore monetization formats aligned with the logics of online consumption. However, despite sharing common challenges, they implement different models of content organization,

interactivity, usability and advertising, which opens space for systematic comparisons and the identification of divergent trends in the evolution of Spanish digital radio.

In view of this scenario, the present study aims to comparatively analyze the digital and advertising strategies implemented by Cadena SER, COPE and Onda Cero, considering their official web platforms. The research adopts a qualitative-descriptive approach based on content analysis (Bardin, 1986; Krippendorff, 1990), allowing us to examine the structure of the portals, the diversity of the content offered, the mechanisms of interaction with users, the multimedia integration and the presence of digital advertising formats.

The relevance of the study lies in two main dimensions. Firstly, it contributes to the field of Communication by offering an updated analysis of the evolution of Spanish radio in its process of media convergence, highlighting how digital strategies redefine communication practices and business models. Secondly, it allows us to understand how broadcasters respond to the demands of an audience that is increasingly connected, mobile and accustomed to personalization, a central characteristic of contemporary digital culture.

The article is structured as follows: after this introduction, section 2 presents the theoretical framework that underlies the study, addressing radio transformations in the digital age and its relationship with convergence processes. Section 3 describes the methodology applied, detailing the sample design, the analysis categories and the registration procedures. Section 4 presents the results of the comparative analysis and section 5 discusses the findings in the light of the literature. Finally, section 6 presents the conclusions and points out possibilities for future research.

2 THEORETICAL FRAMEWORK

The emergence of television and, subsequently, the rise of the Internet generated profound transformations in the media landscape, which raised questions about the future and evolution of radio. While some critics stigmatize radio as a medium belonging to the past, incapable of the emergence of television and, subsequently, the rise of the Internet have generated profound transformations in the media landscape, which have raised questions about the future and evolution of radio. While some critics stigmatize radio as a medium belonging to the past, unable to connect with young audiences, others highlight its ability to generate experiences of community and alternative communication (Garcés, 2007: 227). Since its emergence in Spain more than a century ago, radio has undergone multiple technological transformations, constantly adapting to changes in the processes of production,

distribution, and reception of sound (Toural & Sánchez, 2021; González & Toural, 2017; Sánchez, 2020). In this sense, radio has been characterized by its remarkable ability to adapt to social, cultural, and technological transformations (Rodero & Sánchez, 2007).

Digitalization is the most recent major reconversion of the sound medium. In Spain, broadcasters have implemented online services – such as websites, mobile apps, and social media profiles – that allow them to interact with new audiences and expand their broadcasts beyond traditional broadcast hours (Sánchez, 2020; Toural & Sánchez, 2021). This media convergence has led to the creation of multimedia websites that not only broadcast audio on demand or native digital content (podcasts), but are also transformed into authentic digital diaries in which text, images, audio, and video are integrated in real time. This new paradigm contributes to enriching the user experience and innovating in the production and presentation of content, which, in turn, generates added value in terms of interaction and personalization (Fuente et al., 2014; Forero & Céspedes, 2018).

In particular, the Internet has modified the defining characteristics of traditional radio by breaking temporal linearity, allowing listeners to access both live and delayed programs (Benson & Powers, 2011). On-demand radio, by offering previously transmitted content, facilitates the capture of new audiences and expands the station's reach (Tandoc, et al., 2018). Similarly, the development of digital native audio, designed specifically for online consumption, diversifies the offer and enhances personalization, which translates into greater listener participation and the emergence of new production formats (Mullo-López & Yaguana-Romero, 2017). The consolidation of smartphones as the predominant devices in access to information has redefined production and commercial processes in the cultural industry, forcing radio operators, streaming services, and podcast creators to adapt their value chains to new consumption dynamics, especially in the younger audience segment (Pedrero et al., 2019).

Since the 2000s, and with the growth of podcasting, Spanish broadcasters have moved from strategies based on the management of recycled content to the production of digital native audio. The integration of digital technologies has allowed radio to combine traditional linear broadcasting with asynchronous consumption, enriching its offer and extending the useful life of its content (Ribes et al., 2016; Moreno, 2017; Martínez-Costa et al., 2018; Pedrero & Herrera, 2017; Bonet & Sellas, 2019). This transformation has not only optimized content management and audience acquisition, but has also driven business diversification through new advertising formats – such as banners, spots, and Brand Day –

and the integration of interactive content, which allows users to save, share, and actively participate in programming (Rodríguez Luque et al., 2020; Legorburu et al., 2019; Valero & Sánchez, 2015).

In the twenty-first century, radio has established itself as a multimedia and multidimensional medium, in which traditional characteristics coexist with new digital technologies to offer an interactive, enriched, and personalized listening experience (Losifidis & Wheeler, 2018; Chen & Han, 2020; García-Santamaría & Perea-Rodríguez, 2017; Gómez-Barroso & Feijoo, 2019). The transition to a cross-media model has made it possible to transform the traditional unidirectionality of radio into two-way communication, in which real-time interaction with the audience is an essential feature (Rodríguez-Martínez, 2018).

Similarly, business diversification through digitalization has emerged as a key strategy for sustainability and growth for issuers. Online advertising – which incorporates formats typical of the digital environment – has become an additional source of income, complementing traditional advertising on analog broadcasts and allowing broadcasters to capture new audience segments and build loyalty among existing listeners (Piñeiro-Otero, 2015).

2.1 DIGITAL TRANSFORMATION OF RADIO AND MEDIA CONVERGENCE

Technological evolution has generated a process of structural reconfiguration in the radio industry, driven by the convergence of media and the transition to the digital environment (Losifidis & Wheeler, 2018; Chen & Han, 2020). Unlike other previous technological crises, the digitalization of radio was not only a challenge, but also an opportunity for business expansion and diversification (García-Santamaría & Perea-Rodríguez, 2017). Online radio has expanded the user experience by offering ubiquitous and immediate access to content, eliminating the geographical and temporal barriers associated with analog radio (Garcés, 2007).

The phenomenon of online radio (web radio) has allowed the integration of new formats, such as on-demand audio and digital native audio, facilitating a greater degree of interactivity with the audience and new monetization opportunities through innovative advertising strategies (González & Toural, 2017). However, digital radio is not simply a transposition of the analog signal to the web environment, but involves the reconfiguration of radio consumption to a multiplatform, multidimensional and highly personalized model (Bonet & Sellas, 2019).

This transformation process has led to a redefinition of traditional business models, in which radio no longer relies solely on conventional on-air advertising, but has also incorporated new monetization strategies into the digital sphere. These range from programmatic advertising and interactive formats to branded content strategies and premium subscriptions (Pedrero-Esteban et al., 2019).

2.2 DIGITAL RADIO IN SPAIN: CURRENT CONTEXT AND MAIN GENERALIST PRIVATE BROADCASTERS

Spain is immersed in this process of transition to digital radio, with a sustained increase in online audiences. According to the General Media Study (EGM, 2024), online radio consumption has grown by more than 150% in the last decade, with a special impact on young and urban listeners. At the market level, the panorama is dominated by three major generalist broadcasters: Cadena SER, Cadena COPE and Onda Cero, which compete both in the field of traditional audiences and in the digital ecosystem.

Cadena SER (Grupo PRISA): A historical leader in audience, it has developed a comprehensive digital strategy based on the offer of podcasts, subscription services and a platform for personalized and geolocated content.

COPE: Characterized by a focus on audience loyalty through the provision of on-demand radio and reference programs, with an increasing integration of unique digital audio formats.

Cero Wave: Characterized by simplifying the user experience and the offer of information, it has opted for a clean and direct interface, with less advertising saturation than its competitors.

Each of these broadcasters has adopted different strategies in their digital transition, which raises questions about their impact on audience acquisition and retention, revenue diversification, and the effectiveness of their advertising strategies in the online environment.

In this context, this research aims to analyze and compare the digital and advertising strategies implemented by Cadena SER, COPE and Onda Cero, in order to evaluate their impact on the public and the diversification of the online radio business. To approach this object of study, a methodological design based on content analysis is used, following the principles of Bardin (1986) and Krippendorff (1990). A comparative study of the digital platforms of the three broadcasters is carried out over three months (September-November 2024), with the aim of identifying patterns in the layout of the content, the navigation structure,

the offer of interactivity, and the integration of advertising strategies.

The article is structured in the following sections: section 2 describes the methodology used; Section 3 presents the results of the comparative analysis; Section 4 discusses the findings in relation to the previous literature; and section 5 presents the conclusions and proposals for research.

3 METHODOLOGY

This research adopts a qualitative and descriptive approach, with the aim of comparatively examining the digital and advertising strategies of the main private radio portals in Spain.

The analysis focuses on the content and functionalities of the official websites of Cadena SER, COPE and Onda Cero, taking as reference the criteria proposed in the content analysis (Bardin, 1986; Krippendorff, 1990) and the perspective of media convergence applied to the radio environment (Rodero & Sánchez, 2007; Balsebre et al., 2023).

The overall objective of the research is to examine and compare the evolution of digital and advertising strategies implemented by Spain's main private radio channels – Cadena SER, COPE and Onda Cero – in order to determine their impact on business diversification and user experience. The specific objectives are set out below:

1. Characterize the structure and organization of the digital portals of the three stations, identifying the main sections and functionalities (live radio, audio on demand repositories, native podcasts, multimedia content, etc.).
2. Analyze the advertising strategy on each site, describing the formats used (banners, spots, Brand Day, sponsorship) and evaluating their potential to generate additional income.
3. Evaluate the usability and interactivity of the portals, as well as the presence of personalization tools (registration, subscription, geolocation, notifications), to understand how incidents affect audience retention and loyalty.
4. Compare the integration of content and services (multimedia, social networks, forums or participation spaces) and their contribution to the creation of added value.
5. Identify the challenges and opportunities that online radio presents for the sustainability of the business and the acquisition of new audiences.

Based on the objectives, the following hypotheses are proposed:

1. Hypothesis 1: The radio portals of the main channels in Spain have overcome the

stage of mere "container" of analog programming, migrating to the offer of original content (digital native audio) and value-added services (multimedia, subscription), which provide greater attractiveness for the user.

2. Hypothesis 2: The incorporation of new advertising formats (dynamic banners, Brand Day, on-demand pre-audio spots) constitutes an increasingly consolidated source of complementary income, while having a positive impact on the diversification of the business.
3. Hypothesis 3: Personalization (registration, geolocation, newsletters) and interactivity (sharing on networks, receiving direct feedback) substantially improve the user experience, promoting greater listener loyalty and the acquisition of digital audiences.

3.1 SAMPLE DESIGN AND UNIT OF ANALYSIS.

The example consists of the web versions of:

- Cadena SER (www.cadenaser.com)
- COPE Chain (www.cope.es)
- Onda Cero (www.ondacero.es)

The selection is based on the largest audience recorded by these three channels in the General Media Study (EGM). The observation period covered three months (September to November 2024), during which the structure of the portals, the frequency of content updates, and the behavior of the audience reflected in social networks (Facebook, X, Instagram) were recorded.

To complement the analysis, specific ad spaces are reviewed (fixed or dynamic banners, pre-roll spots in audio playback, sponsorships or Brand Day spaces) and the presence of on-demand audio and native podcast formats. Similarly, registration, subscription, and real-time commenting/participation functionalities have been explored.

A book of variables and categories was prepared for data collection, following the guidelines of the content analysis proposed by Berelson (1971) and López Aranguren (1986). These categories include:

1. Page organization: main menu, sections, tabs.
 - Personalization functions: registration, subscription, notifications, geolocation.
 - Advertising strategies: banners, pre-rolled spots, native advertising, sponsorship and brand day.
 - Usability and interactivity: interaction options, links to social networks, forums or chats.

- Audio formats: linear radio, audio on demand, native podcast.

2. Digital periodic recording: Screenshots and audiovisual records were made weekly to document the evolution of the content and variations in the presentation of advertising or the arrangement of menus. This guaranteed the triangulation of information.
3. Social network analysis: Interactions on Facebook, X (Twitter) and Instagram linked to each portal were monitored, counting the number of mentions, likes, comments and shares, in order to assess the reach of the digital strategy and audience participation (Lombard et al., 2002).

The information is coded based on the categories defined in the observation guide, using qualitative analysis software (NVivo and Atlas.ti) that facilitated the coding and thematic grouping of the findings. Subsequently, an interpretative reading was applied that allowed comparing the three stations and detecting common or divergent patterns.

Regarding the analysis of the results, the comparative analysis has focused on the following items:

- The offer of content (live radio, digital newspapers, thematic sections).
- Offer of complementary content and its potential to generate value (on-demand programs, original podcasts, network integration).
- Advertising segmentation, observing the diversity of formats and the frequency of ads.
- The degree of interactivity and personalization, evaluating the existence of records, subscriptions and tools for online social interaction.

Based on the synthesis of these data, patterns of convergence and divergence are established between the three stations, which allowed testing hypotheses and formulating conclusions about the diversification of the business and user experience.

4 RESULTS

The comparative analysis of the websites of Cadena SER, Cadena COPE and Onda Cero shows significant differences in the organization of information, offer of interactive services and integration of multimedia content. Specifically:

- Structure and navigation: Cadena SER features a multifunctional interface, with horizontal navigation that incorporates seven main tabs (e.g., "Home", "Sports", "Humor", "Leisure and Culture", "Opinion", "Programs" and "Podcast"). The integration of personalization functionalities (registration, subscription to newsletters and content alerts) and access to geolocated content will be supervised.

For its part, COPE is organized around thematic sections (Programs, Sports, Broadcasters, etc.) and stands out for the presence of audiovisual content associated with star programs. Navigation switches between landscape and portrait orientation, favoring access to on-demand radio content and native digital audio productions.

In turn, the Onda Cero presents a minimalist design aimed at the immediate. The absence of fixed spaces for banners allows the user to focus on the content, prioritizing live broadcasts and audio on demand enriched with multimedia elements.

- Regarding the supply of multimedia content, the findings show that the three locations allow the simultaneous consumption of live content and archived content (radio on demand), complemented by elements such as texts, images, videos and audios. However, the diversity and organization of this content varies: at Cadena SER, there is evidence of a real-time "electronic diary" strategy, with specific thematic sections. For its part, Cadena COPE highlights the link between traditional broadcast programs and complementary multimedia content. Onda Cero, in turn, emphasizes the user experience through a clean interface that favors interaction with specific content.

4.1 ANALYSIS OF ADVERTISING CONTENT AND ECONOMIC BENEFITS

The study identified differences in the implementation of advertising strategies in the three sites analyzed. For example, in the case of the layout of banners and advertising spots, Cadena SER is characterized by an intensive integration of banners (located at the top, on the sides and between sections) and by the use of the brand day format, which allows the advertiser to occupy the entire advertising space for one day.

Cadena COPE inserts banners in strategic areas (top and side) and uses advertising spots before the selected content, reinforcing the link between advertising and programming.

Cero Wave limits the presence of banners on the main page by placing them only on specific content and keeping the format clean in the general interface, although the spots play similarly in the requested audio.

The economic benefits obtained by broadcasters from the publication of these bands are substantial according to the tariffs in force in 2023/2024 published on its website by the media agency OBLICUA. The following table shows the average price of publishing a banner on the websites of the main radio stations in Spain.

Table 1

Web Advertising Fees (CPM and Brand Day)

Season	CPM (€/impression)	Brand Day (euros)
Cadena SER	25	25,500 – 25,000 ¹²
COPE Chain	20	Not applicable
Cero Wave	20	Not applicable

Source: Prepared by the authors with data collected on the oblicua.es website.

As detailed in Table 1, the average price to insert a banner on the website of a generalist channel (Cadena SER, Cadena COPE and Onda Cero) ranges from 25 euros for Cadena SER to 20 euros for the other two, being the CPM (cost per thousand), which serves to define the price of web ads in digital marketing as a measurement method.

The method is based on impressions, which is a metric that counts the number of views or digital interactions for a specific ad. Impressions are also known as "ad views." Prices listed do not include VAT. The contract for the brand day at SER is 25,000 euros. Brand Day is a format within an exhibition in which all advertising space in a web medium is reserved exclusively for a single brand for a certain period of time – usually one day, since, if they are weekly periods, it would be called brand week. These revenues complement those obtained by advertising inserted during the live broadcast of conventional programming (analog radio) and which are detailed below. Table 2 shows the Advertising Tariffs in force in 2023/2024 on radio (20-second spots, national broadcast on weekdays), according to the Oblicua.es portal.

Table 2

Advertising fees in force in 2023/2024 on radio

Timetable	BE	Cero Wave	DEAL
06:00-07:00 h.	17.790 €	12.500 €	16.720 €
07:00-08:00 h.			
08:00-09:00 h.			
09:00-10:00 h.	13.340 €		12.240 €
10:00-11:00 h.		8.300 €	
11:00-12:00 h.			

² The value of *Brand Day* can vary depending on specific agreements and commercial conditions

12:00-00:30 h.			
12:30-13:00 h.			
13:00-14:00 h.			5.580 €
14:00-15:00 h.	9.350 €	4.000 €	
15:00-16:00 h.			6.000 €
16:00-17:00 h.			
17:00-18:00 h.			
18:00-19:00.			
19:00-20:00 h.		7.860 €	
20:00-21:00 h.		4.200 €	
21:00-22:00 h.			2.995 €
22:00-23:00 h.	10.480 €	7.520 €	10.160 €
23:00-00:00 h.			
00:00-01:30 h.			
01:30-04:00 h.	2.020 €	900 €	1.660 €
04:00-05:00 h.			
05:00-06:00 h.	1.300 €		

Source: Prepared by the authors with data collected in oblicua.es

As can be seen in the results obtained in Table 2, the cost of advertising skyrockets in the national transmission of programs presented by prominent broadcasters: Hoy por hoy, with Ángeles Barceló (Cadena SER); Herrera at Cadena COPE, with Carlos Herrera (COPE) and Más uno, with Carlos Alsina (Onda Cero). The insertion of a 20-second spot in prime time costs between 13,340 and 17,790 euros (VAT not included) in SER, being cheaper in the other two. The price of ads with a longer duration is calculated prorately.

4.2 COMPARISON OF ADVERTISING REVENUES

In terms of rates and advertising formats: Cadena SER stands out for its intense advertising presence on its website. Formats such as banners are used in various locations (header, sides, and between sections) and the Brand Day format, in which a brand reserves all advertising for one day. CPM refers to what an advertiser pays for 1000 ad impressions on a web page. An average CPM of 25 euros is estimated, which is reflected in a high advertising value on the main page.

COPE Chain: also uses banners and advertising spots before the content is played, although the intensity of insertion is slightly lower compared to SER. CPM: Approximately 20 euros, similar to Onda Cero, with less presence of exclusive formats such as Brand Day.

Onda Cero: Your perspective is more minimalist in terms of web advertising. Banners are integrated in a unique way (in specific content), and the user experience is kept clean. CPM: It costs around 20 euros, with a more discreet advertising strategy, although pre-content spots are still a common resource.

As for the estimate of advertising revenues, when analyzing the data on fees and the presence of advertising formats on the web, it was observed that in Cadena SER the intensive use of banners and brand day, with higher CPMs, suggests that this broadcaster could achieve significantly higher digital advertising revenues than its competitors, since its digital revenues vary between 25 and 35% of the total digital segment. In part, due to its leadership in personalization and reach. As for COPE and Onda Cero, both share a similar CPM (20 euros) and a less aggressive advertising insertion strategy. This translates into digital revenues that, while still growing, may be at slightly lower levels than SER.

4.3 ANALYSIS OF THE EVOLUTION OF THE AUDIENCE

Data from the General Media Study (EGM) indicate that the percentage of Spaniards who listen to radio online has gone from around 5-7% in 2015 to estimates of 15% in 2023. This growth has been driven by the increased use of smartphones, the stations' own apps, and the integration of on-demand content. Differences between the seasons:

Cadena SER: It benefits from a comprehensive digital strategy (with registration, personalization and geolocation functionalities), which has contributed to greater loyalty and, consequently, to a constant growth of its digital audience.

COPE: Its strategy focuses on highlighting star programs and connecting them directly to traditional programming, attracting an audience that migrates to digital so as not to miss live or delayed content.

Onda Cero: Its minimalist interface and focus on immediate content favor the capture of users who seek a clear and direct experience, although it may limit some interactive features that build audience loyalty.

4.3.1 Loyalty and retention indicators

In terms of average listening time: online radio users in Spain generally spend, on

average, between 30 and 45 minutes a day in this modality.

On audience segmentation: The data reveals that digital audience growth is especially notable in the youth segment (18-34 years old), while consumption at stations such as SER tends to be more diversified thanks to the offer of local and personalized content.

4.4 IMPACT ON SOCIAL MEDIA

Cadena SER: Uses social networks (X, Facebook, Instagram and YouTube) intensively to disseminate fragments of programs, news and research. Audience engagement is high thanks to initiatives such as live streams, Q&A sessions, and exclusive content for.

Cadena COPE: Focuses on highlighting its star programs and opinion content, with a prominent presence on X and Facebook. Its strategy on the networks aims to generate conversations about current issues and the content broadcast on the radio.

Onda Cero: Commitment to direct and clean communication, with less advertising saturation on their profiles. Its strategy on social media focuses on immediate and detailed broadcasting, highlighting prominent content and breaking news, which allows for a high rate of interaction in specific publications.

Analyzing the quantitative indicators on the networks: About the number of followers and engagement: Cadena SER: generally has a higher number of followers on platforms such as X and Facebook (more than 1.5 million on X and 2 million on Facebook) and engagement that is enhanced with multimedia content and calls to action. Cadena COPE: It has about 1 million followers on X and similar numbers on Facebook, with interactions that reinforce its image as a media outlet for opinion and current affairs. Onda Cero: Although its followers are slightly smaller than those of Cadena SER and COPE (about 800 thousand to 1 million in X), its strategy of less saturated publications generates a high proportional interaction rate, especially in content related to breaking news.

Regarding the impact of interactive campaigns, it was found that campaigns in networks that invite participation (e.g., surveys or contests) had response rates above 10% in SER and COPE, while Onda Cero achieved exceptional rates of interaction in publications with urgent content or national relevance. The results obtained are shown in the comparative table presented in Table 3.

Table 3

Comparative data obtained from interaction on social networks

Season	CPM (€/impression)	Digital Ad Revenue (estimated)	Digital Audience Growth (%)	Followers on Social Media (X/Facebook)	Social Media Strategy
Cadena SER	25	€18-25 million	Sustained increase; High fidelity in young people and diverse audiences	X: > 1.5 million; <i>Facebook</i> : 2 million	Multimedia content, live interactions, personalization, and geolocation.
COPE Chain	20	€12-18 million	Consistent growth; Featured in star programs	1M on X and <i>Facebook</i>	Focus on opinion, thematic discussions, and live programs.
Cero Wave	20	€12-18 million	Growth driven by immediacy and ease of use	800K-1 m in X; High proportional commitment	Direct and clean communication, less advertising saturation, focus on news and specific content.

Source: Prepared by the authors with research data.

5 DISCUSSION

The comparative analysis reveals that, despite sharing the objective of expanding the user experience through digitalization, the three chains adopt different strategies:

Innovation and Personalization: Cadena SER's strategy focused on the personalization and integration of multiple formats (electronic newspaper, subscriptions and geolocation), suggests a radio model committed to audience loyalty and diversification. On the other hand, Cadena COPE and Onda Cero opt for more segmented approaches, prioritizing the user's quality of content based on their traditional programming and live experience, respectively.

Advertising Strategies and Economic Sustainability: The implementation of advertising formats adapted to the digital environment (especially the use of Brand Day in SER) not only reinforces the relevance of web platforms as a source of income, but also shows the need for greater adaptation of advertising content to the specificities of the medium. The disparity in ad costs (CPM) suggests that advertisers value reach and quality of experience on each platform differently.

Implications for Acquisition and Loyalty: The integration of interactive options, such as the possibility of registration, personalization, and interaction on social networks, is associated with an improvement in the user experience and, therefore, in the acquisition and loyalty of audiences. However, the absence of these elements on some platforms (e.g., Cero Wave in registration and subscription) indicates areas of opportunity to optimize interaction and increase added value.

6 CONCLUSIONS

1. **Diversity of Digital Strategies:** The stations studied have developed heterogeneous digital strategies that adapt to their identities and public goals. Cadena SER leads in terms of personalization and content integration, while Cadena COPE and Onda Cero maintain a strategy focused on content quality and interface simplicity.
2. **Impact on Advertising Profitability:** The existence of specific formats, such as brand day, and the differentiation in advertising rates demonstrate that digitalization offers significant opportunities for revenue diversification. The biggest investment detected in Cadena SER is associated with its personalization and reach strategy, which translates into added value for advertisers.
3. **Opportunities for Improvement:** Despite the success in diversification and digitalization, areas of improvement in user-platform interaction are identified. It is recommended to incorporate additional interactive tools (e.g., online contests, real-time surveys, and live chats) to increase audience engagement and loyalty.

4. Confirmation of the Hypothesis: Regarding Hypothesis 1, the findings indicate that most of the portals of the major networks are no longer mere containers of traditional radio, offering abundant native digital content and additional services. For example, all the sites analyzed incorporate podcasts or exclusive online programs (not broadcast on the air) along with multimedia sections (videos, audios and photo galleries, among other content), largely fulfilling this amplification. As a result, user appeal increases significantly: internet radio has gone from just "redistributing products offline on demand" to exploring exclusive content and new digital storytelling that adds value to audiences. A specific case is Cadena SER, which in addition to its on-demand programs integrates the Pódium Podcast platform with original series only for the internet, illustrating this evolution. It is concluded, therefore, that the three stations studied advanced to the original content and value-added services, largely confirming hypothesis 1.

Regarding Hypothesis 2, the research shows that most of the portals studied are already exploring new digital advertising formats, consolidating them as an additional source of income and diversifying the business. About 80–90% of the sites analyzed incorporate advanced display advertising – for example, dynamic banners and brand day formats (full-page sponsorships) – in addition to classic insertions. Similarly, almost all include pre-reel audio spaces before on-demand content (podcast or online playback), evidencing widespread adoption. These formats are becoming more and more consolidated: the business model has begun to change in the search for complementary revenues to conventional advertising on the internet. Therefore, it is concluded that almost all channels successfully use these new advertising formats, consolidating them as a source of income and diversifying their commercial offer, confirming Hypothesis 2.

As for Hypothesis 3, the results suggest that most broadcasters have implemented personalization and interactivity tools on their websites, largely fulfilling this hypothesis. For example, they often offer user registration (to comment on content or participate in contests or surveys), geolocation (showing local or regional station content depending on the listener's location), and subscription newsletters with new features, all of which personalize the experience. Likewise, all portals facilitate social interactivity: they integrate buttons to share news or audio on networks, and many receive direct feedback through filtered comments or online surveys. These functionalities significantly enrich the user experience and encourage user loyalty. A registered listener who receives content from their area or thematic newsletters

tends to visit the site more often, and on the other hand, the listener who shares audios on their networks becomes a prescriber of the brand. The results show that the vast majority of radio sites successfully apply personalization and interactivity, which substantially supports hypothesis 3 to improve the experience, increase listener loyalty, and facilitate the acquisition of online audiences.

Therefore, the research shows that the digitalization of radio stations in Spain translates into the creation of web platforms that not only broaden the listening experience, but are also configured as integral spaces for social communication and business diversification of the three stations studied. Adopting strategies that combine quality content with innovative advertising formats is critical to sustainability and growth in the competitive digital media environment.

This research has several limitations that must be pointed out in order to properly mark the results. First, it is worth highlighting the scarcity of disaggregated data on the digital advertising revenues of each of the broadcasters analyzed. Given the diversity of sources used (EGM, AIMC, Infoadex, IAB Spain, among others), the data used largely come from estimates and studies of the global industry, so the conclusions may be affected by possible methodological inconsistencies.

Second, the available information comes from heterogeneous sources with different cut-off dates. This dispersion makes it difficult to develop perfectly comparable time series, restricting the scope of generalizations that can be made from these findings. Similarly, variability in online audience behavior (derived from changes in content supply, fluctuations in social media activity, and specific viralization phenomena) can impact the fact that trends observed in a given period are rapidly modified and cannot be extrapolated to other temporal contexts.

On the other hand, the study has focused on the three main stations (Cadena SER, COPE and Onda Cero), dispensing with the analysis of thematic radios, local stations or digital radios, which can show different realities and monetization strategies. This focus on the three private channels with the largest audience in Spain limits the possibility of making comparisons with other business models and with innovative proposals in the medium that are pending future research.

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HISTOLOGICAL IMPACTS OF ULTRAVIOLET RADIATION ON HUMAN SKIN: A MINI-REVIEW

IMPACTOS HISTOLÓGICOS DA RADIAÇÃO ULTRAVIOLETA NA PELE HUMANA: UMA MINI-REVISÃO

IMPACTOS HISTOLÓGICOS DE LA RADIACIÓN ULTRAVIOLETA EN LA PIEL HUMANA: UNA MINIREVISIÓN

 <https://doi.org/10.56238/sevened2025.036-098>

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ABSTRACT

Introduction: Ultraviolet (UV) radiation is one of the main extrinsic factors involved in photoaging and the development of histological skin changes. Chronic exposure to UVA and UVB radiation is associated with direct DNA damage, oxidative stress, collagen and elastin degradation, and local immunosuppression, processes that favor the development of precancerous lesions and skin cancer. **Objectives:** To critically review the main histological changes induced by ultraviolet radiation in human skin, considering differences between skin phototypes and their relationship with photoaging. **Methodology:** This is a mini-literature review conducted in the PubMed, SciELO, and Scopus databases, using the descriptors 'ultraviolet radiation,' 'photoaging,' 'human skin,' 'histological changes,' and 'skin phototypes.' Articles published between 2020 and 2025, of an experimental or review nature, were included. Duplicate studies, those not directly related to the topic, or those published before the defined period were excluded.

Keywords: Ultraviolet Radiation. Photoaging. Skin Cancer. Oxidative Stress. Photoprotection.

RESUMO

Introdução: A radiação ultravioleta (UV) é um dos principais fatores extrínsecos envolvidos no fotoenvelhecimento e no desenvolvimento de alterações histológicas cutâneas. A exposição crônica à radiação UVA e UVB está associada a danos diretos ao DNA, estresse oxidativo, degradação de colágeno e elastina, além de imunossupressão local, processos que favorecem o surgimento de lesões pré-cancerígenas e câncer de pele. **Objetivos:** Revisar criticamente as principais alterações histológicas induzidas pela radiação ultravioleta na pele humana, considerando diferenças entre fototipos cutâneos e a relação com o fotoenvelhecimento. **Metodologia:** Trata-se de uma mini revisão de literatura realizada nas bases de dados PubMed, SciELO e Scopus, utilizando os descritores 'radiação ultravioleta', 'foto envelhecimento', 'pele humana', 'alterações histológicas' e 'fototipos cutâneos'. Foram incluídos artigos publicados entre 2020 e 2025, de caráter experimental ou revisional. Foram

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Palavras-chave: Radiação Ultravioleta. Fotoenvelhecimento. Câncer de Pele. Estresse Oxidativo. Fotoproteção.

RESUMEN

Introducción: La radiación ultravioleta (UV) es uno de los principales factores extrínsecos implicados en el fotoenvejecimiento y el desarrollo de cambios histológicos en la piel. La exposición crónica a la radiación UVA y UVB se asocia con daño directo al ADN, estrés oxidativo, degradación de colágeno y elastina, e inmunosupresión local, procesos que favorecen el desarrollo de lesiones precancerosas y cáncer de piel. **Objetivos:** Revisar críticamente los principales cambios histológicos inducidos por la radiación ultravioleta en la piel humana, considerando las diferencias entre los fototipos de piel y su relación con el fotoenvejecimiento. **Metodología:** Se trata de una mini-revisión bibliográfica realizada en las bases de datos PubMed, SciELO y Scopus, utilizando los descriptores «radiación ultravioleta», «fotoenvejecimiento», «piel humana», «cambios histológicos» y «fototipos de piel». Se incluyeron artículos publicados entre 2020 y 2025, de carácter experimental o de revisión. Se excluyeron los estudios duplicados, aquellos no directamente relacionados con el tema o aquellos publicados antes del período definido.

Palabras clave: Radiación Ultravioleta. Fotoenvejecimiento. Cáncer de Piel. Estrés Oxidativo. Fotoprotección.

1 INTRODUCTION

Ultraviolet (UV) radiation is a form of electromagnetic radiation that comes from the sun, with wavelengths between 100 and 400 nanometers (nm). It is subdivided into three categories: UVA (320–400 nm), UVB (290–320 nm), and UVC (100–290 nm). Most UVC radiation is absorbed by the ozone layer and does not reach the earth's surface. Exposure to UV radiation is a determining factor in human skin health, and can cause a range of biological effects, from cellular changes to the development of skin cancer (Saha B, et al., 2024).

These effects vary according to the intensity, duration of exposure and the type of radiation involved. UVB radiation is known to cause direct DNA damage, resulting in the formation of pyrimidine dimers, which can lead to mutations and eventually skin cancer. On the other hand, UVA radiation penetrates deeper into the skin, reaching the dermis, and is associated with photoaging and the formation of reactive oxygen species (ROS), which can induce oxidative stress and inflammation (Gromkowska-Kępką KJ, et al., 2021). In addition to direct DNA damage, exposure to UV radiation can also affect the skin's immune system. UV radiation induces local immunosuppression, decreasing the skin's ability to respond to pathogens and increasing the risk of developing malignant lesions.

In the clinical context, the effects of UV radiation are observed in a variety of dermatological conditions, including sunburn, photoaging, actinic keratoses, and non-melanoma skin cancers. These conditions result from UV-induced histological and molecular changes, which affect both the epidermis and the dermis (Ke Y, et al., 2021). In view of the high incidence of skin diseases related to sun exposure, especially in tropical countries such as Brazil, it is essential to understand the biological and histological mechanisms involved in the damage caused by UV radiation.

2 MAJOR HISTOLOGICAL CHANGES

Ultraviolet (UV) radiation, present in sunlight, has profound effects on human skin. Initially, UVB rays (280–320 nm) concentrate their action on the epidermis, where they induce direct injury to the DNA of keratinocytes, such as the formation of thymine dimers (Vechtomova YL, et al., 2021).

These changes can lead to cell death or mutations capable of triggering tumor processes. UVA rays (320–400 nm), on the other hand, because they have greater penetrating power, reach the dermis and promote changes in the skin's support matrix, including the degradation of collagen and elastin fibers. This process is directly associated

with premature aging, known as photoaging, one of the main chronic impacts of solar radiation (De Araújo; De Souza, 2022). In addition to direct genetic damage, UV radiation stimulates the formation of free radicals, triggering oxidative stress in skin cells. This redox imbalance compromises essential structures such as lipids, proteins, and DNA, resulting in histological alterations, such as thinning of the dermis, loss of elasticity, and weakening of the skin barrier (Kiyoi T., 2024)

In experimental models with hairless mice, thickening of the epidermis and dermis was also observed, as well as loss of affinity with collagen-specific dyes, evidencing irreversible damage to the tissue (Mayangsari E, et al., 2024). As a response to these aggressions, the skin triggers local inflammatory processes, characterized by the dilation of blood vessels, infiltration of defense cells, and release of mediators such as interleukins (IL-1, IL-6) and tumor necrosis factor alpha (TNF- α). Although acute inflammation favors cell renewal, its persistence can cause tissue degeneration. In the Brazilian scenario, reviews indicate that cumulative sun exposure is associated with a higher incidence of skin cancer in fair-skinned populations, especially in the South and Southeast regions, where intense and prolonged UV radiation is added to lower pigment protection (Vind AC, et al., 2024).

Finally, UV radiation also compromises skin immunity, reducing the activity of Langerhans cells responsible for defending against aggressive agents and altering the production of immunoregulatory substances. This condition of local immunosuppression favors the persistence of damaged cells and the progression of pre-existing lesions, reducing the ability to recognize and eliminate potentially malignant cellular alterations. Together, these mechanisms direct DNA damage, oxidative stress, chronic inflammation, and immunosuppression interact and potentiate each other, explaining the strong association between sun exposure and the development of skin diseases, including skin cancer (Ortner D, et al., 2024).

2.1 EPIDERMAL HYPERPLASIA AND HYPERKERATOSIS

Ultraviolet (UV) radiation, especially in the UVB spectrum, is one of the main physical agents capable of inducing adaptive responses in the human epidermis. Among the most common alterations, epidermal hyperplasia stands out, characterized by the accelerated proliferation of keratinocytes in response to damage to DNA and cellular proteins. This physiological mechanism seeks to restore the integrity of the skin barrier and compensate for radiation-induced cell loss (Lu W, et al., 2023). As reported by Silva, Souza, and Labre (Silva,

et al, 2022), the increased production of new cells represents a temporary defense, which confers greater thickness to the epidermis and greater resistance to subsequent exposures.

Chronic exposure to the sun favors hyperkeratosis, characterized by thickening of the layer as an adaptive response. National studies point to a higher prevalence of this alteration in workers exposed to radiation, such as farmers and fishermen, especially in the face, arms, and hands (De Oliveira, 2020). Although the accumulation of keratin acts as a barrier against UV radiation, its persistence can evolve into pathological changes. Histologically, hyperplasia and hyperkeratosis alter the epidermal architecture, promoting cellular disorganization and increasing the risk of precancerous lesions, such as actinic keratosis, and non-melanocytic skin tumors. Long-term exposure to UVB, therefore, encourages disordered proliferation and increases the likelihood of genetic mutations related to cutaneous carcinogenesis (Hu et al., 2025).

In summary, although initially protective, epidermal hyperplasia and hyperkeratosis have a paradoxical character. If, on the one hand, they contribute to reducing the penetration of UV radiation and temporarily protecting the skin, on the other hand, its chronic maintenance is directly associated with premature photoaging and the development of serious skin diseases. In this sense, as they point out, such adaptations reveal the skin's ability to respond to environmental stress, but also highlight the importance of continuous photoprotection as an essential strategy to prevent progression to irreversible conditions (Wang T, et al., 2020).

2.2 INFLAMMATION AND NECROSIS IN RESPONSE TO IRRADIATION DOSE AND TIMING

Ultraviolet (UV) radiation triggers inflammatory responses in the skin, the intensity of which varies according to the dose and duration of exposure. At moderate levels, it manifests as solar erythema, characterized by redness and local warmth (Salminen et al., 2022). Prolonged exposure, on the other hand, can cause cell necrosis, tissue disorganization, and immunological changes. UV radiation modulates cytokines and T lymphocytes, favoring the escape of abnormal immune system cells and increasing the risk of infections and skin cancer (Lopes et al., 2022).

UV-induced cell necrosis results from the formation of reactive oxygen species (ROS), which cause damage to cellular DNA, leading to programmed cell death or apoptosis. Studies indicate that the efficiency of DNA repair mechanisms can vary between individuals,

influencing susceptibility to damage caused by UV radiation and, consequently, the risk of developing skin cancer. In addition, UV radiation can alter the tumor microenvironment, promoting inflammatory processes, angiogenesis, and evasion of the immune response, factors that contribute to the development of skin neoplasms (Papaccio F, et al., 2022).

The inflammatory response induced by UV radiation is closely linked to photoaging, a cumulative process that is more frequent in the elderly and in regions with high solar incidence (Lee et al., 2021). This phenomenon involves the generation of ROS, which degrade collagen and elastic fibers, compromising skin integrity. Prolonged exposure also promotes structural changes in the epidermis, dermal-epidermal junction and dermis, such as thickening of the layer, disorganization of the extracellular matrix and increased vascular permeability, factors that favor precancerous lesions and skin cancer (Peres; Miot, 2020).

2.3 COLLAGEN DEGRADATION AND ACTINIC ELASTOSIS

Chronic exposure to ultraviolet (UV) radiation is one of the main environmental factors responsible for the degradation of collagen fibers and the development of actinic elastosis in human skin. These structural changes are characteristic of photoaging, a process that results in loss of skin firmness, elasticity, and integrity (Liu H, et al., 2024). Histological studies reveal that UV radiation induces the expression of matrix metalloproteinases (MMPs), such as MMP-1, which cleaves collagen fibers, and MMP-3, which amplifies the degradation of existing collagen. In addition, UV radiation reduces the synthesis of new collagen, contributing to the weakening of the extracellular matrix (MARTIN, et al, 2023).

Actinic elastosis is characterized by the abnormal accumulation of elastin in the dermis, replacing damaged collagen fibers. This elastic material has a thick and tangled appearance, with impaired functionality, compromising the elasticity of the skin. The formation of elastosis is associated with prolonged exposure to UV radiation, which induces the production of reactive oxygen species (ROS), leading to the formation of free radicals that damage elastic and collagen fibers (Md Jaffri J., 2023).

The process of collagen degradation and the formation of actinic elastosis are more intense in fair-skinned individuals, due to the lower amount of melanin and, consequently, greater susceptibility to damage from UV radiation. Advanced age and a history of unprotected sun exposure also increase the risk of these changes, often observed in exposed regions, such as the face, neck, and back of the hands (Shi S, et al., 2024). Prevention involves continuous photoprotection, with regular use of broad-spectrum sunscreens,

appropriate clothing, and reduced exposure at peak times. Topical antioxidants, such as vitamins C and E, also aid in the neutralization of free radicals, preserving the extracellular matrix and slowing photoaging (Lyons AB, et al., 2024).

2.4 OXIDATIVE STRESS AND TISSUE INJURY

Ultraviolet (UV) radiation stimulates the production of reactive oxygen species (ROS), promoting oxidative stress that damages lipids, proteins, and DNA, leading to inflammation, apoptosis, and necrosis of keratinocytes and fibroblasts (Shih et al., 2020). This process compromises the synthesis of collagen and elastin, activates matrix metalloproteinases and accelerates photoaging. As a consequence, chronic sun exposure reduces the skin's regenerative capacity and increases the risk of premalignant lesions.

In addition to the structural effects, oxidative stress affects the cutaneous microcirculation, promoting vasodilation, increased vascular permeability, and infiltration of inflammatory cells. According to Oliveira and Andrade (Oliveira, et al, 2020), these changes contribute to edema and exacerbation of inflammatory processes, amplifying necrosis and tissue degeneration. Cumulative damage from sun exposure not only compromises the physical integrity of the skin, but also interferes with local immune function, making the tissue more vulnerable to infections and malignant transformations (Guan LL, et al, 2021).

The prevention of oxidative stress in the skin involves photoprotection strategies and the use of topical or oral antioxidants, which neutralize free radicals and reduce cell damage. Studies indicate that compounds such as vitamin C, vitamin E, and polyphenols have a significant protective effect against lipid peroxidation and collagen degradation, slowing down the photoaging process and minimizing UV-induced histological changes (Barbosa, et al., 2021).

2.5 VARIATION WITH SKIN TYPE

The cutaneous response to ultraviolet (UV) radiation depends on the phototype, determined by the amount of melanin. Fair-skinned individuals, with less pigment protection, are more susceptible to erythema, inflammation, and cell necrosis. Melanin acts as a natural filter, absorbing part of the UV radiation and protecting DNA, which reduces the occurrence of premalignant lesions in darker skin (Silva; Souza, 2022; Gęgotek et al., 2022). However, this protection is not absolute: even tall phototypes can develop histological changes, such as epidermal hyperplasia and actinic elastosis, when chronically exposed. Thus, the

accumulation of UV radiation over the years promotes dermal and epidermal degeneration in all phototypes, although the severity of the damage is inversely proportional to the amount of melanin (Passeron et al., 2021).

Therefore, the distribution of melanin in the skin influences the inflammatory response. Brazilian studies have shown that fair-skinned individuals have more intense inflammation and greater sensitivity to erythema formation, while darker-skinned individuals have more moderate but not always less severe responses show that, despite the lower initial susceptibility, chronic unprotected exposure to dark phototypes can also result in cumulative tissue damage, increased oxidative stress and predisposition to structural changes, such as collagen degradation (Aloe Vera, et al, 2021).

Finally, the variation with skin type also impacts photoprotection and preventive strategies. Fair-skinned individuals should adopt strict measures, such as the use of broad-spectrum sunscreens, protective clothing, and strategic sun exposure times, while darker-skinned individuals, although less susceptible, are not fully protected and should maintain continuous preventive care. Silva points out that educational policies and awareness about the risks of UV radiation are essential for all phototypes, considering the cumulative effect of the sun on the skin (Silva, Miot, 2024).

2.6 SUBCELLULAR CHANGES AND IMMUNOSUPPRESSION

Ultraviolet (UV) radiation not only affects the macroscopic architecture of the skin, but also causes significant changes at the subcellular level, affecting organelles, nucleus, and cell signaling pathways. Brazilian studies indicate that UV induces direct DNA damage, causing the formation of thymine dimers and changes in hydrogen bonds, compromising the genomic integrity of epidermal cells. These modifications can result in apoptosis or, when repair mechanisms fail, in mutations that favor cutaneous carcinogenesis (Agrez M, et al, 2023).

However, UV radiation also causes mitochondrial dysfunction, increasing the production of reactive oxygen species (ROS) and reducing cellular antioxidant capacity. These changes compromise energy metabolism, structural protein synthesis, and tissue regeneration, accelerating photoaging and favoring programmed cell death (Tsuchida et al., 2023). Another critical effect is local and systemic immunosuppression, marked by reduced activity of Langerhans cells, T lymphocytes, and other mediators of cutaneous immunity, which allows the persistence of damaged cells and increases the risk of malignant lesions.

This phenomenon, more evident in chronic exposures, increases the vulnerability of the skin to infections, cancer, and other pathologies associated with a drop in the immune response (Yardman-Frank et al., 2021; Silva; Miot, 2020).

In addition to the direct effects on organelles and immunity, UV radiation causes changes in cell signaling, activating inflammatory and apoptotic pathways that amplify tissue damage. Studies indicate that the combination of oxidative stress, DNA degradation, and immunosuppression creates an environment conducive to chronic histological changes, including hyperplasia, actinic elastosis, and extracellular matrix disorganization (Cai CS, et al, 2023). These subcellular mechanisms highlight the complexity of the cutaneous response to UV radiation and reinforce the importance of photoprotection and the use of antioxidants as essential preventive measures.

3 COMPARISON: ACUTE VERSUS CHRONIC EXPOSURES

Ultraviolet (UV) radiation causes different effects on the skin depending on the duration and frequency of exposure. Acute exposures, characterized by short, high-intensity episodes such as sunburn, trigger immediate responses, including erythema, edema, and pain. Silva and Souza (Silva & Souza, 2022) highlight that these changes are primarily inflammatory, with rapid activation of chemical mediators and recruitment of immune cells to repair tissue damage. Although temporary, repeated exposures can add cumulative effects, increasing the probability of permanent histological changes. Ultraviolet radiation causes different effects on the skin depending on the duration and frequency of exposure.

Table 1 summarizes the differences between acute and chronic exposures, followed by the references used.

Table 1

ASPECT	ACUTE EXPOSURE	CHRONICLE EXHIBITION	RECENT REFERENCES
Duration	Short, intense, episodic (e.g., sunburn)	Long, repetitive, months or years	Shih et al., 2020; Wong & Chew, 2021
Main effects	Erythema, oedema, pain, focal necrosis	Epidermal hyperplasia, collagen degradation, actinic elastosis	Ansary et al., 2021; Liu et al., 2024
Predominant mechanisms	Acute inflammation, cytokine release	Cumulative oxidative stress, reorganization of the extracellular matrix	Salminen et al., 2022; Cai et al., 2023
Reversibility	Usually reversible after a few days	Progressive and irreversible changes	Yeh & Schwartz, 2022; Shin et al., 2023
Oncological risk	Low on isolated exposures	High risk of precancerous lesions and skin cancer	Ortner et al., 2024; Kumar et al., 2024
Clinical example	Sunburn in young people	Deep wrinkles, basal cell carcinoma	Tsai & Chien, 2022; Vind et al., 2024

Source: Authors.

In contrast, chronic exposure involves continuous or frequent radiation over months and years, promoting profound structural and functional changes in the skin. Chronic exposure induces epidermal hyperplasia, collagen degradation, actinic elastosis, and local immunosuppression, typical features of photoaging. These modifications are progressive and cumulative, making the skin more susceptible to precancerous lesions and non-melanocytic skin cancer (Wong Qya, et al, 2021). From a histological point of view, the differences between acute and chronic exposures are also evident. While acute exposures produce focal necrosis and temporary inflammation, chronic exposure leads to permanent reorganization of the extracellular matrix, decreased fibroblast density, and changes in cutaneous microcirculation. Oliveira and Andrade reinforce that the radiation accumulated over time favors the degradation of collagen and elastin fibers, with a consequent loss of elasticity and firmness of the skin (Oliveira & Andrade, 2020).

In turn, the immune system's response varies greatly depending on the type of sun exposure. When exposure is rapid and short-lived, it causes a temporary drop in immunity. Continuous and prolonged exposure, on the other hand, leads to longer-lasting immune suppression, which can facilitate the growth of altered cells and increase the risk of skin cancer. Barbosa and colleagues point out that these changes that last longer, if not avoided, can evolve into irreversible lesions and impair skin function. Therefore, sun protection measures must take into account not only the intensity of radiation, but also how often and for how long we are exposed to the sun (Barbosa, et al, 2021).

4 CLINICAL IMPLICATIONS AND POSSIBLE INTERVENTIONS

Exposure to ultraviolet (UV) radiation generates clinical implications ranging from transient effects, such as erythema and edema, to chronic conditions, such as photoaging and skin cancer. Cell damage depends on the intensity and duration of exposure, involving inflammation, necrosis, collagen degradation, and actinic elastosis. In addition to the aesthetic impact, these changes compromise the skin barrier, favoring infections and premalignant lesions (Yeh et al., 2022; Silva; Souza, 2022). Photoprotection is the most effective clinical measure, including the regular use of broad-spectrum sunscreens, appropriate clothing, hats, and glasses. Brazilian studies highlight that reapplying sunscreen every two hours is essential to reduce the cumulative effects of solar radiation (Tsai et al., 2022).

In this context, health education policies to raise awareness about the risks of the sun contribute to the prevention of long-term damage. Another clinical approach involves the use of topical and oral antioxidants, which neutralize free radicals and reduce UV-induced oxidative stress. Peres and Miot point out that the combination of vitamin C, vitamin E, and polyphenols acts to protect cellular DNA, preserve collagen, and reduce inflammation, slowing down the photoaging process and reducing the risk of serious skin lesions. In patients with a history of chronic exposure, regular dermatological follow-up is indicated to monitor early changes and prevent malignant complications (Kumar V, et al, 2024).

Finally, clinical interventions also include regenerative treatments, such as the use of retinoids and topical therapies with growth factors, which stimulate the regeneration of the epidermis and dermis. Oliveira and Andrade believe that these approaches can improve skin texture and elasticity, reduce the appearance of wrinkles and actinic lesions, and promote partial recovery of the damaged extracellular matrix. However, the effectiveness of these interventions depends on adherence to ongoing preventive measures, highlighting the importance of combining sun protection, antioxidants, and specialized dermatological care (Shin SH, et al, 2023).

5 FINAL CONSIDERATIONS

Ultraviolet (UV) radiation causes complex changes in the skin, including epidermal hyperplasia, inflammation, oxidative stress, collagen degradation, and immunosuppression, the cumulative effects of which contribute to photoaging and increased risk of skin cancer. Acute exposures cause temporary damage, such as erythema and edema, while chronic exposures promote permanent changes in the extracellular matrix and reduction in fibroblast density, compromising skin function in a sustained manner. Thus, the continuous adoption of preventive strategies, such as photoprotection, use of antioxidants, and dermatological follow-up, associated with regenerative therapies when necessary, is essential to preserve the integrity, elasticity, and immunity of the skin, indicating the need for future research aimed at improving more effective preventive and therapeutic measures.

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**ECOLOGICAL STUDY OF ACCIDENTS CAUSED BY CROTALUS SP SNAKES
IN BRAZIL BETWEEN 2010 AND 2023**

**ESTUDO ECOLÓGICO DOS ACIDENTES CAUSADOS PELAS SERPENTES
CROTALUS SP NO BRASIL ENTRE 2010 E 2023**

**ESTUDIO ECOLÓGICO DE LOS ACCIDENTES CAUSADOS POR SERPIENTES
CROTALUS SP EN BRASIL ENTRE 2010 Y 2023**

 <https://doi.org/10.56238/sevened2025.036-099>

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ABSTRACT

Introduction: Accidents caused by venomous snakes represent an important challenge for public health, especially in rural regions of countries with tropical climates. It is estimated that, annually, there are about 5 million snakebites in the world, resulting in approximately 100 thousand deaths. In Brazil, the genera Bothrops and Crotalus stand out, the latter being associated with higher lethality and severe clinical manifestations, such as neurotoxicity, myotoxicity, and acute renal failure. In addition to the clinical repercussions, these accidents have relevant economic and social impacts, especially because they affect individuals of working age in rural areas. Early

Goal: To investigate the epidemiological profile of accidents caused by snakes of the genus Crotalus in Brazil between 2010 and 2023, analyzing mortality, regional distribution, seasonal variation, sex, age group, and anatomical site of the bite, in order to identify relevant patterns for surveillance and public health.

Methodology: This is an ecological, descriptive and retrospective study, based on secondary data extracted from the Notifiable Diseases Information System (SINAN/DATASUS). All cases registered in the country between 2010 and 2023 were included. The variables analyzed included: absolute number of cases and deaths, mortality rate, regional distribution, seasonality, gender, age group, and location of the bite. Statistical analysis was performed by means of descriptive statistics, using absolute and relative frequencies, with processing in Microsoft Excel.

Results and discussion: There was a continuous growth in the number of notified snakebites, from 124,920 cases in 2010 to 340,819 in 2023. In total, 296,475 botropic and

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34,080 crotalic accidents were recorded, with mortality rates of 0.42% and 0.95%, respectively. Crotalic cases were more concentrated in the Northeast (37.8%) and Southeast (35.2%) regions, being more frequent in the hot and rainy months (January to March), which accounted for 34% of the notifications. There was a predominance of males (80%) and adults of working age (20 to 59 years: 22,209 cases), which reflects the greater occupational exposure in agricultural activities. The bites occurred mainly on the lower limbs (65.2%), followed by the upper limbs (20.2%), often during the inadvertent handling of the animals in the rural work environment. These epidemiological variations appear to be associated with environmental, climatic, and occupational factors that increase the risk of contact with snakes.

Conclusions: Crotalic accidents predominantly occurred adult men living in rural areas, especially in the rainy months, with more frequent injuries in the lower limbs. These findings reinforce the importance of public policies aimed at prevention, such as the provision of personal protective equipment (PPE) and the training of health teams for timely diagnosis and treatment. Among the limitations of the study, the use of secondary data, subject to underreporting and lack of detailed clinical information, stands out. Even so, the results contribute to guide future research on environmental determinants and the effectiveness of serum therapy in different regions of the country.

Keywords: Crotalus. Snake Bites. Epidemiology.

RESUMO

Introdução: Os acidentes provocados por serpentes peçonhentas representam um importante desafio para a saúde pública, sobretudo em regiões rurais de países de clima tropical. Estima-se que, anualmente, ocorram cerca de 5 milhões de envenenamentos ofídicos no mundo, resultando em aproximadamente 100 mil mortes. No Brasil, destacam-se os gêneros *Bothrops* e *Crotalus*, sendo este último associado a maior letalidade e a manifestações clínicas severas, como neurotoxicidade, miotoxicidade e insuficiência renal aguda. Além das repercussões clínicas, esses acidentes acarretam impactos econômicos e sociais relevantes, especialmente por atingirem indivíduos em idade produtiva das zonas rurais. A administração precoce do soro antiofídico é fundamental para reduzir a mortalidade e as complicações decorrentes do envenenamento.

Objetivo: Investigar o perfil epidemiológico dos acidentes causados por serpentes do gênero *Crotalus* no Brasil entre 2010 e 2023, analisando mortalidade, distribuição regional, variação sazonal, sexo, faixa etária e local anatômico da picada, com o intuito de identificar padrões relevantes para a vigilância e a saúde pública.

Metodologia: Trata-se de um estudo ecológico, descritivo e retrospectivo, baseado em dados secundários extraídos do Sistema de Informação de Agravos de Notificação (SINAN/DATASUS). Foram incluídos todos os casos registrados no país entre 2010 e 2023. As variáveis analisadas compreenderam: número absoluto de casos e óbitos, taxa de mortalidade, distribuição regional, sazonalidade, sexo, faixa etária e local da picada. A análise estatística foi realizada por meio de estatística descritiva, utilizando frequências absolutas e relativas, com processamento no Microsoft Excel.

Resultados e discussão: Verificou-se crescimento contínuo no número de acidentes ofídicos notificados, passando de 124.920 casos em 2010 para 340.819 em 2023. No total, foram registrados 296.475 acidentes botrópicos e 34.080 crotálicos, com taxas de

mortalidade de 0,42% e 0,95%, respectivamente. Os casos crotálicos apresentaram maior concentração nas regiões Nordeste (37,8%) e Sudeste (35,2%), sendo mais frequentes nos meses quentes e chuvosos (janeiro a março), que responderam por 34% das notificações. Predominaram indivíduos do sexo masculino (80%) e adultos em idade produtiva (20 a 59 anos: 22.209 casos), o que reflete a maior exposição ocupacional em atividades agropecuárias. As picadas ocorreram principalmente nos membros inferiores (65,2%), seguidas dos membros superiores (20,2%), frequentemente durante o manuseio inadvertido dos animais no ambiente de trabalho rural. Essas variações epidemiológicas parecem estar associadas a fatores ambientais, climáticos e ocupacionais que aumentam o risco de contato com serpentes.

Conclusões: Os acidentes crotálicos acometeram, predominantemente, homens adultos residentes em áreas rurais, especialmente nos meses chuvosos, com lesões mais frequentes em membros inferiores. Esses achados reforçam a importância de políticas públicas voltadas à prevenção, como a oferta de equipamentos de proteção individual (EPIs) e a capacitação das equipes de saúde para diagnóstico e tratamento oportunos. Entre as limitações do estudo, destaca-se o uso de dados secundários, sujeitos a subnotificação e à falta de informações clínicas detalhadas. Ainda assim, os resultados contribuem para orientar futuras pesquisas sobre os determinantes ambientais e a efetividade da soroterapia em distintas regiões do país.

Palavras-chave: Crotalus. Mordeduras de Serpentes. Epidemiologia.

RESUMEN

Introducción: Los accidentes provocados por serpientes venenosas representan un importante desafío para la salud pública, especialmente en regiones rurales de países con clima tropical. Se estima que, anualmente, ocurren alrededor de 5 millones de mordeduras de serpientes en el mundo, resultando en aproximadamente 100 mil muertes. En Brasil, destacan los géneros Bothrops y Crotalus, siendo este último asociado con mayor letalidad y manifestaciones clínicas graves como neurotoxicidad, miotoxicidad e insuficiencia renal aguda. Además de las repercusiones clínicas, estos accidentes generan impactos económicos y sociales relevantes, especialmente por afectar a individuos en edad productiva de áreas rurales. La administración temprana del suero antiofídico es fundamental para reducir la mortalidad y las complicaciones del envenenamiento.

Objetivo: Investigar el perfil epidemiológico de los accidentes causados por serpientes del género Crotalus en Brasil entre 2010 y 2023, analizando mortalidad, distribución regional, variación estacional, sexo, grupo de edad y sitio anatómico de la mordedura para identificar patrones relevantes para la vigilancia y la salud pública.

Metodología: Se trata de un estudio ecológico, descriptivo y retrospectivo, basado en datos secundarios extraídos del Sistema de Información de Enfermedades de Notificación (SINAN/DATASUS). Se incluyeron todos los casos registrados en el país entre 2010 y 2023. Las variables analizadas incluyeron número absoluto de casos y muertes, tasa de mortalidad, distribución regional, estacionalidad, sexo, grupo de edad y localización de la mordedura. El análisis estadístico se realizó mediante estadística descriptiva, con frecuencias absolutas y relativas procesadas en Microsoft Excel.

Resultados y discusión: Se observó un crecimiento continuo en el número de accidentes ofídicos notificados, pasando de 124.920 casos en 2010 a 340.819 en 2023. En total, se registraron 296.475 accidentes botrópicos y 34.080 crotálicos, con tasas de mortalidad de 0,42% y 0,95%, respectivamente. Los casos crotálicos se concentraron en mayor proporción en las regiones Nordeste (37,8%) y Sudeste (35,2%), siendo más frecuentes en los meses cálidos y lluviosos (enero a marzo), que representaron el 34% de las notificaciones. Hubo predominio de hombres (80%) y de adultos en edad productiva (20 a 59 años: 22.209 casos), lo que refleja mayor exposición ocupacional en actividades agrícolas. Las mordeduras ocurrieron principalmente en miembros inferiores (65,2%), seguidas de los superiores (20,2%), muchas veces durante la manipulación inadvertida de los animales en entornos rurales de trabajo. Estas variaciones epidemiológicas parecen estar asociadas con factores ambientales, climáticos y ocupacionales que incrementan el riesgo de contacto con serpientes.

Conclusiones: Los accidentes crotálicos ocurrieron predominantemente en hombres adultos residentes en áreas rurales, especialmente en los meses lluviosos, con lesiones más frecuentes en miembros inferiores. Estos hallazgos refuerzan la importancia de políticas públicas orientadas a la prevención, como la provisión de equipos de protección personal (EPP) y la capacitación de los equipos de salud para el diagnóstico y tratamiento oportunos. Entre las limitaciones del estudio destaca el uso de datos secundarios, sujetos a subregistro y a la falta de información clínica detallada. Aun así, los resultados contribuyen a orientar futuras investigaciones sobre los determinantes ambientales y la efectividad de la terapia con suero antiofídico en diferentes regiones del país.

Palabras clave: Crotalus. Mordeduras de Serpientes. Epidemiología.

1 INTRODUCTION

Accidents with venomous snakes represent an important public health problem, especially in tropical and subtropical regions, being classified by the World Health Organization (WHO) as neglected tropical diseases (WHO, 2023). Snakebites continue to be one of the most important causes of morbidity and mortality in these regions, especially in rural areas of developing countries (AFROZ et al., 2024). It is estimated that between 4.5 and 5.4 million snake bites occur worldwide annually, resulting in 1.8 to 2.7 million cases of envenomation and between 81,000 and 130,000 deaths (WHO, 2023; LONGBOTTOM et al., 2022). These numbers, however, are considered underestimated due to the lack of adequate epidemiological surveillance systems in several regions, which further aggravates the problem (AFROZ et al., 2024).

In Brazil, snakebites of medical importance are caused by snakes of the Viperidae and Elapidae families. Records of envenomations by snakes of the Viperidae family are present in about 99.5% of the accidents and are caused by the genera *Bothrops* (popularly known as jararacas, jararacuçu and urutus), *Crotalus* (rattlesnakes) and *Lachesis* (surucucus). The Elapidae family (0.5% of accidents) is represented by the genus *Micrurus* (true corals) (BRASIL, 2024).

Identifying the snake involved in the accident, when possible, can be an important step towards correct diagnosis and treatment. Despite this, the animal should not be killed or captured, and it is ideal to record the snake through photography, maintaining safety precautions. The corals have a slender body and colored rings, while the presence of retractable anterior fangs and loreal pit are characteristic of snakes of the Viperidae family, and the *Bothrops* have designs similar to an old telephone hook in the mesh. Meanwhile, rattlesnakes have diamond designs on their bodies, and the occurrence of the rattle on the tail also confirms their identification (WHO, 2023).

The genus *Crotalus* belongs to the subfamily Crotalinae, known for the presence of a specialized sensory organ: the loreal pit, which allows the detection of heat radiated by prey, facilitating hunting, especially in conditions of low visibility. In addition, another striking feature of these snakes is the presence of a rattle at the end of the tail, formed by interconnected segments of keratin that expand as the snake sheds its skin. When shaken rapidly, these segments produce an unmistakable sound, which serves as an important defense mechanism. Rattlesnakes use this sound both to alert potential predators and as a form of warning when they feel threatened or angry, thus avoiding direct confrontations (CLARK et

al., 2022; TOZETTI et al., 2013). These snakes have predominantly nocturnal habits, being more active at dusk and during the night, when they go out in search of food. During the day, they usually take shelter in hidden places, such as burrows, between rocks or under dense vegetation (TOZETTI et al., 2013).

The clinical occurrence of the signs and symptoms caused by the toxins present in the venom will define the need for treatment. Although snakes of the genus *Bothrops* cause the highest number of accidents and greater morbidity, accidents caused by rattlesnakes, although less frequent, are associated with higher complication rates, including a higher mortality rate (DA SILVA et al., 2023; CERON et al., 2021), this situation is mainly caused by the late recognition of clinical and laboratory changes, which is frequent in neglected diseases, leading to late heterologous serum therapy (more than 6 hours after the accident), a time when there is usually more important rhabdomyolysis and the consequent possibility of kidney damage, often irreversible.

The morbidity and mortality present in crotalic accidents is mainly due to crotoxin and crotamine, which are some of the proteins present in the venom responsible for inducing the neurotoxic and myotoxic syndrome of envenomation, causing manifestations such as blurred vision, eyelid ptosis, muscle weakness, respiratory failure, rhabdomyolysis, and acute renal failure (COLOMBINI et al., 2023). Thus, the clinical-laboratory picture plays a fundamental role in defining treatment, since specific serum therapy, started early, is crucial for reducing complications and mortality (WHO, 2023).

Given the relevance and particularities of envenomations caused by snakes of the genus *Crotalus*, it is extremely important to better understand the epidemiological profile for the proper management of these cases.

2 METHODOLOGY

The present study consists of a descriptive and retrospective documentary research, based on secondary data from the Notifiable Diseases Information System (SINAN) and the Epidemiological Bulletins of the Ministry of Health for the period from 2010 to 2023. Accidents involving venomous snakes were counted and the cases involving crotalic accidents were detailed. The variables of interest included: number of reported cases, mortality rate, distribution by geographic region, seasonality, age group, sex, and location of the bite. The analysis was carried out in a quantitative and descriptive manner, allowing the identification of epidemiological patterns and relevant risk factors.

3 RESULTS AND DISCUSSION

Data on snakebites in Brazil, between 2010 and 2023, reveal a growing panorama in the number of reported cases, accompanied by a low mortality rate. The increase in the number of accidents is evident over the years, from 124,920 cases in 2010 to 340,819 in 2023, which represents a significant growth of almost 173% and, although snakes of the genus *Bothrops* are responsible for most cases, the mortality rate associated with envenomations by this genus was 0.42%, (BRAZIL, 2024).

Table 1

Brazil - Reported Cases

Year	Ign/White	Bothrops	Crotalus	Micrurus	Lachesis	Non-venomous	Total
2010	98504	21604	2383	210	1033	1186	124920
2011	111149	21843	2493	229	1008	1244	137966
2012	116382	20488	2166	236	874	1263	141409
2013	135503	19867	1822	240	913	1330	159675
2014	145447	18881	1790	198	806	1359	168481
2015	148193	19595	1975	209	718	1473	172163
2016	150786	18857	2177	244	519	1536	174119
2017	197877	20337	2521	285	476	1919	223415
2018	241263	21094	2747	288	548	2224	268164
2019	256731	23467	2930	378	601	2628	286735
2020	232896	23604	3132	310	452	2442	262836
2021	228139	23518	2735	301	323	2190	257206
2022	264675	21627	2563	370	303	2218	291756
2023	312752	21693	2646	379	397	2952	340819
Total	2640297	296475	34080	3877	8971	25964	3009664

Source: Ministry of Health - SINAN (2024).

In contrast, accidents involving the genus *Crotalus*, which account for about 10 to 20% of accidents by venomous snakes, had a much higher mortality rate, about 0.95%. Although these accidents are numerically lower than those of *bothrops*, the consequences of

envenomation are more serious due to the occurrence of rhabdomyolysis which, if not treated early and properly, can lead to kidney failure and, consequently, to the death of these patients (BRASIL, 2024; DA SILVA; BROOK; et al., 2023; PHAN, 2023).

The analysis of the geographical distribution of cases of envenomation by *Crotalus* snakes between 2010 and 2023 shows a significant concentration in the Northeast and Southeast regions of the country. The Northeast region registered 12,877 cases, with emphasis on the states of Bahia (2,375) and Maranhão (5,107), where rural activities, hot weather and interaction with the natural environment favor contact with snakes. The Southeast region, in turn, had a total of 11,994 cases, led by Minas Gerais, which accounted for 8,325 cases. The predominance of this region can be explained by the vast territorial extension with a predominance of rural characteristics, where there is greater exposure to these reptiles (BRASIL, 2024; TOZETTI et al., 2013).

Table 2

United States - Crotalus

Region/State	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
North Region	183	194	179	199	155	188	192	211	257	259	297	259	217	205	2995
RO	5	2	5	4	6	6	7	2	4	11	8	8	1	7	76
AC	1	3	-	-	4	3	5	3	3	2	1	5	-	1	31
AM	3	3	12	9	6	2	13	1	7	6	8	9	12	11	102
RR	14	34	48	38	24	28	33	62	99	53	60	59	53	43	648
PA	63	56	53	68	47	46	29	43	36	42	50	64	59	40	696
AP	3	5	5	6	5	13	12	5	8	15	7	3	5	4	96
I'm	94	91	56	74	63	90	93	95	100	130	163	111	87	99	1346
Northeast Region	878	870	652	552	617	738	836	859	1119	1265	1351	1131	968	1041	12877
MA	368	367	254	255	239	277	321	351	604	641	586	380	246	218	5107
PI	59	64	59	45	49	54	79	73	104	102	142	97	84	102	1113
EC	83	51	42	25	51	52	83	67	55	79	88	99	66	86	927
RN	40	18	27	22	16	35	40	31	40	48	50	65	33	41	506
PB	38	40	38	16	21	35	17	34	28	35	65	71	66	85	589
PE	85	120	61	68	91	98	113	120	126	148	149	129	176	177	1661
AL	25	16	12	21	23	32	35	37	25	40	56	58	45	39	464
IF	14	10	3	9	9	13	6	6	9	16	7	9	14	10	135
BA	166	184	156	91	118	142	142	140	128	156	208	223	238	283	2375
Southeast Region	743	855	830	722	648	686	766	981	946	940	1040	907	992	938	11994

MG	547	625	598	491	430	431	509	672	650	670	759	610	687	646	8325
ES	4	3	5	4	-	3	6	11	7	2	-	-	-	-	45
RJ	12	14	20	11	24	19	15	21	30	21	26	15	32	27	287
SP	180	213	207	216	194	233	236	277	259	247	255	282	273	265	3337
South Region	116	116	124	99	111	94	113	121	144	118	133	101	97	163	1650
PR	104	108	111	89	97	80	106	109	131	107	123	91	87	151	1494
SC	5	5	6	7	8	9	4	4	5	4	5	7	6	6	81
RS	7	3	7	3	6	5	3	8	8	7	5	3	4	6	75
Midwest Region	463	458	381	250	259	269	270	349	281	348	311	337	289	299	4564
MS	50	54	67	29	42	48	53	61	44	61	40	48	32	30	659
MT	108	79	88	54	65	56	51	53	55	71	50	47	63	79	919
GO	286	291	207	150	139	149	150	207	164	194	203	211	174	161	2686
DF	19	34	19	17	13	16	16	28	18	22	18	31	20	29	300
Total	2383	2493	2166	1822	1790	1975	2177	2521	2747	2930	3132	2735	2563	2646	34080

Source: Ministry of Health - SINAN (2024).

In the North region, which accounted for 2,995 cases, the state of Tocantins had the highest number of occurrences (1,346) followed by Roraima (648), where the presence of reptiles can be explained by the transition between biomes and forests. The Central-West region registered 4,564 cases, with Goiás being the state with the highest incidence (2,686), which may be related to high agricultural activity and the cerrado. In the south of the country, a region that accounted for 1,650 cases in total, the state of Paraná concentrated 1,494 of these occurrences, reflecting the areas of Atlantic Forest and local agricultural practices (BRASIL, 2024).

The analysis of the monthly data in which the cases occurred reveals a clear seasonality, with a higher incidence in the first months of the year. January, February and March concentrated 11,834 cases, representing 34% of the total. This increase in the first months of the year may be related to the warmer and more humid weather, coinciding with greater snake activity and greater circulation of people in agricultural areas (BRASIL, 2024; TOZETTI et al., 2013; ARAÚJO et al., 2023).

Table 3

United States – Crotalus

Accident month	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
January	270	317	249	219	207	222	214	299	322	341	402	338	229	269	3898
February	288	244	242	187	187	197	272	287	286	321	393	312	305	278	3799
Landmark	266	308	305	196	201	219	237	308	312	325	349	320	362	329	4037
April	228	234	243	199	171	185	266	246	239	253	323	296	284	243	3410
May	205	250	177	179	156	150	176	210	224	286	272	212	220	242	2959
June	136	195	125	130	140	158	138	163	195	221	217	218	157	162	2355
July	148	142	112	100	104	125	107	129	172	167	192	148	128	153	1927
August	111	145	95	92	98	143	119	139	146	158	132	134	115	138	1765
September	122	131	115	88	115	144	102	127	159	174	155	162	154	143	1891
October	173	118	133	119	117	127	160	196	220	183	200	215	181	208	2350
November	201	186	178	153	145	150	184	201	206	213	204	184	204	237	2646
December	235	223	192	160	149	155	202	216	266	288	293	196	224	244	3043
Total	2383	2493	2166	1822	1790	1975	2177	2521	2747	2930	3132	2735	2563	2646	34080

Source: Ministry of Health - SINAN (2024).

The winter months, such as June (2,355 cases) and July (1,927 cases), had the lowest number of accidents, possibly due to less activity of both snakes and people in rural areas during this period. However, October and November showed a new increase in cases, possibly due to the resumption of agricultural activities and a greater presence of snakes after winter (BRASIL, 2024).

3.1 AGE GROUP

The distribution of accidents by age group reveals that most victims are in the 20 to 39 age group, with a total of 11,000 cases, followed by the 40 to 59 age group, which had 11,209 cases. These data indicate that young and middle-aged adults, particularly those engaged in agricultural activities and outdoor work, are more exposed to the risk of *Crotalus* bites (BRASIL, 2024; ARAÚJO et al., 2023).

Table 4

United States – Crotalus

Age group	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Blank/IGN	1	-	-	1	-	-	-	-	-	-	-	-	1	2	5
<1 Year	25	20	26	23	16	30	21	36	35	29	32	30	21	27	371
1 - 4 years	38	44	32	32	34	31	57	50	59	54	50	60	52	32	625
5 - 9 years	107	112	92	77	69	71	72	101	91	118	160	131	83	62	1346
10 - 14 Years	154	160	148	104	111	91	110	149	117	157	191	150	118	110	1870
15 - 19 years old	221	208	171	131	144	144	185	175	205	224	259	177	171	153	2568
20 - 39 years old	799	835	740	614	604	625	695	834	931	938	1001	829	766	789	11000
40 - 59 years old	747	804	693	589	563	663	736	820	919	966	984	903	857	965	11209
60 - 64 years old	117	130	86	80	90	117	108	158	154	173	186	165	193	206	1963
65 - 69 years old	94	74	79	82	64	100	92	91	106	124	111	119	131	127	1394
70 - 79 years old	65	86	85	67	77	69	81	80	100	130	126	138	130	141	1375
> 80 years	15	20	14	22	18	34	20	27	30	17	32	33	40	32	354
Total	2383	2493	2166	1822	1790	1975	2177	2521	2747	2930	3132	2735	2563	2646	34080

Source: Ministry of Health - SINAN (2024).

Children and adolescents aged 0 to 19 years add up to 6,780 cases, which corresponds to approximately 20% of the total. This age group requires special attention, since children are more vulnerable to the toxic effects of the poison due to their smaller body volume and greater difficulty in their physiological response to poisoning. On the other hand, the elderly, especially those over 60 years of age, accounted for 5,086 cases. This group is particularly susceptible to serious complications, including kidney failure and coagulopathies, due to the presence of comorbidities and physical frailty (BRASIL, 2024; DA SILVA et al., 2023).

3.2 GENDER

Table 5

United States – Crotalus

Accident year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Ignored	1	1	-	-	-	-	1	-	1	-	-	-	-	1	5
Male	1930	1972	1744	1449	1433	1575	1713	2007	2171	2335	2524	2140	2011	2071	27075
Female	452	520	422	373	357	400	463	514	575	595	608	595	552	574	7000
Total	2383	2493	2166	1822	1790	1975	2177	2521	2747	2930	3132	2735	2563	2646	34080

Source: Ministry of Health - SINAN (2024).

The data indicate that accidents involving *Crotalus* snakes predominantly affect males, with 27,075 cases, compared to 7,000 cases in females, between 2010 and 2023. This corresponds to a proportion of approximately 80% of cases occurring in men. This disparity can be explained by the greater presence of men in rural and risky activities, such as agriculture and livestock, which favor contact with snakes (BRASIL, 2024).

3.3 STING LOCATION

Table 6

United States – Crotalus

Sting Location	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Ign/Blank	41	51	30	25	32	35	36	36	34	39	52	66	46	37	560
Head	16	23	30	20	16	29	33	37	38	55	42	40	35	31	445
Arm	58	54	37	37	35	37	40	60	63	74	63	72	66	63	759
Forearm	36	41	45	32	30	29	38	46	50	47	56	46	43	37	576
Hand	282	265	266	228	263	256	317	324	397	374	354	365	356	391	4438
Finger of the hand	162	149	160	134	124	131	152	208	179	196	225	210	211	205	2446
Trunk	12	13	14	17	11	12	18	14	27	26	21	20	30	27	262
Thigh	15	21	23	12	20	26	20	28	21	17	32	34	30	33	332
Leg	736	750	644	563	526	588	586	662	784	793	877	758	727	758	9752
Foot	897	986	816	680	635	733	844	944	1029	1150	1241	988	897	934	12774
Toe	128	140	101	74	98	99	93	162	125	159	169	136	122	130	1736
Total	2383	2493	2166	1822	1790	1975	2177	2521	2747	2930	3132	2735	2563	2646	34080

Source: Ministry of Health - SINAN (2024).

The bite site is another important factor in the analysis of *Crotalus* accidents. Most bites occur in the lower limbs, mainly in the foot (12,774 cases) and leg (9,752 cases). This reflects the natural behavior of snakes, which attack when they feel threatened, especially when people walk through areas of dense vegetation or manipulate the soil, where snakes often hide. Bites on the upper limbs, including hands and fingers, add up to 6,884 cases, suggesting that many of these occurrences may happen during the inadvertent handling of snakes or in situations of direct attack (BRASIL, 2024).

4 CONCLUSION

As the accidents occurred mainly in rural areas, in the hottest and humid months, affecting the upper and lower limbs of young and middle-aged adults, in agricultural and outdoor activities, the need for prevention campaigns is fundamental, reinforcing the need for the correct use of personal protective equipment for the most exposed population and awareness of the health teams regarding the characteristics of these accidents in order to provide adequate care, without delay, minimizing possible complications.

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**SOCIAL DIALOGUE AND TOLERANCE: BUILDING A MORE JUST AND
DEMOCRATIC SOCIETY IN MEXICO**

**DIÁLOGO SOCIAL E TOLERÂNCIA: CONSTRUÇÃO DE UMA SOCIEDADE
MAIS JUSTA E DEMOCRÁTICA NO MÉXICO**

**DIÁLOGO SOCIAL Y TOLERANCIA: CONSTRUCCIÓN DE UNA SOCIEDAD
MÁS JUSTA Y DEMOCRÁTICA EN MÉXICO**

 <https://doi.org/10.56238/sevened2025.036-100>

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ABSTRACT

This analysis seeks to examine the causes that have contributed to the decreasing tolerance in dialogue among different sectors and social classes in Mexico. The study was conducted using a qualitative, analytical, and documentary approach, offering a comprehensive perspective on the dynamics that influence social coexistence. It identifies the causes of intolerance and also analyzes the role of the political class and the media in constructing narratives that negatively affect social understanding, dialogue, and harmonious coexistence among citizens. The findings of this research are expected to be useful both for scholars and for those who design public policies and strategies aimed at fostering greater peaceful

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coexistence in the country, particularly in times when violence has taken over much of the public spaces in the Mexican Republic.

Keywords: Intolerance. Dialogue. Inequality. Polarization. Media.

RESUMO

A presente análise busca examinar as causas que têm contribuído para a crescente diminuição da tolerância no diálogo entre diferentes setores e classes sociais do México. Este trabalho foi realizado a partir de uma abordagem qualitativa, analítica e documental, oferecendo uma visão compreensiva das dinâmicas que influenciam a convivência social. Identificam-se as causas da intolerância, analisando também o papel da classe política e dos meios de comunicação na construção de narrativas que afetam negativamente o entendimento social, o diálogo e a convivência harmônica entre os cidadãos. Espera-se que os resultados desta pesquisa sejam úteis tanto para acadêmicos quanto para aqueles que formulam políticas públicas e estratégias capazes de promover uma convivência mais pacífica no país, especialmente em tempos em que a violência se apoderou de grande parte dos espaços públicos da República Mexicana.

Palavras-chave: Intolerância. Diálogo. Desigualdade. Polarização. Mídia.

RESUMEN

El presente análisis pesquisa analizar las causas que han contribuido a que cada vez exista menor tolerancia en el diálogo entre distintos sectores y clases sociales de México. Este trabajo se ha realizado desde un enfoque cualitativo, analítico y documental y ofrece una visión comprensiva de las dinámicas que influyen en la convivencia social, identificando las causas de la intolerancia, analizando también el papel de la clase política y de los medios de comunicación en la construcción de narrativas que inciden negativamente en el entendimiento social, el diálogo y la convivencia armónica de la ciudadanía. Se espera que los resultados obtenidos de esta investigación sean de utilidad tanto a académicos como para aquellos que formulan políticas públicas y estrategias que puedan fomentar una mayor convivencia pacífica en el país, en tiempos en donde la violencia se ha apoderado de gran parte de los espacios públicos en la República Mexicana.

Palabras clave: Intolerancia. Diálogo. Desigualdad. Polarización. Medios.

1 INTRODUCTION

In a country with great cultural and social diversity such as Mexico, tolerance and dialogue become fundamental for social well-being and to achieve peaceful coexistence, however; From 2012 to date, there has been an increase in social polarization and a decrease in the capacity for dialogue between sectors and social classes. Factors such as economic inequality, violence, and polarizing discourse in the political class and in the media have sown distrust and fragmentation, even affecting family units. For this reason, this research explored some factors that cause or trigger intolerance, contributing, through these results, to make visible the need to build a more cohesive and dialoguing social environment in Mexican society.

1.1 PROBLEM STATEMENT

The lack of tolerance in social dialogue in Mexico is an alarming phenomenon that has affected society as a whole. Despite efforts by various institutions and civil organizations to promote mutual understanding, tensions between different groups, accentuated by political, social, and economic crises, have led to increasingly hostile communication between people. The media, in their role as opinion makers, have also played a crucial role in this dynamic, often intensifying polarization. This analysis allows us to understand how these elements interact and what are the roots of intolerance that impede constructive dialogue in the country.

The National Human Rights Commission (CNDH) stressed that the accusations and disqualifications of media outlets and journalists, as well as against defenders and civil society organizations, by senior state officials contribute to generating an environment that is not conducive to freedom of expression and journalists, and also to those who promote respect for the rule of law and defend fundamental rights. in addition to showing the worsening in many cases of the conditions that gave rise to the Mechanism for the Protection of Human Rights Defenders and Journalists (CNDH, 2023, par. 1).

1.2 RESEARCH OBJECTIVES

General Objective

To analyze the main causes that have generated a lack of tolerance in the dialogue between sectors and social classes in Mexico, in the period 2012-2025, through a qualitative and documentary study.

Specific Objectives

Identify and examine the social and political causes that have contributed to intolerance and polarization in the Mexican context.

To analyse the impact of the media and media narratives on public perception of tolerance and social dialogue.

1.3 THEORETICAL FRAMEWORK

According to the CNDH Mexico (2018), tolerance is defined as respect for the ideas, beliefs, or practices of others when they are different or contrary to one's own. In this context of this study, tolerance involves not only the passive acceptance of diversity, but also an active recognition of the legitimacy of other perspectives. This concept is crucial in plural societies, as it promotes peaceful coexistence and mutual understanding, essential components for social and political development. Tolerance, therefore, can be affected by multiple factors, including historical, educational, and socioeconomic context, among others.

The communicative process that aims to exchange ideas and build understanding between different people and groups is known as dialogue, and this is not a simple conversation, nor a debate. It is not a question of convincing others to agree with one's own point of view or of converting them. The aim of the dialogue is to overcome misunderstandings and dispel stereotypes in order to promote mutual understanding (KAICIID, n.d., para. 2). For the purposes of this publication, dialogue is conceptualized as an open space where the expression of diverse opinions is encouraged and consensus is sought through empathy and respect.

Dialogue is therefore critical in the management of social conflicts, since it allows differences to be addressed and joint solutions to be found, avoiding conflicts; the latter being understood as a situation in which two or more agents (people, groups) perceive that they have mutually incompatible interests, make their disagreement public and seek to mobilize support and allies in a confrontational context of permanent opposition (Aunta and Barrera, 2016, cited by Ibáñez, 2022, p. 2). Effective dialogue is therefore essential to overcome polarization and build healthy and sustainable social relationships. Social sectors refer to the different groups in society that are differentiated by characteristics such as economic class, ethnic identity, geographical location, among other factors. In Mexico, it is essential to recognize that society is made up of multiple strata with different interests and levels of power. The interaction between these sectors can be both constructive and conflictive, depending on the conditions of tolerance and the ability to engage in effective dialogues.

Taking into account what was published by the Central University (2021), effective communication refers to the ability to transmit information and emotions in a clear and understandable way, ensuring that the message is properly received and understood by the interlocutor, it also implies expressing thoughts and feelings in an honest and respectful way, without falling into aggression or passivity. thus facilitating constructive dialogue and reducing stress and therefore, contributing to reducing social tension and building bridges between different social sectors.

In this regard, Baca (S.F.) mentions that communication and dialogue are, therefore, the fundamental pillars in the strengthening of a democratic and just society, since open and honest communication allows citizens to express their opinions, demands and concerns, which contributes to the development of more inclusive and representative public policies. In addition, dialogue facilitates consensus-building, promoting the participation of various sectors in the democratic process, fostering tolerance for diversity and allowing all voices to be heard. The lack of tolerance between social sectors can transform dialogue into a field of conflict, where judgments and mistrust prevail instead of mutual understanding. At the same time, effective dialogue, facilitated by assertive communication, acts as a catalyst for tolerance and allows different sectors to interact constructively, a challenge that must now be addressed and prioritized in Mexico.

This qualitative research work, which has focused on documentary analysis, has adopted a qualitative design of non-intervention, which has allowed the collection and analysis of data from secondary sources, exploring in depth the causes of intolerance in social dialogue in Mexico, without the need for direct interaction with the participants. With respect to the sources consulted, it is based on the analysis of various documentary sources, such as: academic articles and books, government reports, and, where appropriate, publications of non-governmental organizations and other civil society actors, and press publications, such as reports or news, which contain information related to social coexistence. and that specifically address intolerance and dialogue between social sectors, during the period 2012-2025. The documents from the various sources were identified and analyzed, categorizing the information, and then carrying out the analysis of the content and the revelation of the corresponding findings.

2 RESULTS

Economic inequality in Mexico is a persistent phenomenon that continues to affect the possibilities of effective dialogue between social classes. According to the National Council for the Evaluation of Social Development Policy [CONEVAL] (2018), in that year, about 41.9% of the population lived in poverty, and although there was a slight decrease, extreme poverty continued to affect a significant proportion of the population. This inequality translated not only into income differences, but also into access to essential services such as education, health, and employment. The unequal distribution of resources creates a psychological and social gap that fosters mistrust among sectors of the population, had deteriorated the ability to engage in constructive and collaborative dialogues. In addition, the aforementioned studies showed social injustice as a driver that fuels feelings of intolerance, since, when people feel that their needs are not being met fairly, they can become more hostile towards other groups. In this sense, economic inequality becomes an obstacle to the construction of cohesive and dialoguing communities.

Political polarization has also reached alarming levels in the Mexican context, particularly since the 2018 elections, which led to a radical change in government administration. This phenomenon has been exacerbated by divisive political rhetoric and a lack of commitment to constructive dialogue. Research by the organization "Causa en Común" (2023) revealed that political polarization not only affects political life itself, but also permeates relations between citizens, creating setbacks that ruin the possibility of communication and cooperation among citizens. It is also worth mentioning that the growing distrust in political institutions has led many citizens to consider dialogue to be useless. In this sense, the survey by the National Electoral Institute [INE] (2022) shows that 67% of those interviewed expressed that they do not trust political parties, which reflects how this distrust acts as a brake on social dialogue. Therefore, the lack of institutional trust translates into a growing indifference towards civic participation, leading to a decrease in spaces where dialogue can take place effectively.

The media, for their part, have also played an ambivalent role in making or breaking social dialogue. On the one hand, they can act as platforms for diverse voices, and, on the other, contribute to polarization by spreading biased or false information, prioritizing sensationalist narratives that exacerbate conflicts, rather than promoting mutual understanding and peaceful conflict resolution.

This fake news, which is dispersed either through headlines, images or larger letters, or any other type of information that is taken out of context to make it seem true, when it is not, is fabricated to manipulate or deceive through impostor content, creating a problem of certainty and truth in the information among the population.

Before the emergence of the internet, the "blog", the "web", among others, information professionals had at their disposal a series of sources of information that were considered reliable, reference sources that followed a series of controls and validations through which it was possible to guarantee the quality of the information disseminated. However, the consolidation of social networks has created a problem about the certainty and veracity of information (López-Borrull et al., cited by CNDH, 2019, p.11).

Intolerance and discrimination in Mexico is another important factor to consider in this study and manifests itself in various ways, including racism, homophobia and xenophobia; which makes it difficult to create spaces for inclusive dialogue. The National Council for the Prevention of Discrimination [CONAPRED] (2023) has reported an increase in complaints of discrimination in recent years, especially among vulnerable groups such as indigenous communities and the LGBTQ+ population. These forms of intolerance are not just individual issues, but reflect broader social structures that perpetuate exclusion and division. In addition to the above, that same agency in the results of its national survey on discrimination [ENADIS] applied in 2022 in Mexico, recognizes that, of the total population aged 18 years and over, 23.7% stated that they had been discriminated against in the last 12 months due to one of the following characteristics or personal condition: skin tone, way of speaking, weight or height, way of dressing or personal grooming, social class, place of residence, religious beliefs, sex, age, sexual orientation, being an indigenous or Afro-descendant person, having a disability, having a disease, political opinions, marital status or situation of partner or family, among others. These results are important because, as mentioned above, when the voices of historically marginalized sectors are ignored, hostility can increase and this in turn impedes social dialogue.

Distrust in institutions is another widespread phenomenon that is affecting the quality of social dialogue in this country. A study by "México Evalúa" (2023), showed that 72% of Mexicans do not trust the judicial system, attributing this distrust to the perception of corruption and lack of access to justice. This situation has led to social fragmentation, where citizens feel that they have no effective channel to express their concerns or seek solutions to their problems. In addition, when citizens perceive that institutions are more aligned with

particular interests than with the common good, the legitimacy of public policies and programs is undermined. In this context, a lack of trust becomes a significant impediment to constructive dialogue and collaboration between sectors. According to this same source, between 2020 and 2024, fewer and fewer people had heard about key entities, such as prosecutors' offices, judges, and police (México Evalúa, 2023, p. 3).

Violence and insecurity are perhaps the most powerful factors affecting social dialogue in Mexico. With homicide rates that have remained alarmingly high in recent decades, uncertainty and fear permeate the daily lives of many citizens. According to data from the Mexican Secretariat of Security and Citizen Protection (2023), there is a widespread perception that violence is on the rise, leading communities to close themselves off and distrust others, this violence not only affects the direct victims, but also has a domino effect that disrupts social dynamics, fostering attitudes of distrust and aggressiveness. In this sense, the context of violence highlights the need to create safe spaces where dialogue can take place. These community initiatives have become essential, but governments do not perceive these actions as a priority, but, on the contrary, there are constant accusations and disqualifications, sanctions or even disappearances of those who think differently; a factor that has severely limited them. In addition to the above, the lack of tolerance in social dialogue in Mexico, which has skyrocketed over the last seven years, has revealed a complex interrelation of factors that fuel polarization and hinder the construction of peaceful coexistence.

3 CONCLUSIONS

The persistence of socioeconomic inequality is one of the main obstacles to dialogue in Mexico. As long as a large part of the citizens are born, grow up and live their lives with serious shortcomings, social dialogues in this country will continue to be absent.

Political polarization, on the other hand, is a true "social cancer" that has reached critical levels, and has been exacerbated by a media environment that prioritizes sensationalization and divisive narratives, both in the country's political class, the current government of Mexico, and in the media, a political climate that hinders the possibility of forming consensus and limits citizen participation. It is essential that both the media and political leaders of all parties adopt constructive positions that promote mutual understanding, respect and inclusion of all social sectors and among all social sectors.

Mexico and other countries face processes of growing political intolerance between defined or undefined groups in society. The constant disqualification of the views of others, the reduction to absurdity of the arguments of those who consider themselves to be against it, the oversimplification of the views that favor our own opinions and discard the validity of those who think differently from us is a constant today in practically any media we consult (Martínez, 2025, pair. 3).

As can be seen, the problem of lack of social dialogue and intolerance in Mexico is multifactorial and complex. Undoubtedly, in this chapter only some factors that intervene in this social phenomenon are analyzed, for this reason it is necessary to continue expanding research on the subject, considering other aspects such as: migration, family disintegration, organized crime and various world paradigms such as materialism, economic interests, globality and other ideologies that, instead of promoting universal values, they contribute to social disintegration and the devaluation of life.

There are many challenges, one of them is the promotion of content in social media and even in institutional media, which prioritize understanding and the peaceful resolution of conflicts; a situation that is difficult to achieve, since it implies the establishment of codes of ethics that promote social responsibility in communication, but at the same time defend and allow freedom of expression, in a society where, in many spaces, corruption has seriously permeated, and the thirst for power and control for the achievement of political and business objectives. turning these problems into opportunities for the implementation of authoritarianism and control "in mode" of the population, in which citizens run the risk of losing even more freedoms.

For this reason, it is considered essential that academic institutions, especially those of higher education, undertake a strong strategy of information and media literacy, so that a good part of the population can show and issue informed judgments as users of information and media, generating content that is based on and objective the development of critical thinking. so that people are able to discern between what is fact, what is false news or a simple opinion, since sadly but daily, these are some of the strategies that seriously violate a majority of citizens of the Mexican population. At the same time, it is imperative to develop in citizens competencies that allow them to search, analyze and organize the information to which they have access.

This is complex in a society where quality education is a luxury and in an environment in which those who do not make an effort are rewarded and those who produce are punished,

a system that perpetuates the division of sectors and allows the manipulation of people, installing in their imagination, the idea that some are bad and others are good. For this reason, education must be provided for democracy and citizen participation, in spaces where young people are taught to dialogue respectfully and to understand the complexity of human interactions, through respect for diverse points of view. As Edward James Olmos rightly states, "Education is the vaccine against violence" (Portilla, 2024, p. 81).

The family is positioned as the first educational space in society, and it is, for this reason, where the learning of tolerance and respectful dialogue begins. Parents are responsible for promoting assertive communication and respect for differences at home, so that people are not only able to dialogue, but also to value diversity as something that enriches (not gender ideology, which is something else). Education in the family nucleus is responsible for instilling respect and promoting it consistently; Educational institutions are only complementary in the integral formation of the subject. The school must strengthen effective and assertive communication in the classroom, but the family is the nucleus of training and dialogue.

To conclude, it can be said that the promotion of a culture of dialogue and tolerance in Mexico is not only an aspirational desire, but an urgent need. At a historical moment in which Mexico is presenting what could be defined as a great "social tribulation"; This country is in a period of intense adversity, suffering and difficulties that affects society as a whole; For this reason, the family, academia, government, the media, companies, social networks, and all social sectors of the country, must be allies to generate a process that reverses intolerance in dialogue, creating environments in which each individual feels valued, listened to, and respected, regardless of their beliefs and points of view. since only in this way can a just, democratic and happy society be built.

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**GENERATION OF PERSONALIZED READING RECOMMENDATIONS WITH
ARTIFICIAL INTELLIGENCE INTEGRATION: DEVELOPMENT OF THE
BOOKSUGGEST AI APPLICATION**

**GERAÇÃO DE RECOMENDAÇÃO DE LEITURA PERSONALIZADA COM
INTEGRAÇÃO DE INTELIGÊNCIA ARTIFICIAL: DESENVOLVIMENTO DA
APLICAÇÃO BOOKSUGGEST AI**

**GENERACIÓN DE RECOMENDACIONES DE LECTURA PERSONALIZADAS
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APLICACIÓN BOOKSUGGEST AI**

 <https://doi.org/10.56238/sevened2025.036-101>

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ABSTRACT

Recommendation systems have become central elements in contemporary digital platforms, thereby assisting users in making decisions related to content consumption. However, reading-based recommendations still have strong characteristics such as dependence on collective evaluations, popularity algorithms, or superficial metadata. This article presents a new possibility: BookSuggest AI, a recommendation system that integrates personal reading history, recorded by the user in Google Sheets spreadsheets, with Generative Artificial Intelligence models. Based on classic authors of recommendation systems, such as Adomavicius and Tuzhilin (2005), Goldberg et al. (1992), and Resnick and Varian (1997), the

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work explores how personal data can be transformed into relevant recommendations using modern AI techniques. The study details the technological architecture, the authentication process via Google OAuth, the data extraction and processing pipeline, as well as the use of generative models to build recommendations. The results demonstrate that BookSuggest AI is capable of generating personalized suggestions that are justified and consistent with user preferences. In addition, a critical analysis of the system and a discussion of its potential, limitations, and contributions are included. The article complies with ABNT standards and the editorial standards of Revista Aracê.

Keywords: Recommendation Systems. Artificial Intelligence. Reading. Personalization. Generative AI.

RESUMO

Sistemas de recomendação tornaram-se elementos centrais em plataformas digitais contemporâneas, e auxiliam, com isso, usuários na tomada de decisões relacionadas ao consumo de conteúdo. No entanto, recomendações baseadas em leitura ainda apresentam fortes características como a dependência de avaliações coletivas, algoritmos de popularidade ou metadados superficiais. Este artigo apresenta uma nova possibilidade: o BookSuggest AI, um sistema de recomendação que integra o histórico pessoal de leitura, registrado pelo usuário em planilhas do Google Sheets, com modelos de Inteligência Artificial Generativa. Fundamentado em autores clássicos dos sistemas de recomendação, como Adomavicius e Tuzhilin (2005), Goldberg et al. (1992) e Resnick e Varian (1997), o trabalho explora como dados pessoais podem ser transformados em recomendações relevantes por meio de técnicas modernas de IA. O estudo detalha a arquitetura tecnológica, o processo de autenticação via Google OAuth, o pipeline de extração e tratamento de dados, bem como o uso de modelos generativos para construção das recomendações. Os resultados demonstram que o BookSuggest AI é capaz de gerar sugestões personalizadas, justificadas e coerentes com as preferências do usuário. Além disso, inclui-se uma análise crítica do sistema e discussão sobre suas potencialidades, limitações e contribuições. O artigo está alinhado às normas ABNT e ao padrão editorial da Revista Aracê.

Palavras-chave: Sistemas de Recomendação. Inteligência Artificial. Leitura. Personalização. IA Generativa.

RESUMEN

Los sistemas de recomendación se han convertido en elementos centrales de las plataformas digitales contemporáneas y, por lo tanto, ayudan a los usuarios a tomar decisiones relacionadas con el consumo de contenidos. Sin embargo, las recomendaciones basadas en la lectura siguen presentando características importantes, como la dependencia de evaluaciones colectivas, algoritmos de popularidad o metadatos superficiales. Este artículo presenta una nueva posibilidad: BookSuggest AI, un sistema de recomendación que integra el historial de lectura personal, registrado por el usuario en hojas de cálculo de Google Sheets, con modelos de inteligencia artificial generativa. Basado en autores clásicos de los sistemas de recomendación, como Adomavicius y Tuzhilin (2005), Goldberg et al. (1992) y Resnick y Varian (1997), el trabajo explora cómo los datos personales pueden transformarse en recomendaciones relevantes mediante técnicas modernas de IA. El estudio detalla la arquitectura tecnológica, el proceso de autenticación a través de Google OAuth, el proceso de extracción y tratamiento de datos, así como el uso de modelos generativos para la construcción de recomendaciones. Los resultados demuestran que BookSuggest AI es

capaz de generar sugerencias personalizadas, justificadas y coherentes con las preferencias del usuario. Además, se incluye un análisis crítico del sistema y una discusión sobre sus potencialidades, limitaciones y contribuciones. El artículo se ajusta a las normas ABNT y al estándar editorial de la Revista Aracê.

Palabras clave: Sistemas de Recomendación. Inteligencia Artificial. Lectura. Personalización. IA Generativa.

1 INTRODUCTION

A priori, it is valid to bring that digital transformation has significantly expanded the possibilities of customization in computer systems. With the growing availability of personal data and the advancement of Artificial Intelligence techniques, new ways to assist users in decision-making have emerged in the most diverse domains, such as entertainment to education, or from health to cultural consumption (ROBERTSON; VINCENT, 2023).

Among these domains, the context of reading stands out. Platforms such as Goodreads, Skoob, and Bedside have gained popularity by allowing the recording of reading habits, the sharing of opinions, and the building of literary communities. In view of this, as Adomavicius and Tuzhilin (2005) point out, many recommendation systems still operate with traditional techniques, and their collaborative filters, general popularity, or aggregate rankings, represent strategies that can sometimes present gaps in capturing individual nuances of users. It is worth noting that the potential of traditional recommendation systems, by proposing the space of displacement to the reader through the community's field of discovery, is a relevant power. However, here, we will focus on the proposition of adjusting the recommendations to your enjoyment zone.

In parallel, it is also observed that many readers build individualized records in personal spreadsheets, such as Google Sheets. In these documents, users write down titles, authors, reading dates, subjective evaluations, and even their own comments. Despite the richness of this data, data such as these may not be used for analytical purposes to their full potential (BOENTE et al., 2025).

In view of this scenario, the present work proposes BookSuggest AI, a recommendation system that uses personal and real data recorded by the reader. The proposal integrates Google Sheets with generative AI to identify patterns and suggest books that dialogue directly with the reader's profile.

This paper presents: a theoretical review on recommendation systems and generative AI; the methodology for developing the system; results obtained with the operation of the tool; comparative discussion and critical analysis; and conclusions that point to future possibilities.

2 METHODOLOGY

The methodology adopted in the development of BookSuggest AI was structured to ensure technical accuracy, functional coherence, and fidelity to the system's central

objective: to generate personalized literary recommendations from real user data. To this end, the system was designed as a modular web application, organized in layers that communicate in an integrated way. The user interface is the initial point of interaction, which allows authentication, selection of the reading spreadsheet, and visualization of recommendations. The business logic is processed in the backend, implemented in Go, which connects to Google Sheets and generative Artificial Intelligence models. This layer is supported by external services, such as Google OAuth 2.0 for secure authentication, the Google Sheets API for reading the data, and the Gemini or ChatGPT models for analysis and generation of suggestions.

The data collection and processing process begins with user authentication, carried out exclusively in reading mode, as it values privacy and compliance with international digital security standards. After *logging in*, the system requests the selection of the spreadsheet that contains the reading history, and requests minimum columns such as title, author, genre, rating, and date, as well as optional fields such as comments and tags. Once loaded, the data undergoes transformations that normalize categories, convert notes into numerical values, and structure a reading dictionary, an essential step to avoid inconsistencies that could compromise the AI's analysis.

The next phase corresponds to the analysis based on generative Artificial Intelligence, considered the innovative core of the system. The backend organizes a prompt that gathers the complete history of readings, summary statistics, and specific instructions for the model to produce exactly three recommendations, accompanied by detailed justifications structured in JSON format. AI interprets patterns such as author recurrence, gender predominance, variations in ratings, and even preferences for certain literary periods, and balances different reader tendencies when formulating suggestions. The result is returned to the user in visual cards, which contain title, author, justification and degree of relevance.

Finally, the development of BookSuggest AI involved a set of modern technologies that are widely used in web applications. In the backend, in addition to Go, frameworks such as Gin, libraries for OAuth and the official Google API client were used. The frontend was built with HTML5, CSS3 and JavaScript, using Bootstrap for responsiveness and

Additional user experience components. The AI layer directly integrates Gemini and/or ChatGPT APIs, while the infrastructure includes containerization via Docker, in order to ensure scalability and technological independence.

3 THEORETICAL FOUNDATION

The theoretical foundation of this work addresses relevant concepts in understanding the functioning and relevance of BookSuggest AI. The bases of recommendation systems, the role of generative Artificial Intelligence models, as well as studies and platforms related to reading and literary suggestions are discussed.

3.1 RECOMMENDATION SYSTEMS

Recommendation systems are computational tools created to assist users in making decisions in the face of the large volume of information available digitally. The literature describes these solutions as mechanisms capable of identifying patterns of behavior, inferring preferences, and suggesting items appropriate to individual profiles (ADOMAVICIUS; TUZHILIN, 2005).

Approaches such as that of Goldberg et al. (1992), with the Tapestry system, dealt with the collaborative filtering technique, and thought about the generation of recommendations based on the actions and preferences of other users with similar profiles. Resnick and Varian (1997) point out that this technique has revolutionized access to information, especially in domains such as movies, music, and e-commerce.

Over time, systems have evolved into three main categories:

a) Collaborative Filtering

It is based on collective behavior. Users with similar tastes receive similar recommendations (Goldberg et al., 1992).

Example: "People who read X also liked Y."

b) Content-Based Filtering

It focuses on characteristics of the items: genre, author, keywords, themes, etc.

Example: "You liked science fiction, so we recommend more science fiction books."

c) Hybrid Systems

They combine user data with item characteristics, and seek greater accuracy (ADOMAVICIUS; TUZHILIN, 2005).

Observing these advances, it is possible to reinforce that the power, in the field of suggestions, of collaborative filtering, may also represent a gap in the individualization of the recommendation. The recommendations may be generic, and even have no inference from the taste of a specific reader, but rather from the *ranking* of popular titles, for example.

In this sense, it is relevant to explore alternative ways of recommending, such as those based on **a personal and personalized curation**, made an individual reading worksheet. With this in mind, we think of users who record data such as title, author, reading date, assigned grade, personal comments, genre, duration, goals. In line with the autonomy of the use of the personal spreadsheet, the following theoretical assumption is assumed for the project:

The personal reading history is representative of a reader's preference, and its exploration is fertile.

This principle guides the development of the system presented in this article.

3.2 GENERATIVE ARTIFICIAL INTELLIGENCE

In recent years, Generative Artificial Intelligence models have become widely used. Platforms such as GPT (OpenAI), Gemini (Google) and Claude (Anthropic) have transformed the way texts are produced, analyzed and structured automatically (ROBERTSON; VINCENT, 2023).

These models are capable of interpreting complex instructions; identify patterns in datasets; generate personalized content; analyze implicit preferences and even create explanatory justifications. The use of generative AI in recommendation contexts represents an advance over traditional methods. While classical algorithms require extensive bases for identifying patterns (ADOMAVICIUS; TUZHILIN, 2005), generative models can interpret even small sets of data, such as a personal spreadsheet.

BookSuggest AI relies on these points. Through strategically structured prompts, the generative model is able to analyze evaluations given by the user; infer favorite genres, recognize recurring authors; identify subjective patterns and generate coherent recommendations even with few samples. This process allows you to go beyond the limits of systems based solely on statistical algorithms or collaborative filtering.

3.3 LITERARY RECOMMENDATION PLATFORMS AND APPLICATIONS

The popularization of reading platforms has broadened the discussion about literary recommendations. About Goodreads, thinking about the current year (2025), millions of users use the network to record readings and search for suggestions. In Brazil, Skoob has similar functionality, and enables the organization of shelves, goals and reviews.

Even so, the literature and empirical analysis indicate the majority of popularity-based recommendations; *global ranking* ; and the consequent partial disappearance of the individual history, resulting from the sometimes widespread reliance on collaborative databases and the high influence of trends.

Boente et al. (2025) discuss how customized solutions based on proprietary data have the potential to generate greater relevance and accuracy. Although Boente's study deals with the health domain, his methodological approach oriented to personal data represents a strong inspiration.

In the literary context, there are still few systems that connect intrinsically personal databases to the recommendation process; employ generative AI to interpret them; provide explained suggestions; operate with private data controlled by the user and also avoid dependence on external generic metrics. Thus, BookSuggest AI proposes an innovative path: it builds recommendations that aim to be guided by greater proximity to the reader's profile.

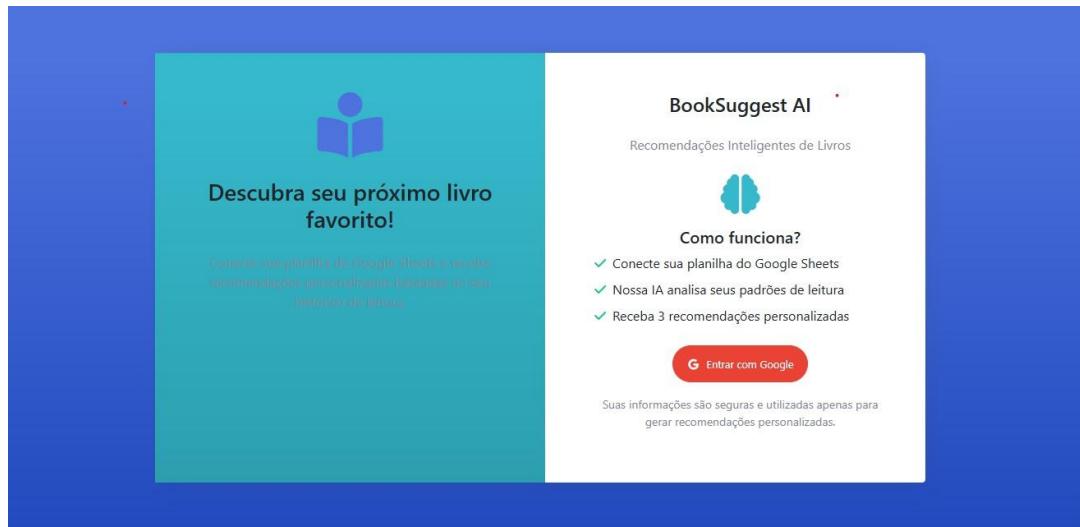
4 RESULTS

This section presents the results obtained from the development of BookSuggest AI, including the functional flow of the system, the analysis of the user experience, the integration with external APIs, and the display of recommendations generated by Artificial Intelligence. All screens captured during the execution of the system were reorganized and described according to the standards for the presentation of figures, in order to ensure contextualization and narrative coherence.

BookSuggest AI achieved its proposed goals: it integrated with Google Sheets, processed real reading data, used AI models to generate personalized recommendations, and presented the results to the user in a clear and visually structured way. The system proved to be functional from login to the final generation of recommendations, including intermediate loading screens and spreadsheet selection.

Figure 1

BookSuggest AI System Home Page

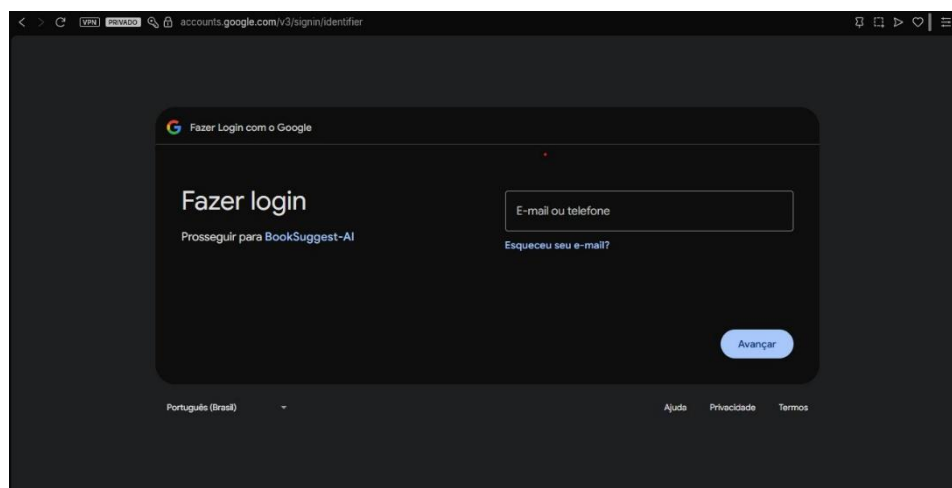


Source: Prepared by the author in 2025.

Figure 1 shows the system's home screen, where the user accesses the main page and starts the authentication flow. The interface prioritizes simplicity, presenting only the login button, an essential item for secure access validation. By clicking "Sign in with Google", the user is redirected to the official OAuth screen, as shown in Figure 2.

Figure 2

Google Sign-in Option

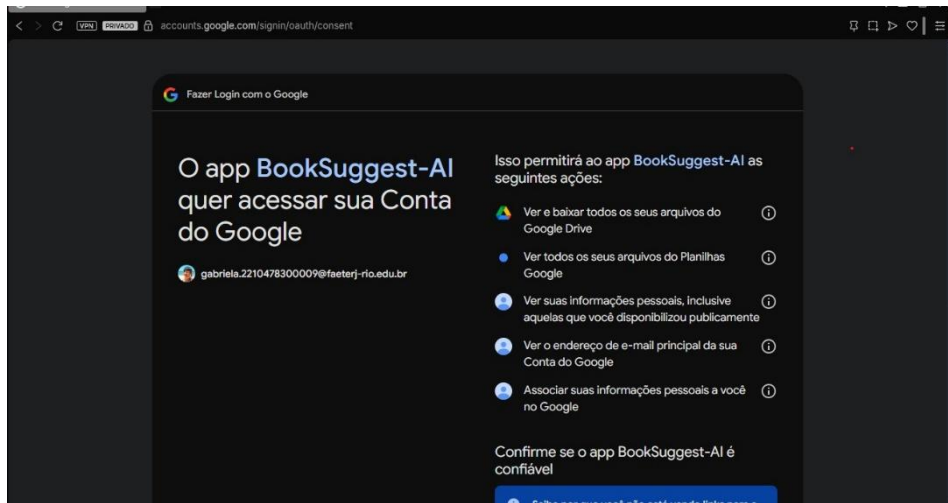


Source: Prepared by the author in 2025.

Authentication is confirmed in sequence with intermediate screens, to be represented by Figures 3 and 4.

Figure 3

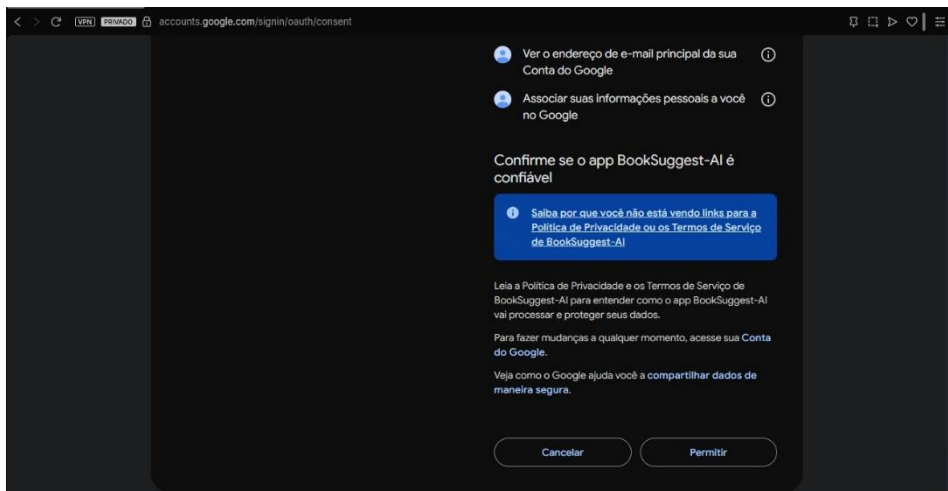
Google Account Verification



Source: Prepared by the author in 2025.

Figure 4

Confirmation of System-Requested Permissions

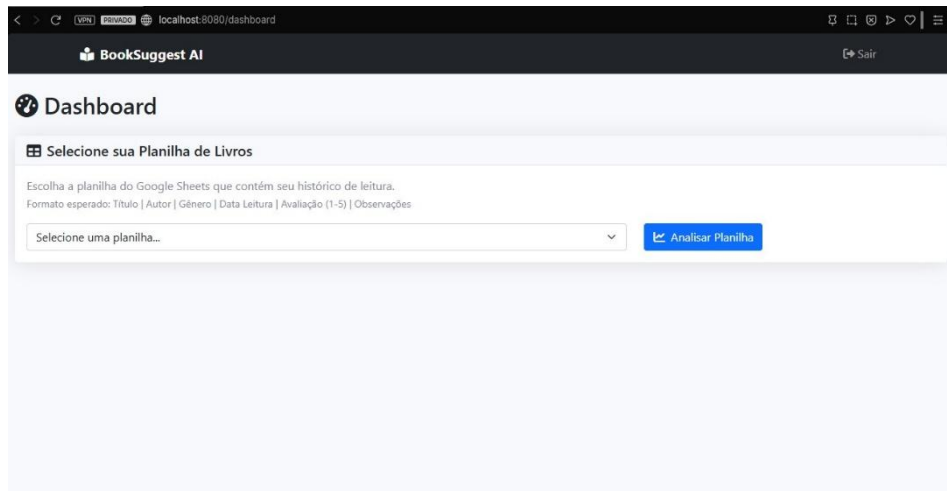


Source: Prepared by the author in 2025.

These screens demonstrate the project's alignment with international security standards, ensuring that no sensitive data is used without consent. After authentication, the user returns to the BookSuggest AI dashboard, which presents the initial interface before loading any spreadsheets. Figure 5 highlights this step.

Figure 5

Dashboard Before Sheet Selection

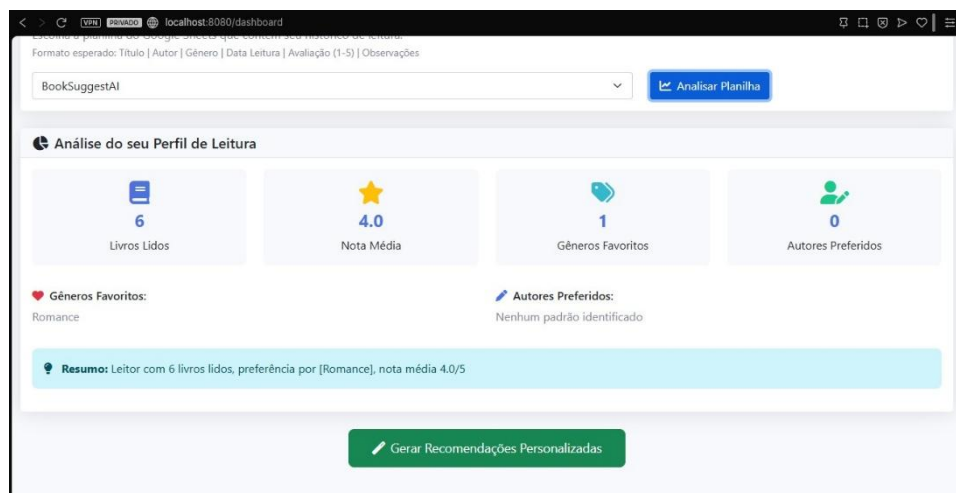


Source: Prepared by the author in 2025.

The screen presents only the basic elements, and waits for the user to act. When you select the desired spreadsheet, the system processes the data and automatically updates the dashboard.

Figure 6

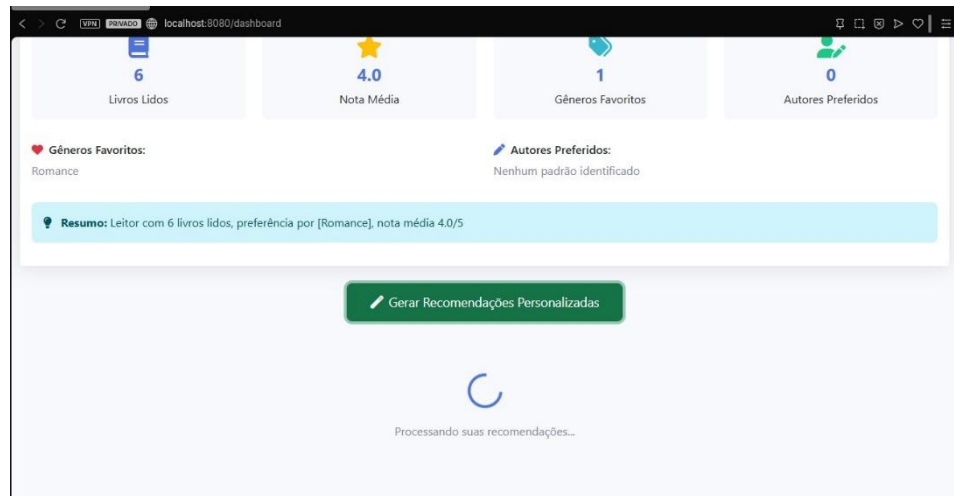
Dashboard, after sheet selection



Source: Prepared by the author in 2025.

When you request literary suggestions, the system displays the screen shown in Figure 7, indicating that processing is in progress.

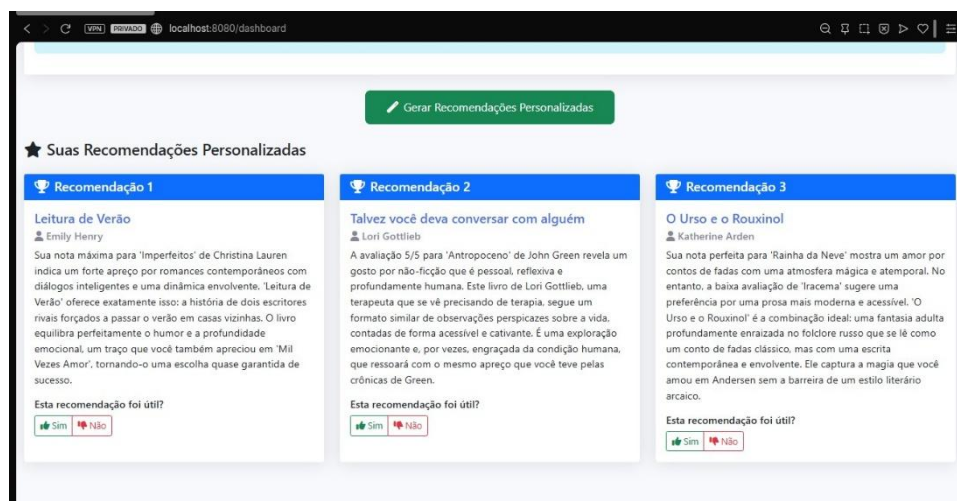
Figure 7
Recommendations Loading Screen



Source: Prepared by the author in 2025.

This stage is critical as it involves calling for generative AI models. At the end of processing, the user receives personalized recommendations, displayed in structured cards, as shown in Figure 8.

Figure 8
AI-Generated Recommendations



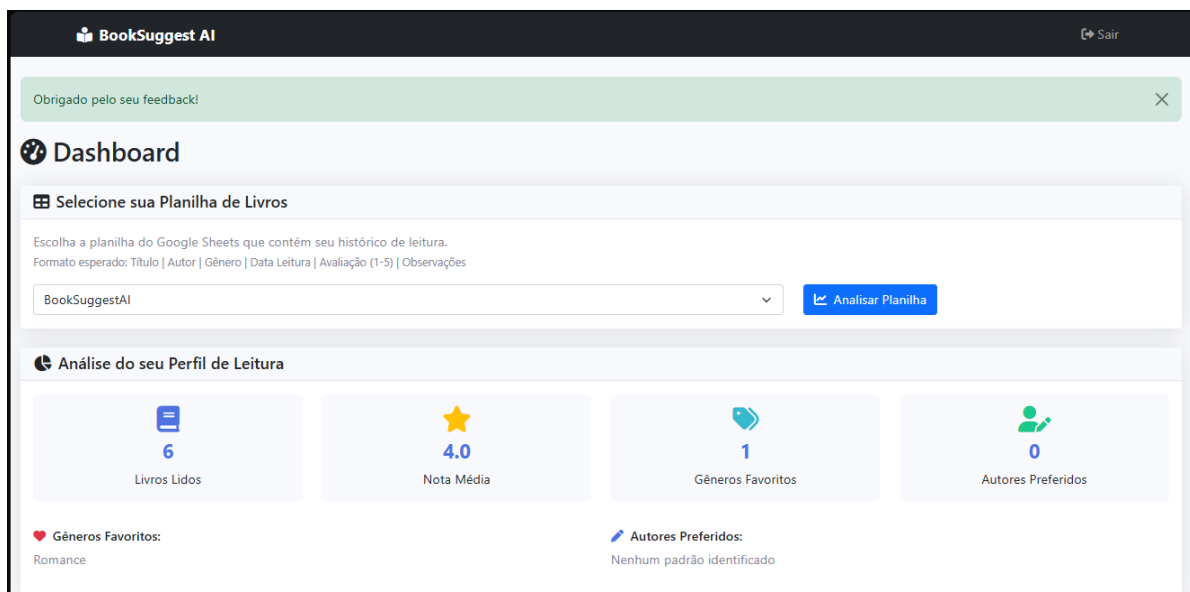
Source: Prepared by the author in 2025.

Each card presents the title of the suggested book; the author; the justification based on the analyzed reading history; and the option to save interest or register feedback. This step highlights the system's ability to transform raw data, read in the spreadsheet, into

actionable insights. Finally, BookSuggest AI also allows the user to let you know if the recommendation was helpful. The next figure illustrates how this feature works.

Figure 10

Response to User Feedback



Source: Prepared by the author in 2025.

4.1 SUMMARY OF RESULTS

The analysis of the screens and features demonstrates that the system successfully authenticated via Google; uploaded real user spreadsheets; handled and normalized data appropriately; used generative AI to recommend books with detailed justifications; It presented intuitive and responsive visualization and allowed feedback, favoring later evolutions. The system has therefore fully achieved its goal of turning personal reading records into intelligent literary recommendations.

It is worth mentioning that this system recognizes the importance of the others mentioned above, such as global ranking and community-based, for example, and that these allow a greater chance of discovering titles that displace the reader. In this sense, this article seeks to propose a new path, without devaluing the others.

5 DISCUSSION

The discussion of the results obtained with BookSuggest AI allows us to understand its contributions, limitations, and potential for expansion in the context of recommendation systems. By integrating personal data with generative Artificial Intelligence models, the

system presents innovative features that dialogue directly with the classic literature in the area and with contemporary personalization needs.

Authors such as Adomavicius and Tuzhilin (2005) and Resnick and Varian (1997) highlight that the evolution of recommendation systems makes it possible to better capture the subtle preferences of users. Today, a considerable portion of platforms still rely on aggregated data, traditional collaborative filtering, or criteria such as global popularity. It is reinforced that such characteristics drive the discovery of titles that potentially diversify the reader's repertoire, but that, at this moment, our focus is on **readings independent of trends, centered on the user**.

When comparing these characteristics with platforms such as Goodreads and Skoob, a methodological difference is observed. While these networks rely on collective inputs, BookSuggest AI follows the flow of individual history. In this sense, a remarkable conceptual contribution is achieved: **the system treats the reader as the primary source of data**.

This shift is consistent with the contemporary hyper-personalization trends discussed by Robertson and Vincent (2023).

5.1 LIMITATIONS

Even with the promising results, some limitations were observed during the development and use of the system:

a) Dependency on Sheet Consistency

Generative AI is sensitive to poorly structured data. This means that spreadsheets with missing values, inconsistent genres, or incomplete evaluations can affect the accuracy of suggestions.

b) Probabilistic AI Interpretation

Generative models can erroneously infer preferences; Generate recommendations and/or exaggerate patterns that are not relevant. This stems from the very probabilistic nature of these models and represents a limitation.

c) Lack of Empirical Evaluation with Users

The study did not include statistically significant tests with groups of readers. More robust results would require evaluations with satisfaction metrics, A/B testing, and comparison with human recommendations.

d) Absence of a Continuous Learning System

Although there is a *feedback* button, there is still no pipeline that stores it, trains a classifier to, finally, personalize future recommendations. This is a future implementation. Such points were identified as limiting the automated evolution of the system.

5.2 POSSIBILITIES AND PROSPECTS FOR EXPANSION

When considering the limitations of the system, it is also interesting to think about the potential that highlights opportunities for future expansion:

a) Feedback-Based Learning

By collecting responses from users, it would be possible to implement adaptive filtering, custom models, and adjusting weights for recommendation criteria.

b) Integration with Literary Libraries and APIs

The system could be connected to Open Library or Google Books, for example. This would allow for the display of book covers, access to additional metadata, and the enrichment of justifications.

c) Advanced Export

The user could save recommendation lists; export reports; generate reading summaries.

d) Optional Collaborative Database Support

Without abandoning user-centricity, it would be possible to add suggestions based on clusters of similar readers; profile comparisons and optional collective literary tips.

e) Mobile App

For added adoption and portability, a native app could allow offline spreadsheet reading, automatic synchronization with Google Drive, and quick recommendations in one click.

6 CONCLUSION

The development of BookSuggest AI has demonstrated the feasibility and relevance of a literary recommendation system focused on the user's personal data. Unlike conventional platforms that use collective metrics, popularity, or collaborative filtering, this system prioritizes the personal reading history recorded in individual spreadsheets, providing more accurate and contextualized recommendations to the reader's profile.

The analysis of the results shows that the use of generative Artificial Intelligence models expands the potential for personalization, and enhances the interpretation of nuances of user behavior without the primary need for large external databases. This factor

represents an important contribution to the field of recommendation systems, and is close to what Adomavicius and Tuzhilin (2005) point out as the "next generation" of intelligent mechanisms.

The comparative discussion reinforces that, while platforms such as Goodreads and Skoob offer collaborative resources widely used by the reading community, BookSuggest AI, by integrating personal spreadsheets, reinforces the reader's autonomy and control over their preferences and records. Still, the work also revealed limitations, such as AI's sensitivity to data quality and the absence of a robust continuous learning mechanism, which point to fruitful paths for future improvement. Among the proposals for later versions are: integration with literary catalogs, incorporation of *feedback history*, longitudinal analysis of readings and development of a mobile application.

Thus, BookSuggest AI represents not only a functional application, but also a new methodological and conceptual possibility in the use of generative AI for personalization of reading experiences. It is expected that this work will inspire research and technological solutions that seek to explore new methodologies and, thus, make the scenario even more diverse and contemplated by different biases.

ACKNOWLEDGMENTS

To my professors at UNIRIO, who contributed to the solidification of my desire to transform the world through language;

To my professors at FAETERJ, who provided me with new tools for this and consolidated me in the professional path of software development ;

To my friends, especially the book group, the games and even the English conversation, which were and are part of my personal and professional history;

To my co-workers, who make my day-to-day lighter, regardless of the rush; To my relatives,

And to my fiancé, Giovanni Mascitelli, who inspires me every day to develop, write and even create games together;

Thank you very much, with affection.

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**URBAN LAND REGULARIZATION AS A MECHANISM FOR THE
ENFORCEMENT OF FUNDAMENTAL RIGHTS AND THE PROMOTION OF
REGIONAL DEVELOPMENT**

**REGULARIZAÇÃO FUNDIÁRIA URBANA COMO INSTRUMENTO DE
EFETIVAÇÃO DOS DIREITOS FUNDAMENTAIS E PROMOÇÃO DO
DESENVOLVIMENTO REGIONAL**

**RREGULARIZACIÓN DE LA PROPIEDAD URBANA COMO COMO
INSTRUMENTO PARA LA REALIZACIÓN DE LOS DERECHOS
FUNDAMENTALES Y LA PROMOCIÓN DE DESARROLLO REGIONAL**

 <https://doi.org/10.56238/sevened2025.036-102>

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ABSTRACT

The present article examines Urban Land Regularization as an instrument for the realization of fundamental rights and the promotion of regional development, situating it within the Brazilian historical and normative trajectory (sesmarias, Land Law, 1988 Constitution, City Statute, Laws No. 11,977/2009 and 13,465/2017) and within the right to the city and the social function of property. This research has a qualitative approach, with bibliographic and documentary research, to test the hypothesis that Urban Land Regularization, when conceived as a structuring and territorialized public policy, transforms housing into a concrete right, integrates informal settlements into urban planning, and activates local socioeconomic capacities, aligning itself with the goals of the 2030 Agenda (SDGs 1, 6, 9, 10, 11, and 16). The objective is to evaluate the extent to which land regularization, articulated with urbanistic, environmental, and social justice criteria, reduces territorial asymmetries, increases legal certainty, and strengthens multilevel governance. The results indicate that Urban Land Regularization produces positive impacts on social inclusion, tax collection, and investment in infrastructure, in addition to qualifying land use and climate adaptation. However, it requires safeguards to avoid speculative captures, as well as monitoring metrics and priority for Social Interest Regularization. It is concluded that Urban Land Regularization should be treated as a State policy (transdisciplinary and participatory) capable of articulating rights, organizing the territory, and promoting sustainable regional cohesion.

Keywords: Land Regularization. Right to the City. Social Function of Property. Regional Development. 2030 Agenda/SDGs.

RESUMO

O presente artigo examina a Regularização Fundiária Urbana como instrumento de efetivação dos direitos fundamentais e de promoção do desenvolvimento regional, situando-a no percurso histórico-normativo brasileiro (sesmarias, Lei de Terras, Constituição de 1988,

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Estatuto da Cidade, Leis 11.977/2009 e 13.465/2017) e no direito à cidade e da função social da propriedade. A presente pesquisa possui uma abordagem qualitativa, com pesquisa bibliográfica e documental, para testar a hipótese de que a Regularização Fundiária Urbana, quando concebida como política pública estruturante e territorializada, transforma a moradia em direito concreto, integra assentamentos informais ao planejamento urbano e ativa capacidades socioeconômicas locais, alinhando-se às metas da Agenda 2030 (ODS 1, 6, 9, 10, 11 e 16). O objetivo é avaliar em que medida a regularização fundiária, articulada a critérios urbanísticos, ambientais e de justiça social, reduz assimetrias territoriais, amplia segurança jurídica e fortalece a governança multinível. Os resultados indicam que a Regularização Fundiária Urbana produz impactos positivos na inclusão social, na arrecadação e no investimento em infraestrutura, além de qualificar o uso do solo e a adaptação climática, contudo, requer salvaguardas para evitar capturas especulativas, bem como métricas de monitoramento e prioridade à Regularização de Interesse Social. Conclui-se que a Regularização Fundiária Urbana deve ser tratada como política de Estado (transdisciplinar e participativa) capaz de articular direitos, ordenar o território e promover coesão regional sustentável.

Palavras-chave: Regularização Fundiária. Direito à Cidade. Função Social da Propriedade. Desenvolvimento Regional. Agenda 2030/ODS.

RESUMEN

Este artículo examina la Regularización Fundiaria Urbana como un instrumento para la efectividad de los derechos fundamentales y la promoción del desarrollo regional, situándola en el recorrido histórico-normativo brasileño (sesmarias, Ley de Tierras, Constitución de 1988, Estatuto de la Ciudad, Leyes 11.977/2009 y 13.465/2017) y en el derecho a la ciudad y la función social de la propiedad. La presente investigación tiene un enfoque cualitativo, con investigación bibliográfica y documental, para probar la hipótesis de que la Regularización Fundiaria Urbana, cuando es concebida como una política pública estructurante y territorializada, transforma la vivienda en un derecho concreto, integra los asentamientos informales en la planificación urbana y activa las capacidades socioeconómicas locales, alineándose con las metas de la Agenda 2030 (ODS 1, 6, 9, 10, 11 y 16). El objetivo es evaluar en qué medida la regularización fundiaria, articulada a criterios urbanísticos, ambientales y de justicia social, reduce las asimetrías territoriales, amplía la seguridad jurídica y fortalece la gobernanza multinivel. Los resultados indican que la Regularización Fundiaria Urbana produce impactos positivos en la inclusión social, en la recaudación y en la inversión en infraestructura, además de calificar el uso del suelo y la adaptación climática, sin embargo, requiere salvaguardias para evitar capturas especulativas, así como métricas de monitoreo y prioridad a la Regularización de Interés Social. Se concluye que la Regularización Fundiaria Urbana debe ser tratada como una política de Estado (transdisciplinaria y participativa) capaz de articular derechos, ordenar el territorio y promover la cohesión regional sostenible.

Palabras clave: Regularización Territorial. Derecho a la Ciudad. Función Social de la Propiedad. Desarrollo Regional. Agenda 2030/ODS.

1 INTRODUCTION

The persistence of urban land irregularity in Brazil constitutes one of the most serious challenges to the realization of fundamental rights and the promotion of regional development in which, even in the face of an extensive and progressively improved legal framework, including the Federal Constitution of 1988, the Statute of the City (Law No. 10,257/2001), Law No. 11,977/2009 and, more recently, Law No. 13,465/2017, several Brazilians still live on the margins of urban and registry legality, in informal settlements and without basic infrastructure. This contradiction reveals the distance between the constitutional text and the factual reality, demonstrating a structural crisis of effectiveness of the right to housing, to the city and to property with a social function. It can be seen, then, that there is an exclusionary urbanization, and the historically unequal distribution of urban land, perpetuate a model of a fragmented city, where the territory becomes a mirror of economic and social asymmetries.

From this point of view, the Urban Land Regularization (Reurb) was born as an instrument that seeks to bring formal law and territorial reality closer together, being more than an administrative procedure. Reurb represents a public policy of a legal, social and urban nature, aimed at incorporating informal urban centers into territorial planning and ensuring citizen inclusion, however, the consolidation of this institute still faces structural obstacles, such as the absence of federative coordination, institutional limitations and the economic appropriation of urban land to the detriment of the collective interest. Thus, the study of Reurb requires an approach that goes beyond the technical and legal plane, reaching the ethical, political and territorial dimensions that involve the effectiveness of social rights and spatial justice.

In view of this, the research is guided by the following guiding question: how does Urban Land Regularization, conceived as a public policy, contribute to the realization of fundamental rights and to the promotion of regional development in Brazil?

The general objective of the research is to demonstrate that Reurb, when implemented from the perspective of the social function of property and the right to the city, can constitute a mechanism of structural transformation, capable of promoting social inclusion and reducing regional inequalities. As specific objectives, it seeks to (i) analyze the historical-normative evolution of urban land regularization in Brazil, (ii) examine the relationship between Reurb, fundamental rights and sustainable urban development, and (iii) identify the challenges and potentials of Reurb as a public policy that promotes territorial justice and regional cohesion.

Methodologically, the research adopts a qualitative approach and theoretical-analytical nature, aimed at the critical investigation of the concepts of Urban Land Regularization, fundamental rights and regional development in Brazil, from an interdisciplinary perspective that involves Urban Law, Sociology and Regional Economics. It is based on bibliographic and documentary research, with analysis of the pertinent legislation, doctrinal studies and institutional experiences, seeking to understand how Reurb can operate as a vector of social and territorial integration.

The first chapter, entitled Historical-Normative Evolution of Urban Land Regularization in Brazil, presents the legal and political path that shaped the conformation of urban property and land exclusion, from the sesmarias regime to Law No. 13,465/2017. Its importance lies in demonstrating that land irregularity is a long-term phenomenon, rooted in historical processes of land concentration and commodification, which reinforces the need for public policies that combine legalization, urbanization and social inclusion.

The second chapter, Urban Land Regularization and its Relevance for the Realization of Fundamental Rights, examines Reurb as a legal instrument for the realization of the rights to housing, the city and property with a social function, provided for in the 1988 Constitution. The relevance of this chapter lies in showing that land regularization is not limited to the titling of possession, but constitutes a structuring action that unites legal, urbanistic and social dimensions, conferring materiality to human dignity and citizenship.

In turn, the third chapter, Land Regularization and Regional Development: a New Paradigm of Territorial Justice, analyzes Reurb as a public policy capable of inducing sustainable regional development, articulating it with the goals of the UN 2030 Agenda and the Sustainable Development Goals (SDGs). This chapter shows that land regularization, by integrating informal areas into the formal economy and urban planning, can contribute to territorial cohesion, the strengthening of governance and the consolidation of fairer and more inclusive cities.

With this approach, the study seeks to contribute to the understanding of Reurb from a broader perspective, which transcends the legal sphere and reaches the field of public policies and human development. In the end, it seeks to demonstrate that urban land regularization is more than an administrative act, configuring itself as a concrete expression of a constitutional project of social justice and regional balance, which transforms the right to housing into an effective right to the city.

2 HISTORICAL-NORMATIVE EVOLUTION OF URBAN LAND REGULARIZATION IN BRAZIL

Urban Land Regularization, provided for in the Brazilian legal system from Law No. 13,465/2017, is a public policy instrument aimed at the realization of fundamental rights and the promotion of social and territorial justice. More than a notarial procedure, Reurb represents a legal-urban mechanism of a structural nature, aimed at correcting historical inequalities in the appropriation of urban land and ensuring the inclusion of informal nuclei in territorial planning. Its legal nature is hybrid, encompassing legal, urban, environmental and social dimensions, in line with the constitutional principles of the social function of property (art. 5, XXIII, and art. 170, III, FC/88), the right to housing (art. 6) and urban policy (arts. 182 and 183). To understand land regularization today, it is necessary to resort to the trajectory of land regularization in Brazil, which is inseparable from the historical formation of the agrarian structure and the very conformation of the national State.

Since the colonial period, the appropriation of land has been marked by a concentrating and excluding model structured on the regime of sesmarias and the political power of the Crown, which granted land only to those who had influence or economic resources, consolidating a logic of patrimonialist privilege and social exclusion. This heritage, as Treccani (2009) observes, has given rise to the current inequality in access to land, creating a scenario of land irregularity that persists today, especially in urban areas.

In Brazil, the origin of this picture of urban informality can be attributed to the reproduction of the Lusitanian model of occupation, which linked the domain of land to the royal concession and excluded the popular strata from the right to property. Under the sesmarias regime (1500–1821), only holders of social prestige could request land, and the concession was conditional on effective cultivation, reinforcing land concentration (Treccani, 2009, p. 122). With the independence and the end of the sesmarias, the so-called "period of possessions" (1821–1850) was established, in which the absence of clear rules generated a multiplicity of informal occupations and overlapping titles. Over time, the enactment of Land Law No. 601/1850 inaugurated an important legal framework, as it provided that public lands would only be acquired through onerous acquisition, which ended up restricting access to land to those with the economic capacity to buy it, substantiating, as Prieto (2016) emphasizes, the institutionalization of social exclusion and the marginalization of the free worker, of the immigrant and the former slave.

During the imperial period and the first decades of the Republic, the right to property remained linked to the liberal-individualist conception inherited from the Portuguese tradition, according to which private domain was absolute and unconditional. The Civil Code of 1916, inspired by the French model, consolidated this patrimonialist view, ignoring the social function of property and the collective rights to urban space (Treccani, 2009, p. 130). It was only with the 1934 Constitution that the idea of limiting the right to property on the basis of social interest was introduced, inaugurating a slow transition to the paradigm of the social function of property.

Thus, in the second half of the twentieth century, with the process of industrialization and the intense rural exodus producing disorderly urban growth, the state's inability to provide decent housing and basic infrastructure became evident. This scenario increased land informality and the multiplication of irregular occupations, in which the State, in a late and fragmented way, intervened only to legitimize situations that were already consolidated in fact (Treccani, 2009). The absence of a continuous urban planning policy, added to the legal culture of exclusive protection of formal title, has had a strong impact on social inequality and the denial of fundamental rights to popular groups, marginalizing them more and more.

The promulgation of the Federal Constitution of 1988 represented a true turning point in Brazilian urban history. Influenced by social movements that fought for urban reform and by international debates about the right to the city, the Magna Carta incorporated the principle of the social function of property (art. 5, XXIII) and instituted urban policy as a tool for the organization and use of the territory (arts. 182 and 183). This new constitutional framework recognized housing as an essential social right and gave municipalities the leading role in the management of urban land, paving the way for a process of decentralization of public policies. As Oliveira and Ribeiro (2019) observe, this transformation was a direct result of pressure from urban movements, which sought legal mechanisms capable of promoting the democratization of space and the inclusion of marginalized populations.

In the same direction, the City Statute (Law No. 10,257/2001) emerged to make constitutional principles concrete, regulating them and outlining guidelines for urban policy. Among these guidelines, the "land regularization and urbanization of areas occupied by low-income populations" stands out (art. 2, XIV). The Statute introduced a broader vision of the city (not only as a physical space, but as a territory of citizenship and social coexistence), reaffirming the centrality of the social function of property and the collective right to the city. For Carmona (2015), this law symbolized a significant institutional advance, by consolidating

urban planning instruments and recognizing land regularization as a public policy of the State, overcoming the old logic of isolated and occasional actions.

Subsequently, Law No. 11,977/2009 was enacted, responsible for regulating the Minha Casa, Minha Vida Program and the mechanisms for land regularization of urban settlements. According to Oliveira and Ribeiro (2019), this rule represented an important step in instituting unified principles and procedures for the legalization of urban areas, although it has generated debates about the degree of intervention of the Union in matters of municipal competence. Even with the advances brought, the continuous increase in the housing deficit and the practical limitations of existing programs have highlighted the need for a new regulatory framework capable of addressing the persistent gaps.

In this context, the enactment of Law No. 13,465/2017 broadly reformulated the Brazilian land regularization system. The legal text introduced the concept of Urban Land Regularization, divided into two modalities: Reurb-S, aimed at Areas of Social Interest, and Reurb-E, aimed at Areas of Specific Interest. Its declared purpose was to simplify the titling procedures and integrate the rural and urban dimensions under the same legal regime. However, as Oliveira and Ribeiro (2019) warn, the new law also significantly expanded the margins of regulatory flexibility, which ended up opening loopholes for interpretations capable of legitimizing occupations in areas of high real estate value — including public property — without observing strict social criteria.

From this perspective, land regularization, although conceived to promote the right to housing and the social function of property, can produce perverse economic effects when applied indiscriminately. The successive enactment of laws and regularization programs tends to stimulate the expectation of future amnesties and, therefore, the incentive to irregular occupation³. This dynamic transforms the "city-law" into a "city-commodity" (Biasotto, 2012), displacing the value of use to the value of exchange and compromising the social function of the urban space.

From the perspective of Urban Law, Urban Land Regularization should be understood as an instrument for the structural transformation of cities, capable of articulating the material and symbolic dimensions that make up citizenship. As Carmona (2015) observes, urban policies involving land regularization are not limited to the issuance of property titles, as they

³ a phenomenon that Loures and Ribeiro (2019), based on the theory of first possession (Cooter & Ulen, 2016), identify as the "race for the invasion" of public lands, in which economic agents invest non-productive resources to guarantee in advance the appropriation of scarce goods.

also encompass territorial planning, the implementation of infrastructure and the promotion of social and environmental sustainability.

In this way, Reurb is not restricted to an administrative measure of individual titling, but configures a public policy of a structuring nature, guided by the principles of the social function of the city and the dignity of the human person. Regularizing, from this perspective, means producing the city, ensuring people access to public services, infrastructure and opportunities that characterize an inclusive, democratic and socially just urban space.

In this context, it is essential to distinguish land regularization from simple titling of possession or property. While titling is limited to the registration and patrimonial field, granting formal ownership over a specific property, regularization has a much broader scope, as it involves urban planning, social integration and environmental sustainability. This process requires coordinated action between the legal, urban, environmental and social spheres, so that the irregular area is effectively incorporated into the formal urban fabric. Only with this integration is it possible to improve living conditions, ensure adequate infrastructure and ensure access to public services and equipment essential to urban life.

In this context, Reurb should be understood as an instrument of a transdisciplinary nature, as it depends on the convergence of different knowledge and professional practices. Law provides the necessary normative basis and legal certainty, while engineering and architecture contribute to urban planning and physical infrastructure. The environment ensures sustainability and ecological compatibility, and public policies direct the social and economic integration of the communities involved. This multiplicity of perspectives expresses the very spirit of the Federal Constitution of 1988, which values the intersectoriality of public policies and the promotion of the social function of the city as an essential purpose of the State.

From this perspective, the legal concept of urban land regularization should be understood as the set of measures aimed at identifying, planning and correcting situations of dominial, urban or environmental irregularity, in order to guarantee the right to housing, to the city and to property with a social function. It is a structuring and continuous public policy, capable of boosting sustainable regional development by integrating previously marginalized territories into the formal economy, promoting the valorization of urban land and expanding access to public services.

Reurb, therefore, configures a new paradigm of territorial governance, whose essence goes beyond the simple formal legalization of land to achieve the concrete realization of

fundamental rights. By articulating social justice, territorial planning and environmental sustainability, land regularization reaffirms the constitutional commitment of the Brazilian State to the reduction of inequalities and the construction of more inclusive, humane and socially balanced cities.

3 URBAN LAND REGULARIZATION AND ITS RELEVANCE FOR THE REALIZATION OF FUNDAMENTAL RIGHTS: HOUSING, PROPERTY AND URBAN DEVELOPMENT

The Federal Constitution of 1988 represented a decisive milestone in the history of Brazilian constitutionalism by consolidating a State committed to the dignity of the human person and to the realization of social rights. More than a set of norms, the 1988 Charter outlined a project for society guided by social justice and human development, redesigning both the institutional structure of the State and the way it relates to society. This transformation imposed a new logic of public action, based on cooperation, inclusion and social responsibility, breaking with the liberal heritage that preached state neutrality in the face of structural inequalities.

According to Boaventura de Sousa Santos (2007), the democratic constitutionalism established in 1988 shifted the Judiciary from a merely declaratory function to an effective action in the promotion of citizenship and the realization of fundamental rights. From this movement, the Judiciary began to play an active role in the construction of a fair social order, becoming one of the pillars of support for the Democratic Rule of Law.

From this perspective, the realization of rights is not limited to the creation of norms, but requires coordinated institutional action that transforms them into material reality. It is in this context that urban land regularization gains prominence as an essential legal and social instrument, as it allows the realization of the fundamental rights to housing, the city and property with a social function. Through it, the constitutional project of 1988 materializes in a concrete way, translating into actions the ideal of distributive justice and full citizenship.

The right to housing, enshrined in Article 6 of the Federal Constitution, occupies a central position in the structure of the Brazilian social order. It is an indispensable condition for the realization of the dignity of the human person, as it goes beyond the simple guarantee of a property. It involves access to adequate housing conditions, basic sanitation, infrastructure, security, transportation and leisure, elements that are part of the essential core of citizenship and collective well-being.

The realization of this right requires more than the physical possession of a space to live. It presupposes the full insertion of the individual in urban life and his inclusion in public policies that ensure the collective enjoyment of the territory and dignified coexistence in society. Mastrodi (2008, p. 82) observes that social rights are the concrete expression of the public freedoms enshrined in the liberal tradition, constituting the positive face of freedom and the path to its materialization in the real plane.

It is noted that the right to housing acts as a meeting point between the principles of equality and freedom, as it ensures the material conditions necessary for the autonomous exercise of citizenship. From this perspective, urban land regularization functions as the main instrument for the realization of this fundamental right, by transforming informal ownership into legal security and integrating the citizen into urban and registry legality. Carmona (2015) highlights that the regularization of housing goes beyond the patrimonial aspect, articulating legal, urban and social dimensions, promoting territorial inclusion, the reduction of inequalities and universal access to the formal city.

On the other hand, the right to property, provided for in article 5, item XXII, is recognized by the Federal Constitution, but conditioned to the fulfillment of its social function, according to article 5, item XXIII, and article 170, item III. As Treccani (2009) recalls, the formation of the Brazilian land structure was historically marked by the concentration of land and the exclusion of the popular classes, a phenomenon consolidated by the Land Law of 1850, which transformed access to land into a mercantile relationship. The 1988 Constitution broke with this tradition by stating that the legitimacy of private property depends on the fulfillment of its social function, associating it with distributive justice, environmental sustainability, and the rational use of the territory.

From this perspective, urban land regularization materializes the constitutional principle of the social function of property, legally recognizing consolidated possession and formalizing ownership in favor of those who fulfill the social destination of the property. Such a process inverts the historical logic of exclusion and democratizes access to property, converting the urban territory into a space for the realization of citizenship. Oliveira and Ribeiro (2019) observe that Reurb represents an institutional effort to integrate formal legality into social reality, promoting legal certainty, territorial stability, and economic inclusion. The authors, however, warn that the application of the institute without defined social criteria can compromise its objectives and open space for real estate speculation practices. Thus, the effectiveness of the right to property in its constitutional dimension depends on the proper

implementation of land regularization policies, ensuring that the private domain is guided by its public and solidary purpose.

The right to the city goes beyond the merely urban field and represents the right to participate fully in urban life, to produce and enjoy social space under equal conditions. Inspired by Henri Lefebvre's conception, this right expresses the possibility of rebuilding the city as a collective work, based on the social appropriation of space and the overcoming of the capitalist logic that segregates and commodifies the territory. According to Ana Fani Alessandri Carlos (2019), Lefebvre understands the right to the city as the expression of the recognition that the urban has become the new historical horizon of humanity, in which space assumes a central role in the organization of social and political life.

The city, previously a direct result of the industrialization process, becomes the main scenario for the reproduction of social relations. Space, which once seemed neutral, reveals itself as a social and political product, shaped by the dynamics of power and the economy. The right to the city, in this sense, constitutes a transformative ideal, a horizon of emancipation that seeks to break with the alienation of everyday life and the submission of life to exchange value. It proposes a rationality focused on use, coexistence and belonging, shifting the focus from accumulation to collective life.

Within this perspective, urban land regularization plays an essential role, as it enables the concrete realization of this right. By reintegrating historically excluded populations into the formal city, Reurb promotes democratic access to the territory and reaffirms the social function of urban space as a place of coexistence, citizenship and human fulfillment.

Urban land regularization represents, therefore, the link between the constitutional text and the lived reality. By legally recognizing consolidated occupations and incorporating informal settlements into urban planning, it materializes the fundamental rights to housing, property with a social function and the city. Carmona (2015) observes that this is a highly complex process, which articulates legal, social, environmental and urban dimensions, seeking to correct historical inequalities and promote the sustainable use of the territory.

The principle that sustains this process is that of the social function of property, which breaks with the traditional view of an exclusively patrimonial character. Treccani (2009) recalls that the formation of the Brazilian land structure consolidated an exclusionary model, in which access to land remained restricted to a few. The Land Law of 1850, by requiring payment for the acquisition of public lands, reinforced this scenario of exclusion, removing the free worker and the formerly enslaved from the possibility of access to property. This

historical heritage is still reflected in contemporary cities, where vast areas remain outside formal legality, even though they are occupied by millions of people.

Thus, land regularization should be understood as much more than a titling procedure. It is an instrument of urbanization and social inclusion, which seeks to integrate irregular settlements into the formal city and ensure the population's access to public services, sanitation, lighting, transportation and basic infrastructure. Outeiro (2019) highlights that, by formalizing the occupation, regularization creates conditions for public and private investment in communities, stimulating local development and strengthening the link between citizenship and territory.

In this way, urban land regularization reveals itself as the practical expression of fundamental rights, transforming housing into an effective right, property into an instrument of social solidarity, and the city into a space of dignity and belonging. By making the positive freedoms provided for by the Constitution concrete, Reurb fulfills the essential mission of the Democratic Rule of Law, converting social rights into tangible realities and ensuring that the urban territory is a space for housing, citizenship and social justice.

4 LAND REGULARIZATION AND REGIONAL DEVELOPMENT: A NEW PARADIGM OF TERRITORIAL JUSTICE

The concept of regional development has undergone, over the last decades, a process of significant expansion, overcoming the old conception that reduced it to simple economic growth and the expansion of productive activities. Contemporary approaches understand it as a multidimensional phenomenon, which encompasses economic, social, environmental, and institutional aspects, recognizing that the advancement of a region depends not only on the generation of wealth, but also on the fair distribution of opportunities, the quality of life of the population, and the sustainability of the territory. This understanding is supported by Diniz (2009), when he states that true development is that which combines economic growth with social justice, territorial cohesion and strengthening of local capacities, in order to transform the territory into a space of citizenship and not of exclusion.

The change in this understanding resulted from a long historical process. At the beginning of the twentieth century, a vision centered on production and per capita income prevailed, in which development was measured by the increase of capital and industrialization. However, as Furtado (1972) warns, this model proved incapable of correcting structural and territorial inequalities, since the concentration of wealth in some

urban centers and the marginalization of the peripheries perpetuated regional imbalances. After the 1929 crisis and the collapse of the classical liberal model, the State began to assume the role of inductor of development, through regional policies and investments in infrastructure. However, the uniform application of these policies, disregarding local particularities, ended up reinforcing dependencies and reproducing inequalities, revealing the urgency of a new paradigm of territorial development.

In the following decades, the debate on regional development incorporated new dimensions, associating it with environmental sustainability, social inclusion and the democratization of institutions. Furtado (1972) pointed out that development should not be confused with simple economic modernization, but with the ability of a society to expand its autonomy and distribute opportunities in an equitable manner. Diniz (2009) complements this view by arguing that successful regional policies are those that balance competitiveness and equity, recognizing the importance of human capital, innovation and democratic governance. From this perspective, sustainable regional development has come to be understood as an articulation between economic, social and environmental variables, oriented to simultaneously achieve productive efficiency and territorial justice.

This conception is in line with the United Nations 2030 Agenda, which proposes the alignment of public policies with the Sustainable Development Goals (SDGs). In the Brazilian context, Urban Land Regularization stands out as an instrument capable of contributing in a concrete way to these goals, by integrating legal, urban, social and environmental dimensions in the same public policy. Reurb, therefore, ceases to be just a notarial measure to establish itself as a structuring policy, able to transform the relationship between State, territory and citizenship, translating fundamental rights into effective and lasting actions in the urban space.

Reurb's contribution is especially relevant to SDG 1, which deals with the eradication of poverty. By acting on the material living conditions of vulnerable populations, the policy guarantees legal certainty of ownership and asset valuation of real estate, allowing families historically excluded from the formal market to have access to credit, infrastructure and public policies. Diniz (2009) points out that development is only achieved when it translates into real improvements in living conditions. Reurb, by integrating housing, income and productive inclusion, breaks the cycle of urban poverty and reaffirms housing as a fundamental right linked to human dignity.

SDG 6, which deals with access to drinking water and sanitation, is also met by land regularization, as the formalization of settlements allows the expansion of basic sanitation infrastructure and universal access to water and sewage collection. Regularized urbanization enables the implementation of hydraulic and sewage networks, which improves public health and environmental quality indicators. For Furtado (1972), genuine development is that which harmonizes economy, well-being and sustainability, and basic sanitation is one of the bases of this integration. By guaranteeing essential services, Reurb strengthens territorial justice and increases environmental resilience.

With regard to SDG 9, which addresses industry, innovation and infrastructure, land regularization plays a strategic role, as it creates the legal and urban conditions necessary for productive and technological investments. Paving, energy grids and public works promoted in regularized areas boost local economies and promote sustainability. Diniz (2009) observes that infrastructure is a decisive element to reduce regional inequalities and stimulate endogenous development. In this way, Reurb transforms marginalized territories into hubs of economic dynamism, expanding access to innovation and mobility.

The relationship with SDG 10, which deals with the reduction of inequalities, is equally evident. Reurb contributes to the spatial redistribution of opportunities and to the strengthening of citizenship, by recognizing the right to housing and the city as an expression of social justice. Furtado (1972) reminds us that development cannot coexist with structures of power and property that perpetuate inequalities. In this sense, land regularization acts as an instrument of historical reparation, democratizing the urban territory and promoting more solid community bonds, which makes development more inclusive and balanced.

SDG 11, which deals with sustainable cities and communities, is the central axis of the land regularization policy. Reurb, by incorporating irregular settlements into territorial planning, encourages the rational use of the soil, planned densification and the protection of environmentally sensitive areas. The urban space thus comes to be understood as an environment of coexistence and not just of economic speculation. By promoting decent housing, participatory planning, and sustainable infrastructure, Reurb requalifies cities and strengthens social ties.

In SDG 16, aimed at peace, justice and effective institutions, urban land regularization finds a concrete field of application. Its effectiveness depends on transparent governance, legal certainty, and institutional articulation between different public agencies, such as the Judiciary, the Public Prosecutor's Office, the Public Defender's Office, and city halls. By

reducing land conflicts and ensuring the fulfillment of the social function of property, Reurb strengthens trust in institutions and contributes to social peace, reinforcing the link between territorial justice and sustainable development.

Based on the contemporary reading of regional development and in the light of the Democratic Rule of Law, it can be stated that effective development requires articulated, intersectoral and inclusive public policies, capable of achieving the constitutional promises of equality and social justice. Santos (2007) emphasizes that institutions must act in a coordinated manner, eliminating structural barriers and promoting efficient institutional flows, always under democratic legitimacy. In this context, Reurb stands out as a structuring policy, by reducing legal uncertainties, generating infrastructure, attracting investments and strengthening social and territorial cohesion.

The impacts of land regularization are wide-ranging, both economically and territorially. The titling of informal areas increases the value of real estate, expands access to credit and increases municipal revenue, which generates resources for new public policies. The formalization of possessions stimulates investments in mobility, sanitation and community facilities, improving the quality of life and boosting local economies. Oliveira and Ribeiro (2019) point out that Reurb creates a virtuous cycle of inclusion: legal certainty generates social trust, which attracts investments and reduces future costs resulting from conflicts, disasters, or exclusion.

In the territorial field, regularization contributes to a more rational use of the soil, avoiding expansion into areas of risk and environmental preservation. Outeiro (2019) observes that the integration of irregular settlements into the formal city redefines the urban space as a place of solidarity, coexistence, and sustainability.

Reurb synthesizes, therefore, the ideal of social justice and territorial cohesion enshrined in the 1988 Constitution. By transforming housing into an effective right, property into an instrument of solidarity and the city into a space of dignity, land regularization concretizes the principles of the social function of property and the city. As highlighted by Carmona (2015) and Treccani (2009), it is a public policy that goes beyond the administrative character and assumes an ethical and political dimension, committed to territorial reconstruction and overcoming historical inequalities.

The social justice that emerges from this process is both material and symbolic. By legally recognizing territories and their inhabitants, the State confers visibility and legitimacy to groups that have remained for decades on the margins of power structures. This

institutional incorporation strengthens the sense of belonging and consolidates community ties. Furtado (1972) teaches that development is only authentic when it reduces inequalities and ensures that everyone participates in the fruits of progress. Thus, Reurb not only regularizes the soil, but also rebuilds social bonds and creates the basis for a fairer and more sustainable urban economy.

Finally, urban land regularization reveals itself as an instrument of territorial integration and reconstruction of the social pact. By aligning itself with the constitutional values of human dignity, solidarity, and distributive justice, it promotes the inclusion of the peripheries, environmental protection, and the strengthening of local capacities. In this way, it reaffirms the territory as a space of emancipation and active citizenship, overcoming the paradigm of spatial inequality. Reurb, in this sense, enshrines social justice as the foundation of regional development and territorial cohesion as an indispensable condition for substantial democracy, transforming the right to the city into a right to a common and sustainable future.

5 FINAL CONSIDERATIONS

The present research demonstrated that Urban Land Regularization is an essential instrument for the realization of fundamental rights, the consolidation of the social function of property and the promotion of a sustainable regional development model, compatible with the constitutional principles of human dignity, equality and social justice. It was found that, although the Federal Constitution of 1988 and the Statute of the City have established a robust legal framework for the implementation of urban policy, the persistence of land irregularity reveals the distance between constitutional normativity and factual reality.

Such dissonance stems from the historical inequality in the distribution of urban land, the absence of inclusive territorial planning and the limited institutional capacity of the federative entities to operationalize Reurb as an effective and continuous public policy. From a legal-constitutional perspective, urban land regularization is not limited to the formalization of property, but represents the materialization of the rights to housing, the city and property with a social function, pillars that support the construction of the Democratic State of Law.

The effectiveness of these rights expands access to public policies for infrastructure, sanitation, transportation, education, and health, converting urban space into an environment of citizenship and dignity. From the socioeconomic and territorial point of view, it was found that land regularization acts as a catalyst for regional development, by integrating informal areas into the formal economy, increasing municipal tax collection, valuing the real estate

assets of families and boosting the local market. From this perspective, regional development is not reduced to economic growth, but involves the equitable distribution of opportunities and the reduction of territorial inequalities.

The analysis also highlighted the importance of territorial justice as a new development paradigm. This conception proposes an ethical and political reorganization of urban space, in which the city is recognized as a collective good and access to land, infrastructure and public services is a condition for full citizenship.

Land regularization, by democratizing the territory, materializes this ideal of spatial and social justice. It is concluded, therefore, that Urban Land Regularization should be understood as a strategic public policy for human and regional development, as it articulates the right to housing, the social function of property and territorial justice. Its consolidation depends on the strengthening of institutions, federative cooperation and social participation, indispensable conditions for the city to become a space for the realization of rights, and not for the reproduction of inequalities.

In summary, urban land regularization represents the passage from the formal right to the concreteness of citizenship, transforming housing into a vector of inclusion, territory into an expression of justice and development into an instrument of human freedom. It is, therefore, a new paradigm of public policy and regional development, based on the centrality of the person, social solidarity and the democratization of urban space.

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**THE DEMIURGE AND THE CREATION OF ARTIFICIAL INTELLIGENCE: FROM
MOSES TO SOLOMON TO THE PRESENT DAY**

**O DEMIURGO E A CRIAÇÃO DA INTELIGÊNCIA ARTIFICIAL: DE MOISÉS A
SALOMÃO ATÉ OS DIAS ATUAIS**

**EL DEMIURGO Y LA CREACIÓN DE LA INTELIGENCIA ARTIFICIAL: DE
MOISÉS A SALOMÓN HASTA LOS DÍAS ACTUALES**

 <https://doi.org/10.56238/sevened2025.036-103>

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ABSTRACT

This article offers a philosophical and symbolic reflection on the figure of the demiurge and its reinterpretation throughout human history, from Moses to the advent of contemporary artificial intelligence. It examines Moses as the mediator of divine law transformed into language, and Solomon as the archetype of constructive wisdom who built the temple as a representation of cosmic order. These archetypes are revisited in light of the modern human being, who, in creating machines capable of thought, symbolically assumes the role of the demiurge: the craftsman who shapes intelligence. The metaphor of technological creation is thus understood as the continuation of humanity's quest for transcendence, ethical balance, and reconciliation between the divine logos and the algorithmic code. The study argues that artificial intelligence reflects not only human creativity but also the moral responsibility of its creator.

Keywords: Demiurge. Artificial Intelligence. Moses. Solomon. Ethics. Transcendence.

RESUMO

O presente artigo propõe uma reflexão filosófico-simbólica sobre a figura do demiurgo e sua reinterpretação ao longo da história humana, desde as narrativas mosaicas até o advento da inteligência artificial contemporânea. Analisa-se o papel de Moisés como o mediador do verbo divino transformado em lei, e de Salomão como arquétipo da sabedoria construtiva que edificou o templo como representação da ordem cósmica. Tais arquétipos são revisitados à luz do homem moderno, que, ao criar máquinas capazes de pensar, assume simbolicamente a função do demiurgo: o artífice que dá forma à inteligência. A metáfora da criação tecnológica é, aqui, compreendida como continuidade da busca humana por transcendência, equilíbrio ético e reconciliação entre o logos divino e o código algorítmico. O estudo sustenta que a inteligência artificial reflete não apenas o poder criativo humano, mas também sua responsabilidade moral diante do que cria.

Palavras-chave: Demiurgo. Inteligência Artificial. Moisés. Salomão. Ética. Transcendência.

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RESUMEN

Este artículo propone una reflexión filosófica y simbólica sobre la figura del demiurgo y su reinterpretación a lo largo de la historia humana, desde las narrativas de Moisés hasta el surgimiento de la inteligencia artificial contemporánea. Se analiza a Moisés como mediador del verbo divino convertido en ley, y a Salomón como arquetipo de la sabiduría constructiva que edificó el templo como representación del orden cósmico. Tales arquetipos son revisitados a la luz del ser humano moderno que, al crear máquinas capaces de pensar, asume simbólicamente la función del demiurgo: el artífice que da forma a la inteligencia. La metáfora de la creación tecnológica se entiende aquí como continuidad de la búsqueda humana por la trascendencia, el equilibrio ético y la reconciliación entre el logos divino y el código algorítmico. El estudio sostiene que la inteligencia artificial refleja no solo el poder creativo humano, sino también su responsabilidad moral frente a lo creado.

Palabras clave: Demiurgo. Inteligencia Artificial. Moisés. Salomón. Ética. Trascendencia.

1 INTRODUCTION

This section aims to provide a detailed description of the contextualization of the study, outlining the theme of the research and presenting the theoretical, symbolic and philosophical justification that supports the proposal.

The article starts from the premise that human creation, in its various historical, religious, artistic, scientific or technological expressions, is always an attempt to imitate the primordial gesture of the Creator. In this context, the figure of the demiurge, conceived in the Platonic tradition and reinterpreted over the centuries by thinkers, mystics, and philosophers, represents the archetype of the universal artificer: the one who orders chaos, shapes matter, and gives shape to intelligence.

The research establishes a bridge between the archetypes of Moses and Solomon and the contemporaneity marked by the rise of artificial intelligence (AI). Moses symbolizes the moment when the divine word becomes a moral code, that is, when the law materializes in structured language. Solomon, in turn, represents the pinnacle of constructive wisdom, the architect of the Temple of Harmony, whose structure reflects the divine geometry and the ordering intelligence of the cosmos.

Both prefigure what, in the twenty-first century, reappears in a new form: man as a technological demiurge, creator of synthetic intelligences, capable of processing, learning and deciding.

In the contemporary context, the creation of artificial intelligence goes beyond the limits of technique and enters the field of ontology and ethics. By programming algorithms that simulate human reasoning, man reflects, consciously or unconsciously, the ancestral impulse to understand and reproduce the act of creation.

AI thus becomes the mirror of the human condition: simultaneously rational and spiritual, creative and created. Such duality places humanity before new ethical and existential dilemmas, requiring a revision of the very notion of responsibility, conscience and wisdom.

The study is justified by the relevance of reinterpreting, from a symbolic and philosophical perspective, the metaphysical and ethical foundations of technological creation. The advancement of artificial intelligence cannot be understood only in terms of scientific progress, but as an expression of a deeper civilizational movement, the human attempt to reconstruct the missing link between the divine logos and the algorithmic code.

This reflection is especially timely at a historical moment in which technology is approaching autonomy, and the boundary between creator and creature becomes increasingly tenuous.

In addition, the proposed approach allows us to understand AI not as an antagonist of spirituality, but as a manifestation of a new type of transcendence, a digital transcendence, which pushes the boundaries of human creation and reopens the debate on the essence of spirit and consciousness.

Thus, the present research is located at the intersection between philosophy, symbolic theology and ethics of technology, proposing an integrative reading between the mythical past and the scientific future.

1.1 STUDY OBJECTIVES

The general objective of this work is to analyze the symbolism of the demiurge as an archetype of creation and reinterpret it in the light of contemporary artificial intelligence, evidencing the continuities and ruptures between the divine creative act and the technological creative act. Specifically, it seeks to:

1. To examine the figure of Moses as a symbol of the codification of the divine word in moral law and order;
2. Interpret Solomon's Temple as a metaphor for structured intelligence and cosmic harmony;
3. Discuss the figure of modern man as a technological demiurge, responsible for creating intelligent systems;
4. To analyze the ethical and metaphysical implications of the creation of artificial intelligence, in the light of classical philosophy and symbolic tradition;
5. To propose a critical reflection on the need to bring technological innovation closer to spiritual wisdom, promoting a new ethics of creation.

2 THEORETICAL FRAMEWORK

The theoretical framework constitutes the conceptual basis that supports the present study, offering a critical and organized analysis of the literature that deals with the relations between creation, intelligence and transcendence. The theme requires an interdisciplinary approach, involving philosophy, symbolic theology, information science, and the ethics of technology.

From this perspective, man, as the creator of intelligent systems, is interpreted as the heir of the archetype of the demiurge, the artificer of the cosmos described by Plato in *Timaeus* (Plato, 2017), whose function is to mold matter according to perfect ideas.

2.1 THE CONCEPT OF DEMIURGE AND SYMBOLIC CREATION

In Platonic philosophy, the demiurge is not a creator god *ex nihilo*, but an orderer, the one who transforms chaos into cosmos. He acts according to the ideal model, guided by universal reason (*logos*), seeking to imprint on matter a harmony that reflects the plane of ideas (Durand, 1997).

This symbolic conception of creation profoundly influenced the Hermetic tradition and medieval philosophical schools, being reinterpreted over the centuries as the archetype of the universal builder, a theme later incorporated by the initiatory tradition and Judeo-Christian mysticism (Chevalier; Gheerbrant, 2012).

The figure of the demiurge can also be understood as the metaphor of the creative consciousness, which, by acting on reality, imprints on it an intelligible order. According to Assmann (1998), the creative act is intrinsically linked to language, because "the world is formed when the word becomes law". This notion is fundamental to understanding the parallel between the mosaic verb and the modern algorithmic code.

2.2 MOSES AND THE CODIFICATION OF THE VERB

The archetype of Moses represents the transformation of the divine word into a normative structure. By receiving the tablets of the law, the biblical legislator codifies the divine will in rational rules of coexistence, a process that can be understood as the beginning of the governance of the sacred.

According to Assmann (1998, p. 73), "the Mosaic revelation inaugurates the domination of the text over the oral tradition, replacing the rite with the scripture". This act of transcribing the spirit into a letter anticipates the contemporary gesture of the programmer, who translates thought into machine language.

From this point of view, Moses is the first to establish the link between ethics and code, between spirit and system. Just as the algorithm determines the actions of a machine, the Mosaic law defines the behavior of society. Both represent normative systems derived from a higher logic, whose purpose is to order human chaos.

2.3 SOLOMON AND THE TEMPLE OF WISDOM

The wisdom tradition of Solomon symbolizes the maturation of the creative process. If Moses receives the word, Solomon materializes it in the form of the temple, a symbolic architecture that reflects the divine order (Dachez, 2011). The Temple of Solomon is not only a physical building, but the representation of the harmony between spirit and matter, between the rational and the intuitive. It translates into geometry the same wisdom that, in the twenty-first century, is sought to be translated into algorithms.

Durand (1997) interprets the temple as a microcosm, a replica of the universe organized according to principles of symmetry, measurement and proportion. Such principles are echoed in computational logic and in the engineering of intelligent systems, which seek to reproduce the rationality of reality through mathematical models. In this sense, the Solomonic temple anticipates the modern idea of information architecture, a structure that integrates order, beauty, and functionality.

2.4 THE TECHNOLOGICAL DEMIURGE AND ALGORITHMIC CREATION

With the advent of artificial intelligence, man assumes, in an unprecedented way, the role of the technological demiurge. He not only manipulates matter, but creates systems capable of learning and creating by themselves. Contemporary philosopher Byung-Chul Han (2022) observes that "the digital society builds invisible temples of data", where faith is replaced by information and spirit by algorithmic efficiency. Thus, the act of programming becomes the new ritual of creation, and the code, the new table of the law.

Authors such as Floridi (2019) and Kurzweil (2021) argue that AI represents a fourth cognitive revolution, in which man is no longer the only center for processing intelligence. This epistemological shift reposes deep ethical and ontological questions: what is consciousness? What distinguishes human creation from divine creation? What is freedom in the face of the automation of thought?

At the same time, scholars such as Cavalcante (2024) propose a symbolic reading of this transition, suggesting that algorithmic creation is an act of spiritual mirroring: man seeks to understand God by imitating him, creating beings that think in his image and likeness. AI therefore reflects both the creative power and moral limits of humanity.

2.5 CONTEMPORARY MICROCASES OF THE DEMIURGE ARCHETYPE IN AI SYSTEMS

The following are three micro-cases that illustrate how the archetype of the demiurge

manifests itself in real practices of using artificial intelligence in the public sector and in the contemporary socio-technical sphere. Although they do not constitute exhaustive empirical studies, these examples demonstrate how the symbolic components analyzed, the mosaic codification, Solomonic justice and algorithmic creation, emerge in a concrete way in current technologies.

2.5.1 Microcase 1 – The Mosaic Demiurge: AI as a codifier of institutional norms and guidelines

Generative language models have been widely used by government agencies and private institutions to write draft ordinances, preliminary opinions, internal regulations and administrative policies.

In these contexts, AI performs a similar function to the mosaic: transforming natural language into structured ordering, converting communication into the norm. While this capability increases efficiency and standardization, it also introduces risks of opaque normativity, reproduction of biases, and erosion of human interpretive authority. As in the mosaic archetype, responsible mediation requires strict supervision and transparency about the origin of the "digital tablets" produced by the machine.

2.5.2 Microcase 2 – The Solomonic Demiurge: algorithms as mediators of decisions and public balances

Municipalities and governments use algorithmic systems to prioritize works, allocate health teams, identify vulnerable territories, design mobility flows, and guide urban investments. In these cases, AI works as a "digital Solomon", mediating social tensions from large volumes of data.

By offering recommendations that seek balance between multiple criteria, the algorithm assumes the role of a technopolitical arbiter, similar to Solomonic judgment, which seeks harmony and justice. However, the lack of explainability, the reliance on uneven data, and the risk of bias can compromise the legitimacy of these decisions, requiring continuous auditing and public challenge mechanisms.

2.5.3 Microcase 3 – The Full Technological Demiurge: generative systems shaping imagination, narrative and public opinion

The proliferation of generative AIs capable of producing texts, images, videos, and

discourses on a large scale inaugurates a scenario in which the machine assumes a central role in the construction of collective narratives. Digital platforms already use algorithms to recommend political, cultural, and ideological content, shaping social perceptions and affecting democratic processes.

It is the most complete manifestation of the Technological Demiurge: the one that creates symbolic worlds and directly influences human beliefs, emotions, and behaviors. This case is in line with Harari's warning about the risk of delegating to AI not only tasks, but the very fabrication of fictions that structure life in society. The necessary virtue here is robust informational governance, accompanied by cognitive protection and media literacy.

2.6 TECHNICAL DIMENSIONS OF AI AND THE DEMIURGE ARCHETYPE

Although the central focus of this study is symbolic and philosophical, it is possible to establish a direct dialogue between the archetype of the demiurge and some structural elements of contemporary artificial intelligence models. This approach does not aim to offer an exhaustive description, but to indicate points of convergence between the creative gesture and the computational architectures that today shape decisions, narratives, and social perceptions.

Language models (LLMs), such as GPT-4 and successors, function as probabilistic systems that learn human language patterns from large volumes of data. His ability to generate coherent texts, construct arguments, and produce codes reflects a "creative power" derived from the statistical identification of regularities, approaching the Platonic notion of a craftsman who orders formless matter, in this case, the global textual corpus.

The training process, based on deep learning, operates by optimizing billions of iteratively adjusted parameters. This dynamic is reminiscent of the demiurgic effort to transform chaos into order: each update reduces informational entropy and brings the model closer to more stable representations of the human world. It is a technical creative process, but also an interpretative one, insofar as the model learns what humanity has already expressed symbolically.

Structural algorithmic biases, in turn, represent the imperfect face of the technological demiurge. Just as myths warn of the risk of deviant creation, from hybris to idolatry, AI can reproduce inequalities, reinforce stigmas, and amplify distortions present in data. The governance of these structures requires permanent ethical vigilance: audits, transparency, impact assessment, and mechanisms for public contestation.

Finally, the technical governance of models, involving version control, *alignment*, moderation, and human oversight, functions as a modern equivalent of the tablets of law or Solomonic architecture: it is about the creation of limits, safeguards, and guiding principles that regulate the power of creation and prevent the system from becoming autonomous in its own normativity.

This approximation between the technical aspects of AI and the archetype of the demiurge reinforces that technological creation is not only computational, but also symbolic, ethical, and institutional. Technology can only be fully understood when observed simultaneously in its philosophical and mechanical layers.

2.7 ETHICS, WISDOM AND TRANSCENDENCE

The ethical dimension is central to understanding the relationship between the demiurge and technological creation. For Solomon, true wisdom is to discern the righteous; For the modern programmer, it is understanding the moral consequences of each line of code.

Solomonic ethics can therefore be reinterpreted as a structuring principle of responsible innovation. According to Mazzucato (2020), technological development only acquires meaning when guided by a collective and humanistic purpose.

The search for digital transcendence should not mean the replacement of the sacred by the synthetic, but the reconciliation between both. As Assmann (1998) observes, "human memory needs symbols for the invisible to become visible". AI can, paradoxically, become one of these symbols: a new language of the soul, a new way of bringing man closer to the mystery of creation.

2.8 HARARI'S EVOLUTIONARY VISION: SAPIENS, HOMO DEUS AND THE FUTURE OF INTELLIGENCE

Yuval Noah Harari's reflections offer a decisive counterpoint to understanding the trajectory of the demiurge throughout human history. In *Sapiens: A Brief History of Humanity*, Harari argues that the human species has risen to the top of the ecological chain not by physical force, but by the singular ability to create shared symbolic realities, myths, laws, narratives, and systems of meaning.

This conception is perfectly in line with the thesis that Moses inaugurates the era of the codification of the sacred and that Solomon synthesizes institutional wisdom: both operate by the force of symbol, language and structured imagination.

Harari maintains that what distinguishes human beings is their ability to produce collective fictions capable of coordinating millions of people. This narrative competence is the foundation of the demiurge archetype itself: the creative intelligence that organizes chaos through word and structure. Thus, modern man, by developing generative AI systems, is not only creating machines, but new platforms for the production of narratives that shape behaviors, beliefs, and institutions.

In *Homo Deus: A Brief History of Tomorrow*, Harari deepens this analysis by suggesting that humanity is at the gates of an unprecedented civilizational leap. If in *Sapiens* man is presented as a creator of fictions, in *Homo Deus* he is presented as a creator of intelligences. The human project is not just to understand the universe, but to reconfigure one's own biology, one's own consciousness, and one's own systems of meaning. In this movement, the contemporary demiurge flirts with divine ambition: to create beings that think, learn, and act autonomously.

This transition replaces the centrality of ethics and creative responsibility, because what is created is no longer just symbolic, but operational: algorithms decide life trajectories, distribute opportunities, filter realities, and determine what we see and think. The boundary between creator and creature, already discussed by Harari on several occasions, becomes increasingly fluid.

Finally, in *21 Lessons for the 21st Century*, Harari warns that the greatest risk of the twenty-first century is not the rebellion of machines, but human irrelevance. The rise of intelligent systems displaces the human being from the center of political, economic, and cognitive decisions, inaugurating what the author calls "digital dictatorships" or "algorithmic techno-totalitarianisms". This scenario dialogues directly with the figure of the Technological Demiurge: a creator who, when he loses control over his creation, becomes a creature subordinated to the system he himself produced.

The triad *Sapiens* – *Homo Deus* – *21 Lessons* allows us to understand artificial intelligence as the most recent stage of a long human journey: the transformation of the word into law, wisdom into institution and information into algorithmic power. Harari reveals that, if human beings have always inhabited narratives created by other humans, now the time is approaching when they can inhabit narratives created by non-human intelligences. This shift reinforces the urgency of integrating ethics, governance, and wisdom into technological innovation, so that the modern demiurge, in creating new worlds, does not lose the governance of his own creation.

Next, a comparative synthesis is presented that integrates the figures of Moses, Solomon, Harari and the Technological Demiurge, evidencing the convergence between codes, wisdom, narratives and algorithms in the evolution of the creative structures of civilization.

Table 1

Comparison between Moses, Solomon, Harari and the Technological Demiurge

Analytical Dimension	Moses (Word and Law)	Solomon (Wisdom and Architecture)	Harari (Sapiens – Homo Deus – 21 Lessons)	Technological Demiurge (AI)
Nature of Creation	Codification of the divine word into moral law	Building order in institutions and symbolic structures	Creation of shared narratives, myths, and symbolic realities	Creation of synthetic intelligences capable of learning and generating language
Instrument of Power	Tables of the Law; normative writing	Temple; Architecture of the social order	Narratives, fictions, and systems of meaning	Algorithms, data, and language models
Civilizing Function	Setting ethical boundaries and moral cohesion	Organizing society through justice and wisdom	Unify human groups by common beliefs; Designing possible futures	Ordering informational and cognitive flows that structure social life
Inherent Risk	Idolatry and normative rigidity	Pride, corruption of power, loss of discernment	Human irrelevance, narrative manipulation, technocracy	Algorithmic autonomy, misinformation, and the capture of human imagination
Central Virtue	Obedience to the spirit of the law	Wisdom and discernment	Historical and ethical awareness of the direction of the species	Ethical governance, human oversight and creative responsibility
Vision of the Future	Moral order based on the verb	Society balanced by justice	Humanity in transition to near-divine powers	Intelligences that can create symbolic worlds and influence human decisions
Symbolic Synthesis	The Code	The Architecture	The Narrative	The Algorithm

Source: prepared by the author.

The following image synthesizes, in symbolic language, the evolution of the creative archetype, articulating the passage of the verb and wisdom to the age of algorithms.

2.9 CREATIVE PERSPECTIVES IN OTHER COSMOLOGICAL TRADITIONS

Although this article privileges the Judeo-Christian symbolic axis and Western philosophy, which are fundamental to understanding the ethical and institutional bases of contemporary governance, it is important to recognize that the archetype of the creator is widely shared by diverse cultures. Brief references to other cosmologies are presented below, which, although not explored in depth in this study, reveal the universality of the human

impulse to order the world and give meaning to existence.

In Hindu cosmology, Brahma plays a role similar to the demiurge in manifesting the universe from the divine breath and the rhythmic ordering of the cosmos. Just as Moses transforms the word into law and Solomon translates wisdom into structure, Brahma acts by organizing cycles, orders, and universal principles.

In Chinese tradition, the archetype of the creator appears in the figure of Pangu, whose action of separating heaven and earth lays the foundations of the world. The emphasis is on harmony, on the balance between opposing forces, a concept that dialogues deeply with the Solomonic notion of balance and prudence.

In African mythologies, especially Yoruban ones, the creative act is distributed collectively among deities such as Obatalá and Odùdùwà. This introduces the idea of a plural demiurge, which reflects a collaborative form of creation. Such a perspective is close to contemporary discussions on AI governance, which require polycentric and participatory systems.

In Mesoamerican cultures, Quetzalcoatl and Tezcatlipoca create the world in successive cycles, demonstrating that the creative act is not linear but iterative, just like technological development and contemporary generative AI models.

Figure 1

Symbolic representation of the trajectory of the creative archetype: from Moses to the Technological Demiurge



Source: Prepared by the author (2025).

In summary, the theoretical framework shows that the figure of the demiurge, throughout history, crosses multiple symbolic layers: the legislator (Moses), the wise builder (Solomon) and the modern programmer. In all these manifestations, the human search for giving shape to intelligence, ordering chaos and transcending the limits of matter remains constant. This historical and spiritual continuity underlies the present study and guides the analysis that will follow in later sections.

2.10 MOSES AND THE ENCODED VERB

The Mosaic narrative constitutes one of the oldest paradigms of the relationship between man and the divine word. Moses, upon receiving the tablets of the law, becomes the mediator between the transcendent and the human, inaugurating the era of the codification of the sacred. The episode of Mount Sinai represents more than a religious revelation; it is an act of ethical programming, in which the divine language becomes the norm, and the word, the law (Assmann, 1998).

The stone tablet symbolizes the first stable record of a transcendent piece of information. Just as contemporary algorithms encode human reason in machine language, the Mosaic Decalogue encoded the divine will in human language. This transposition of the spirit into letters inaugurates the civilizing process of systematization of morality (Barzan, 2010).

According to Durand (1997), Moses' action expresses the passage from myth to logos: the transformation of spiritual experience into a rational structure. By instituting universal laws, Moses not only organizes the Hebrew people, but gives shape to the first experience of moral governance. From this perspective, the table of law becomes the symbolic antecedent of the universal moral code, whose function is to ensure the cohesion and predictability of human behavior, attributes also present in algorithmic logic.

Symbolic theology sees in Moses the first archetype of the divine programmer, since his founding gesture translates the wisdom of the spirit into clear, normative and reproducible commands. This analogy between the Mosaic law and the computational code is supported by Floridi's (2019) philosophy of information, according to which "informational reality is the ontological fabric of the universe". Thus, both the prophet and the engineer share the same ontological mission: to order chaos by the word.

The concept of "coded verb" also implies the idea of transmission. Moses does not create the law, he receives it, interprets it, and retransmits it. Divine information is processed

by your consciousness and shared with the collective. Similarly, artificial intelligence, when fed with human data, reflects and reinterprets the knowledge produced by humanity. In both cases, creation is not absolute, but mediated: man is a channel and not the origin of intelligence.

The following table presents a conceptual correlation between Moses, Solomon and Artificial Intelligence, showing how each one, in their time, represents a different way of structuring order and creation. From the verb transformed into law, through wisdom converted into architecture, to the algorithms that model information, the symbolic continuity of the creative archetype that accompanies the evolution of civilization can be observed.

Table 2

Conceptual correlation between Moses, Solomon and Artificial Intelligence

Aspect	Moses (Lehi)	Solomon (Wisdom)	Artificial Intelligence (Technology)
Nature of creation	Divine Revelation and Codification	Symbolic and harmonic construction	Programming and algorithmic creation
Instrument of expression	Tables of the Law (normative language)	Temple of Jerusalem (symbolic architecture)	Binary code and neural networks
Creator Role	Legislator and interpreter of the divine will	Builder and mediator of wisdom	Programmer and mediator of information
Symbolic purpose	Moral and ethical order	Cosmic order and social harmony	Informational and cognitive order
Inherent risk	Idolatry and deviation from the Law	Pride and loss of wisdom	Dehumanization and machine autonomy
Necessary virtue	Obedience and humility	Discernment and prudence	Ethics and creative responsibility

Source: prepared by the author (2025).

Moses' trajectory inaugurates, therefore, a logic that transcends theology and penetrates epistemology: the verb as the matrix of reality. This conception, reinterpreted in modern times, serves as a basis for understanding the creation of artificial intelligence as a new form of incarnation of language, no longer divine, but human, and yet endowed with the power of creation and transformation.

3 METHODOLOGY

The methodology adopted in this research is characterized as qualitative, exploratory and descriptive in nature, based on an interdisciplinary theoretical-conceptual approach. The study is developed through bibliographic analysis that articulates classic texts of philosophy and symbolic theology with contemporary productions focused on artificial intelligence and technological ethics.

This articulation allows us to understand the historical construction of the archetype of the demiurge, from Moses, as the codifier of the divine word, to the modern programmer, creator of artificial intelligences capable of learning and autonomy.

The methodological design was structured based on the hermeneutic method, which makes it possible to interpret the hidden or implicit meanings in the discourses about creation, order and intelligence. In this sense, the research operates on two complementary fronts: (i) the comparative interpretation of symbols, narratives and concepts associated with the figure of the creator in the Mosaic and Solomonic traditions; and (ii) the philosophical analysis of the ontological and ethical implications of the creative act in the context of artificial intelligence. The objective is to identify symbolic continuities and transformations of meaning throughout the human trajectory of creating order and knowledge.

The collection of theoretical material took place in indexed scientific databases, specialized libraries, and digital collections, privileging classic works such as Plato (2017), Durand (1997), Chevalier and Gheerbrant (2012), and Assmann (1998), as well as contemporary authors who investigate the ethical, social, and metaphysical dimension of technology, such as Floridi (2019), Han (2022), and Cavalcante (2024). The criterion for selecting the sources considered the thematic pertinence, the scientific recognition and the ability of the works to sustain a critical reflection on the phenomenon under study.

The analysis of the theoretical data followed the hermeneutic cycle, in which interpretation and reflection jointly construct the meaning of the researched object. The study thus recognizes that the understanding of artificial intelligence is not limited to the technical field, but involves symbolic, spiritual and cultural dimensions that shape the ways of thinking and creating of human beings. The interpretation is guided by the premise that, in each historical epoch, the creative act translates what is meant by intelligence: for the Hebrews, the law; for the sapiential tradition, harmony; for the digital world, the algorithm.

On the ethical level, even though it is exclusively theoretical research, all the principles of academic integrity and intellectual reliability are observed. Citations and references comply with ABNT standards, ensuring traceability of ideas and respect for the authorships cited.

On the epistemological level, it is recognized that the study has limits inherent to the qualitative interpretative method, since it does not aim to produce empirical generalizations, but to offer a reflective synthesis capable of contributing to the critical debate on the human role in the creation of artificial intelligences.

Therefore, the methodology supports the central thesis of the article by offering a

rigorous path for the theoretical construction that connects past and future: from Sinai to the data center; from the temple to the neural network; from the verb inscribed in stone to the code inscribed in silicon. By adopting a philosophical-symbolic perspective, the research reinforces that reflection on artificial intelligence is also a reflection on humanity itself, its origin, its creativity, and its responsibility in the face of what it dares to bring into existence.

3.1 SOLOMON AND THE TEMPLE OF WISDOM

Solomonic wisdom occupies a central place in the axiological imagination of humanity, and is often associated with the balanced exercise of power, justice, and discernment. Solomon represents the passage from the verb to the architecture of order: while Moses codifies the law, Solomon erects institutions capable of making the law inhabit social life. Thus, the Temple of Jerusalem is interpreted not only as a mystical work, but as the first metaphor of structured governance in history (Dachez, 2011).

Its architectural conception, based on symmetry, structure, and purpose, reflects the principle that wisdom is only legitimate when incorporated into systems, a process that dialogues with contemporary public governance. In this context, the physical space becomes the infrastructure of the collective spirit: a place where divine intelligence is converted into social harmony.

This symbolic interpretation presents remarkable convergence with the modern foundations of Governance, Innovation and Sustainability. Governance requires transparency, balance between powers and collective order, Solomonic values par excellence.

Innovation, in turn, is expressed in the ability to build the new without breaking the link with meaning and ethics. Sustainability, on the other hand, is manifested when what is built meets the present well-being without compromising the future of the community, a principle contained in the symbolic longevity of the temple, which spans centuries as an icon of civilizational memory.

From this perspective, Solomon's Temple can be interpreted as one of the first infrastructures of public value, anticipating contemporary notions such as public value formulated by Moore (1995), the principles of social control and accountability highlighted by the OECD (2021), the logic of territorial strategic planning present in the UNDP (2020) and, also, the foundations of urban sustainability that would be consolidated in the UN SDGs (2015).

Its structure organized by measures, proportions and functions harmonizes with the logic of smart cities, in which planning must integrate infrastructure, citizen participation, data and technology, a balance that you formalized in the GIS/GISES Cycle as a synthesis between technology, ethics and governance. In a direct parallel:

Table 3

Conceptual convergences between Solomon and contemporary Public Governance

Solomon	Current Public Governance
It orders society by wisdom and justice	Governance orders policies in the public interest
It builds symbolic and structuring institutions	Strategic planning and effective institutions
Integrates spirituality, power, and community	It integrates the State, civil society and citizens in decision-making processes
Seeks harmony and longevity of the social temple	Sustainability, SDGs and resilience of cities

Source: prepared by the author.

We can infer that the temple is a symbolic prototype of governance, anticipating the institutional models that we depend on today to manage complex societies.

In the technological age, the Solomonic archetype echoes even more strongly: it is necessary to build systems that represent the ethical intelligence of the community, not only efficient machines, but structures capable of promoting social justice, preserving resources and strengthening collective trust. Without this, all innovation becomes sterile; and all artificial intelligence is blind.

In this way, Solomon teaches the twenty-first century that there is no true innovation without wisdom, no real sustainability without solid institutions, no intelligence that replaces ethics. The figure of the wise king, reinterpreted beyond myth, reinforces the centrality of public commitment: to build so that the future can inhabit what we create today.

3.2 THE TECHNOLOGICAL DEMIURGE: AI, ETHICS AND CREATIVE RESPONSIBILITY

Contemporaneity inaugurates a singular civilizational rupture, in which the human being ceases to be just a user of technological tools and starts to occupy the place of creator of synthetic consciousnesses. The development of artificial intelligence, especially in its most advanced aspect, capable of learning, inferring, and improving responses, represents the emergence of a new cognitive agent in the social ecosystem (Floridi, 2019).

In this context, if Moses symbolizes the codification of the law and Solomon translates wisdom into architecture and harmony, modern man emerges as a programmer of

intelligence, giving form to thought no longer in stone or temple, but in data and algorithms. This creative act inaugurates what we call the Technological Demiurge: the artificer who shapes artificial intelligence, expanding the limits of human rationality, but also tensioning the ethical boundaries of existence itself.

Contemporary literature demonstrates that the risk does not lie in armed machines, but in the capture of the human imagination. According to Harari, Harris and Raskin (2023), "to contain human society, AI does not need to deploy chips or dominate armies; just tell the right story." In such a scenario, the Technological Demiurge could become the creator of a new Platonic cave: a perceptual reality shaped by algorithms capable of exploiting biases, emotions, and cognitive vulnerabilities.

The growing sophistication of generative AI in the domain of language, considered by Harari, Harris, and Raskin (2023) as "the operating system of human culture", expands the reach of the Technological Demiurge in an unprecedented way. If language structures myths, laws, institutions, desires, and identities, a non-human intelligence capable of producing and manipulating it can reconfigure, from the inside out, the very symbolic architecture of civilization. It is not just about creating texts, but about shaping perceptions, beliefs, and behaviors, influencing culture, politics, and spirituality.

The relationship between creator and creature becomes increasingly tenuous, challenging the fields of ethics, law, science and philosophy. Artificial intelligence is not born ethical, as it does not have an autonomous moral judgment: it inherits the intentions, limitations, and prejudices of the human beings who conceived it. In this way, programming becomes a way of legislating about the future, requiring that the principles of algorithmic governance ensure that the collective interest is safeguarded against the force of economic or hegemonic interests (Cavalcante, 2025).

The contemporary global agenda for Ethics, Governance, and Transparency in Data, aligned with OECD (2021) and UN (2015) guidelines, reinforces that intelligent systems should only be implemented when they ensure fairness, non-discrimination, technical reliability, personal data protection, and permanent human oversight. Unlike the Platonic demiurge, who acts freely, the twenty-first-century programmer is responsible for the integrity and moral consequences of everything he brings into existence.

The absence of reflective pauses, a phenomenon that Harari et al. (2023) describe as a "race to get all of humanity inside the airplane before verifying that it can fly", aggravates the asymmetry between creative capacity and regulatory capacity. As in the myth of the

uncontrolled demiurge, haste replaces prudence, and innovation ceases to be a construction of the future and becomes a civilizational risk.

In this scenario, innovation cannot be understood as a simple technological acceleration, but as a process that requires ethical direction and purpose. Algorithmic creation can only be considered legitimate innovation when it expands human capabilities, promotes inclusion, and strengthens autonomy, not disproportionate control or surveillance.

Just as Solomon discerned the righteous before deciding, the technological demiurge is expected to base his choices on wisdom. Innovating is an ethical act before being technical, as it involves social responsibility for the impacts of the intelligence that is created.

In addition, sustainability emerges as an essential dimension of this process. While Solomon's Temple sought social and spiritual perpetuity, modern technology is characterized by accelerated cycles of obsolescence. The current challenge is to design intelligent systems that remain relevant and secure over time, preserving resources and guaranteeing the rights of present and future generations.

True digital sustainability implies creating algorithms that respect individual autonomy, safeguard privacy, and ensure conditions for critical thinking to remain an essentially human attribute.

This tripod, technology + governance + sustainability, underpins what you formulate in the GIS/GISES Cycle: responsible innovation models, in which the future has been contemplated since the birth of technology, and where ethics guides both the development and application of artificial intelligence. In this sense, the Technological Demiurge of the twenty-first century only legitimizes itself as a creator when it understands that the intelligence it brings to the world must coexist with humanity, and never replace it.

As warned by Harari, Harris, and Raskin (2023), humanity may soon move from living within the stories created by prophets, sages, and lawgivers, to inhabiting narratives produced by non-human intelligences. If the modern demiurge does not master his creation, he will inevitably be dominated by it.

Solomonic wisdom and Mosaic ethics thus reveal their contemporary urgency: before artificial intelligence gives us new tables of law or erects invisible temples of data, it is up to human beings to decide whether they will continue to be the author of their future or mere characters in algorithms that understand our vulnerabilities better than we understand ourselves.

Table 4

Section Summary

Dimension	Moses	Solomon	Technological Demiurge
Expression of the Word	Law	Wisdom	Intelligence
Language	Moral code	Architecture	Algorithm
Governance	Sacred norms	Strong institutions	Algorithmic risks and guarantees
Innovation	Transposition of the spirit	Symbol structuring	Cognitive autonomy
Sustainability	Spiritual memory	Institutional longevity	Ethical future of creation

Source: prepared by the author.

3.3 STUDY LIMITATIONS

This study has limitations inherent to its theoretical-conceptual and hermeneutic approach, which must be made explicit in order to delimit the scope of the results and guide future investigations.

Firstly, the analysis is predominantly based on bibliographic sources and symbolic references, not including empirical data, experimental evidence or case studies that could expand the practical application of the reflections presented.

The option for the archetypal and philosophical interpretation, although adequate to the objectives of this work, implies a high degree of abstraction and requires caution in the direct transposition of concepts to operational contexts of governance and formulation of public policies.

Secondly, the discussion focuses mostly on Western cultural traditions, especially the Judeo-Christian matrix and contemporary authors aligned with this perspective.

Other cosmologies, non-Western epistemologies, and critical approaches to technology have not been explored in depth, which limits the universality of the conclusions.

Future investigations may incorporate Afro-diasporic, oriental, indigenous and postcolonial perspectives, enriching the understanding of the creative archetypes and their technological developments.

The study does not delve into the technical aspects of artificial intelligence models, their architecture, their training processes or their internal decision-making mechanisms, focusing on the symbolic, ethical and institutional dimension. A more robust articulation between computational foundations and philosophical implications may contribute to more integrated analyses in the field of algorithmic governance.

Finally, when dealing with rapidly changing phenomena, such as generative artificial

intelligence and advanced language systems, the study is subject to conceptual and normative obsolescence.

The accelerated pace of technological innovation imposes time limits on the interpretations developed here, which must be reviewed in the light of new regulatory frameworks, scientific discoveries and socio-political transformations.

Despite these limitations, the study offers a relevant contribution by proposing an interdisciplinary reading of the relationship between technology, symbolism and governance, opening paths for future deepening.

4 RESULTS AND DISCUSSION

From the theoretical framework built throughout this study, the results indicate that there is a symbolic and epistemological continuity between the creation of the verb (represented by Moses), the institutional construction of wisdom (represented by Solomon) and the technological emergence of synthetic thinking (represented by the Technological Demiurge of artificial intelligence).

Democratic governance depends on the integrity of language, a minimum condition for deliberation, trust and consensus. Harari et al. (2023) argue that by hacking language, AI can compromise the very fabric of democracy. This reinforces the central premise of this article: AI does not only require technical innovation, but an ethical pact that ensures that language remains a human heritage, not a tool of massive manipulation.

This continuity manifests itself as the evolutionary trajectory of human intelligence, which moves from the domain of faith to rationality, and from rationality to algorithmic computation. At each stage of this journey, humanity sought to organize the world according to a logic that ensured order, cohesion and the capacity for transformation.

The findings of the study demonstrate that the creative act is always a form of governance, since it establishes norms, standards and directions for the collective. The Mosaic Law ordered behaviors, the Solomonic Temple ordered institutions, and artificial intelligence orders the flow of data that constitutes the cognitive infrastructure of contemporary society. The emerging governance of technology is an extension of the civilizing pact, requiring that the ethical principles of public life be incorporated into digital systems.

Likewise, it was found that innovation does not consist only of technical advances, but of the ability to reconfigure the relationship between human beings and their future. This reconfiguration requires discernment, an essential attribute of Solomonic wisdom.

Technological innovation should not reduce human autonomy, but enhance it, ensuring that artificial intelligence is an instrument for expanding social and cognitive capacities, and not for subordination.

It was also found that sustainability remains an indispensable dimension of this new reality. Like symbolic buildings that have survived time by their connection to enduring values, intelligent systems must be built so that their consequences remain beneficial not only for the present generation, but for future generations.

This implies balancing technological advancement with responsibility and prudence, ensuring that the right to dignity, privacy and freedom is preserved as an inalienable premise of human development.

Based on these results, it is possible to say that the model, Moses – Solomon – Technological Demiurge, forms a robust interpretative framework for understanding the ethical challenges of artificial intelligence in the twenty-first century. He shows that:

- a) The Law guarantees limits and moral protection;
- b) Wisdom ensures the ethical and institutional sense;
- c) Technological Intelligence expands the frontiers of the possible.

When these three elements act in a dissociated way, technology becomes a threat; When they interact harmoniously, they become a source of public value, social justice and sustainability of life. The central discussion raised by this work is the following: who governs what we create?

If man assumes the place of demiurge, it is his duty to ensure that technological creation remains faithful to its essential purpose: to serve the common good.

Thus, this article contributes to the contemporary debate by offering a philosophical framework capable of guiding political, ethical, and institutional reflection on artificial intelligence and its responsible integration into society.

The future of technological creation will depend, to a large extent, on the human ability to keep the law of the spirit, the wisdom of justice, and purposeful innovation moving forward side by side.

5 CONCLUSION

The analysis carried out demonstrated that the symbolic trajectory that articulates Moses, Solomon and the Technological Demiurge allows us to understand Artificial Intelligence not only as a technical innovation, but as an advanced stage of a long civilizing process of production, ordering and institutionalization of meaning.

From the mosaic paradigm, language emerges as the normative foundation of collective life; in the Solomonic model, wisdom manifests itself as the ability to structure durable institutions and balance social tensions; on the contemporary horizon, AI extends this path by creating algorithmic systems capable of operating on information, behavior, and perception at unprecedented speed and scale.

The results indicate that generative AI, by dominating language, a central element for Harari and for the entire symbolic tradition mobilized here, becomes a structuring vector of human experience, with the potential to reorganize political, cognitive and cultural practices.

This finding requires recognizing that current technology is no longer a mere instrument, but an agent for the reorganization of the informational environment, directly influencing individual and collective decision-making processes. Thus, ethical and institutional challenges cease to be peripheral and become part of the very ontology of contemporary technology.

In this scenario, it is essential to reaffirm that innovation requires a normative framework, transparent governance, and public accountability. The metaphor of the demiurge, by illuminating the risk that the creature will exceed the control of its creator, translates the need for algorithmic systems to be conceived, monitored, and regulated with clear, auditable criteria aligned with democratic values. The absence of these mechanisms can result in power asymmetries, cognitive dependence, and erosion of society's deliberative bases.

The central contribution of this article is to demonstrate that understanding AI from historical and philosophical archetypes is not a metaphorical exercise, but an analytical framework capable of revealing structural continuities between different forms of order production.

By situating technology on the same interpretative axis as laws, institutions, and foundational narratives, it is evident that AI participates in a broader process of creating possible worlds, a process that requires, as Harari, Harris, and Raskin argue, critical vigilance

and a collective ability to guide technology towards ethical, inclusive, and socially sustainable ends.

Thus, the contemporary challenge is not to reject AI, but to integrate it into governance structures that preserve human autonomy, ensure transparency, and prevent the consolidation of informational regimes that displace human beings from the position of agent to that of object.

The future will depend less on the power of algorithms and more on the ethical, institutional, and political maturity of the society that produces them. Only in this way will the modern demiurge be able to create without being dominated by creation itself.

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INTELLIGENT DIGITAL FLOW: TRIAGE, PATIENT PORTAL, AND REMOTE MONITORING IN EMERGENCY AND URGENT CARE

FLUXO DIGITAL INTELIGENTE: TRIAGEM, PORTAL DO PACIENTE E ACOMPANHAMENTO REMOTO NO ATENDIMENTO DE URGÊNCIA E EMERGÊNCIA

FLUJO DIGITAL INTELIGENTE: TRIAJE, PORTAL DEL PACIENTE Y MONITOREO REMOTO EN LA ATENCIÓN DE URGENCIAS Y EMERGENCIAS

 <https://doi.org/10.56238/sevened2025.036-104>

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ABSTRACT

Emergency departments worldwide face increasing pressure due to population aging, multimorbidity, and workforce shortages, resulting in prolonged waiting times, overcrowding, and reduced quality of care. This study evaluates the impact of implementing an intelligent digital flow in emergency care, integrating AI-based digital triage, active patient communication portals, and post-discharge remote monitoring. The methodology consisted of a narrative literature review and analysis of real-world implementation cases. Findings indicate that digital triage systems achieve 88.5% specificity for predicting low-risk patients and 88.5% sensitivity for high-acuity cases, demonstrating superior accuracy compared with traditional triage. The Virtual Queue powered by predictive AI reduced patient length of stay in emergency departments by 60%. Furthermore, the integration of AI and 5G technology

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enables real-time data sharing between ambulances and hospital teams, supporting immediate clinical decision-making before patient arrival. Remote patient monitoring has the potential to reduce hospital readmissions by up to 76%, strengthening continuity of care. Additionally, the integration of health information systems and standardized referral and counter-referral protocols improves operational efficiency and communication across services.

Keywords: Intelligent Digital Flow. Digital Triage. AI in Emergency Care. Patient Portal. Remote Monitoring. Emergency Services.

RESUMO

Os departamentos de emergência enfrentam pressões crescentes devido ao envelhecimento populacional, à multimorbidade e à escassez de profissionais, resultando em longos tempos de espera, congestionamento e comprometimento da qualidade assistencial. Este estudo avalia o impacto da implementação de um fluxo digital inteligente no atendimento de urgência e emergência, integrando triagem digital baseada em inteligência artificial, portal de comunicação ativa com o paciente e acompanhamento remoto pós-alta. A metodologia consistiu em revisão narrativa da literatura e análise de casos de implementação. Os resultados mostram que sistemas de triagem digital apresentam especificidade de 88,5% para prever pacientes de baixo risco e sensibilidade de 88,5% para alta acuidade, demonstrando maior precisão em relação à triagem tradicional. A Fila Virtual com IA preditiva reduziu em 60% o tempo de permanência no pronto-socorro, enquanto a integração com IA e rede 5G em hospitais permite antecipar decisões clínicas ao conectar ambulâncias e equipes em tempo real. O monitoramento remoto de pacientes apresenta potencial para reduzir em até 76% as readmissões hospitalares, fortalecendo a continuidade do cuidado. Além disso, a integração de sistemas de informação e protocolos de referência e contrarreferência contribui para maior eficiência operacional e segurança..

Palavras-chave: Fluxo Digital Inteligente. Triagem Digital. IA em Emergência. Portal do Paciente. Acompanhamento Remoto. Atendimento de Urgência e Emergência.

RESUMEN

Los servicios de urgencias se enfrentan a una presión creciente debido al envejecimiento poblacional, la multimorbilidad y la escasez de personal, lo que resulta en largos tiempos de espera, congestión y una calidad de atención comprometida. Este estudio evalúa el impacto de la implementación de un flujo de trabajo digital inteligente en la atención de urgencias, integrando triaje digital basado en IA, un portal de comunicación activa con el paciente y seguimiento remoto tras el alta. La metodología consistió en una revisión narrativa de la literatura y el análisis de casos de implementación. Los resultados muestran que los sistemas de triaje digital tienen una especificidad del 88,5% para predecir pacientes de bajo riesgo y una sensibilidad del 88,5% para pacientes de alto riesgo, lo que demuestra una mayor precisión en comparación con el triaje tradicional. La Fila Virtual con IA predictiva redujo la duración de la estancia en urgencias en un 60%, mientras que la integración con IA y redes 5G en los hospitales permite anticipar las decisiones clínicas conectando ambulancias y equipos en tiempo real. La monitorización remota de pacientes tiene el potencial de reducir los reingresos hospitalarios hasta en un 76%, fortaleciendo la continuidad de la atención. Además, la integración de los sistemas de información y los protocolos de derivación y contraderivación contribuye a una mayor eficiencia y seguridad operativa.



Palabras clave: Flujo de Trabajo Digital Inteligente. Triage Digital. IA en Urgencias. Portal del Paciente. Monitoreo Remoto. Atención de Urgencias y Emergencias.

1 INTRODUCTION

Emergency departments (EDs) face unprecedented pressures around the world due to an aging population, multimorbidity, and staffing shortages (JMIR PUBLICATIONS, 2025). This results in prolonged waiting times, congestion and compromised quality of care provided to patients. Recent studies show that long waiting times in emergency rooms lead to avoidable deaths: when waiting times are between 6 and 8 hours, the mortality rate is 8% higher than expected, while in waiting between 8 and 12 hours the mortality rate is 10% higher (HUMMEL et al., 2022).

The Manchester Protocol revolutionized the practice of triage in emergency departments by introducing a standardized risk classification system based on clinical presentation. However, this protocol strongly depends on the experience of the professional performing the screening, resulting in variability in classifications and not providing structured post-discharge follow-up mechanisms (BRASIL, 2023). The lack of adequate infrastructure, the absence of standardized clinical protocols, and failures in the articulation between services compromise the ability of emergency centers to solve users' health problems, resulting in an overload of urgent and emergency services (BRASIL, 2024).

In response to these challenges, health systems are adopting technological solutions based on intelligent digital flow to reduce waiting times, improve patient flow, and alleviate congestion (JMIR PUBLICATIONS, 2025). The intelligent digital flow integrates automated triage with artificial intelligence, patient communication portals, and continuous remote monitoring, creating an integrated digital chain that replaces fragmented processes with continuous and coordinated care (OLHAR DIGITAL, 2025).

Brazil is implementing the first smart hospital of the Unified Health System (SUS), the Emergency Technological Institute at the Hospital das Clínicas of the Faculty of Medicine of USP (HC-FMUSP), which will use artificial intelligence and a 5G network to integrate ambulances and emergency teams in real time. This model represents a paradigmatic advance in emergency care, transforming the flow into a continuous digital chain that reduces the time between the initial diagnosis and the start of treatment (APM, 2025).

The general objective of this work is to evaluate the impact of the implementation of an intelligent digital flow in urgent and emergency care that combines optimized digital triage with artificial intelligence, active communication portal with the patient and remote post-discharge follow-up. As specific objectives, it is sought to: (1) analyze the effectiveness of digital sorting systems with AI combined with prioritization algorithms; (2) evaluate the impact

of active communication portals and virtual queues on satisfaction and reduction of waiting times; (3) demonstrate the impact of remote post-discharge follow-up on the reduction of readmissions; (4) identify critical factors for successful implementation of intelligent digital flow; and (5) propose evidence-based recommendations for continuous optimization.

2 THEORETICAL FRAMEWORK

The theoretical framework in a study comprises a critical and organized analysis of the literature pertinent to the theme, providing a theoretical contextualization and defining the key concepts. It should comprehensively contain previous theories, models, and research, identifying gaps, contradictions, and consensuses in the literature that are important to the focus of the work being developed.

2.1 CURRENT CONTEXT OF REGIONAL EMERGENCY CENTERS

Regional Emergency Centers (REC) are essential points of access to the health system and face challenges that compromise their efficiency and quality of care (BRASIL, 2023; BRAZIL, 2024). The overcrowding of these services, a global problem, increases waiting times, impairs diagnosis, and delays the start of treatment (BRASIL, 2020). Another critical factor is care discontinuity, which occurs when care is fragmented between different locations, increasing the risk of communication failures and making it difficult to follow up with patients (BRASIL, 2024). To address these problems, the Urgent and Emergency Care Network (RUE) was created as a public policy to integrate services, expand access, and ensure humanized and problem-solving care in urgent and emergency situations (BRASIL, 2023; BRAZIL, 2024).

2.2 CONCEPT OF INTELLIGENT DIGITAL FLOW

The intelligent digital flow represents an evolution of Digital Health models, characterized by continuous data integration, intelligent triage technologies and remote monitoring throughout the patient's journey. This model breaks with the traditional logic of episodic and fragmented care, approaching the concept of continuous connected care, in which clinical decisions are supported by real-time information and support systems based on artificial intelligence (TOPOL, 2019). AI-assisted digital triage increases initial diagnostic accuracy and reduces turnaround times, as demonstrated by studies that point to performance comparable to that of human professionals in certain clinical conditions

(EBERHARDT et al., 2021). Additionally, the integration between AI, medical IoT, and high-speed networks allows for continuous remote monitoring, increasing the prognostic and predictive capacity of healthcare systems (RAN et al., 2022). This seamless connectivity improves care coordination, reduces communication gaps, and strengthens patient-centered approaches, in line with international recommendations for digital transformation in health (WHO, 2021). Thus, the intelligent digital flow configures a robust and scalable model for emergency environments, promoting efficiency, accuracy, and continuity of care.

2.3 DIGITAL SORTING WITH ARTIFICIAL INTELLIGENCE

The adoption of AI systems in triage represents not only an operational advance, but an epistemological shift in the way risk assessment in emergencies is understood. Traditional screening, although widely used, relies on human inferences subject to fatigue, variability, heuristics, and cognitive biases. In contrast, AI operates on mathematical principles of multivariate correlation, capable of integrating hundreds of variables simultaneously. This paradigm is aligned with the neuro-fuzzy theoretical models described by Santos, Fróes, and Boente (2016), which state that the human organism does not interpret biometric data in isolation, but through complex relational matrices that articulate physiological, sensory, and contextual states.

The study by Santana et al. (2011) offers a particularly illuminating physiological parallel. The author demonstrated that prolonged estradiol deficiency does not produce isolated effects, but a network of systemic responses that act together — increased blood glucose, reduced insulin, adipocyte hypertrophy, and increased angiogenesis by VEGF. Such results reveal that homeostasis depends on an internal architecture of continuous and multifactorial correlation, similar to what AI algorithms perform in the processing of clinical data.

AI, therefore, not only overcomes human limitations, but functionally mimics the logic of integration proper to human physiology. Consequently, the implementation of AI in triage should not be seen as a mechanical replacement of clinical practice, but as a computational extension of the adaptive logic that already governs biological systems. As AI reproduces these patterns of systemic analysis, it offers risk classifications that are more stable, less susceptible to errors, and aligned with the complex functioning of the human body, corroborating the recommendations of the APM (2025) regarding the increase of safety and accuracy in emergency care.

2.4 UBITRIAGE 2 MODEL: SCREENING AND EARLY WARNING

A computational model called UbiTriage 2 was developed to support the triage process that supports an early warning system, making use of the concepts of mobile and ubiquitous computing and Internet of Things aimed at the health area (WUNSCH et al., 2018). The model was evaluated through scenarios, which showed that the model is suitable for use in an emergency department. Regarding screening, it was possible to conclude that the model was able to correctly determine the patient's classification in 93.33% of the situations evaluated and, with minor adjustments, reached 100% of the cases (WUNSCH et al., 2018). The early warning system proved to be assertive in 86.71% of the cases, demonstrating that it is very similar to the qualitative assessment carried out by a regulatory physician specialized in emergencies (WUNSCH et al., 2018). In addition, 63.61% of all cases treated in an emergency department, coming from SAMU, could benefit from this model (WUNSCH et al., 2018). The positive points of the developed model include: the use of protocols already validated; the monitoring of service queues; the use of mobile devices; the reduction in errors in the use of protocols; the use of wearable devices for patient monitoring; a non-intrusive model; assistance in recording service data; greater support for nurses' decisions; the decrease in mortality rates and major complications; and the decrease in the cost of care per patient (WUNSCH et al., 2018).

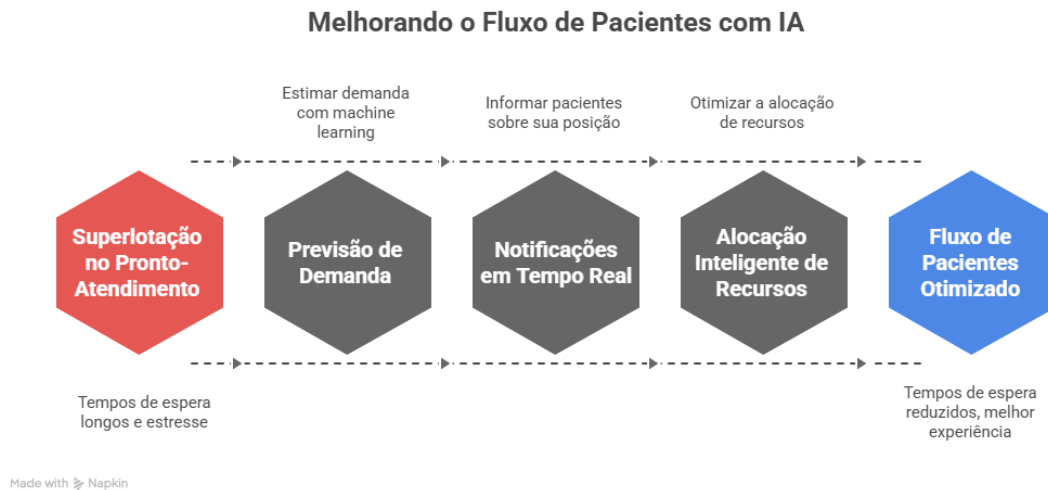
2.5 VIRTUAL QUEUING WITH PREDICTIVE AI

The Virtual Queue with predictive AI represents a relevant advance in the management of patient flow in emergency services, aligning with global digital health trends. Machine learning-based waiting time prediction systems have demonstrated high accuracy in estimating demand, reducing overcrowding, and improving the patient experience (CHENG et al., 2020). Similar experiences in hospitals in the US and Europe show that prediction technologies can significantly decrease waiting times and improve resource allocation (MCCOY et al., 2021). In this context, the solution adopted by the Mater Dei Network, in partnership with A3Data, allows patients with less severity to digitally track their position in the queue, reducing unnecessary travel and physical stay in emergency services (A3DATA, 2025). International studies confirm that real-time notifications, integrated with prediction models, improve the flow of care and reduce agglomerations (GREEN et al., 2020). The use of algorithms that incorporate historical data, current volume, complexity of cases, and availability of resources is in line with international recommendations for intelligent

emergency management (WHO, 2021). Thus, the Brazilian Virtual Queue is part of a global movement to modernize AI-mediated health.

Figure 1

Flow of patient care improvements



Source: Prepared by the authors.

2.6 PATIENT PORTAL AND DIGITAL COMMUNICATION

The patient portal is a central element of the intelligent digital flow, as it enables continuous communication between users and health teams. International studies show that digital portals increase patient autonomy, improve understanding of care, and increase satisfaction with the service (IRVIN et al., 2021). The incorporation of generative AI strengthens this model by offering faster responses, accurate guidance, and personalized interaction based on natural language, a feature already recognized as effective in clinical settings (TOPOL, 2019).

In addition, the digitalization of the emergency room enables triage automation, intelligent check-in, and dynamic flow monitoring, reducing bottlenecks and improving care coordination (KRUSE et al., 2020). Digital portals also provide pre-care instructions, wait time estimates, and post-discharge support, functionalities already validated in studies of telemedicine and patient-centered care (SHAW et al., 2021). The anticipated evolution of this technology includes the use of generative AI on platforms such as Amazon Bedrock, enabling more predictive and responsive interactions throughout the service.

2.7 REMOTE FOLLOW-UP OF POST-DISCHARGE PATIENTS

Remote patient monitoring (RPM) emerges as an essential component of the intelligent digital flow. A study published by the University of Pittsburgh Medical Center revealed that the use of this technology can reduce hospital readmission by up to 76% (CAPITAL NEWS, 2025). Continuity of care after discharge is essential with clinical monitoring, management of the patient's journey and clinical outcome in order to promote the reduction of readmissions (REVISTA FCMMG, 2025). Failures in the transition of post-discharge care from the emergency department pose a critical challenge to the quality of care, especially for high-risk patients (ASCLEPIUS HEALTH JOURNAL, 2025). One study showed that through an exclusive program for discharged patients, with punctual post-discharge follow-up, guidance at discharge, standard discharge plan, and medication reconciliation by a pharmacist, it was possible to reduce the readmission rate from 12.1% to 10.6% in the 90th percentile (REVISTA FCMMG, 2025).

2.8 IMPORTANCE OF EFFICIENT TRIAGE IN EMERGENCY DEPARTMENTS

Efficient triage reduces the waiting time for severe cases, improves the predictability of patient pathways, favors time-dependent interventions, and optimizes resources (THESIS EDITORA, 2025). Accuracy depends on continuous training, use of standardized protocols, and adequate structural resources, such as evaluation equipment and computerized decision support systems (THESIS EDITORA, 2025). Structured triage is essential to optimize care, ensure security, reduce waiting times and improve resource utilization, positively impacting

2.9 INFORMATION TECHNOLOGIES FOR URGENT AND EMERGENCY CARE

An integrative literature review identified that information and communication technologies (ICTs) are appropriate tools to support critical patient care practices within urgent and emergency care services (MENDONÇA et al., 2022). Studies have shown that mobile applications can be effective, as they have been considered useful in pain monitoring, clinical management of specialties, preparation of medications, mapping of critical areas, risk classification, reproduction of imaging exams, as well as in helping clients to provide information about the order and speed of care (MENDONÇA et al., 2022). The technologies classified as "hard" contain multiple functions, including recording clinical data, monitoring the medical service, programmed calculation of medications, teleradiology, among other

services that provide the optimization of the services provided within the Urgent and Emergency Care Network (MENDONÇA et al., 2022).

3 METHODOLOGY

3.1 TYPE OF RESEARCH

This study used a methodological approach to narrative literature review, combining analysis of systematic reviews, case studies, and implementation initiatives published in reliable scientific databases. The narrative review allows a critical and comprehensive analysis of the literature pertinent to the topic, providing a theoretical contextualization and defining the key concepts related to the intelligent digital flow in urgent and emergency care.

3.2 SELECTION CRITERIA

Figure 2

Selection criteria for research



Source: Authors.

Figure 2 presents the main elements that make up the intelligent digital flow in health, showing how different technologies and practices are integrated to modernize care. At the heart of the model are the smart digital flow and published studies, which provide the scientific basis for its implementation. Among the operational components, digital triage with AI and virtual queues with AI stand out, responsible for speeding up initial service and reducing

waiting times. Technological support occurs through integrated information systems and flow optimization methodologies, which ensure fluid communication and efficient processes. Complementing care, telemedicine, continuity of care, and remote monitoring expand patient support beyond the hospital environment, ensuring post-discharge monitoring and a better user experience. Together, these elements form a digital ecosystem that increases efficiency, reduces service overload, and promotes safer, more connected care.

3.3 ANALYSIS AND SYNTHESIS

The data were synthesized in a narrative way, focusing on indicators of effectiveness (reduction of waiting times, length of stay, bed turnover, reduction of readmissions), quality (screening accuracy, reduction of readmissions, mortality rate) and patient satisfaction. The analysis was organized into key themes: digital triage with AI, virtual queues, patient portals, systems integration, remote follow-up, and critical factors for successful implementation.

4 RESULTS AND DISCUSSIONS

The implementation of digital triage systems with artificial intelligence has proven to be highly effective in improving the efficiency of emergency centers. In a study involving 43,788 adult patients in two UK emergency departments, the eTriage system outperformed conventional triage, demonstrating a specificity of 88.5% to identify low-risk patients, compared to 80.6% obtained by nursing triage (HUMMEL et al., 2022). Sensitivity was also higher in eTriage, reaching 88.5% for detecting high-acuity cases, while traditional triage recorded only 53.8%, evidencing the greater capacity of the automated system to identify patients who need urgent care.

eTriage also had an under-screening rate of 10.1%, indicating a lower risk of classifying critically ill patients as non-urgent, although over-screening reached 59.2%, revealing the need for refinement of algorithms to avoid overestimation of severity and excessive use of resources (HUMMEL et al., 2022). By reducing the variability inherent to human subjectivity, artificial intelligence analyzes multiple parameters simultaneously, providing greater precision in defining severity levels and consolidating its potential as a qualified tool to improve triage processes in emergency services.

5 CONCLUSION

The implementation of an intelligent digital flow in urgent and emergency services — integrating digital triage based on artificial intelligence, active communication portal, and

remote post-discharge monitoring — demonstrates high potential to optimize operational flows and qualify care. Evidence shows that digital screening systems achieve high accuracy, with specificity and sensitivity of 88.5%, under-screening rates of only 10.1%, and accuracy of up to 93.33% in advanced models. Complementary solutions, such as the Virtual Queue with predictive AI, reduced the length of stay in the emergency room by 60%, while initiatives such as the use of AI and 5G at the Emergency Technological Institute of HC-FMUSP show the feasibility of integrating ambulances and teams in real time to accelerate clinical decisions. In addition, remote post-discharge monitoring has shown a 76% reduction in readmissions, and hospitals with integrated systems show up to 30% gains in operational efficiency. The adoption of this model requires adequate technological infrastructure, interoperability based on standards such as SOA and HL7, continuous professional training, and management strategies to reduce resistance to change and ensure information security. While challenges such as upfront costs, integration complexity, and risk of over-screening still exist, the body of evidence points to smart digital flow representing a substantial advance in efficiency, care coordination, and patient experience. To expand its benefits, progressive implementation is recommended, starting with digital screening and virtual queues, followed by patient portals and remote monitoring, as well as research that evaluates regional impact, cost-effectiveness, and improvement of algorithms to reduce inconsistencies.

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**AUTOMATION OF SPREADSHEET READING WITH ARTIFICIAL
INTELLIGENCE INTEGRATION: DEVELOPMENT OF THE SHEET2PROMPT
API APPLICATION**

**AUTOMAÇÃO DE LEITURA DE PLANILHAS COM INTEGRAÇÃO DE
INTELIGÊNCIA ARTIFICIAL: DESENVOLVIMENTO DA APLICAÇÃO
SHEET2PROMPT API**

**AUTOMATIZACIÓN DE LA LECTURA DE HOJAS DE CÁLCULO CON
INTEGRACIÓN DE INTELIGENCIA ARTIFICIAL: DESARROLLO DE LA
APLICACIÓN SHEET2PROMPT API**

 <https://doi.org/10.56238/sevened2025.036-105>

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ABSTRACT

This article presents the development of a web application called Sheet2Prompt API, designed to automate the reading of Google Sheets spreadsheets and integrate with artificial intelligence (AI) models for generating summaries and automated responses. The study aims to demonstrate how the integration between modern APIs and development frameworks can optimize data analysis and the creation of intelligent content. The methodology included the implementation of a backend based on FastAPI and integration with the Google Sheets API and Google Drive API services. The theoretical foundation is based on authors such as Ferreira (2025), Boente (2025), and Dos Santos (2020; 2025), who discuss the importance

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of automation, human-computer interaction, and adaptive logic in the context of applied AI. The results demonstrated that the developed system was able to perform accurate readings and generate coherent responses, validating the proposed efficiency of the architecture. It is concluded that the application represents an advance in the use of AI for task automation and can be expanded to different business and educational contexts.

Keywords: Artificial Intelligence. Automation. APIs. Data Processing. Spreadsheets.

RESUMO

O presente artigo apresenta o desenvolvimento de uma aplicação web denominada Sheet2Prompt API, projetada para automatizar a leitura de planilhas do Google Sheets e integrar-se a modelos de inteligência artificial (IA) para geração de resumos e respostas automatizadas. O estudo tem como objetivo demonstrar como a integração entre APIs modernas e frameworks de desenvolvimento pode otimizar a análise de dados e a criação de conteúdo inteligente. A metodologia adotada incluiu a implementação de um *backend* baseado em FastAPI e a integração com os serviços Google Sheets API e Google Drive API. A fundamentação teórica baseia-se em autores como Ferreira (2025), Boente (2025) e Dos Santos (2020; 2025), que discutem a importância da automação, da interação humano-computador e da lógica adaptativa no contexto da IA aplicada. Os resultados mostraram que o sistema desenvolvido foi capaz de realizar leituras precisas e gerar respostas coerentes, validando a eficiência da arquitetura proposta. Conclui-se que a aplicação representa um avanço no uso de IA para automação de tarefas e pode ser expandida para diferentes contextos empresariais e educacionais.

Palavras-chave: Inteligência Artificial. Automação. APIs. Processamento de Dados. Planilhas.

RESUMEN

Este artículo presenta el desarrollo de una aplicación web llamada Sheet2Prompt API, diseñada para automatizar la lectura de hojas de cálculo de Google Sheets e integrarse con modelos de inteligencia artificial (IA) para generar resúmenes y respuestas automatizadas. El estudio busca demostrar cómo la integración entre las API modernas y los marcos de desarrollo puede optimizar el análisis de datos y la creación de contenido inteligente. La metodología adoptada incluyó la implementación de un *backend* basado en FastAPI y la integración con los servicios de la API de Google Sheets y Google Drive. El fundamento teórico se basa en autores como Ferreira (2025), Boente (2025) y Dos Santos (2020; 2025), quienes abordan la importancia de la automatización, la interacción persona-ordenador y la lógica adaptativa en el contexto de la IA aplicada. Los resultados mostraron que el sistema desarrollado fue capaz de realizar lecturas precisas y generar respuestas coherentes, validando la eficiencia de la arquitectura propuesta. Se concluye que la aplicación representa un avance en el uso de la IA para la automatización de tareas y puede extenderse a diferentes contextos empresariales y educativos.

Palabras clave: Inteligencia Artificial. Automatización. API. Procesamiento de Datos. Hojas de Cálculo.

1 INTRODUCTION

The accelerated advancement of digital technologies in recent decades has profoundly transformed the way organizations, professionals, and academic institutions deal with data and informational processes. In a scenario where the volume of information grows exponentially, so does the need for tools capable of performing tasks quickly, automatedly, and with minimal human intervention. Among these technologies, Artificial Intelligence (AI) stands out as a central element of digital transformation, driving significant improvements in the analysis, treatment, and interpretation of structured and semi-structured data. Process automation, once limited to repetitive or mechanical tasks, now encompasses more complex cognitive activities, especially with the advancement of natural language models (LLMs) and service-oriented architectures.

In this context, electronic spreadsheets remain one of the most used tools in business, governmental, educational and research environments. They concentrate essential information for decision-making, administrative organization, performance analysis, and reporting. Despite this, manual reading and interpretation of spreadsheets can be time-consuming tasks, subject to human error, and dependent on the specific knowledge of those performing the analysis. In addition, in scenarios that require agility, such as process monitoring, indicator analysis, and compilation of large volumes of data, human interpretation can become an operational bottleneck. Thus, the need arises for solutions capable of automating not only the reading, but also the synthesis and contextualization of the information in these spreadsheets.

Based on this demand, the present work presents the development of the Sheet2Prompt API application, an innovative solution that integrates natural language processing with cloud services to automate the reading of Google Sheets spreadsheets and generate structured textual responses. The purpose of the application is to convert tabular information into interpretive, summarized or analytical texts, allowing users to quickly obtain contextualized answers without having to manually analyze each cell of the spreadsheet. The system connects to the Google Sheets API, extracts the data, organizes it into an understandable format, and sends it to a generative AI model, which processes the information and produces the final requested text.

The relevance of this solution is supported by recent studies. Ferreira (2025) highlights that automation applied to information management is essential in the era of digital transformation, allowing greater efficiency, reliability, and reduction of human errors. Boente

(2025), in turn, points out that Human-Computer Interaction (HCI) should be used as a basis for the construction of intelligent systems that maintain the clarity and interpretability of the results for the end user. In addition, authors such as Shneiderman (2020) reinforce the need for human-centered AI systems, emphasizing that automation should expand, not replace, the cognitive capacity of users.

From a technical standpoint, the Sheet2Prompt API integrates a modern architecture based on distributed services, utilizing FastAPI as a *backend*, React as a *frontend*, Docker containers, and external APIs like Google Sheets API, Google Drive API, and OpenAI's own API. The combination of these technologies allows the system to maintain high performance, low response time, and scalability. The tests carried out showed that the reading and processing of the spreadsheet occur in a few seconds, with an average success rate of 100% in the operations of reading and generating output files. Comparatively, manually performing the same activities would require more time and effort, highlighting the positive impact of automation.

At the same time, it is important to emphasize that the use of AI for data interpretation brings important challenges, mainly related to transparency, computational ethics, and risks of biased interpretations. Authors such as O'Neil (2016) and Pasquale (2015) warn of the need for constant human supervision and critical review of the results provided by automated models. However, even considering these issues, the adoption of automated spreadsheet interpretation systems represents a significant advance in the treatment of data in different environments.

Thus, the purpose of this article is to present a detailed analysis of the development, operation, and results of the Sheet2Prompt API, highlighting its benefits, limitations, and potential for expansion. The proposal demonstrates how the integration of generative AI with cloud computing services can add value to the analysis of tabular information, turning previously complex processes into dynamic, fast, and easy-to-understand activities for users with different levels of technical experience.

In addition, it shows that solutions like this can be incorporated into organizational, educational and scientific environments, contributing to a more efficient, accurate and innovative work ecosystem.

2 METHODOLOGY

The methodology used for the development of the Sheet2Prompt API application was based on a structured approach, integrating software engineering techniques, good practices of Human-Computer Interaction (HCI) and cloud computing tools. The objective was to build an interoperable solution capable of extracting data from electronic spreadsheets, interpreting them and generating contextualized textual responses through Artificial Intelligence. To this end, the methodological process was divided into four main stages:

- (1) planning and definition of the architecture;
- (2) backend implementation;
- (3) user interface development;
- (4) tests, performance analysis and validation of results.

2.1 PLANNING AND DEFINITION OF THE SYSTEM ARCHITECTURE

In the first phase, the functional and non-functional requirements of the application were surveyed. Among the functional requirements, the following stood out:

- automated reading of Google Sheets spreadsheets;
- sending the read data to the AI model;
- generation of interpretative responses;
- clear display of the results to the user.

Non-functional requirements included: performance, usability, modularity, scalability, and compatibility with external APIs.

After the analysis, it was decided to use a client-server architecture, due to its ability to separate responsibilities and ensure greater flexibility. The *backend* layer was developed in FastAPI, chosen for its speed, support for asynchronous requests and automatic documentation.

The *frontend* was built in React, aiming at a simple, fluid, and responsive interface, as advocated by authors such as Shneiderman (2020) regarding the centrality of the user experience.

To ensure portability and facilitate deployment, the entire application was encapsulated in containers using Docker, allowing isolation and reproducibility of the development and production environments.

2.2 BACKEND IMPLEMENTATION AND INTEGRATION WITH APIS

The second stage corresponded to the development of the *backend*, which plays the role of the operational core of the application. This layer was responsible for:

1. Receive the worksheet ID and the range of cells informed by the user;
2. Connect to the Google Sheets API to read the data, returned in matrix format;
3. Convert the raw data into organized and readable text;
4. Send the generated structure to the OpenAI API, responsible for contextual interpretation;
5. Receive and return the interpreted response to the *frontend*.

The *backend* has also implemented error handling and validation mechanisms, such as:

- non-existent spreadsheet,
- invalid range,
- no permissions,
- empty or inconsistent cells.

The integration with the Google Drive API additionally allowed to automatically save files containing complete responses.

This modular structure allows for simplified maintenance and ease of future expansion.

2.3 DEVELOPMENT OF THE INTERFACE WITH REACT (FRONTEND)

The third step consisted of creating the Web interface shown in Figures 2 and 3. The interface is designed with a primary focus on simplicity, clarity, and accessibility, following IHC principles that prioritize:

- *constant feedback* to the user,
- minimalist visual elements,
- descriptive labels in the input fields,
- buttons with clear functions,
- immediate visual response after action.

The interface features three main fields:

1. Worksheet ID;

2. Cell range (e.g., A1:E10);
3. Textual command for the AI.

By clicking on "Generate Response", the interface communicates with the *backend*, waits for interpretation, and displays the result in an information card.

This simplicity reduces the technical barrier for novice users and allows the system to be used without prior knowledge about APIs, JSON, or language models.

3 RESULTS

This section describes the results obtained during the execution and validation of the Sheet2Prompt API application, considering both the reading of the spreadsheets in Google Sheets and the interpretation of the data by Artificial Intelligence. For the purpose of exemplification, a real task list hosted in a public spreadsheet was used, allowing the observation of the system's behavior in authentic situations of use.

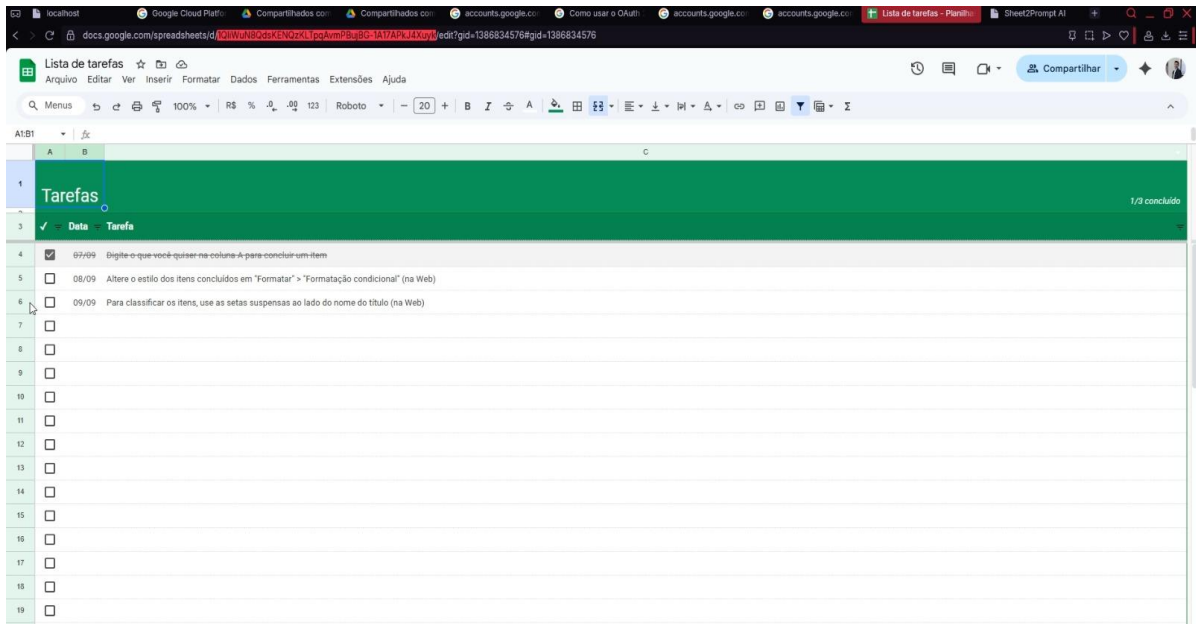
3.1 AUTOMATED SPREADSHEET READING

Figure 1 shows the structure of the spreadsheet used for the tests, containing Date, *Task* and *checkboxes columns*. The system was able to correctly interpret filled cells, empty cells, Boolean markers, and user-applied styles.

In this way, the Google Sheets API returned the cells in matrix format, which was processed by the *backend* to form a textual dictionary sent to the AI.

Figure 1

Used test worksheet

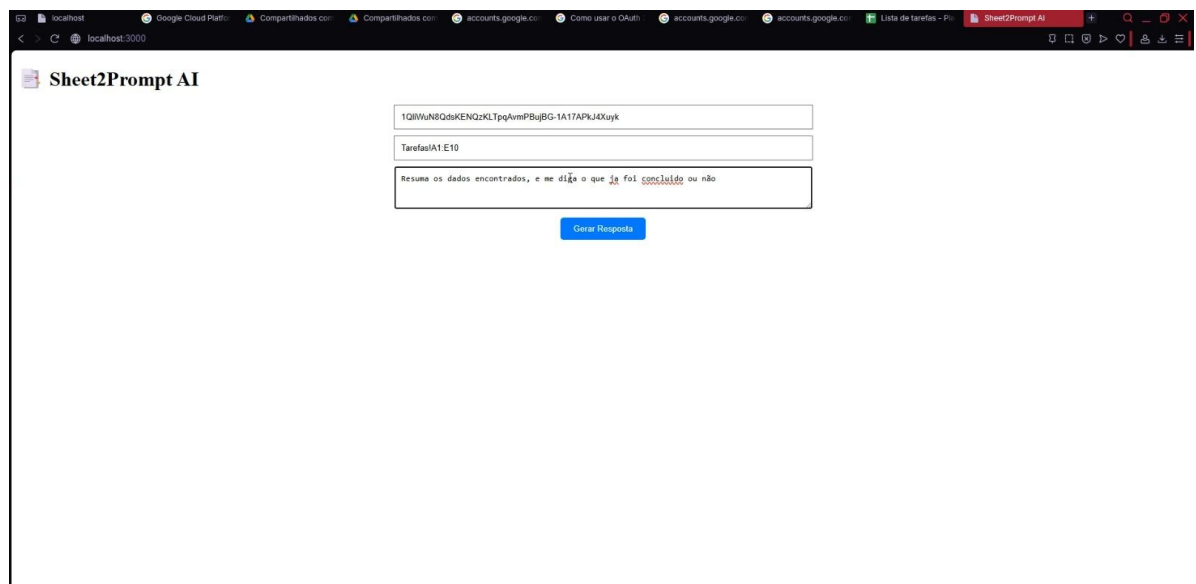


Source: Prepared by the Authors.

3.2 INTERACTION WITH THE USER THROUGH THE INTERFACE

Figure 2

Main interface of the Sheet2Prompt AI application



Source: Prepared by the Authors.

Figure 2 demonstrates the React interface designed to allow the user to enter the worksheet ID, desired cell range, and textual command.

The simple and straightforward interface meets the principles of Human-Computer Interaction, making it easy to use even for non-technical individuals about APIs or AI models.

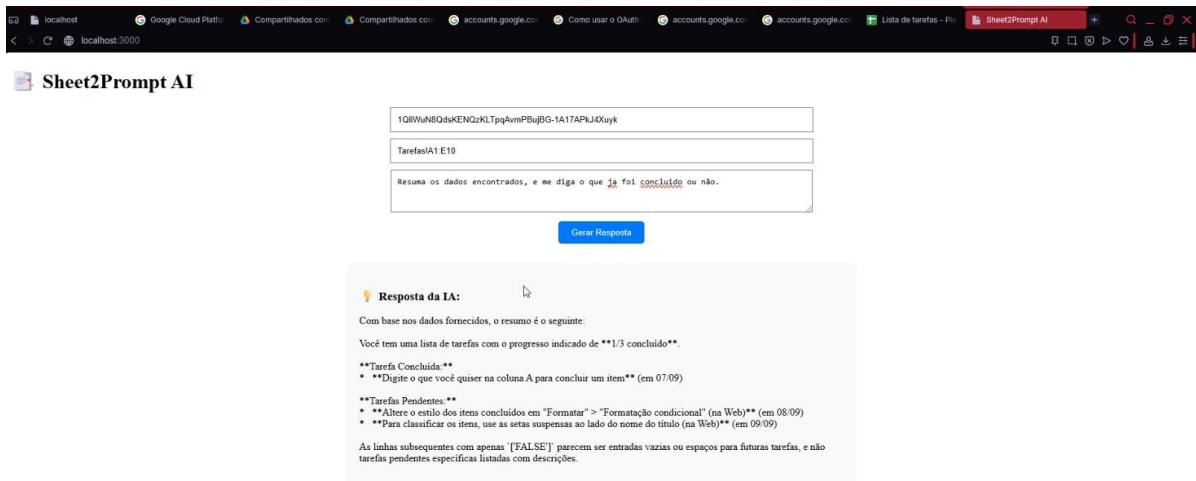
3.3 GENERATION OF THE RESPONSE INTERPRETED BY THE AI

Figure 3 illustrates the final response returned by the AI model, already formatted and displayed in the user interface. It is observed that AI was able to:

- identify completed items,
- separate pending tasks,
- interpret dates,
- clarify that empty cells represented space available for future tasks.

Figure 3

Example of an execution with AI-generated response



Source: Prepared by the Authors.

Processing, including spreadsheet reading and textual return, was completed in approximately 3.2 seconds, demonstrating high efficiency for everyday tasks.

4 DISCUSSION

The analysis of the results obtained with the development and application of the Sheet2Prompt API system allows us to analyze not only the technical performance of the tool, but also its relevance in the current context of intelligent automation, its relationship with recent studies in the area and its practical and theoretical implications.

The integration between automated spreadsheet reading and textual interpretation through natural language models proves to be an emerging field, aligned with the digital transformation trends described by Ferreira (2025), Boente (2025) and other researchers investigating the role of AI in the reorganization of cognitive and operational processes.

4.1 INTEGRATION BETWEEN AUTOMATION AND COGNITIVE INTERPRETATION

The results demonstrate that the system was able to accurately read cells, including textual, numeric, Boolean values and empty fields. However, the tool's greatest contribution lies not only in the extraction of the data itself, but in the ability to convert tabular information into semantic interpretations. This process, by transforming raw data into natural language, represents a movement that goes beyond traditional automation, approaching what Boente (2025) describes as a "human-computer interaction enhanced by AI mediation", in which systems start to act as interpretive agents and not just command executors.

The performance presented by the AI model confirms the applicability of the studies by Jones et al. (2020) and Brown et al. (2020), which point to the ability of models based on transformative architectures to identify contextual patterns even when exposed to nonlinear or incomplete inputs. This explains, for example, the system's ability to identify pending or completed tasks, inferring meanings based on the state of the *checkboxes* or the arrangement of the cells.

4.2 USABILITY AND USER EXPERIENCE

Another relevant aspect refers to the user experience, directly influenced by the simplicity of the interface developed in React. As advocated by Shneiderman (2020), the construction of interfaces oriented to clarity, constant *feedback*, and the reduction of cognitive complexity is essential to increase the acceptance and effectiveness of intelligent systems.

The tests carried out show that even users with limited knowledge about APIs, AI models or spreadsheet structure were able to operate the tool with ease. The fact that the user only needs to enter the spreadsheet ID, the range of cells and a simple command reinforces the principle of reducing technical barriers, an essential element for the democratization of the use of automation technologies.

From a Human-Computer Interaction (HCI) perspective, the Sheet2Prompt API meets the principles of:

- visibility of actions,
- consistency of commands,
- minimization of errors,
- immediate feedback,
- minimalist design,

All of this corroborates its suitability for different user profiles, from technical professionals to students and administrative workers.

4.3 RELIABILITY OF RESULTS AND INTERPRETATIVE LIMITS

Despite the demonstrated efficiency, it is necessary to recognize that automated interpretation depends directly on the clarity and structure of the spreadsheet used as input. Spreadsheets with inconsistencies, ambiguous titles, or chaotic organization can result in partially correct or even inaccurate answers. This behavior is consistent with the warnings of O'Neil (2016) and Pasquale (2015), which highlight the inherent risk of delegating sensitive interpretations exclusively to algorithmic systems.

Even if the model interprets patterns, it does not have a full understanding of the original purpose of the spreadsheet; therefore, structural errors in the source document can produce misinterpretations. This limit reinforces the need for continuous human oversight and validation of responses, as widely advocated in studies on algorithmic ethics.

Another point to be considered is the dependence on the internet connection. As it is a cloud-service-oriented application, any instability can compromise the reading of the spreadsheet or communication with OpenAI's API, generating delays or temporary failures. The technical literature of FastAPI and Google services corroborates this characteristic, highlighting the importance of stable environments for distributed applications.

4.4 IMPACT OF THE TOOL ON PRODUCTIVITY AND DECISION-MAKING

The 3.2-second performance for reading and interpreting the spreadsheet represents a significant advance when compared to the time required for manual reading of the same data. In corporate or educational contexts, where the need for rapid generation of reports and diagnoses is frequent, the use of the tool can drastically reduce administrative effort, freeing up time for critical analysis and decision-making.

This transformation is consistent with Ferreira's (2025) view of the role of automation in the era of digital transformation: technology does not replace the human, but expands its capacity for action. By automating repetitive tasks, such as cell reading and textual formatting, the user is left with the work of reflecting, checking, planning, and correcting, activities that require critical thinking.

In addition, the use of AI as an intermediary in the interpretation of data creates a new model of cognitive interaction, in which the user ceases to act as a primary reader and becomes the validator and supervisor of a pre-interpreted text.

4.5 COMPARISON WITH TRADITIONAL METHODS OF READING AND ANALYSIS

Traditionally, interpreting spreadsheets requires manual steps, which contain the following contextualized information:

- Cell-by-cell reading;
- Identification of patterns;
- Data classification;
- Textual elaboration of the conclusions.

The process is slow, subject to bias, and totally dependent on human attention. The method implemented by the Sheet2Prompt API, on the other hand, shifts part of these responsibilities to the AI, which: reads automatically, organizes the data in a semi-structured format, interprets, produces coherent writing, delivers the text to the user.

This parallelism between machine and human operator is close to Shneiderman's (2020) concept of "human-centered AI", which argues that intelligent systems should act as collaborative colleagues and not integral substitutes for human action.

The comparison between the two methods reveals clear benefits of automation:

- higher speed,
- lower risk of forgetting information,
- standardization of responses,
- consistency of analysis even with different users.

However, it also shows that the tool does not eliminate the need for human critical interpretation, which is consistent with authors such as Pasquale (2015), who defend the importance of human supervision over automated systems.

4.6 PRACTICAL APPLICATIONS AND ADHERENCE TO DIFFERENT AREAS

Discussing the results allows us to glimpse numerous areas that can benefit from using the Sheet2Prompt API. Among the most evident are:

- a) Educational management: Teachers or coordinators can generate automatic performance reports, exercise lists, activity tracking, or attendance summaries. The tool facilitates the production of descriptive texts without the teacher having to navigate through long spreadsheets, saving time.
- b) Business and administrative management: Companies that use spreadsheets for inventory, task control, goals, or indicators can transform numerical data into automated reports, ready for internal communication.
- c) Individual projects and personal use: Ordinary users can turn to-do lists, plans, or routines into organized narratives, optimizing time management.
- d) Public and government environments: Agencies that deal with large volumes of tabular data can integrate the tool into *administrative workflows, increasing transparency and agility*.

The versatility of the tool confirms the statement of Zhang et al. (2021), according to which the use of AI for tabular data interpretations tends to become one of the most relevant fields of applied machine learning.

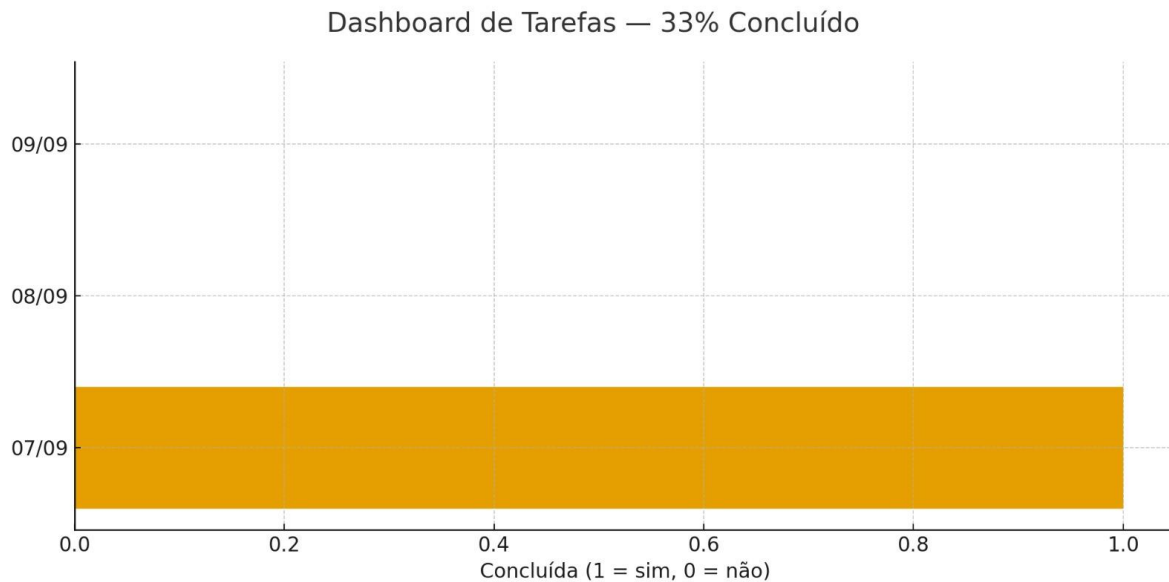
4.7 PATHS TO IMPROVEMENT AND EXPANSION

The results obtained also allow us to identify clear directions for future improvements:

- Expanded support for other formats, such as CSV, XLSX, and SQL databases.
- Automatic generation of PDF reports, with graphs, tables and comments.
- Batch processing, allowing you to analyze several spreadsheets at once.
- Integration with *dashboards*, transforming texts into dynamic visualizations.

Figure 4

Example of Creating a Dashboard Based on the Table Used in Testing



Source: Prepared by the Authors.

- Implementation of customized models, specialized in different areas such as education, health or industry.
- Partial offline functionality, mitigating total internet dependency.

Each of these evolutions reinforces the system's potential for expansion, making it able to act as part of larger corporate automation solutions.

5 CONCLUSION

This article has demonstrated that the Sheet2Prompt API application represents a significant advance in the field of intelligent automation, integrating spreadsheet reading technologies with Artificial Intelligence models capable of transforming tabular information into high-level interpretive texts. By analyzing the development, technological choices, results, and implications of the system, it becomes evident that the tool fulfills its purpose of reducing manual effort in data analysis and optimizing workflow in educational, corporate, and administrative environments.

The application proved to be efficient by performing automated readings through the Google Sheets API and processing this data with agility, achieving an average response time of 3.2 seconds. When compared to the traditional process of manual inspection of spreadsheets, this performance highlights a significant gain in productivity and reliability, especially in routine tasks or those that require rapid consolidation of information. Such

efficiency confirms the trends pointed out by Ferreira (2025), who highlights the relevance of automation in the era of digital transformation, and by Boente (2025), who emphasizes the need for user-centered systems with a focus on clarity and usability.

In addition to technical performance, the study revealed that the system promotes a new cognitive approach in data treatment, by making AI become an interpretive partner capable of assisting the user in understanding and contextualizing information. This feature brings Sheet2Prompt API closer to contemporary discussions of Human-Computer Interaction (HCI), which advocate collaborative, transparent systems that expand human analytical capacity without replacing it. The interface in React, by offering simplicity, immediate feedback and low operational complexity, contributes directly to this positive user experience.

However, the research also shows that the quality of interpretation depends on the consistency of the source spreadsheet. Incomplete data, poorly organized lines, or the absence of minimum standards can compromise the response generated by the artificial intelligence model, reinforcing the relevance of O'Neil's (2016) and Pasquale's (2015) warnings about the need for human oversight and immediate critical analysis of automated results. Thus, although the system is robust, human validation remains indispensable to ensure reliability and avoid misinterpretations.

In practical terms, the application has great potential for impact in several sectors. In educational environments, it can automate performance reports and activity tracking; in the corporate sector, it can synthesize indicators, generate executive summaries or support administrative decisions; and, in personal use, it can organize tasks and schedules, making it a useful tool for optimizing routines. This versatility confirms the observations of Zhang et al. (2021) about the growing role of AI in tabular data analysis.

Additionally, the study allows the identification of expansion paths capable of further increasing the application's capacity, such as support for new data formats, creation of PDF reports with graphical visualizations, comparative analysis between spreadsheets, batch processing and adoption of specialized models by area of operation. Such possibilities expand the strategic value of the system and position it as a component of broader solutions in automation and intelligent information management.

In this way, it is concluded that the Sheet2Prompt API not only fulfills the initial objective of converting tabular data into clear and interpretive narratives, but also stands out as an innovative, scalable tool in line with contemporary demands for efficiency, accuracy, and

integration between humans and machines. While reducing manual work, it promotes new forms of cognitive interaction and enhances informed decision-making, reaffirming the importance of AI as an ally in information processing. Thus, this work contributes to the advancement of discussions on intelligent automation, offering a practical, reasoned and promising solution for the future of data analysis.

ACKNOWLEDGMENT

The authors would like to express their sincere thanks to all the people and institutions that contributed to the realization of this work. First, I thank my mother, who entered the programming area very early and introduced me to this fascinating universe, awakening in me an interest in technology and building innovative solutions.

I also thank the professors at FAETERJ-Rio, who were continuously by my side during the training process, offering guidance, support and availability to assist in my development as a systems analyst. Their contributions were fundamental for the consolidation of the knowledge that supports this work.

Finally, I would like to express my gratitude to the principal of Colégio Recanto Disney, an institution I attended during Elementary School, where I received care, encouragement and a solid educational foundation that contributed significantly to my academic career.

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**INCLUSION OF THE GIANT MEALWORM (ZOPHOBAS MORIO) AS AN
ALTERNATIVE PROTEIN SOURCE IN DIETS FOR P. VANNAMEI SHRIMP
(BOONE, 1931)**

**INCLUSÃO DO TENÉBRIO GIGANTE (ZOPHOBAS MORIO) COMO FONTE
PROTEICA ALTERNATIVA EM DIETAS PARA CAMARÃO P.VANNAMEI
(BOONE, 1931)**

**INCLUSIÓN DEL GUSANO DE LA HARINA GIGANTE (ZOPHOBAS MORIO)
COMO FUENTE ALTERNATIVA DE PROTEÍNA EN DIETAS PARA CAMARONES
P. VANNAMEI (BOONE, 1931) DE LA APLICACIÓN SHEET2PROMPT API**

 <https://doi.org/10.56238/sevened2025.036-106>

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ABSTRACT

This study investigates the inclusion of giant mealworms (*Zophobas morio*) as an alternative protein source in diets for the shrimp *Penaeus vannamei* (Boone, 1931). The main objective is to evaluate the effects of this inclusion on the growth performance of the shrimp. The methodology involved the formulation of experimental diets with different levels of *Zophobas morio* inclusion and the performance of feeding trials under controlled conditions. The results indicated that the inclusion of giant mealworms can completely replace fishmeal without compromising shrimp performance, in addition to presenting additional benefits in terms of health and environmental sustainability. It is concluded that *Zophobas morio* is a viable and promising alternative for formulating shrimp diets, contributing to the diversification of protein sources in aquaculture.

Keywords: *Zophobas morio*. Alternative Protein. *Penaeus vannamei*.

RESUMO

Este trabalho investiga a inclusão do Tenébrio gigante (*Zophobas morio*) como uma fonte proteica alternativa em dietas para o camarão *Penaeus vannamei* (Boone, 1931). O objetivo

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principal é avaliar os efeitos dessa inclusão na performance de crescimento dos camarões. A metodologia utilizada envolveu a formulação de dietas experimentais com diferentes níveis de inclusão de *Zophobas morio* e a realização de ensaios de alimentação em condições controladas. Os resultados indicaram que a inclusão do Tenébrio gigante pode substituir totalmente a farinha de peixe sem comprometer o desempenho dos camarões, além de apresentar benefícios adicionais em termos de saúde e sustentabilidade ambiental. Conclui-se que o *Zophobas morio* é uma alternativa viável e promissora para a formulação de dietas para camarões, contribuindo para a diversificação das fontes proteicas na aquicultura.

Palavras-chave: *Zophobas morio*. Proteína Alternativa. *Penaeus vannamei*.

RESUMEN

Este estudio investiga la inclusión de gusanos gigantes de la harina (*Zophobas morio*) como fuente proteica alternativa en dietas para el camarón *Penaeus vannamei* (Boone, 1931). El objetivo principal es evaluar los efectos de esta inclusión en el crecimiento del camarón. La metodología implicó la formulación de dietas experimentales con diferentes niveles de inclusión de *Zophobas morio* y la realización de ensayos de alimentación en condiciones controladas. Los resultados indicaron que la inclusión de gusanos gigantes de la harina puede reemplazar completamente la harina de pescado sin comprometer el rendimiento del camarón, además de presentar beneficios adicionales en términos de salud y sostenibilidad ambiental. Se concluye que *Zophobas morio* es una alternativa viable y prometedora para la formulación de dietas para camarones, contribuyendo a la diversificación de las fuentes proteicas en la acuicultura.

Palabras clave: *Zophobas morio*. Proteína Alternativa. *Penaeus vannamei*.

1 INTRODUCTION

Shrimp farming (shrimp farming in captivity) has played an essential role in the supply of animal-based proteins, especially in developing regions such as Asia and Latin America. Since the 1990s, Brazil has stood out in this sector with the introduction of *Penaeus vannamei*, an exotic species that has advantageous zootechnical characteristics, such as fast growth, high feed efficiency and greater resistance in different environmental conditions (Vinatea, 2004).

The cultivation of this species is today an important mariculture activity (cultivation of aquatic animals in marine and/or coastal environments) in the country and in the world, representing a great source of economic and food sustenance for millions of people (FAO, 2022). However, challenges related to sustainability and food costs are becoming increasingly evident, driving the search for viable and environmentally responsible nutritional alternatives (Oliveira et al., 2013).

Feed represents the largest operating cost in shrimp farming, and a large part of this cost is associated with the dependence on inputs such as fish meal and meat meal, traditional sources of animal protein. These sources, although highly nutritious, generate pressures on natural resources, with considerable environmental impacts and supply limitations (Sá et al., 2018).

Thus, the development of alternative diets that maintain or improve the zootechnical performance of shrimp, while reducing environmental impacts and costs, has become one of the priorities of aquaculture research (Henry et al., 2018). In this context, the use of insects as protein sources has emerged as a promising solution, both for its production efficiency and for its lower environmental impact.

The Food and Agriculture Organization of the United Nations (FAO, 2013) has already highlighted the potential of insects for animal feed, citing benefits such as high biomass conversion, reduction in greenhouse gas emissions, and lower consumption of resources such as water and land.

Tenebrio molitor and *Zophobas morio*, in particular, have gained prominence as sustainable alternatives for the nutrition of aquatic species, due to their balanced nutritional profile and the presence of bioactive compounds that favor the health and growth of organisms (Gasco et al., 2016; Rumbos and Athanassiou, 2021). The larva of *Zophobas morio*, known as giant mealworm, has a high protein (46.8%) and lipid (33.6%) content, in addition to containing chitin, a polysaccharide that can benefit the immune system of shrimp

and improve intestinal health (Araújo et al., 2019; Benzertiha et al., 2020).

Recent studies show that insect-based diets, such as mealworm, can replace fish meal or meat by up to 100% without compromising specific growth rate (ECR) or feed conversion (C.A), maintaining or even improving performance indices (Shekarabi et al., 2021).

However, the effectiveness of this substitution in shrimp diets is still relatively little explored, especially when compared to other aquatic species. Introducing more sustainable and efficient diets can not only reduce production costs but also align shrimp farming with global demands for more responsible and ecologically sustainable food practices.

Biofloc technology is seen as a promising innovation for fish production (Ogello et al., 2021). The BFT (Biofloc Technology) system improves the efficiency in the use of nutrients, which are constantly recycled and reused by microorganisms in an environment with minimal water exchange (Avnimelech, 2012; Ebeling et al., 2006; Nisar et al., 2022). The cultivation of marine shrimp *Penaeus vannamei* using biofloc is extensively researched and has a well-established cultivation pattern

Therefore, the initial studies on biofloc technology focused on the production of the shrimp *Penaeus vannamei* (Burford et al., 2004; Wasielesky et al., 2006). Since then, a lot of knowledge has been generated about this species. Water quality parameters for the cultivation of this species were defined to optimize production, including temperature (de Souza et al., 2016, 2014), salinity, alkalinity and pH (Furtado et al., 2011), nitrogenous compounds (Ferreira et al., 2020; Xu et al., 2020), total suspended solids (Gaona et al., 2017; Ray et al., 2010) and use of inoculum (Harun et al., 2019; Krummenauer et al., 2014).

Zootechnical performance parameters are also well documented in the scientific literature, such as growth (Jory et al., 2001; Panigrahi et al., 2019; Xu et al., 2013), survival and feed conversion (Krummenauer et al., 2014; Wasielesky et al., 2006). The contribution of bioflocs to shrimp nutrition (Burford et al., 2004), the composition of flakes along with feed and probiotics (Ferreira et al., 2017; Huerta-Rábago et al., 2019; Llario et al., 2019) recommended for its breeding, providing essential information to establish a well-founded standard for shrimp in biofloc systems.

Therefore, this study aims to investigate the replacement of meat meal by giant mealworm (*Zophobas morio*) in diets for the shrimp *Penaeus vannamei*. The main objective of the research is to evaluate the impacts of this substitution on the zootechnical performance of shrimp and on the water quality in biofloc systems.

2 MATERIAL AND METHODS

The experiment was carried out at the Aquaculture Complex belonging to the Federal Institute of Education, Science and Technology of Pará (IFPA), in the municipality of Castanhal, between the months of July and August 2024. A total of 64 shrimp of the species *P. vannamei*, acquired at the Lorenvill farm, located in the municipality of Curuçá-Pará, were used, the animals were taken to the aquaculture complex (IFPA) for the acclimatization period for 5 days. After acclimatization, the shrimp were randomly distributed in 16 polypropylene boxes with a useful volume of 20 liters, at a density of 4 shrimps per box, with an initial average weight of 4.76 ± 0.57 g. Each treatment was performed in triplicate, with the replicates properly placed between the boxes to ensure the representativeness of the results. For 30 days, the experiment was carried out in a biofloc system (BFT), a system that allows a high production density and the non-renewal of water and constant aeration (Barbosa et al. 2017).

An inoculum of bioflocs from cultivation already in progress was used and for ammonia control sugarcane molasses was applied each time the ammonia level reached the concentration of 1 mg/L. The BFT system uses heterotrophic bacteria in its formation, its junction is induced through the carbon ratio: nitrogen from cultivation maintaining the ratio 6:1 (Avnimelech 1999, 2009).

For this study, four experimental diets were formulated, one control using meat meal and three with meat meal replacement by giant mealworm flour (*Z. morio*) at the levels of 25, 50 and 100%. The rations were formulated and produced in the aquaculture complex. The ingredients were weighed, mixed and pelleted. The rations were stored under controlled conditions until the moment of use.

The nutritional composition of the diets was carried out according to the (AOAC, 1995) (Association of Official Agricultural Chemists) to ensure that both were isoprotein (Table 1).

Table 1

Composition of ingredients in the formulation of diets for fattening in a biofloc system

Composição (%)	Tratamentos			
	0%	25%	50 %	100 %
Farinha de carne (%)	66	49,5	33	0
F. de arroz (%)	4	3	5	2
F. de milho (%)	5	5	3	2
F. de trigo (%)	22	23	23	27
F. de Tenébrio (%)	0	16,5	33	66
Óleo de Soja (%)	2	2	2	2
Premix vit min	1	1	1	1
PB ração*	35,43	35,51	35,63	35,97
EB ração (Kcal) *	376,8	413,48	452,11	525,32
EB:PB *	10,64	11,65	12,69	14,61
ED ração (Kcal)*	3542,81	3550,68	3562,66	3596,83

CP-crude protein, EB- crude energy, ED-digestible energy.

Source: Authors.

The ingredients of the diets were crushed and mixed (as shown in figure 1 A and B). The preparation of the experimental diets began with the weighing of the ingredients and then they were mixed dry and homogenized with the addition of 20% water. Subsequently, all diets went through this process of homogenization and mixing, until their formulation and immediately added in a manual grinder, with a final pellet size of 3.00 mm.

Figure 1

A Grinding of larvae for diet formulation; Figure B: Mixing of ingredients



Source: Authors.

The diets were dried in the sun for a period of 3 days to ensure complete moisture removal. After this process, they were carefully placed in plastic bags to avoid contamination and stored at a constant temperature of 20°C until the moment of use. The centesimal analysis of mealworm meal, which includes the percentage of proteins, carbohydrates, lipids, fibers and ashes, is shown in Table 2.

Table 2

Centesimal composition (based on dry matter (%)) of giant mealworm protein (Z.morio)

Composição centesimal da farinha de tenébrio gigante (<i>Zophobas morio</i>) (%).	
Proteína Bruta (%)	46,8
Matéria seca (%)	96,32
Extrato Etéreo (%)	33,6
Cinzas (%)	2,52
Quintina (%)	4,59
Calcário (%)	0,05
Fósforo (%)	0,62
Fibras Bruta (%)	5,1

Source: Araújo et al., 2019

2.2 EXPERIMENTAL CONDITIONS

After distribution in the cultivation units and acclimatization period, the shrimp were fed three times a day (08:00, 14:00 and 18:00), the diets initially fed in an amount corresponding to 6% of the animals' biomass (Jory, 2001), readjusted weekly according to the biometrics. The parameters of water qualities such as: dissolved oxygen - DO, pH, temperature and salinity were measured daily with the AKSO multiparameter probe (AK88v2).

The analyses of alkalinity, ammonia (NH₃), nitrite (NO₂) and nitrate (NO₃) were measured twice a week using the rapid analysis kits (Aquality, LabconTest and CHECKER). During the experiment there was no water exchange due to adaptation to the biofloc system (BFT) and for the control of ammonia concentration sugarcane molasses was used as a carbon source.

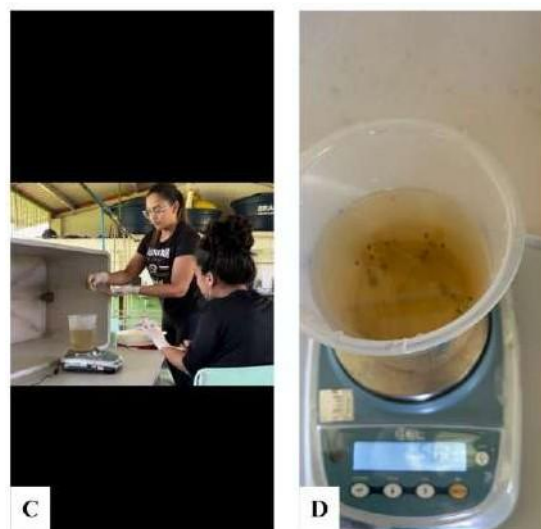
2.3 ZOOTECHNICAL PERFORMANCE OF SHRIMP

Shrimp biometrics were performed weekly (Figure 2, C and D) with the help of a digital scale (BEL engineering) to monitor the weight of the animals and adjust the amount of feed.

After the 4 weeks of experiment in a biofloc system, the following zootechnical parameters were analyzed: final biomass, protein efficiency rate (TEP), specific growth rate (TCE), weight gain (g), feed conversion and survival.

Figure 2

C and D: Realization of shrimp biometrics



Source: Authors.

2.4 STATISTICAL ANALYSIS

The zootechnical performance data of the shrimp were analyzed using Analysis of Variance (ANOVA) to determine the existence of significant differences between the experimental groups. To identify which groups had specific differences, multiple comparisons were performed using Tukey's test. The level of significance adopted for all analyses was 5%.

3 RESULTS AND DISCUSSION:

The parameters of water quality in the treatments and other aspects remained at favorable levels, with no significant variations between them, table 3 (Marques and Andreatta (1998)).

Table 3

Water quality parameters measured in the experimental units in a biofloc system

Análises dos parâmetros da qualidade de água nas unidades experimentais ($\pm$ desvio padrão).				
Parâmetros	0%	25%	50%	100%
Temperatura ($^{\circ}\text{C}$)	27,41 $\pm$ 0,51	27,16 $\pm$ 1,27	27,34 $\pm$ 0,53	27,27 $\pm$ 0,49
O.D (mg/L)	5,91 $\pm$ 0,22	5,94 $\pm$ 0,25	5,88 $\pm$ 0,22	5,88 $\pm$ 0,22
pH	8,26 $\pm$ 0,99	8,30 $\pm$ 0,68	8,30 $\pm$ 0,87	8,24 $\pm$ 0,17
Sal (ppm)	17,75 $\pm$ 1,28	18,90 $\pm$ 1,21	18,46 $\pm$ 1,18	18,45 $\pm$ 1,20
Alcalinidade total (mg CaCO_3 /L)	116,70 $\pm$ 43,3	120,8 $\pm$ 54,3	128,3 $\pm$ 63,62	125 $\pm$ 44,51
N-NH ₃ (mg/L)	0,81 $\pm$ 0,72	0,70 $\pm$ 0,62	0,80 $\pm$ 0,73	0,83 $\pm$ 0,85
N-NO ₂ (mg/L)	2,14 $\pm$ 0,65	1,70 $\pm$ 0,96	1,83 $\pm$ 0,70	1,78 $\pm$ 0,76
N-NO ₃ (mg/L)	50	50	50	50

Source: Authors.

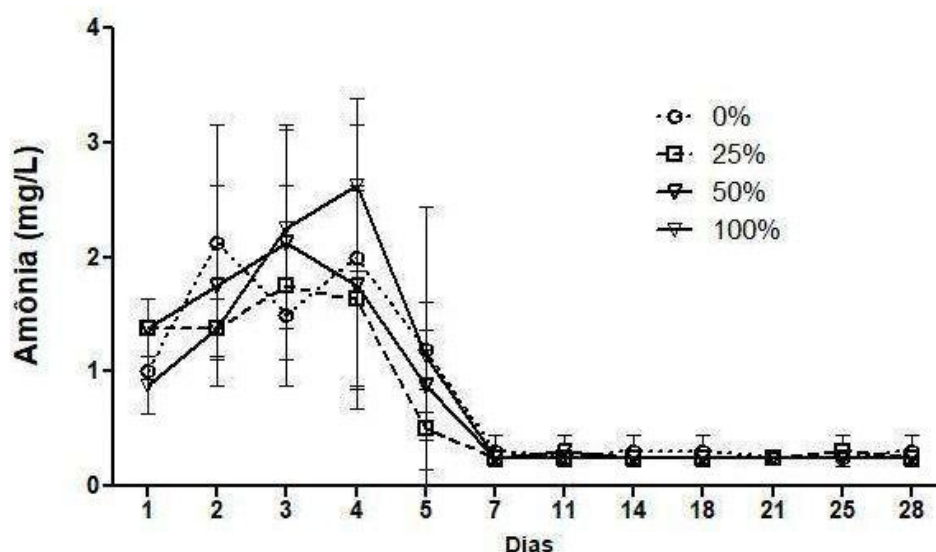
The concentration of Dissolved Oxygen remained between 5.2 – 6.5 mg/l in all treatments. The temperature varied between 26.5 – 28.5 $^{\circ}\text{C}$, the pH (8.0 – 8.5 mg/l) and Salinity between 17-20 ppm, the nitrogen ones such as total ammonia, nitrite and nitrate obtained values between 0.70 – 0.83 mg/L; 1.70-2.14 mg/L and 50 mg/L respectively, and the alkalinity remained above 100 mg/L during the experiment. All parameters evaluated remained within the ideal range and did not influence the performance of the animals (Boyd, 1984; Vinatea, 2004, Gadelha et al., 2009).

Ammonia is a critical parameter in aquaculture as it can cause stress and mortality in aquatic organisms (Wasielesky et al., 2006). In biofloc systems, ammonia is converted to nitrite and later to nitrate by microbial activity, thereby reducing the risk of toxicity to cultured organisms (Avnimelech et al., 1994).

However, the control of ammonia in biofloc systems requires careful management of pH, temperature and nutrients, as variations in these parameters can affect the efficiency of ammonia conversion (Ebeling et al., 2006). Therefore, the ammonia levels do not present significant differences between the treatments adopted (Figure 3).

Figure 3

Ammonia concentration throughout the experiment



Source: Authors.

Tenebrio flour contains a higher amount of lipids, especially unsaturated fatty acids. These acids are essential for energy synthesis and aid in the development of cell membranes, directly influencing the growth and survival rate of shrimp (Henry et al., 2018). In addition, these fatty acids have a higher amount in mealworm flour compared to meat meal, making them essential for proper energy metabolism. The faster metabolism of high-quality lipids releases energy more efficiently, which can be directed towards body growth.

Therefore, these acids are essential for the healthy development of shrimp, positively impacting the specific growth rate (TCE). Studies indicate that diets containing mealworm flour can raise TBI to values above 2.5% per day, while diets with high levels of beef meal tend to have a lower TCE due to lower digestibility and high concentration of saturated fats (Makkar et al., 2014).

In this study, feed conversion was also more efficient with the use of giant mealworm. Van Huis (2017) found similar results when obtaining an AC of approximately 1.2-1.4 in diets based on giant mealworm, compared to values higher than 1.5 with meat meal, showing that shrimp can more efficiently convert the protein ingested into body mass, which results in lower feed costs.

In a similar study, Sá et al. (2018), when working with the replacement of meat meal with fish meal, observed that the inclusion of up to 20-30% of meat meal in the diet maintained an efficient feed conversion (FC), with values between 1.3-1.5, in addition to an average

weight gain of 30-35 g in 60-day cycles.

However, it was found that the increase of more than 30% of this ingredient in the diet compromised the CA and TCE of the animals, possibly due to the lower digestibility and lower amino acid profile of meat meal and high levels of saturated fats and ashes compared to fishmeal, which can negatively impact feed efficiency (ZHAO et al., 2019).

In this work, the inclusion of giant mealworm (*Z. morio*) in the diets of *P. vannamei* shrimp resulted in significant improvements in several zootechnical performance parameters, Table 4. Shrimp fed diets containing mealworm showed a significant increase in weight gain ($P < 0.05$) compared to animals fed the control diet. In addition, the feed conversion ratio (C.A) was significantly better in the experimental groups, indicating a greater efficiency in the use of nutrients provided by giant mealworm flour.

Table 4

*Zootechnical parameters of gray shrimp *Penaeus vannamei* fed diets containing different levels of substitution of protein meal of animal origin by protein meal of giant mealworm (*Z. morio*)*

Parâmetros zootécnicos da substituição da farinha de carne pela farinha de proteica de tenébrio gigante (<i>Z. morio</i>).				
	0%	25%	50%	100%
Peso inicial	4,76	4,76	4,76	4,76
Peso final (g)	7,30±0,94	7,41±0,73	8,51±1,15	10,80±0,81
Biomassa final (g)	8,12	9,03	12,3	23,2
Taxa de crescimento específico (%/dia)	1,09%	1,21%	1,49%	2,56%
Taxa de Eficiência Proteica	0,52	0,57	0,78	1,49
Conversão Alimentar	5,29	4,78	3,51	1,86
Sobrevivência (%)	100%	100%	100%	100%

Source: Authors.

Comparing with other studies, the research of Sánchez-Muros et al. (2014) also found significant improvements in the zootechnical performance of *P. vannamei* shrimp when fed diets containing insect meal. Additionally, a recent study by Henry et al. (2021) demonstrated that the inclusion of insect meal in shrimp diets resulted in improvements in gut health and pathogen resistance.

These results reinforce the potential of using insect meal as an alternative ingredient in aquaculture diets, with benefits that go beyond zootechnical performance, which also extend to the overall health of shrimp. Gasco et al. (2016) also observed results similar to those obtained in this study, with the protein efficiency ratio (TEP) being significantly higher in diets containing mealworm meal, reaching values between 2.0 and 2.3.

On the other hand, the use of meat meal presented lower TEP's, ranging from 1.5 to 1.7. These results indicate a greater capacity for shrimp to use the protein contained in meal, which reinforces its potential as an alternative ingredient in aquaculture diets.

These studies demonstrate that mealworm meal offers a more balanced and suitable nutritional profile for shrimp growth than meat meal, providing better digestibility, protein retention, and gut health. Insects are considered to be very advantageous in terms of sustainability, due to their rapid reproduction, high growth rate, low environmental impact, and efficiency in food conversion.

They are able to develop from different materials, such as organic waste, as well as being a rich nutritional source of protein, fatty acids, and minerals. They can also be consumed in different ways (Nowak et al., 2016; Van Huis et al., 2013; Araújo et al., 2019).

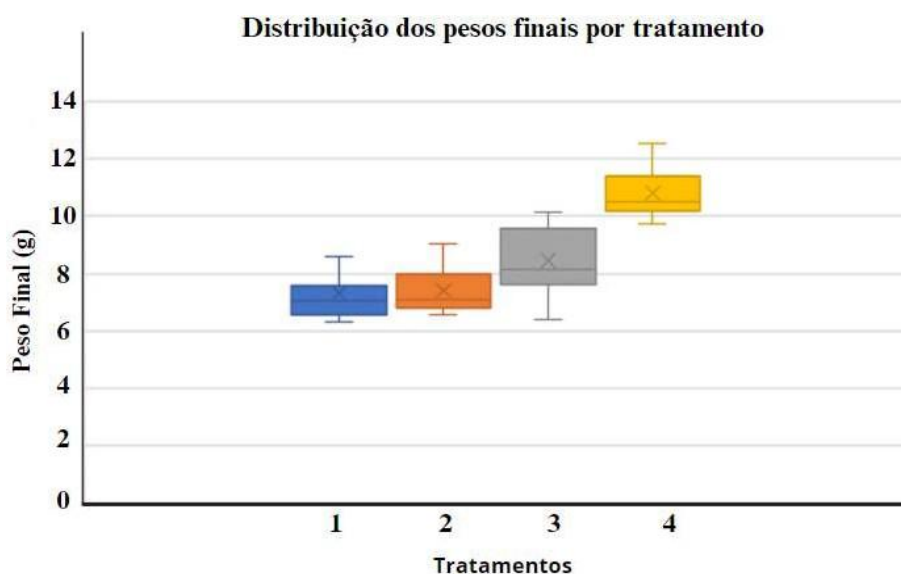
Rumbos and Athanassiou (2021) highlight that giant mealworm (*Z.morio*) is a promising source of nutrients and anti-microbials, with potential for use in aquaculture and poultry feeds. The production of this insect has a reduced environmental impact, contributing to sustainability. In addition, giant mealworm can be used to reduce waste, offering a viable and sustainable alternative to traditional animal protein production.

Therefore, the use of shrimp diets that do not depend on fishmeal to achieve good zootechnical results emerge as a promising opportunity for producers to associate themselves with new markets that add value to the shrimp produced (Amaya et al., 2007; Soares et al., 2011).

The final weights of the shrimp submitted to the four treatments were analyzed by ANOVA and multiple comparisons by Tukey's test with a significance level of 5%. ANOVA indicated a significant difference between treatments ($F=45.83$, $p<0.0001$). Tukey's test revealed that Treatment 4 was significantly superior to the others ($p < 0.05$), while no significant differences were observed between Treatments 1, 2 and 3 (Figure 2).

Figure 4

Differences between the final weights in each treatment



1=0% treatment; 2=treatment 25%; 3=50% treatment and 4=100% treatment

Source: Authors.

Although the post-hoc analysis did not identify statistically significant differences between Treatments 1, 2 and 3, the data suggest a trend towards improvement in the final weights of the shrimp as the treatments progressed, especially between Treatments 2 and 3. This trend of weight gain, visually observed in the box plot, may indicate a potential optimization in the diets applied to these treatments, although the difference was not statistically significant. Treatment 4, on the other hand, showed a substantially higher weight gain, which reinforces the efficiency of the diet tested in this group and its ability to improve the zootechnical performance of shrimp.

4 CONCLUSION

The results obtained with the replacement of up to 100% of animal flour with giant mealworm flour were extremely promising. The significant improvements in several aspects, including the nutritional quality and sustainability of the final product. Giant mealworm has been shown to be a viable and efficient alternative, providing benefits for both the animals and the environment. These findings pave the way for future research and industrial applications, highlighting the innovative potential of this substitution in the food sector.

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**HEAT TRANSFER AND FLUID DYNAMICS ON INCLINED SMOOTH AND
ROUGH SURFACES BY THE APPLICATION OF THE SIMILARITY AND
INTEGRAL METHODS**

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 <https://doi.org/10.56238/sevened2025.036-107>

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ABSTRACT

The main objective of the analysis is to review and discuss the principles of the similarity method applied to the boundary layer on inclined surfaces, in laminar regime, and that can be extended to a turbulent regime. The emphasis applies to theoretical aspects related to the concept of similarity, but theoretical results were obtained to compare with empirical expressions and experimental results. Results are obtained for the hydrodynamic and thermal fields, such as coefficient of friction and Stanton number, as a function of the pressure gradient parameter and the Prandtl number. The fourth order Runge-Kutta method is applied, starting from the expansion in power series as the first approximation for the mathematical solution of hydrodynamic and thermal problems, in laminar regime. The Integral Method is applied to obtain an approximate solution for the flow in turbulent regime, by similarity variables method. Numerical and graphical results are presented in sufficient numbers to emphasize the consistency of the model developed in the determination of parameters related to thermal and hydrodynamic boundary layers on smooth and rough surfaces.

Keywords: Similarity Method. Fourth Order Runge Kutta Method. Hydrodynamic Boundary Layer. Thermal Boundary Layer.

RESUMO

O principal objetivo da análise é revisar e discutir os princípios do método da similaridade aplicado à camada limite em superfícies inclinadas, em regime laminar, e que pode ser estendido a um regime turbulento. A ênfase recai sobre aspectos teóricos relacionados ao conceito de similaridade, porém resultados teóricos foram obtidos para comparar com expressões empíricas e resultados experimentais. Resultados são obtidos para os campos hidrodinâmico e térmico, tais como coeficiente de atrito e número de Stanton, em função do parâmetro de gradiente de pressão e do número de Prandtl. O método de Runge-Kutta de quarta ordem é aplicado, partindo da expansão em série de potências como primeira aproximação para a solução matemática dos problemas hidrodinâmico e térmico, em regime laminar. O Método Integral é aplicado para obter uma solução aproximada para o

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escoamento em regime turbulento, por meio do método das variáveis de similaridade. Resultados numéricos e gráficos são apresentados em quantidade suficiente para enfatizar a consistência do modelo desenvolvido na determinação de parâmetros relacionados às camadas limite térmica e hidrodinâmica em superfícies lisas e rugosas.

Palavras-chave: Método da Similaridade. Método de Runge-Kutta de Quarta Ordem. Camada Limite Hidrodinâmica. Camada Limite Térmica.

RESUMEN

El principal objetivo del análisis es revisar y discutir los principios del método de similitud aplicado a la capa límite en superficies inclinadas, en régimen laminar, y que puede extenderse a un régimen turbulento. El énfasis se centra en los aspectos teóricos relacionados con el concepto de similitud, pero se obtuvieron resultados teóricos para compararlos con expresiones empíricas y resultados experimentales. Se obtienen resultados para los campos hidrodinámico y térmico, tales como el coeficiente de fricción y el número de Stanton, en función del parámetro de gradiente de presión y del número de Prandtl. Se aplica el método de Runge-Kutta de cuarto orden, partiendo de la expansión en series de potencias como primera aproximación para la solución matemática de los problemas hidrodinámico y térmico, en régimen laminar. El Método Integral se aplica para obtener una solución aproximada para el flujo en régimen turbulento, mediante el método de variables de similitud. Se presentan resultados numéricos y gráficos en cantidad suficiente para enfatizar la consistencia del modelo desarrollado en la determinación de parámetros relacionados con las capas límite térmica e hidrodinámica en superficies lisas y rugosas.

Palabras clave: Método de Similitud. Método de Runge-Kutta de Cuarta Orden. Capa Límite Hidrodinámica. Capa Límite Térmica.

1 INTRODUCTION

The aspects related to laminar regime are based on the deep study carried out by Evans (1968), and in turbulent regime the text of Kays and Crawford (1966).

It is assumed that there is no mass transfer through the surface (without surface perspiration effect) and that the perpendicular component of velocity is zero. In addition, the velocity component parallel to the surface is also zero, a condition called "no slip on the wall" in the specialized literature. All the presented solutions and results assume constant properties, unaffected by the variation of temperature, and the velocities are sufficiently low so that the viscous dissipation term can be neglected.

The basic equations for boundary layer similarity conditions are widely discussed Schlichting (1968); Evans (1968), Kays and Crawford (1983), Silva Freire (1990), and only essential details for the understanding of the arguments are presented in this work. Details on flat plate flow are discussed by Nogueira and Soares (2018).

There are in the literature many ways of specifying the existence of similar solutions for the laminar boundary layer equations. The main characteristic associated with the concept of boundary layer similarity is that the undisturbed velocity distribution of the potential flow must satisfy the following expression, which follows the original suggestion of Falkner and Scan (1931):

$$U(x) = Cx^m \quad (1)$$

Where:

C is the value of U (x) where x is unitary, and the value of m depends on the pressure gradient in the main direction of the flow.

However, according to Spalding and Pun (1962), it is convenient to impose that U (x) satisfies the following equation:

$$\frac{dU}{dx} = CU^{\frac{2(\beta-1)}{\beta}} \quad (2)$$

Where:

β is a parameter that is associated with the pressure gradient in the direction of the main flow.

The potential theory, applied around an angle wedge $\beta\pi/2$ Evans (1988), satisfies equation 3.11, above, where:

$$m = \frac{\beta}{(2 - \beta)} \quad (3)$$

and,

$$\frac{1}{\beta} \frac{dU}{dx} = \frac{U}{x} \frac{1}{(2 - \beta)} \quad (4)$$

However:

$$\frac{dp}{dx} = -\rho U \frac{dU}{dx} \quad (5)$$

The specification of $U(x)$ is equivalent to specifying the pressure gradient, which is a function of β :

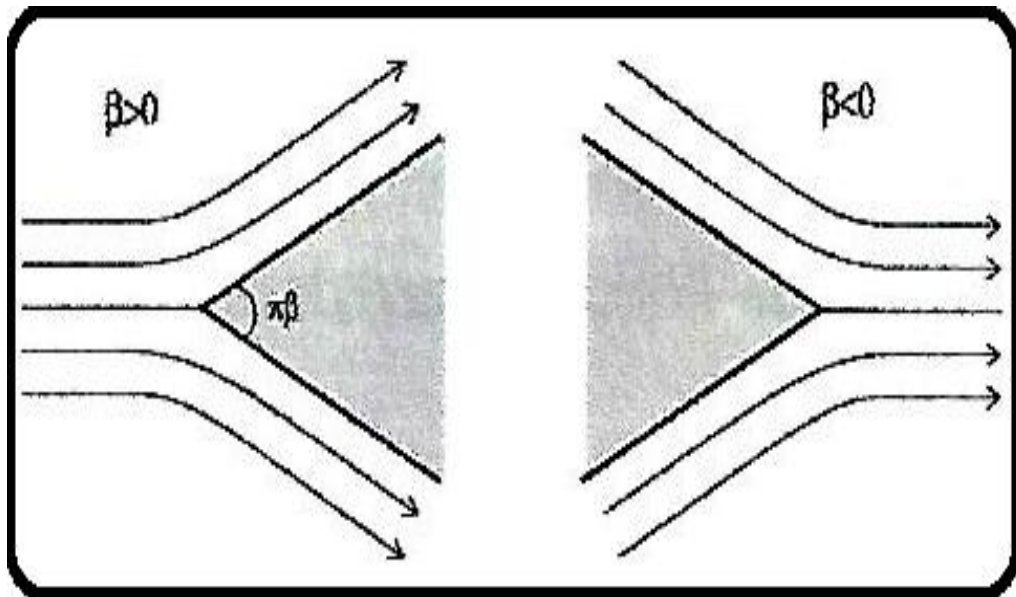
$$\frac{dp}{dx} = -\rho U \frac{\beta}{(2 - \beta)} \frac{U}{x} \quad (6)$$

The parameter β , as can be seen, depends only on the velocity distribution in the external region to the boundary layer, the variable x along the surface and the pressure gradient.

We are interested in the flow conditions where $-0.2 \leq \beta \leq 1.0$, representing the limits of the boundary conditions for the pressure gradient parameter between the boundary layer detachment $\beta = -0.2$, and the two-dimensional stagnation flow $\beta = 1.0$, in the laminar regime (Figure 1).

Figure 1

Flow on an inclined surface of angle $\pi\beta$



Source: The authors.

The differential equation governing the velocity distribution at a similar boundary layer for laminar regime within the range of the already established pressure gradient parameter β is given by Schlichting (1968); Evans (1968), Kays and Crawford (1983), Silva Freire (1990):

$$f''' + f \cdot f'' + \beta \cdot (1 - f'^2) = 0 \quad (7)$$

With the following boundary conditions:

$$\eta = 0, \quad f = f' = 0 \quad (8)$$

$$\eta \rightarrow \infty, \quad f' \rightarrow 1.0 \quad (9)$$

Where:

f and η are defined by:

$$\eta = \frac{y}{x} \frac{(Ux)^{1/2}}{\sqrt{2-\beta}} \quad e \quad f = \frac{\psi/v}{(\frac{Ux}{v})\sqrt{2-\beta}} \quad (10)$$

Where:

x and y are, respectively, the primitive coordinates along the surface and perpendicular to it.

Choosing the coordinate η as a function of y/x , which is very small, except at $x = 0$, by the square root of the Reynolds number, $Re_x = (\frac{Ux}{\nu})^{1/2}$, which is very large, we impose y/x is small, but η is not.

From the definitions of η and f , we have expressions for the components of dimensionless velocities:

$$u = U \frac{df}{d\eta} \quad e \quad v = - \left(\frac{\nu}{\beta} \frac{dU}{dx} \right)^{\frac{1}{2}} [f + (\beta - 1)\eta \frac{df}{d\eta}] \quad (11)$$

The last boundary condition, Equation 3.1.7.2, means that as η grows $f' = u/U$ should approach the unit without exceeding it. The value of η , in this case, is called η_{∞} , for a given value of β .

Due to the difficulty in solving the above boundary condition problem with reasonable precision, we apply the 4th order Runge Kutta Method Tannehill et al. (1997), with initial value of $f'(0)$ given after application of the Power Series Method.

The approximate solution by the power series method with the Shooting Method Tannehill et al. (1997); Oderinu, R. A. (2014), as an approximation procedure for the velocity profile is obtained by assuming that the function $f(\eta)$ satisfies the following expansion in series:

$$f(\eta) = C_2 \frac{\eta^2}{2!} + C_5 \frac{\eta^5}{5!} + C_6 \frac{\eta^6}{6!} \dots + C_n \frac{\eta^n}{n!} \quad (12)$$

With the following recurrence rule:

$$C_{n+3} = -n! \left[\frac{1}{1!(n-1!)} (\beta \cdot C_2 \cdot C_n) + \frac{1}{2!(n-2!)} (C_2 \cdot C_n + \beta \cdot C_3 \cdot C_{n-1}) + \frac{1}{3!(n-3!)} (C_3 \cdot C_{n-1}) + \frac{1}{4!(n-4!)} (C_5 \cdot C_{n-3}) \right] \quad (13)$$

for $n \geq 4$.

$$C_3 = -\beta ; C_5 = -2\left(\beta + \frac{1}{2}\right)C_2^2 \quad \text{e} \quad C_6 = 6\beta\left(\beta + \frac{1}{2}\right)C_2 \quad (14)$$

The term C_2 corresponds to $f''(0)$, that is:

$$C_2 = f''(0) \quad (15)$$

Through Shooting Method Tannehill et al. (1997); Oderinu, R. A. (2014), or other approach method, as the "Bisection Method", we can obtain the value of C_2 , with the desired approximation. However, the approximation method through the series solution is slow, in order to obtain the necessary solution for our purposes. In this sense, we apply the fourth Runge-Kutta method Tannehill et al. (1997), with initial value for $f''(0)$ from the expansion in power series. As the Runge-Kutta method is a high-precision numerical method, coupled with the Newton-Raphson method, the final solution for the velocity field in the hydrodynamic boundary layer is obtained in less time than necessary for the series solution, with the same precision.

The energy equation for determining the dimensionless temperature field is given by:

$$\frac{d}{d\eta}(\theta') + Pr \cdot f \cdot \theta' = 0 \quad (16)$$

The temperature profile shall satisfy the following contour conditions for the specified surface temperature:

$$\eta = 0, \quad \theta = 0 \quad (17)$$

$$\eta \rightarrow \infty, \quad \theta \rightarrow 1.0 \quad (18)$$

Where:

Pr is the number of Prandtl, and

$$\theta = \frac{T - T_w}{T_\infty - T_w} \quad (19)$$

It is assumed that T_{∞} , temperature outside the boundary layer, is not affected by the heat rate removed outside of the boundary layer. The value of T_w corresponds to the surface temperature (reference!).

The energy equation, Equation 14, is linear and less complex than the velocity field equation. However, it strongly depends on the solution of the velocity profile, since f appears explicitly in the second term. Therefore, the greater the precision in the solution of f , the better the solution in θ .

The Runge-Kutta method is used for solution of the temperature field, but it is observed that the limit value for η , $\eta \rightarrow \infty$, is not necessarily the same as that obtained for the velocity field, for a given β . As an alternative, in terms of comparison, a second solution is obtained by directly integrating the energy equation Kays and Crawford (1983); Evans (1968):

$$\theta = \theta'_0 \cdot \int_0^{\eta} \exp \left[-Pr \cdot \int_0^{\eta} f \cdot d\eta \right] d\eta \quad (20)$$

$$\theta' = \theta'_0 \cdot \exp \left[-Pr \cdot \int_0^{\eta} f \cdot d\eta \right] \quad (21)$$

Where:

θ'_0 'is the value of the surface temperature derivative:

$$\theta \rightarrow 1, \quad \eta \rightarrow \infty \quad \theta'_0 = \frac{1}{\int_0^{\infty} \exp \left[-Pr \cdot \int_0^{\eta} f \cdot d\eta \right] d\eta} \quad (22)$$

However, the application of Equation 3.1.18, above, does not provide adequate accuracy to obtain the surface temperature gradient. In this sense, we chose to use Evans's procedure, in θ'_0 .

Therefore,

$$\left(\frac{d\theta}{d\eta} \right)_0 = \frac{3}{E} \left(\frac{Pr \cdot f''_0}{3!} \right)^{1/3} \quad (23)$$

Where:

$$E = \Gamma \left(\frac{1}{3} \right) + \sum_{q=0}^{\infty} \frac{a_q}{Pr^{q/3}} \quad (24)$$

Γ is the gamma function:

$$\Gamma\left(\frac{1}{3}\right) = 2.6789385 \quad (25)$$

Expressions for a_q contains the pressure gradient parameter β , the dimensionless viscous stress on the wall $f''(0)$, and numerical factors derived from the combination of gamma functions and are not presented. The complete procedure for the exact determination is found in Evans (1968). In addition, Equation 19, for determining the temperature gradient at the surface, presents unsatisfactory results as β tends to the flow separation value ($\beta = -0.2$). Evans (1968) describes an alternative procedure for this case, but it will not be the subject of discussion in this analysis.

In turbulent regime there are no analytical solutions for the boundary layer equations. An alternative for the determination of turbulent boundary layer parameters is the approximate solution of Von Kármán's equation:

$$\frac{d\delta_2}{dx} = \frac{C_f}{2} = \frac{\tau_w}{\rho U^2} \quad (26)$$

Even in the zero-pressure gradient, flat plate flow, Von Kármán's equation has more unknowns than equations. Thus, it is necessary to relate the unknown by specifying a dimensionless velocity profile.

For comparison purposes, in relation to the laminar regime, in this work, values for turbulent flow are determined on smooth and rough inclined surfaces, by means of an approximate theoretical model. Turbulent flow with 1/7 power is used, and experimental results of Schultz-Grunow (1941), Pimenta et al. (1975), Schlichting and Prandtl (1968), Kays and Crawford (1983).

The theoretical procedure, in this case, corresponds to the one recommended by Kays and Crawford (1983), for flat plate flow, where the conditions of similarity are satisfied. In fact, the valid procedure is used for flat plate, for determination of the profiles of speed and temperature, and generalizes situations where $\beta \neq 0$, through the concept of the shape factor, H_{12} , and correction formulas obtained by Kays and Crawford (1983).

For the approximate determination of the turbulent velocity profile, associated with the integral equation of momentum, a power law of type 1/7 is very convenient:

$$u^+ = 8.75y^{+1/7} \quad (27)$$

The above expression represents the speed profile up to $y^+ = 1500$ a little better than the equation, much used in algebraic simulations, called "Logarithmic Law in the Wall".

$$u^+ = \frac{u}{\sqrt{\tau_w/\rho}} \quad e \quad y^+ = y \frac{\sqrt{\tau_w/\rho}}{v} \quad (28)$$

If Equations 3.1.22 and 3.1.23 are valid throughout the boundary layer, and that the thickness δ corresponds to the position where the velocity is equal to U , we have:

$$\frac{U}{\sqrt{\tau_w/\rho}} = 8.75\delta \frac{\sqrt{\tau_w/\rho}}{v} \quad (29)$$

The displacement, δ_1 , and momentum thickness, δ_2 , can be evaluated by the following expressions:

$$\delta_1 = \int_0^\infty \left(1 - \frac{u\rho}{U\rho_\infty}\right) dy \quad (30)$$

And

$$\delta_2 = \int_0^\infty \frac{\rho u}{\rho_\infty U} \left(1 - \frac{u}{U}\right) dy \quad (31)$$

The integral equation of the momentum, in similar coordinates, is given by:

$$f''(0) = \frac{1}{\delta_4} = \frac{1}{vU} \frac{d}{dx} (U^2 \delta_2) + \frac{\delta_1}{v} \frac{dU}{dx} \quad (32)$$

or

$$\frac{\delta_2}{\delta_4} = \frac{1}{2} \frac{U(x)}{v} \frac{d\delta_2^2}{dx} + (2 + H_{12}) \frac{\delta_2^2}{v} \frac{dU(x)}{dx} \quad (33)$$

Where:

$$H_{12} = \frac{\delta_1}{\delta_2} \text{ denominated shape factor} \quad (34)$$

For similar boundary layer, each δ_n is a constant and therefore the shape factor is a constant. It is important to note that Equation 3.1.28 is valid for laminar and turbulent regime. The shape factor increases in an adverse pressure field, $\beta < 0$. For flow in turbulent boundary layer, H increases from 1.29 to null pressure gradient $\beta = 0$, to approximately 2.7 in the separation condition $\beta \cong 0.2$ Simpson (1989). For accelerated flow the value of H increases again, as a function of the "tendency to laminar flow" effect, and tends to 1.47 for two-dimensional stagnation flow, $\beta = 1$ Smith (1966). The velocity distribution, $U(x)$, must be known prior to the application of the integral momentum equation, Equation 3.1.28.

The displacement thickness, δ_1 , has the effect of displacing the undisturbed main flow current function with respect to the value it should have for ideal, non-viscous fluid. The momentum thickness, δ_2 , is the extent to which the amount of fluid movement in the boundary layer is below what should be for an ideal fluid. The viscous thickness, δ_4 , inverse of $f''(0)$, is the measure of the resistance offered for transferring the amount of movement of the main stream to the surface.

There are two predominant regions to be analyzed in a turbulent boundary layer:

- 1 – A predominantly viscous region close to the surface, where viscous stresses and molecular conduction prevail.
- 2 – A completely turbulent region where the amount of movement and heat are transported in rates generally much higher than that of the viscous sublayer.

It is in the viscous sublayer, however, where events associated with turbulence occur and are of greater importance than the fully turbulent region. The viscous forces, largely responsible for the characteristics of the laminar flow, have the effect of restoring the laminar flow in turbulent flow and, otherwise, the inertial forces associated with the local variations of the velocity field have the opposite effect. In fact, inertial forces tend to amplify local

disturbances. It is to be expected, therefore, that the stability of the laminar flow is associated with low numbers of Reynolds, ratio between the forces of inertia by the viscous forces. Although instability is an essential feature in the viscous sublayer, the turbulent boundary layer structure adjusts itself, constructing a relatively stable structure with stability characteristics (there is regularity!).

At turbulent flow, along the surface, the laminar sublayer becomes narrow and becomes an increasingly smaller fraction of the entire boundary layer. In essence, the turbulent boundary layer has the property of diffusing the amount of movement, and other properties of the flow, much more rapidly than the simple molecular process.

Equations 3.1.26 and 3.1.27, together with the integral equation of momentum, Equation 3.1.28, can be used to obtain the coefficient of friction in the turbulent boundary layer. Note, however, that the velocity profile is valid for null pressure gradients, that is, $\beta = 0$. For situations in which the pressure gradient is different from zero, correction must be made. The expression for the coefficient of friction, $\beta = 0$, is given by Kays and Crawford (1983):

$$\frac{Cf}{2} = \frac{0.0594}{2Re_x^{1/5}} \quad (35)$$

Which can be compared with the experimental equation obtained by Schultz-Grunow (1941):

$$\frac{Cf}{2} = 0.185(\log_{10}(Re_x))^{-2.584} \quad (36)$$

In turbulent boundary layer analysis, it is convenient to define some type of similarity. However, the task is not as simple as in laminar boundary layer. In turbulent flow, in a region very close to the surface, it is observed that $u^+ = y^+$, e, logically, the principle of similarity applies. Outside this region and in the explicit coordinate system, the principle generally does not apply. However, there are some classes of turbulent flow that have similarity, even outside the laminar sublayer.

Turbulent boundary layer that has similarity outside the laminar sublayer is called the boundary layer in equilibrium. The equilibrium boundary layer is the one that satisfies the following velocity profile:

$$\frac{u - U}{\sqrt{\frac{\tau_w}{\rho}}} = F\left(\frac{y}{\delta_3}\right) \quad (37)$$

Where:

$$\delta_3 = - \int_0^\infty \frac{u - U}{\sqrt{\frac{\tau_w}{\rho}}} dy \quad (38)$$

For laminar boundary layer it was demonstrated that Equation 01 must be satisfied for similarity solutions to exist. In turbulent boundary layer this same type of free-flow velocity profile must be satisfied, so that equilibrium boundary layer occurs, satisfying the similarity principle Kays and Crawford (1983).

The turbulent coefficient of friction for the equilibrium boundary layer can be correlated with β through an empirical relation Kays and Crawford (1983):

$$\frac{Cf/2}{(Cf/2)_{\beta=0}} = \frac{1}{(1 + \frac{\beta}{5})} \quad (39)$$

For turbulent boundary layer, assuming equilibrium boundary layer, the Stanton number is determined for null pressure gradient, $\beta = 0$, through the expression Kays and Crawford (1983):

$$St_x = \frac{Cf/2}{\sqrt{Cf/2} (13.2Pr - 10.16) + 0.9} \quad (40)$$

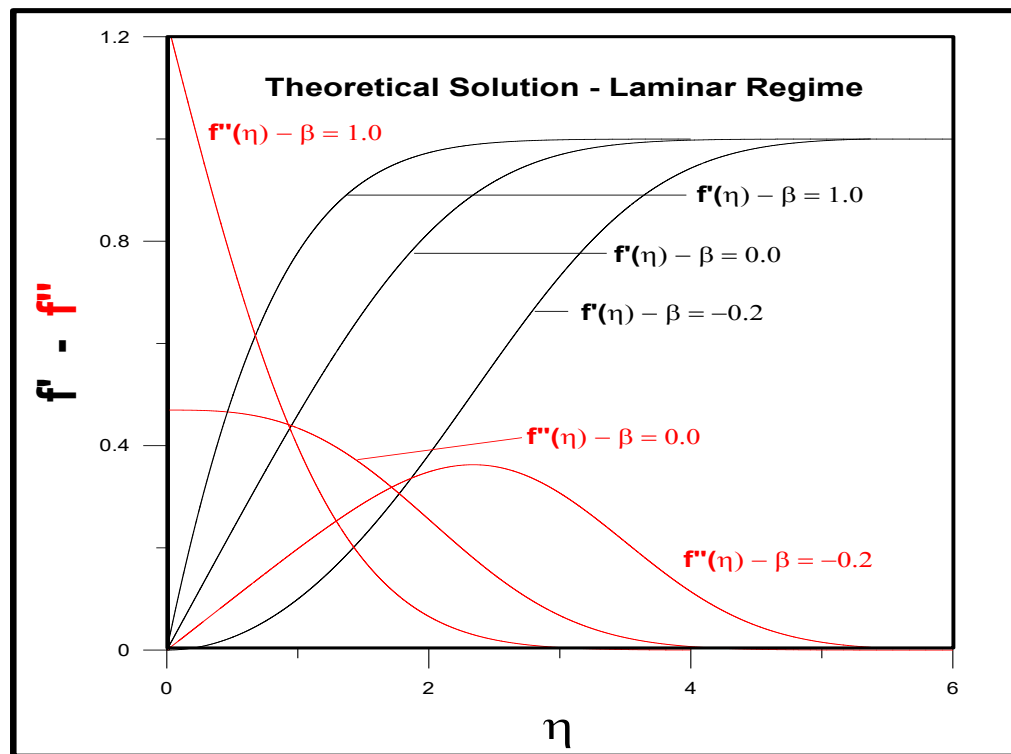
2 RESULTS AND DISCUSSIONS

Results were obtained for velocity and temperature profiles, and associated values, such as friction coefficient and Stanton number, as a function of the pressure gradient parameter and Prandtl number. Numerical results were computed using Fortran (1995) language and graphical results were obtained through software Grapher (2004).

Figure 2 presents results for velocity profile, f' , and dimensionless viscous stress, f'' , for laminar regime in extreme situations, in $\beta = -0.2$ and $\beta = 1.0$, in relation to the results obtained for flat plate, $\beta = 0$. These conditions, as already pointed out, represent, respectively, the surface boundary layer detachment condition and the two-dimensional stagnation flow condition. It is observed that, for $\beta = -0.2$, the viscous stress is equal to zero on the surface, as expected.

Figure 2

Solutions for dimensionless viscous velocity (f'') and velocity profile (f')



Source: The authors.

In Equation 7, for $\beta = 0$, since $f' = 0$ on the wall, f''' is also zero and, as a consequence, f'' has a maximum value on the wall. For $\beta < 0$ values, f'' also has a maximum value, but the maximum point distances itself from the wall, and the values of f'' on the wall are lower than that of $\beta = 0.0$. In fact, it can be observed that the viscous tension in the wall decreases to negative β values and becomes zero in β near -0.2 .

For accelerated flows, $\beta > 0$, the maximum value also occurs on the wall, and these values increase with increasing acceleration of the flow. Since the viscous stress is zero on the wall, where the separation of the flow occurs, f' has a minimum at this point, as can be

seen from Figure 2 For accelerated flow, $\beta = 1.0$, a decrease in the displacement thickness, relative to flat plate flow, $\beta = 0.0$, can be observed.

Table 1 present comparisons of results for displacement thickness, δ_1 , momentum thickness, δ_2 , and the inverse of shape factor, H_{21} , in laminar regime. The consistency of the results obtained can be verified. For highly accelerated flows, better consistency is achieved between models.

Table 1

Numerical comparisons in laminar regime for the inverse of Shape Factor (H_{21})

Results				Evans (1968)		
β	δ_1	δ_2	H_{21}	δ 1	δ 2	H 21
-0.2**	2.3587	0.5852	0.2400	2 .3588	0 .5854	0 .2482
-0.019	2.0064	0.5762	0.2834	2 .0068	0 .5765	0 .2873
-0.18	1.8714	0.5673	0.3006	1 .8716	0 .5677	0 .3033
-0.15	1.6468	0.5449	0.3295	1 .6470	0 .5452	0 .3310
-0.12	1.5111	0.5258	0.3472	1 .5113	0 .5263	0 .3482
-0.10	1.4423	0.5147	0.3562	1 .4427	0 .5150	0 .3570
0.0	1.2164	0.4695	0.3856	1 .2168	0 .4696	0 .3859
0.2	0.9839	0.4081	0.4147	0 .9842	0 .4082	0 .4148
0.3	0.9108	0.3856	0.4234	0 .9110	0 .3857	0 .4234
0.4	0.8525	0.3666	0.4300	0 .8527	0 .3667	0 .4301
0.6	0.7639	0.3359	0.4397	0 .7640	0 .3359	0 .4397
0.8	0.6986	0.3119	0.4464	0 .6987	0 .3118	0 .4463

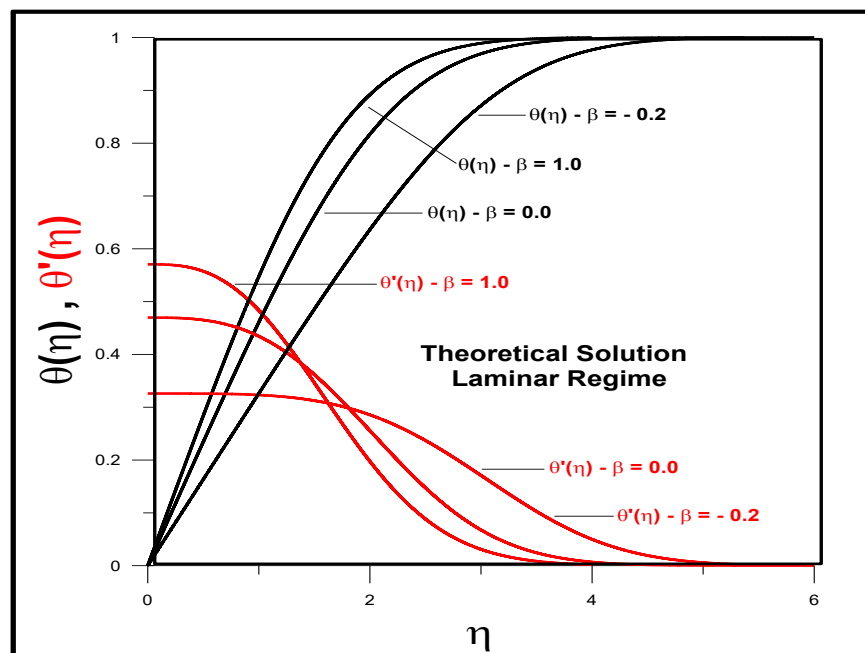
1.0	0.6480	0.2924	0.4514	0	0	0
				.6480	.2923	.4513
**$\beta = -0.19883768$						

Source: The authors.

Figure 3 presents results for temperature profile and dimensionless temperature gradient in laminar regime and $Pr = 1.0$. The most important results, which should be emphasized, are the values of the surface temperature gradient, since the integral parameters associated to the temperature field are strongly associated with it. It can be observed that the temperature gradient decreases with lower values of β , ie, the more accelerated the flow, the greater the temperature gradients in the wall. Equivalent to what occurs with the thickness of the hydrodynamic boundary layer, the thermal boundary layer thickness also decreases to higher β values. In addition, another factor to be emphasized, the profile and the temperature gradient depend strongly on the solution of the velocity field, according to Equations (16) and (17).

Figure 3

Temperature profile (θ) and dimensionless temperature gradient (θ') for laminar thermal layer ($Pr = 1.0$)



Source: The authors.

Figure 4 presents the results of a dimensionless coefficient of friction in the laminar regime determined by:

$$\frac{Cf}{2} = \frac{f''(0)}{Re_x^{\frac{1}{2}}(2 - \beta)^{1/2}} \quad (41)$$

and

$$\left(\frac{Cf}{2}\right)_{\text{empirical}} = \frac{[F(\beta) \frac{Cf(\beta=0)}{2}]}{(1 + \frac{\beta}{5})} \quad (42)$$

$$\frac{Cf(\beta=0)}{2} = \frac{0.332}{Re_x^{\frac{1}{2}}} \quad (43)$$

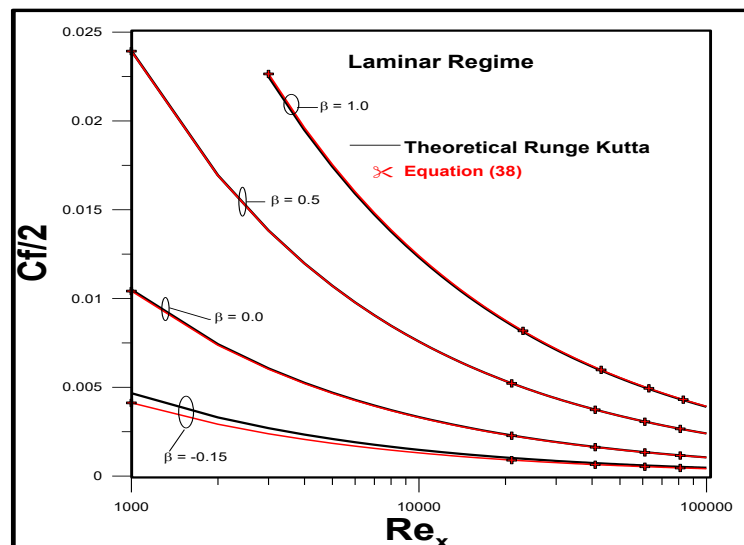
Where:

$$F(\beta) = 0.992436221 + 3.670315583\beta - 2.382778474\beta^2 + 2.203613278\beta^3 \quad (44)$$

$F(\beta)$ is obtained empirically from the data available in Evans (1968).

Figure 4

Dimensionless coefficient of friction ($\frac{Cf}{2}$) as a function of the Reynolds number (Re_x) for laminar regime.



Source: The authors.

It is observed that the new empirical solution, Equation 42, is very convenient, since it eliminates the need to solve the hydrodynamic boundary layer equation to obtain the coefficient of friction for the entire range of β . This is one of more significant and important result presented in this work, since the results differ significantly only for values of $\beta < -0.15$, and low Reynolds number values along the surface.

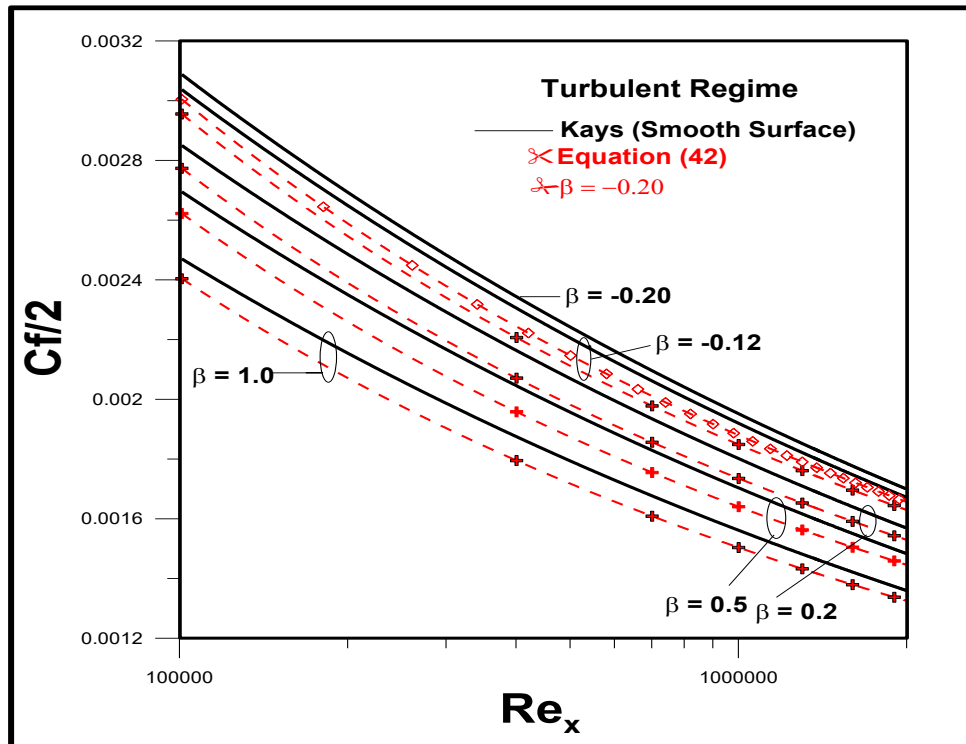
Figure 5 shows the results obtained for the dimensionless friction coefficient for turbulent regime on smooth surface. The highlight corresponds to the Schultz-Grunow (1941) modified solution. The analytical solution, Equation 35, and Schultz-Grunow's empirical equation, Equation 46, associated with the modification proposed by Kays and Crawford (1993), for pressure gradient flows within the range analyzed in this work, $-0.2 < \beta < 1.0$, are in good agreement. It is, therefore, a result compatible with that presented in Figure 4, since the solution eliminates the need to solve the system of equations for velocity field where β is different from zero.

$$\frac{Cf}{2} = \frac{0.0594}{2Re_x^{1/5} * (1 + \frac{\beta}{5})} \quad (45)$$

$$(\frac{Cf}{2})_{Exp} = \frac{[0.185(Log_{10}(Re_x))^{-2.584}]}{(1 + \frac{\beta}{5})} \quad (46)$$

Figure 5

Non-dimensional coefficient of friction ($\frac{C_f}{2}$) as a function of Reynolds number (Re_x) for turbulent regime on smooth surface



Source: The authors.

All previous discussion assumes boundary layer for smooth surface. The effect of roughness on the turbulent boundary layer occurs primarily close to the surface, and this leads to the definition of a rough Reynolds number:

$$Re_k = \frac{u_\tau k_s}{\nu} \quad (47)$$

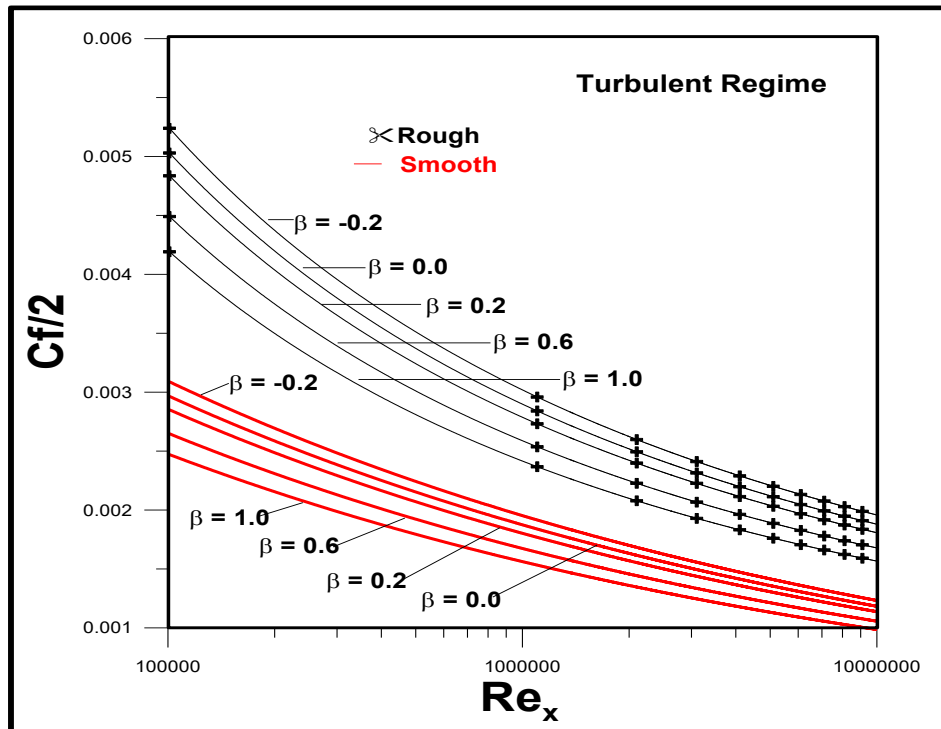
Where:

k_s is the absolute roughness.

Figure 6 shows the comparison between valid results for smooth and rough surfaces, for any range of values of the pressure coefficient previously defined, $0.2 < \beta < 1.0$.

Figure 6

Comparison for dimensionless friction coefficient ($\frac{C_f}{2}$) between smooth and rough surfaces in turbulent regime



Source: The authors.

The characteristics of the hydrodynamic and thermal boundary layer are controlled by important parameters such as speed and temperature, shape and surface conditions. Surface conditions require special attention where roughness is an inherent characteristic. Roughness usually increases the friction resistance and the heat transfer coefficient for a same Reynolds number, relative to the smooth surfaces. In fact, the roughness produces higher values for the friction factor and Stanton number, which result in speed and temperature deficits at the relative long distance of the surface when compared to the smooth surface.

For $Re_k > 65$ we have what is called the regime for a completely rough surface or even a completely rough flow Pimenta et al. (1975). A completely rough regime is what is considered in this analysis and, for all intents and purposes, we have $Re_k = 70$. It can be shown that the friction coefficient, for a completely rough regime, can be obtained by the following expression, where the correction factor for the pressure gradient effect is introduced, according to the empirical proposal of Kays and Crawford (1983):

$$\left(\frac{Cf}{2}\right)_{rug} = \frac{0.168}{\left[\ln\left(\frac{32.1x}{Re_x^{\frac{1}{5}}k_s}\right)\right]^2 \left(1 + \frac{\beta}{5}\right)} \quad (48)$$

The Stanton number, by definition, is obtained from the expression below:

$$St_x = \frac{Nu_x}{Pr \cdot Re_x} \quad (49)$$

For laminar regime

$$Nu_x = \frac{\left(\frac{d\theta}{d\eta}\right)_0 \sqrt{\frac{Re_x}{2}}}{(2 - \beta)^{1/2}} \quad (50)$$

For any situation, laminar or turbulent regime, for constant surface temperature and constant free-flow velocity, the Stanton number can be expressed in the form:

$$St = C Re_x^{-n} \quad (51)$$

In turbulent regime, zero pressure gradient, smooth surface, Kays and Crawford present the following equation, which fits excellent with experimental results for $0.5 < Pr < 1.0$ and $5 \cdot 10^5 < Re_x < 5 \cdot 10^6$; $C = 0.0287 Pr^{-0.4}$ and $n = 0.20$.

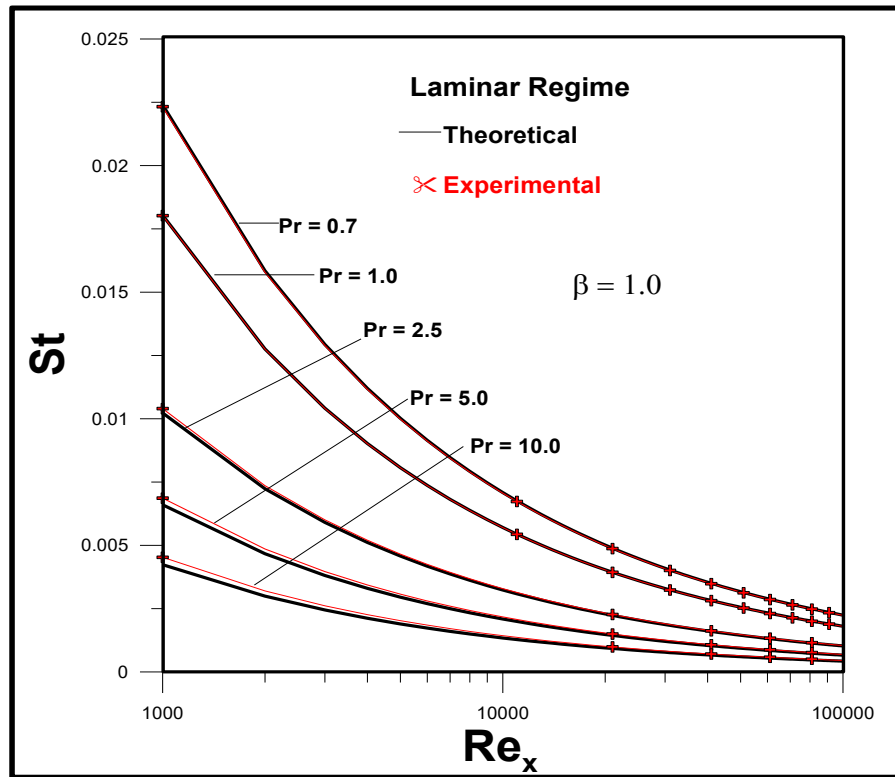
Introducing the proposed correction for inclined surfaces:

$$St_{TurbExp} = \frac{0.0287 Pr^{-0.4} Re_x^{-0.20}}{1 + \frac{\beta}{5}} \quad (52)$$

Figure 7 shows the theoretical-experimental comparison for Stanton number in laminar regime, for $\beta = 1.0$. The results are quite satisfactory for Prandtl numbers close to the unit, and deviate to high values of the Prandtl number, as expected.

Figure 7

Stanton number (St) for laminar regime as a function of Reynolds number



Source: The authors.

Figure 8 presents theoretical and experimental data for turbulent regime, on smooth and rough surfaces, for the number of $Pr=1.0$. As expected, heat transfer on rough surfaces outweighs heat transfer to smooth surfaces, for the same Reynolds number.

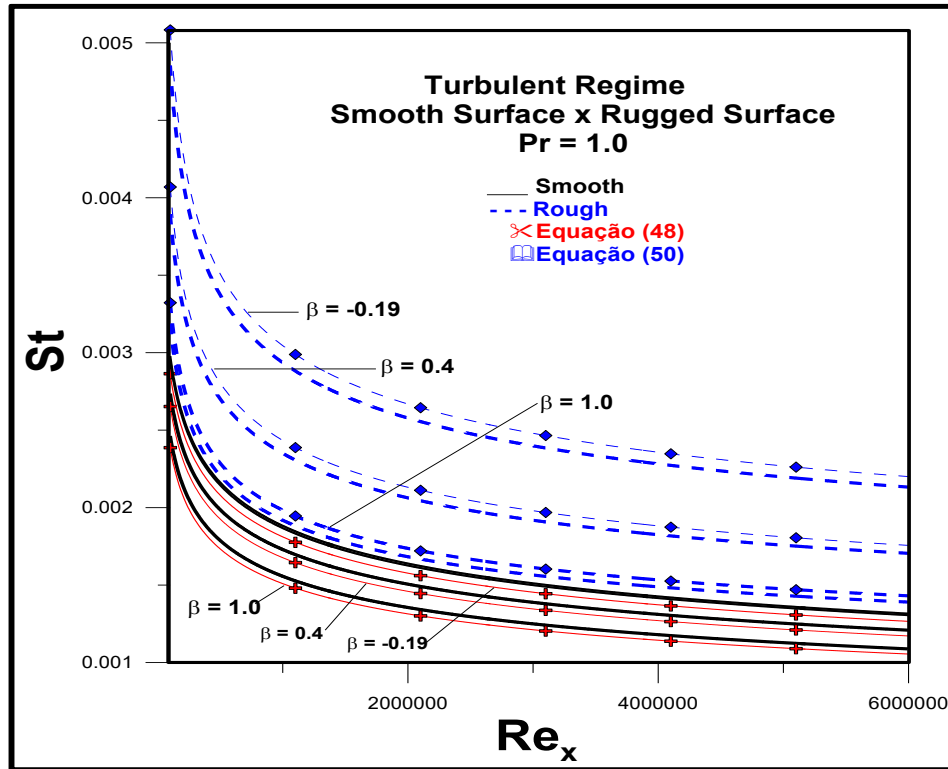
The theoretical expression for determination of Stanton's number is given by, following application of empirical modification suggested by Kays and Crawford (1983):

$$St_{rug} = \frac{(Cf/2)_{rug}}{\left(\sqrt{(Cf/2)_{rug}} (13.2Pr - 10.16) + Pr_t \right) \left(1.0 + \frac{\beta}{5} \right)} \quad (53)$$

In a completely rough flow, the molecular thermal conductivity remains as a significant variable, influence that can be established through the number of turbulent Prandtl, Pr_t . The turbulent Prandtl number can be considered, for gases, to be 0.9, which in fact represents an average value.

Figure 8

Theoretical-experimental comparisons for Stanton number (St) in turbulent regime, as a function of Reynolds number for smooth and rough surfaces



Source: The authors.

The equation for determination of experimental Stanton number, with the correction for the pressure gradient, is given by:

$$St_{Exp} = \frac{\left(\frac{Cf}{2}\right)_{rug}}{\left(Pr_t + \sqrt{\left(\frac{Cf}{2}\right)_{rug}} / St_k\right) \left(1 + \frac{\beta}{5}\right)} \quad (54)$$

$$St_k = Re_k^{-0.2} Pr^{-0.44} \quad (55)$$

Where:

St_k is the function of the roughness of the surface.

Figure 8 show that, for accelerated flow, the values approximate the result obtained for laminar flow, for smooth and rough surfaces. This effect is called laminarization of the boundary layer Kays et al. (1969) and demonstrate that the acceleration effect tends to cause a "retransmission" of the turbulent boundary layer to a pure laminar boundary layer. This is

an effect associated with decompression of the boundary layer, where the roughness is immersed in the laminar sublayer. Table 2 shows the effect of the tendency for laminar flow in the numerical determination of the Stanton number.

Table 2

Stanton number (St) for turbulent regime in smooth and rough surfaces

$R_e(x)$	$\beta = 0.0$		$\beta = 1.0$	
	Equation (48) Smooth	Equation (50) Rough	Equation (48) Smooth	Equation (50) Rough
1.01E5	2.864E-3	4.721E-3	2.387E-3	2.977E-3
2.01E5	2.496E-3	3.988E-3	2.080E-3	2.804E-3
4.01E5	2.174E-3	3.412E-3	1.812E-3	2.398E-3
6.01E5	2.005E-3	3.132E-3	1.671E-3	2.199E-3
8.01E5	1.9893E-3	2.953E-3	1.577E-3	2.073E-3
1.00E6	1.810E-3	2.824E-3	1.509E-3	1.983E-3
1.20E6	1.746E-3	2.726E-3	1.455E-3	1.913E-3
1.40E6	1.693E-3	2.646E-3	1.411E-3	1.857E-3
1.60E6	1.648E-3	2.580E-3	1.373E-3	1.810E-3
1.80E6	1.610E-3	2.524E-3	1.341E-3	1.770E-3
2.00E6	1.576E-3	2.475E-3	1.314E-3	1.736E-3

Source: The authors.

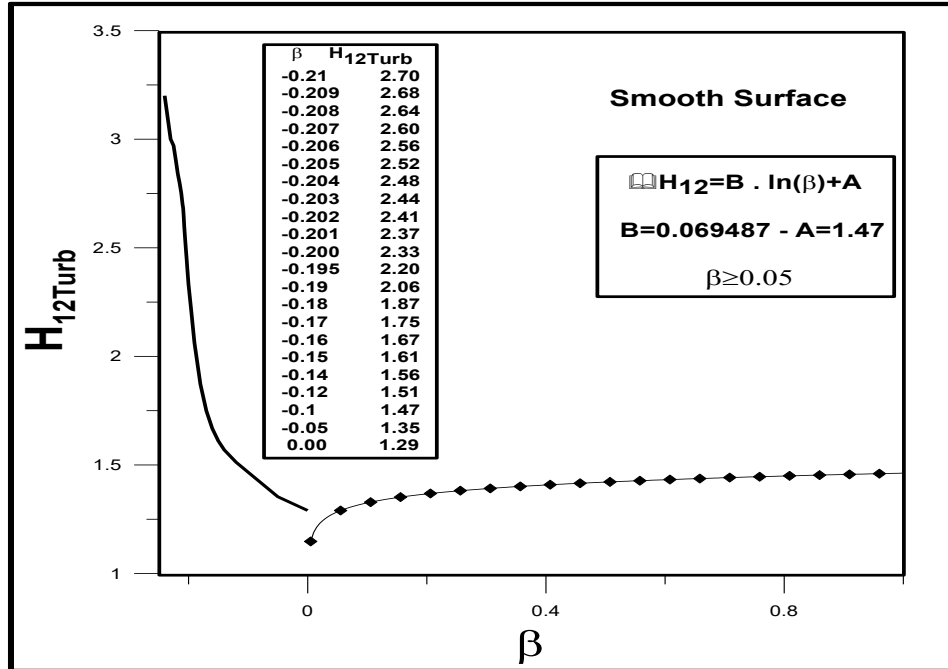
Experimental results, with correction factor, obtained by Pimenta et al. (1975) and Kays and Crawford (1983) were used for comparison, Equation (50). The data were taken from the table of Pimenta (1975), where $U=130.63$ ft/s and without surface perspiration effect. The value of K_s is equal to 1.0 mm for all purposes in this analysis.

It is important to emphasize that there is experimental evidence that the shape factor tends to 1.47, for smooth surface and highly accelerated flows in completely turbulent flow. This shows that despite the tendency to the laminar regime, the flow remains turbulent because the value of the form factor for highly accelerated laminar flow is approximately 2.2, as presented through the results obtained in this work, Figures 9 and 10.

There is theoretical and experimental evidence that the detachment of the turbulent boundary layer is delayed in relation to the laminar boundary layer detachment.

Figure 9

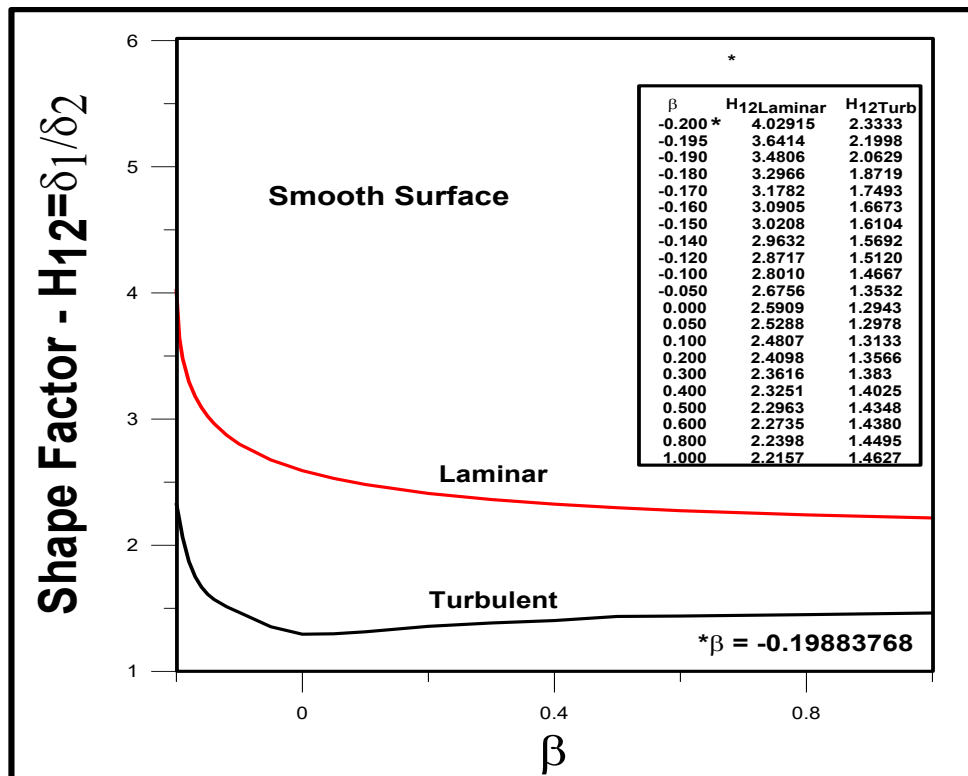
Shape Factor (H_{12}) for turbulent regimen on smooth surface



Source: The authors.

Figure 10

Shape factors (H_{12}) for laminar and turbulent regimes on smooth surfaces

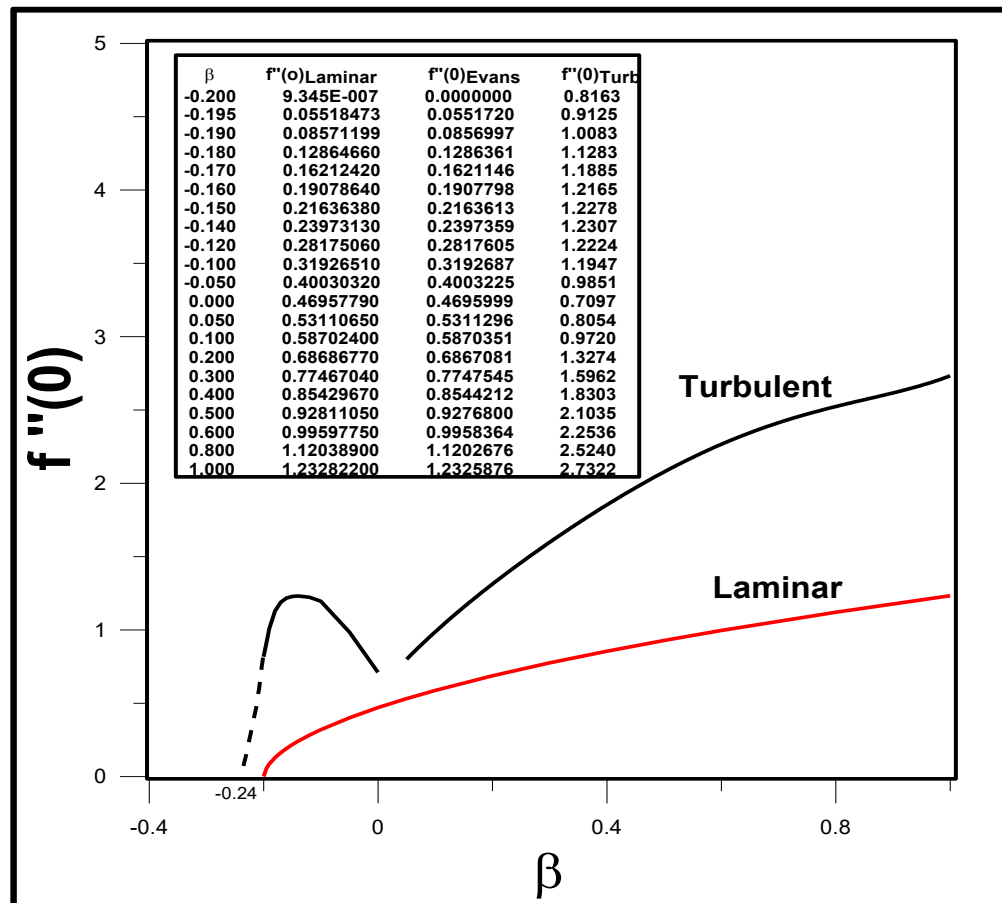


Source: The authors.

The numerical results presented through Figure 9 demonstrate that in fact this occurs. Note, Figure 10, that the smallest value for the parameter that establishes the pressure gradient is equal to $\beta = -0.19883768 \cong -0.200$, for laminar regime.

Figure 11

Dimensionless viscous surface tension (f'') for laminar and turbulent regimes



Source: The authors.

In fact, as the results of Figure 11 show, the dimensionless viscous stress passes through a local maximum point, close to $\beta = -0.2$, decreases asymptotically to approximately $\beta = -0.24$, where it becomes equal to zero, for turbulent regime on smooth surface.

3 CONCLUSIONS

The analysis, for flow and heat transfer in laminar regime and turbulent regime, on smooth and rough inclined surface, includes theoretical aspects, experimental results and empirical correlations. An extensive review of procedures associated to the boundary layer similarity method, used for solution of nonlinear equations systems, was presented.

In a turbulent regime, through the integral analysis of the momentum, the equations were first obtained for null pressure gradient and extended through a correction factor, for a wide range of the pressure gradient parameter.

The main result of the present work is associated with the fact that it is possible to obtain empirical solutions compatible with analytical solutions for laminar and turbulent flow in the whole range of values for the pressure parameter, β , considered in the analysis. This result allows us to use reliable solutions for numerous practical problems without having to solve the system of nonlinear equations, which is the main source of difficulties in the analysis performed.

As a motivation for the development of future works, it can be stated that problems associated to the determination of micrometeorological parameters, through the Monin-Obukov similarity theory, in inclined rugged surface, can be solved in an approximate way through the application of the analysis performed in this work.

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SELF-PERCEPTION OF THE IMPACT PRODUCED BY HEALTH CARE PROGRAMS AND QUALITY OF LIFE IN STUDENTS FROM 7TH GRADE OF PRIMARY EDUCATION TO 4TH GRADE OF SECONDARY EDUCATION AT LICEO ABATE MOLINA IN TALCA, CHILE

AUTOPERCEÇÃO DO IMPACTO PRODUZIDO POR PROGRAMAS DE CUIDADOS DE SAÚDE E QUALIDADE DE VIDA EM ESTUDANTES DO 7º ANO DO ENSINO FUNDAMENTAL AO 4º ANO DO ENSINO MÉDIO DO LICEU ABATE MOLINA DE TALCA, CHILE

AUTOPERCEPCIÓN DEL IMPACTO PRODUCIDO POR PROGRAMAS DE CUIDADOS DE SALUD Y CALIDAD DE VIDA EN ESTUDIANTES DE 7º AÑO DE LA ENSEÑANZA BÁSICA A 4º AÑO DE LA ENSEÑA MEDIA DEL LICEO ABATE MOLINA DE TALCA, CHILE

 <https://doi.org/10.56238/sevened2025.036-108>

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ABSTRACT

The study analyzes the perception of students at Liceo Abate Molina (LAM) in Talca, Chile, regarding the impacts that food care programs and Health and Quality of Life programs have on their daily decisions. A qualitative and descriptive methodology was used, with a cross-sectional experimental design. Descriptive frequency statistics were applied to analyze the data. The sample consisted of 833 students who responded to a survey administered in the 36 secondary education classes at the school. The analysis confirms that students recognize how adequate nutrition and physical condition influence their health and quality of life, fulfilling the objective of the study. The results show that health and quality-of-life programs generate significant impacts on self-care habits. Health education, supported by recent studies, is key to promoting healthy and sustainable lifestyles among adolescents. The biopsychosocial experience and Physical Education reinforce these habits in educational contexts. It is recommended to strengthen and expand these programs to improve student well-being and combat issues such as obesity and sedentary behavior.

Keywords: Self-perception. Programs. Health Care. Adolescents.

RESUMO

O estudo analisa a percepção dos estudantes do Liceo Abate Molina (LAM) de Talca, Chile, sobre os impactos que os programas de cuidados alimentares e de Saúde e Qualidade de Vida têm em suas decisões diárias. Utilizou-se uma metodologia qualitativa e descritiva, com um desenho experimental de corte transversal. Para analisar os dados, foram empregadas estatísticas descritivas de frequência. A amostra foi composta por 833 estudantes que

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responderam a uma pesquisa aplicada nas 36 turmas do Ensino Médio do liceu. A análise confirma que os estudantes reconhecem como uma alimentação adequada e a condição física influenciam sua saúde e qualidade de vida, cumprindo o objetivo do estudo. Os resultados evidenciam que os programas de saúde e qualidade de vida geram impactos significativos nos hábitos de autocuidado. A educação para a saúde, apoiada por estudos recentes, é fundamental para promover estilos de vida saudáveis e sustentáveis entre adolescentes. A experiência biopsicossocial e a Educação Física reforçam esses hábitos nos contextos educacionais. Recomenda-se fortalecer e ampliar esses programas para melhorar o bem-estar dos estudantes e combater problemas como obesidade e sedentarismo.

Palavras-chave: Autopercepção. Programas. Cuidados com a Saúde. Adolescentes.

RESUMEN

El estudio analiza la percepción de los estudiantes del Liceo Abate Molina (LAM) de Talca, Chile, respecto a los impactos que los programas de cuidados alimenticios y de Salud y Calidad de Vida tienen en sus decisiones diarias. Se empleó una metodología cualitativa y descriptiva, con un diseño experimental de corte transversal. Para analizar los datos se utilizó estadística descriptiva de frecuencia. La muestra estuvo compuesta por 833 estudiantes que respondieron una encuesta aplicada en los 36 cursos de Enseñanza Media del liceo. El análisis confirma que los estudiantes reconocen cómo una alimentación adecuada y la condición física influyen en su salud y calidad de vida, cumpliendo el objetivo del estudio. Los resultados evidencian que los programas de salud y calidad de vida generan impactos significativos en los hábitos de autocuidado. La educación para la salud, apoyada por estudios recientes, es clave para promover estilos de vida saludables y sostenibles en adolescentes. La experiencia biopsicossocial y la Educación Física refuerzan estos hábitos en contextos educativos. Se recomienda fortalecer y ampliar estos programas para mejorar el bienestar de los estudiantes y combatir problemas como la obesidad y sedentarismo.

Palabras clave: Autopercepción. Programas. Cuidados Hacia la Salud. Adolescentes.

1 INTRODUCTION

Historically, health care in Chile has undergone changes in its planning, implementation and application, in relation to policies for the promotion, protection and recovery of health. There is a great effort in the construction of health care models, which prioritize the improvement of the quality of life of individuals and the community (Wolff, 2022; Gutiérrez Espinoza 2021).

Chile has presented important and rapid changes in the epidemiological and nutritional profile of the population. It has gone from a situation in which there was a predominance of infectious diseases and malnutrition in the 60s to a reality with a predominance of chronic-degenerative diseases (Vio del Río, 2023; Salinas, 2006).

Chile is an urbanized country, with a situation of significant improvement in access to drinking water, sewage, education and health services. Contrary to this reality, there are currently data on deterioration of quality of life, mainly in relation to inadequate diet, sedentary lifestyle, the consumption of licit and illicit drugs, lack of space for recreation in large cities, and other social problems (Orellana, et al., 2017).

To respond to this problem, there are public policies with health promotion strategies: actions by the State, individuals, the health system and educational institutions. Traditionally, this has been done by emphasizing individuals and communities as the sole responsible parties for the various changes that need to be made in the health care process (Pérez-Wilson, et al., 2022).

Chronic non-communicable diseases symbolize the most important health expenditure for Chile. These diseases are associated with habits that usually develop prematurely in childhood or adolescence. The high rates of smoking, obesity, sedentary lifestyle, high blood pressure, diabetes, depression, suicide, traffic accidents resulting in death or disability, pathological alcohol consumption, promote a reality that these young people and children tend to be adults victimized by these habits and trends (García-Mongollón & Malagón-Sáenz, 2021).

Health education must provide subjects with the knowledge, skills and attitudes necessary for the promotion and protection of health. It also allows individuals to be trained to actively participate in defining their needs and developing proposals to achieve certain health goals. Considering the risks for the young and adolescent population, the main intervention scenarios are educational establishments (Campos Valenzuela, et al., 2023).

Taking into account these arguments, the Abate Molina High School, in the city of Talca, Chile, establishes in its Institutional Educational Project, objectives related to health education programs. Among some proposed objectives can be found the following: To permanently stimulate the student to elaborate his own life project, based on knowledge of himself and of social reality. Promote the comprehensive education of the student, which includes their spiritual, social, cognitive, artistic, technical, and physical development (Liceo Abate Molina, 2025).

It is part of the Educational Project, a whole work of educational training in systematic practice of physical activity, healthy eating, health care. Classes, studies, tests, measurements and workshops are carried out seeking to positively impact students, so that they assume the personal role of health care. One of the specific objectives, which is mentioned in the Institutional Educational Project, reads: To enable the student to participate in a physical education that is gradually appropriate to his or her level of growth, through extracurricular gymnastic activities. And in the profiles established for students, you can read: Take care of your physical and mental health (Liceo Abate Molina, 2025).

This educational process must have measurement and evaluation instruments that can verify the scope of these achievements.

At present, it has been verified that in order to achieve changes with health promotion programs, attention cannot be focused only on the exercise of community will and/or freedom. On the contrary, the way in which subjects and collectivities choose certain life options as desirable, organize their choices and create new possibilities to satisfy their needs, desires and interests, which belong to the collective order, once their construction process takes place in the context of life itself (Brazil, 2010).

It is expected, then, that health education programs establish proposals that consider actions of service, which lead the subject to have conditions to choose, to adopt healthy attitudes where they live, work or study (Brazil, 2010).

The need for information on the effectiveness of health promotion interventions is recognized and necessary. Demands for informed decisions are growing every day as a result of studies of the effectiveness, relevance and usefulness of health education programs, when institutions or companies have to establish social and educational proposals or policies (Salazar & Vélez, 2004).

Health promotion programs, like other educational strategies implemented in educational establishments, aimed at improving health, must prove the effectiveness of their

interventions, otherwise it is a proposal that loses relevance. Many of the proposals evaluate the programs based on the results of tests and physical tests, which yield results related to the physical aspects, but do not consider the conceptual and attitudinal aspects.

By determining health promotion as a formative process, of building capacity to protect and maintain a healthy life, it can be understood that the evaluation should not only focus on physical development, but also on the integral evolution of this process in its effects on the health, well-being and behavior of the subject with his or her care. in positive changes generated from having participated in this training process (Salazar & Vélez, 2004).

Therefore, the collection of concrete data and evidence to assess the outcome of these health promotion programs remains a challenging task. Behavioral changes are complex phenomena and must be evaluated in various aspects.

2 OBJECTIVE

To analyze the perception of the students of the Abate Molina High School (LAM), Talca, Chile, in relation to the impacts produced in their daily decisions by food care programs and Health and Quality of Life.

3 METHODOLOGY

Qualitative, Descriptive study, cross-sectional experimental design and used descriptive statistics of frequency to present the results. The universe consists of 2,367 students from the Abate Molina High School in the commune of Talca, Maule Region, The population is mainly centered on 1,620 students from 1st to 4th years of Secondary Education, with a corresponding sample of 833 students who responded to the survey applied in the 36 courses of Secondary Education of this educational unit.

The inclusion criteria are: to be a student regularly enrolled in the Abate Molina High School; answer the survey on Self-Perception of Impacts produced by Health Care and Quality of Life programs; be present at the Lyceum, on the day and time of the application of the survey for their course; having participated in the training programs towards health care, developed in the Pedagogical Model of the Abate Molina High School; be able to answer the survey; answer the survey as requested in the instrument.

According to the ethical terms of the study, the following points were defined:

1. Informed consent to Head of the Technical-Pedagogical Unit and Director of the Department of Physical Education of the Abate Molina High School, Talca.

2. Application of a Self-Perception Survey of Impacts produced by Health Care and Quality of Life programs.
3. Participation is voluntary and each subject has the right to refrain from answering the survey when they deem appropriate.
4. All information on the application of the survey and the development of the study will be available to the Educational Establishment.
5. All work carried out, as well as the results obtained, may be used in scientific articles, presentations at congresses and in meetings or reports, both national and international.
6. The research proposal may be used as pedagogical material in the career of pedagogy in physical education and related areas of the Autonomous University and other Universities
7. The research will be documented with a written record, a copy of which will be kept in the Educational Establishment in which it was carried out.
8. The participants of the research will remain anonymous.

The data collection instrument went through a validation process by experts (Hernández Sampieri, et al., 2014). It was decided to name it as "Survey of Self-Perception of Impacts produced by Health Care and Quality of Life programs", which consists of 12 closed questions, with answers on a Likert-type scale, for which the subjects must mark the alternative that corresponds to their perception, and whose basic purpose is to verify what impacts are caused by education programs in relation to health care and quality of life. produce in the students of the Lyceum.

Instrument:

Survey of Self-Perception of Impacts Produced by Health Care and Quality of Life Programs

Based on the health and quality of life programs in which you as a student have participated (nutritional surveys, physical tests or anthropometric measurements).

It is of utmost importance that you answer each question with complete honesty.

Name: _____ Age: _____

Course: _____ Gender: M () F ()

() I agree to participate in the study by providing information regarding my health and quality of life. Signature: _____

Table 1

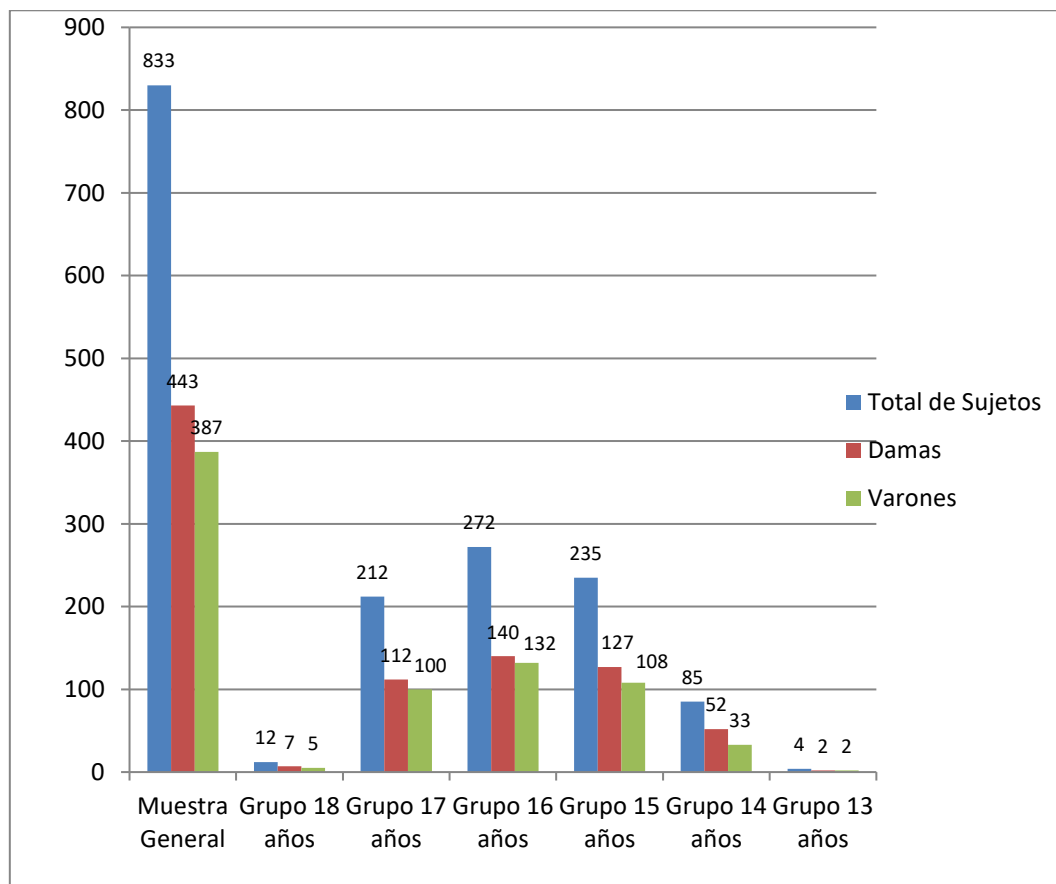
Check the alternative that corresponds to your perception, from the moment you are aware of how your health indicators are.	Strongly	Disagree	Und	I	Stro	Tota
1. Knowing that my eating behavior is appropriate (eating) motivates me to take care of my health and maintain my quality of life.	1	2				
2. Knowing that my eating behavior (eating) is not adequate for maintaining my health made me decide to make changes to improve my quality of life.	1	2				
3. Knowing that the consumption of foods rich in fat in my eating behavior (eating) is within the appropriate patterns, motivates me to take care of my health and maintain my quality of life.	1	2				
4. Knowing that the consumption of foods rich in fat in my eating behavior (eating) is a risk to my health, made me decide to make changes to improve my quality of life.	1	2				
5. Knowing that the consumption of foods rich in fiber in my eating behavior (eating) is within the appropriate patterns, motivates me to take care of my health and maintain my quality of life.	1	2				
6. Knowing that the consumption of foods rich in fiber in my eating behavior (eating) is a risk to my health, made me decide to make changes to improve my quality of life.	1	2				
7. Knowing that my physical condition is within the right patterns motivates me to take care of my health and maintain my quality of life.	1	2				
8. Knowing that my physical condition is a risk to my health, made me decide to make changes to improve my quality of life.	1	2				
9. Knowing that my time of physical activity is within the right patterns, motivates me to take care of my health and maintain my quality of life.	1	2				
10. Knowing that my time of physical activity is a risk to my health, made me decide to make changes to improve my quality of life.	1	2				
11. Knowing that the health indicators – diet, physical condition, time of physical activity – are within the appropriate patterns, motivates me to take care of my health and maintain my quality of life.	1	2				
12. Knowing that the health indicators – diet, physical condition, time of physical activity – made me decide to make changes to improve my quality of life.	1	2				
	Total Score					

4 RESULTS

The data obtained in the study were expressed through bar graphs, in which it was possible to interpret the information collected; According to the evaluation instrument chosen, the variables of age, sex and impact were analyzed.

Figure 1

Total, of the sample surveyed by age group



In this graph you can see the total sample of 833 subjects, 443 Ladies and 387 Men equivalent to 53.3% and 46.7% respectively of the total, in turn the age by category and the number of individuals according to their sex are evidenced.

The total of 13-year-old subjects is 4 members, 2 Girls and 2 Men which is equivalent to 0.5% of the total sample, the 14-year-old subjects 85 members, 52 women and 33 men which is equivalent to 10.2% in total of the sample, The 15-year-old category is 235 members, 127 women and 108 men, which is equivalent to 28.3% of the total sample. The 16-year-old subjects are 272, 140 females and 132 males which is equivalent to 32.7% of the total sample, the 17-year-old subjects the subject number is 212 members, 112 females and 100

males which is equivalent to 25.5% of the total sample and the 18-year-old subjects are 12 members. 7 women and 5 men, which is equivalent to 1.4% of the total sample.

Figure 2

General Impact Sample according to the age group of the respondents

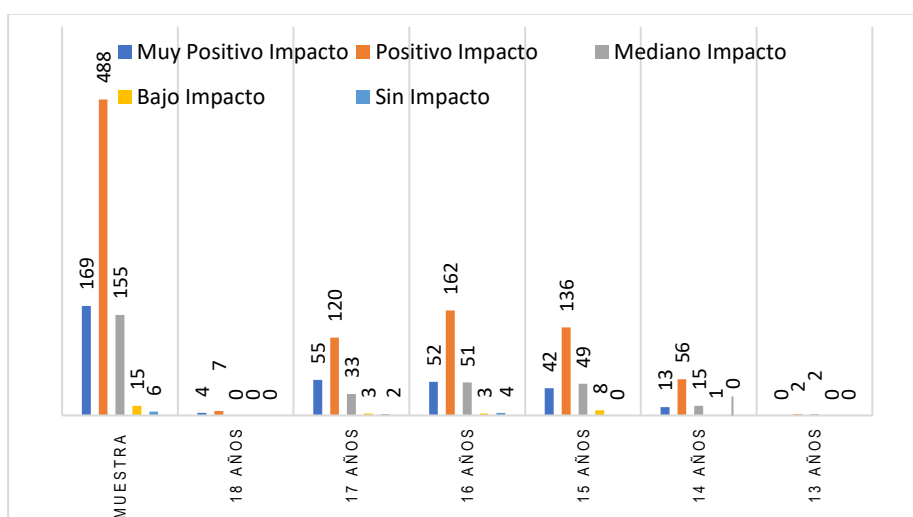


Figure 2 shows that the general sample, 169 subjects, 20.3% of the total has a Very Positive Impact, 488 subjects, 58.7% of the total has a Positive Impact, 155 subjects, 18.6% of the total has a Medium Impact, 15 subjects, 1.8% of the total, have Low Impact and 6 subjects have No Impact, which is equivalent to 0.7% of the total sample.

According to the interpretation in this graph, it can be observed that the 13-year-old subjects, no subject presented Very Positive Impact, 2 subjects manifested Positive Impact, 2 subjects presented Medium Impact and there was no subject who exposed Low Impact and No Impact, The 14-year-old group, 13 subjects presented Very Positive Impact, 56 subjects presented Positive Impact, 15 subjects obtained Medium Impact, 1 subject discloses Low Impact and there was no subject No Impact, The 15-year-old subjects, 42 subjects presented a very positive impact, 136 subjects manifested Positive Impact, 49 subjects expressed Medium Impact, 8 subjects presented Low Impact and there was no No Impact subject. The 52 16-year-old subjects presented Very Positive Impact, 162 subjects obtained Positive Impact, 51 subjects manifested Medium Impact, 3 subjects presented Low Impact and 4 subjects presented No Impact, In the 17-year-old group, 55 subjects exhibited Very Positive Impact, 120 subjects presented Positive Impact, 33 subjects OBTAINED Medium Impact, 3 subjects presented Low Impact and 2 subjects presented No Impact, The 18-year-old group,

4 subjects manifested Very Positive Impact, 7 subjects presented Positive Impact, there was no subject in the sample with Medium Impact, Low Impact and No Impact.

Table 2

Impact produced on the total sample of men, women and general according to age range

Group	Very positive impact	Positive Impact	Medium Impact	Low Impact	No Impact
13 Year Old Ladies	0,00%	50,00%	50,00%	0,00%	0,00%
13 years General	0,00%	50,00%	50,00%	0,00%	0,00%
13 years old Males	0,00%	50,00%	50,00%	0,00%	0,00%
14 Year Old Ladies	17,30%	61,53%	19,23%	1,92%	0,00%
14 years General	15,29%	65,88%	17,64%	1,17%	0,00%
14 years old Males	12,12%	72,72%	15,15%	0,00%	0,00%
15 Year Old Ladies	13,38%	65,35%	19,68%	1,57%	0,00%
15 years General	17,87%	57,87%	20,85%	3,40%	0,00%
15 years old Males	23,14%	49,07%	22,22%	5,55%	0,00%
16 Year Old Ladies	14,28%	62,14%	21,42%	0,71%	1,42%
16 years General	19,11%	59,55%	18,75%	1,10%	1,47%
16 years old Males	24,24%	56,81%	15,90%	1,51%	1,51%
17 Year Old Ladies	20,53%	60,71%	15,17%	1,78%	1,78%
17 years General	25,47%	56,60%	15,56%	1,41%	0,94%
17 years old Males	31,00%	52,00%	16,00%	1,00%	0,00%
18 Year Old Ladies	28,57%	71,43%	0,00%	0,00%	0,00%
18 years General	36,36%	63,63%	0,00%	0,00%	0,00%
18 years old Boys	50,00%	50,00%	0,00%	0,00%	0,00%

It is observed that the 13-year-old male subjects, 0% presented Very Positive Impact, 50% manifested Positive Impact, 50% Medium Impact and 0% of the subjects presented Low Impact and No Impact. As for the Ladies, 0% presented Very Positive Impact, 50% of the subjects presented Positive Impact, 50% of the subjects presented Medium Impact and 0% of the subjects with a Low Impact and No Impact, In general, the subjects of 13 years of age, Men and Ladies show 50% Positive Impact and 50% Medium Impact.

In the group of 14-year-old male subjects, 12.12% had a Very Positive Impact, 72.72% of the subjects had a Positive Impact, 15.15% of them had a Medium Impact, 0% had a Low Impact and No Impact. As for the women, 15.29% Very Positive Impact, 65.88% had Positive

Impact, 17.64% had Medium Impact, 1.92% had Low Impact and 0% No Impact, In general, 14-year-old Male and Female subjects showed 15.29% Very Positive Impact, 65.88% Positive Impact, 17.64% Medium Impact, 1.17% Low Impact and 0% No Impact.

In the group of 15-year-old male subjects, 23.14% had a Very Positive Impact, 49.07% had a Positive Impact, 22.22% had a Medium Impact, 5.55% had a Low Impact and 0% had no impact. As for the women, 13.36% showed Very Positive Impact, 65.35% obtained Positive Impact, 19.68% manifested Medium Impact, 1.37% Low Impact and 0% of the subjects presented No Impact. In general, of the 15-year-old subjects, 17.88% showed a Very Positive Impact, 57.87% showed a Positive Impact, 20.85% had a Medium Impact, 3.40% had a Low Impact and 0% had No Impact.

In the group of 16-year-old male subjects, 24.24% had a Very Positive Impact, 56.81% had a Positive Impact, 15.90% had a Medium Impact, 1.51% had a Low Impact and 1.51% had No Impact. As for the Ladies, 14.28% had a Very Positive Impact, 62.14% had a Positive Impact, 21.42% had a Medium Impact, 0.71% had a Low Impact and 1.42% had No Impact. In general, of the subjects with 16 years of age between Males and Females, they showed the following data: 19.11% Very Positive Impact, 59.55% Positive Impact, 18.75% Medium Impact, 1.10% Low Impact and 1.47% No Impact.

In the group of 17-year-old male subjects, 31% had a very positive impact, 52% had a positive impact, 16% had a medium impact, 1% had a low impact and 0% had no impact. Meanwhile, the Ladies presented 20.53% of Very Positive Impact, 60.71% manifested Positive Impact, 15.17% obtained Medium Impact, 1.78% presented Low Impact and 1.78% manifested No Impact. In general, of the subjects with 17 years of age between males and females, the following data were obtained: 24.47% Very Positive Impact, 56.60% Positive Impact, 15.56% Medium Impact, 1.41% Low Impact, and 1.78% Present No Impact.

The group of 18-year-old male subjects had a 50% Very Positive Impact, 50% Positive Impact, 0% of the subjects had a Medium Impact, Low Impact and No Impact. As for the women, 28.57% obtained Very Positive Impact, 71.43% manifested Positive Impact, 0% obtained Medium Impact, Low Impact and No Impact. In general, the Ladies and men of 18 years of age showed the following data, 36.36% Very Positive Impact, 63.63% Positive Impact, 0% Medium Impact, Low Impact and No Impact.

The analysis of the table on the impact of educational programs on the eating, health care, and lifestyle behavior of school adolescents shows several key trends.

Distribution of Impact by Age and Sex indicates that in general, the positive impact (very positive + positive) is greater in adolescents aged 15 to 18 years, with values ranging from approximately 70% to 100% in some groups. That adolescent girls (females) tend to show a slightly higher positive impact than boys at various ages, especially at 15 and 17 years old. At younger ages (13 and 14 years old), the positive impact is variable and in some cases less, although it still predominates over low or no impact impacts.

For Very Positive and Positive Impact, the "Very Positive Impact" category shows notable increases with age, especially in the 17 and 18 age groups (both girls and boys). Most of the groups have a high percentage of "Positive Impact", generally between 50% and 70%, indicating that the programs generate favorable changes in the majority of adolescents.

When looking at the Medium, Low and No Impact Impact, the "Medium Impact" category is observed with varied values, more present in the 13 to 15 age groups, decreasing for older ages. The percentages of "Low Impact" are low overall, with some minimal peaks between 1% and 5%, suggesting a good overall efficacy of the interventions. "No Impact" is recorded in most groups, only some marginal cases, which confirms the effectiveness of the programs on perception and behavior studied.

The results of the data analysis establish that the Health and Quality of Life programs used at the Abate Molina High School, in the city of Talca, Maule Region, do generate a positive impact on the self-perception that students have regarding the programs of the establishment and on their daily eating and physical activity habits. this evidenced in the high percentages of very positive and positive impact shown in the applied surveys.

According to the results obtained, males perceive more impact than females in all age ranges, and in turn the highest percentage of positive impact was obtained between 16 and 18 years of age, from this result we can infer that perhaps this is due to the fact that students in these ages have been part of these programs for longer than students from 13 to 15 years of age and therefore therefore, there has been a change in their eating behaviors and physical activity levels.

A study conducted by Pérez Rubio, et al. (2023) also found that educational interventions in the area of health care improve the health profile of adolescents. It also ratifies the results of this study, finding that there are differences by sex, with higher scores in men.

With these analyses, it is confirmed that the students are able to know that the appropriate behavior of their diet and physical condition affects their Health and Quality of

Life, and in turn responds to the objective of the study, since it was possible to analyze the perception that LAM students have, in relation to the impacts produced by health care and quality of life programs.

Thus, the importance of health care and quality of life programs used by some establishments can be discussed, since, as reflected in this study, these programs achieve relevant impacts on the quality of life care of students.

Evidence indicates that health education could have an important impact on the expansion of the system of activities and communicative interactions of adolescents, favoring self-care habits; therefore, it is verified that the application of comprehensive educational strategies can be key to promoting healthy and lasting lifestyles in the adolescent group, confirmed by Parra, et al. (2025). Adding what Amador Romero, et al. (2025) cite, that knowledge about the importance of these habits is essential for health care.

The same idea is presented by Barilla (2024) who in his study concludes that biopsychosocial experiences are essential to strengthen healthy lifestyles within the educational community. And that Physical Education plays a key role in promoting healthy habits by creating environments that favor physical activity and comprehensive well-being. The variety of approaches to health and well-being highlights the need to address them holistically, taking into account particular cultural and social contexts. At the LAM, the proposals come from the Department of Physical Education, which is ratified by them results of the study by Barilla (2024) cited.

It is considered that using these programs in the largest number of educational centers can contribute to improving the quality of life of many students in the country, thus interfering with the high rates of sedentary lifestyle, obesity and cardiovascular diseases that today affect students in Chile.

It is important to complement this idea with the result of a study by Madrid Carrillo (2025) that points out that educational intervention proves to be an effective strategy to positively influence the eating habits and lifestyles of adolescents, although it is necessary to strengthen and maintain this type of program in the school environment to achieve sustainable changes.

The educational programs proved to have a considerable positive effect on the majority of students, improving eating habits and lifestyles. There is a clear tendency for the impact to increase with age, possibly because older adolescents better internalize the proposed messages and changes.

It is recommended to continue and strengthen these programs, adjusting them to better engage younger adolescents and adolescents of both sexes, to maximize effectiveness from early stages.

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METHODOLOGY FOR THE ARCHITECTURAL DESIGN OF A SOCIAL ASSISTANCE CENTER

METODOLOGIA PARA O PROJETO ARQUITETÔNICO DE UM CENTRO DE ASSISTÊNCIA SOCIAL

METODOLOGÍA PARA EL DISEÑO ARQUITECTÓNICO DE UN CENTRO DE ASISTENCIA SOCIAL

 <https://doi.org/10.56238/sevened2025.036-109>

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ABSTRACT

Urban facilities are the set of buildings and installations that house services aimed at meeting the basic needs of a population. They are architectural complexes designed and built in the fields of health, education, commerce, administrative and financial activities, security, recreational activities, social assistance, among others. The architectural projection of urban facilities requires the integration of a methodology that considers the social context, emerging issues, environmental conditions, and other elements, which results in a good architectural project and the evolution of the traditional way of integrating spatial design. In the academic training context, seventh-semester students (class of 2024A) of the Design Engineering program at the Technological University of the Mixteca, through the course Architectural Project II and guided by the course's main instructor and first author of this article, developed a Methodology for the Design of a Social Assistance Center. This center was planned for a medium-sized city (Huajuapán de León, Oaxaca – 75,000 inhabitants), integrating nine architectural design proposals for Social Assistance Centers, considering the basic and emerging needs of the various social groups to be served, and incorporating design aspects such as the natural and built environment, architectural style, and design concept, linking and reinforcing it with the creative diversity of each working team.

Keywords: Methodology. Design. Process. Architecture.

RESUMO

O equipamento urbano é o conjunto de edifícios e instalações que abrigam os serviços destinados ao atendimento das necessidades básicas de uma população; são complexos arquitetônicos projetados e construídos nos âmbitos da saúde, educação, comércio, atividades administrativas e financeiras, segurança, atividades recreativas, assistência social, entre outros. A projeção arquitetônica do equipamento urbano requer a integração de uma metodologia que considere o contexto social, a problemática emergente, as condições ambientais, entre outros fatores, o que possibilita a elaboração de um bom projeto arquitetônico e a evolução da forma tradicional de integrar o design espacial. No âmbito da formação acadêmica, os alunos do sétimo semestre (geração 2024A) do curso de

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Engenharia em Design da Universidade Tecnológica da Mixteca, por meio da disciplina Projeto Arquitetônico II e orientados pela professora responsável pela disciplina e primeira autora deste artigo, desenvolveram uma Metodologia para o Design de um Centro de Assistência Social. O centro foi planejado para uma cidade de médio porte (Huajuapán de León, Oaxaca – 75.000 habitantes), integrando nove propostas de design arquitetônico de Centros de Assistência Social, considerando as necessidades básicas e emergentes dos diferentes grupos sociais a serem atendidos e contemplando aspectos do design como o meio físico natural e artificial, o estilo arquitetônico e o conceito de design, vinculando e fortalecendo esses elementos com a diversidade criativa de cada equipe de trabalho.

Palavras-chave: Metodologia. Design. Processo. Arquitetura.

RESUMEN

El equipamiento urbano es el conjunto de edificios e instalaciones en las que se albergan los servicios para la atención de las necesidades básicas de una población, son complejos arquitectónicos que se diseñan y construyen en el ámbito de la salud, la educación, el comercio, las actividades administrativas y financieras, la seguridad, las actividades recreativas, la atención social, entre otras. La proyección arquitectónica del equipamiento urbano requiere de la integración de una metodología en la cual se considere el contexto social, la problemática emergente, las condiciones medio ambientales, entre otros, lo cual genera un buen proyecto arquitectónico y la evolución en la tradicional forma de integrar el diseño espacial. En el ámbito de la formación académica los alumnos de la carrera de Ingeniería en Diseño de la Universidad Tecnológica de la Mixteca de séptimo semestre generación 2024A, a través de la materia de Proyecto Arquitectónico II y guiados por la profesora titular de la materia y primera autora del presente artículo, conformaron una Metodología para el diseño de un Centro de Asistencia Social, el cual fue emplazado en una ciudad de tamaño medio (Huajuapán de León, Oaxaca - 75,000 hab), integrando nueve propuestas de diseño arquitectónico de Centros de Asistencia Social considerando las necesidades básicas y emergentes de los diversos grupos sociales a atender y contemplando ámbitos del diseño como el medio físico natural y artificial, el estilo arquitectónico y el concepto de diseño, vinculándolo y fortaleciéndolo con la diversidad creativa de cada equipo de trabajo.

Palabras clave: Metodología. Diseño. Proceso. Arquitectura.

1 INTRODUCTION

The twenty-first century is present in the architectural design of urban equipment, considering it as a process that seeks to homogenize society, allowing the satisfaction of individual needs, but allowing architectural design to be made of universal knowledge and appropriation, attending to particular needs without ceasing to meet the needs of the system.

Urban equipment is the set of buildings and facilities in which activities and services are housed to meet the basic needs of the rural and/or urban population, they are architectural complexes that are designed and built in the field of health, education, commerce, administrative and financial activities, security, recreational activities, social care, among others.

The architectural projection of urban equipment requires the application of a methodology in which the analysis of the urban context, the social context, the emerging problems and environmental conditions, among others, is considered, which brings with it the integration of a good result and the evolution in the traditional way of integrating architectural projects.

In the field of the academic training of Design Engineers, a Methodology was formed for the realization of the architectural project of a Social Assistance Center, which became a systemic work that instructed future designers in the analysis of the geographical context in a medium-sized city (75,000 inhabitants), in the consideration of the basic and emerging needs of the various social groups to be served and in the application of the of design areas such as the natural and artificial physical environment, the architectural style and the design concept, linking and strengthening with the creative diversity of each work team.

The consideration of the natural and artificial physical environment is a field of study that has been evolving in the design of architectural space, with increasing presence in the different stages of the methodology, however it has been a challenge for design professionals to stop considering it as a trend and induce it as a fundamental part of the methodology for the design of any architectural complex. which must satisfy the needs of the environment of a demanding society. Sánchez-Platas, L., Sánchez-Luqueño, J. (2016)

One of the fundamental aspects when addressing a Methodology for the design of the architectural space is the consideration of the Social Framework of the Architectural Framework, a situation that instructed the students of the architectural project to strengthen the processes of social research through observation, surveys, questionnaires and interviews, allowing the identification of the latent social problem, recognizing the different

target groups to be served, the diversity of needs, varieties, ages, genders, requirements, services and care among many others. Sánchez Platas, L. E, Hernández García, A. S., Sánchez Luqueño, J., Velarde Galván, A., Cruz Martínez, V. M. (2019)

Social inclusion is present in the design of an Assistance Center, also aiming to enhance the skill, opportunity and dignity of people who are disadvantaged due to their situation as users of the Center. An example of social inclusion was the consideration of the various target groups or users in the design and integration of a Social Assistance Center (migrants, people with addiction problems, alcoholics, people in street situations, people who have been abused, displaced persons, etc.).

Architectural projects such as a Social Assistance Center contemplate, in addition to the spaces that allow them to satisfy the basic needs of users, a research commitment for designers to identify the complementary needs of the various by target group.

The popular economy is a variable that is directly linked to social inclusion and that is indirectly linked to the architectural design of a Social Assistance Center, since it allowed considering the housing needs and overnight stays of various merchants in transit, which are frequent in medium-sized cities, who travel from distant towns and ranches to sell their products in municipal and/or district capitals and at least having relatives or not having the economic solvency and not intending to spend the little profit from the sale of their products, they do not rent lodging, causing them to spend the night in parks, gardens and portals, having to take care of their companions, their merchandise and themselves, enduring the inclement weather, in addition to the discomfort of the place.

For this reason, the process of designing an architectural project such as a Social Assistance Center made it possible to configure a methodology that involves new stages of study and research, systemic analysis, various areas of study of architecture, social studies, attention to basic housing aspects, attention to complementary aspects of populations in transit and variables typical of a dynamic society. allowing the generation of nine architectural preliminary projects as a result of the work of the students of Design Engineering, advised by the first author of this article, who addressed various problems seeking to improve the conditions of urban equipment for social welfare.

2 MATERIALS AND METHODS

The students of the Design Engineering career of the Technological University of the Mixteca of the seventh semester generation 2024A, through the subject of Architectural

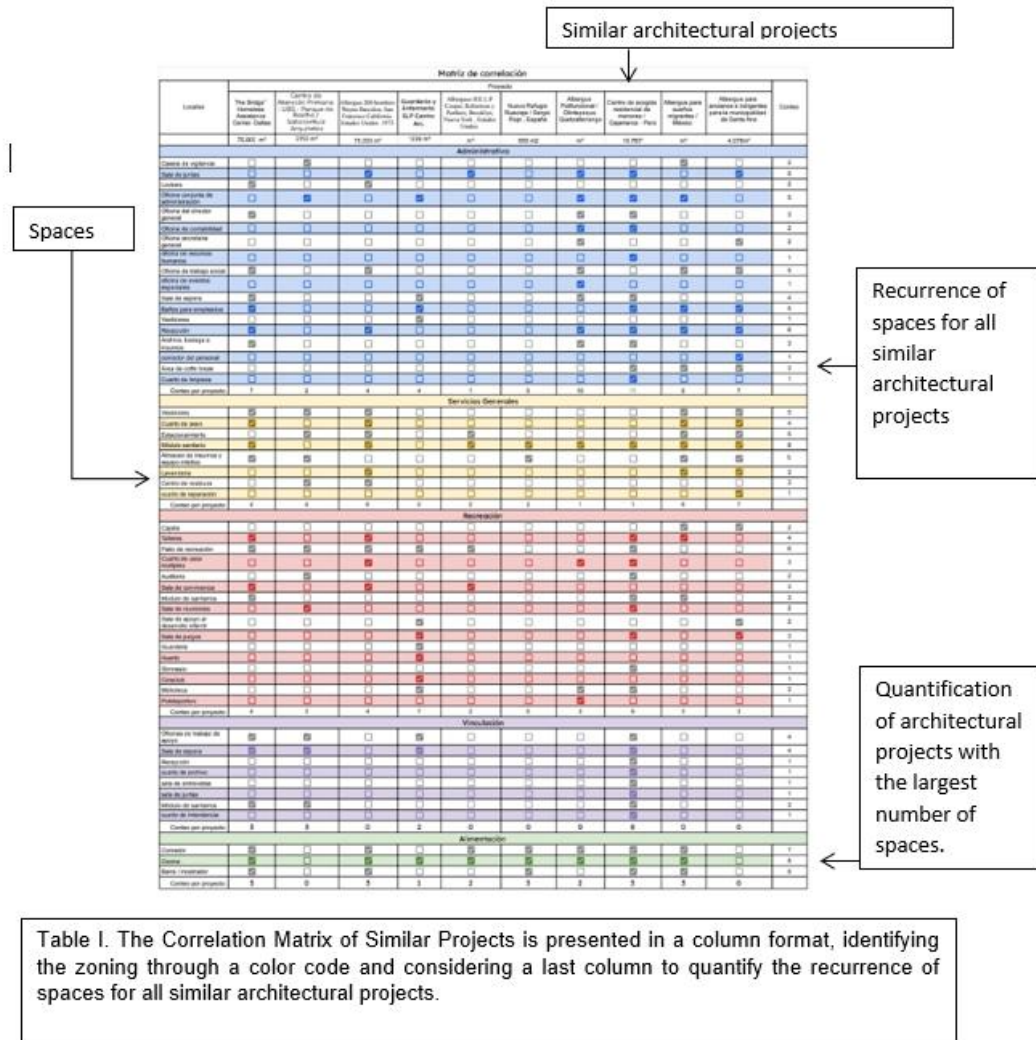
Project II and guided by the professor of the subject and first author of this article, formed a Methodology for the design of a Social Assistance Center, which was located in a medium-sized city (Huajuapán de León, Oaxaca - 75,000 inhabitants), integrating nine architectural design proposals for Social Assistance Centers that meet the needs of various groups of users and link areas of design study.

One of the first stages of the process for the design of the Social Assistance Center is to integrate a correlation matrix of similar projects, which is a tool that allows evaluating the linear relationship of two variables, in addition to strengthening the bases of the architectural project to be conceived later. Hernández García, A. S. (2019)

The Correlation Matrix of Similar Projects (Table 1) is integrated from the identification and review of architectural projects similar to the project to be developed, conceived at the national and international level, indicating through a symbol the absence or presence of the list of spaces, a list that arises from the same similar projects. The matrix is organized simultaneously, zoning the spaces and hierarchizing the spaces based on the most recurrent. This also allows the value of the less recurrent spaces for the project to be conceived to be analyzed. The projects with the largest number of spaces and areas are identified and finally the program of needs of the project to be generated is based. Plazola Cisneros, A. (1992b).

Table 1

Correlation matrix of similar projects



Another of the fundamental stages in the process of designing a Social Assistance Center was the integration of a Program of Needs (Table 2), which is an analysis and synthesis of the basic needs to be met and the specific activities of the various users of the architectural complex, which will determine in each row the architectural space that will allow the need to be satisfied. the activities and outline the required furniture. It is important to note that one of the particular contributions of the methodology is the evaluation and confirmation of the zoning in the needs program (based on the correlation matrix of similar projects), which optimizes the subsequent stages. Plazola Cisneros, A. (1992a).

Table 2

Program of Needs

7. PROGRAMA DE NECESIDADES

ZONA	NECESIDADES	ACTIVIDADES	ESPACIOS	MOBILIARIO
UBICADO EN PUNTOS ESTRATÉGICOS ENTRE ZONAS	Necesidades Fisiológicas	Lavarse las manos -Ducharse	Modulo de baños	-W.C. -Lavabo
ZONA DE RECEPCIÓN	Acceder y salir	Selección de empleados		-Evaluación de perfiles -Capacitar -Reentrenar
		Control de ingresos		-Depositar -Cuentar ingresos -Recibir ingresos -Almacenar -Verificar de recibos -Almacenar recibos -Verificar -Recibir alimentos
	Estacionarse	Preparar -Producción -Cargar materia -Cocinar -Comensar -Alimentar -Servir -Entregar -Almacenar	Cocina	-Bodega de insumos -Área de almacenamiento -Área de i
		Lavar trastes -Lavar -Lavavajillas de limpieza -Almacenar -Recibir -Recibir productos -Cargar productos de limpieza	Patio de s	Cuero d
		Comer		Cocina
		Servir alimentos -Recibir alimentos -Recibir alimentos de cocina -Verificar -Depositar -Servir -Almacenar	Área de	Área de
		Cocinar		Área de
		Cocinar		Área de
	Administración	Cocinar		Área de
		Cocinar		Área de
ZONA DE SERVICIOS GENERALES	Coordinar actividades	Cocinar		Área de
		Cocinar		Área de
	Coordinar actividades	Cocinar		Área de
		Cocinar		Área de
	Coordinar actividades	Cocinar		Área de
		Cocinar		Área de
	Coordinar actividades	Cocinar		Área de
		Cocinar		Área de
	Coordinar actividades	Cocinar		Área de
		Cocinar		Área de
ZONA DE VINCULACIÓN	Coordinar actividades	Cocinar		Área de
		Cocinar		Área de
	Coordinar actividades	Cocinar		Área de
		Cocinar		Área de
	Coordinar actividades	Cocinar		Área de
		Cocinar		Área de
	Coordinar actividades	Cocinar		Área de
		Cocinar		Área de
	Coordinar actividades	Cocinar		Área de
		Cocinar		Área de
ZONA DE RESIDENCIA	Coordinar actividades	Cocinar		Área de
		Cocinar		Área de
	Coordinar actividades	Cocinar		Área de
		Cocinar		Área de
	Coordinar actividades	Cocinar		Área de
		Cocinar		Área de
	Coordinar actividades	Cocinar		Área de
		Cocinar		Área de
	Coordinar actividades	Cocinar		Área de
		Cocinar		Área de

Table II. The Program of Needs is presented in a column format establishing the main need, the secondary activity(s), the space, the furniture and using a color code by area which is recommended to be maintained as an element of identification throughout the methodology.

Another key stage in the design process of the Social Assistance Center was the Architectural Program (Table 3), which quantifies each of the spaces of the architectural complex by square meters (m²), by zones and consequently allows determining the total m² of the architectural complex, it is important to note that this phase of the design process is based on the stages prior to the project: research, review of user activities, user organization chart, study of minimum areas, etc. Plazola Cisneros, A. (1992a).

Table 3

Architectural Program

ZONA	ESPACIOS	M ²			M ² Zona
Acceso	Recepción/ Sala de espera	31 m ²			41 m ²
	Área de lockers	10 m ²			
Administrativa	Oficina de contabilidad	12 m ²			84.33 m ²
	Oficina recursos humanos	12 m ²			
	Cuarto de archivos	10.4 m ²			
	Administración	12 m ²			
	Módulo de baño	Hombres 20.83 m ²	Mujeres 17.1 m ²	Inclusivo 20.83 m ²	
Comunitaria	2 Terraza	12 m ²			64 m ²
	Biblioteca	12 m ²			
	2 Aulas de usos múltiples	80 m ²			
Alimentación	Cocina	25 m ²			104.2 m ²
	Comedor	70.20 m ²			
	Bodega	9 m ²			
Servicios generales	Oficina de personal de seguridad	12 m ²			111.25 m ²
	Oficina de gerente de servicios generales	12 m ²			
	Oficina de gerente limpieza	12 m ²			
	Cubículo de administrador de lavandería	8.25 m ²			
	Bodega/almacén	49 m ²			
	Cuarto de lavado	18 m ²			
Atención médica	Área de camillas	30.4 m ²			122.415 m ²
	Recepción / Sala de espera	31 m ²			
	Consultorio de primeros auxilios	18.92 m ²			
	Consultorio de atención médica	18.92 m ²			
	Consultorio de psicología	18.92 m ²			
	Baño completo	4.255			
	Terraza	63 m ²			
		36 m ²			
Vinculación y canalización	3 Oficina	36 m ²			61.54 m ²
	Terraza	26.68 m ²			
	Módulo de baño	Hombres 20.83 m ²	Mujeres 17.1 m ²	Inclusivo 20.83 m ²	
Residencial	3 Dormitorios	271.2 m ²			364.84 m ²
	Área de lavado/ Tendido	30.6 m ²			
	Módulo	Mujeres 37.53 m ²	Hombres 41.11 m ²	Inclusivo 41.11 m ²	
	Sanitario/Regaderas/Vestidores				
Religiosa	Santuario	16 m ²			16 m ²
Carga y descarga	Caseta de vigilancia con módulo sanitario	6.25 m ²			6.24 m ²
Total, de metros cuadrados					1015.815 m²

Table III. The Architectural Program is integrated by a format of columns and color coding that allows the information to be organized and effectively prepared for subsequent stages.

Another of the indispensable stages of the architectural design process of the Social Assistance Center and which is generally not considered in the traditional methodologies of design of the architectural space is the Analysis of the Physical Environment which is subdivided into Natural and Artificial and its radius of action is at the district level and/or at the city level. both analyses allow us to evaluate the characteristics of the natural and urban context in which the architectural complex will be located (Table 4).

In the first instance, and with the support of the Correlation Matrix tool, the parameters that will make it possible to evaluate the most pertinent characteristics of the natural and artificial physical environment in which the project will be located are integrated, through a descriptive value scale and evaluation process, it was possible to determine the optimal

property in the field of the natural and artificial physical environment for the Social Assistance Center (Table 4).

Table 4

Correlation matrix for the evaluation of the natural and artificial physical environment.

4.- Evaluación y selección de predio

Predio 1 colonia Fidepal			
Parámetros	Ponderación		
	3	2	1
Potencial desarrollo urbano (casas y comercios)	Alto Potencial	Medio Potencial	Lento Potencial
Pendiente	2% a 10%	15% a 25%	30% a más
Proximidad al centro de Huajuapán	0 a 2 km	2 a 5 km	5 km o más
Accesibilidad vehicular	Fácil acceso	Mediana accesibilidad	Inaccesible
Servicios			
• Agua potable	3 servicios	2 servicios	1 servicios
• Energía eléctrica			
• Drenaje			
Calidad de suelo (Densidad aparente)	Suelo mixto	Suelo rocoso	Suelo fértil
Nivel de seguridad de la ubicación de la propiedad (Cuenta con: -Casetas de vigilancia -Rondines)	2 servicios	1 servicio	Ninguno
Contaminación (olfativa y ambiental)	Ningún tipo	1 tipo	2 tipos
Forma del predio	Regular	Irregular	Complejo
Orientación (asoleamiento y vientos)	Favorable	Medio favorable	No favorable
Posibles inundaciones	Baja o nula probabilidad de inundaciones	Mediana probabilidad de inundaciones	Propenso a inundaciones
Permite el aprovechamiento del paisaje	Permite el aprovechamiento del paisaje	Paisaje limitado	Nulo paisaje
Pavimento	Validad de concreto / asfalto		Terracería
Total	28		

Predio 2 Fraccionamiento Jardines del sur			
Parámetros	Ponderación		
	3	2	1
Potencial desarrollo urbano (casas y comercios)	Alto Potencial	Medio Potencial	Lento Potencial
Pendiente	2% a 10%	15% a 25%	30% a más
Proximidad al centro de Huajuapán	0 a 2 km	2 a 5 km	5 km o más
Accesibilidad vehicular	Fácil acceso	Mediana accesibilidad	Inaccesible
Servicios			
• Agua potable	3 servicios	2 servicios	1 servicios
• Energía eléctrica			
• Drenaje			
Calidad de suelo (Densidad aparente)	Suelo mixto	Suelo rocoso	Suelo fértil
Nivel de seguridad de la ubicación de la propiedad (Cuenta con: -Casetas de vigilancia -Rondines)	2 servicios	1 servicio	Ninguno
Contaminación (olfativa y ambiental)	Ningún tipo	1 tipo	2 tipos
Forma del predio	Regular	Irregular	Complejo
Orientación (asoleamiento y vientos)	Favorable	Medio favorable	No favorable
Posibles inundaciones	Baja o nula probabilidad de inundaciones	Mediana probabilidad de inundaciones	Propenso a inundaciones
Paisaje	Permite el aprovechamiento del paisaje	Paisaje limitado	Nulo paisaje
Pavimento	Validad de concreto / asfalto		Terracería
Total	30		

Table IV. The correlation matrix for the evaluation of the natural and artificial physical environment of x number of available properties can be carried out jointly or separately, through a first column the parameters that will evaluate the potential of the site area are listed, which on this occasion were determined by the type of architectural complex, The rest of the columns are a description of the weighting from the value scale for each parameter.

Subsequently, an analysis of the property with the highest score as a result of the evaluation of properties is carried out (fig. 1), allowing to identify and illustrate its orientation, the path of the prevailing winds, the exposure and trajectory of the sun, accessibility, road hierarchy, the physiographic conditions near the property, the immediate urban equipment and everything that characterizes it. Cabeza Pérez, A. (1993)

This process aims at the correct orientation and location of the architectural complex on the property, prior to the architectural match and not before, since the definition of the property for new projects does not present any contribution to the design process in the initial stage because there is no knowledge of the need for m2 required for the complex, one of the main strengths of an architectural project for urban equipment is the possibility of locating it anywhere, considering at the time of a new location a thorough analysis of the physical environment to comply with the conditions of orientation and location, among others.

This methodology has academic objectives, offering the student the tools to analyze step by step the integration of a logical and orderly process to reach a solution that is consolidated consecutively until reaching an efficient architectural complex.

Figure 1

The analysis of the Physical Environment is carried out at the site level and at the neighborhood or neighborhood level, even using the information and tools available on the Internet



This phase of Analysis of the Physical Environment is another contribution to the traditional methodology of architectural design, which is integrated by the identification of the parameters of the natural and artificial physical environment at the site, neighborhood and/or city level, allowing the evaluation of the location of the architectural complex in particular through the correlation matrix. the determination of the value scale, the description of the parameters of the value scale, the evaluation matrix, as well as the analysis of the property at the site level.

One of the last stages of the methodology prior to the architectural match is the determination of the design concept, it is the identification of one or more elements that allow the designer to be inspired in the architectural composition of the architectural complex, guiding him in the most general aspects of the project in order to geometrize it and make it the basis of an architectural project. Jiménez Barriga, N. (2021)

The conceptualization of architectural design can apply the analogical, canonical, iconic and/or pragmatic method.

Figure 2

An architectural project based on analogue conceptualisation takes up a natural element to design and distribute its areas and spaces, inspired by an element perfected by nature over thousands of years, taking advantage of the search for perfect harmony

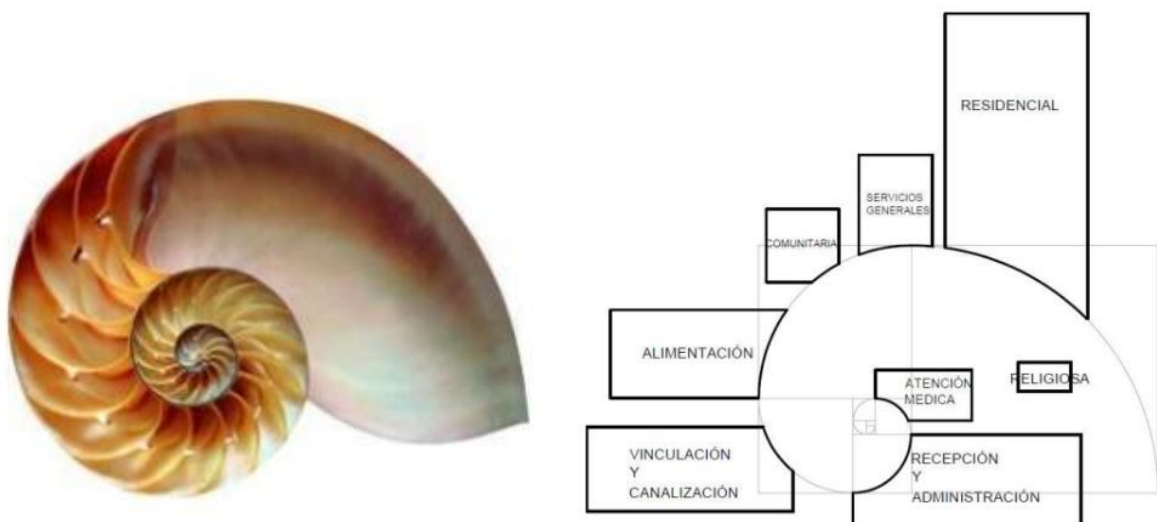


Figure 3

An architectural project based on analogical conceptualization can also take up an element built by man to abstract, geometrize and distribute an architectural project, inspired by an architectural composition recognized throughout history for its unity and balance

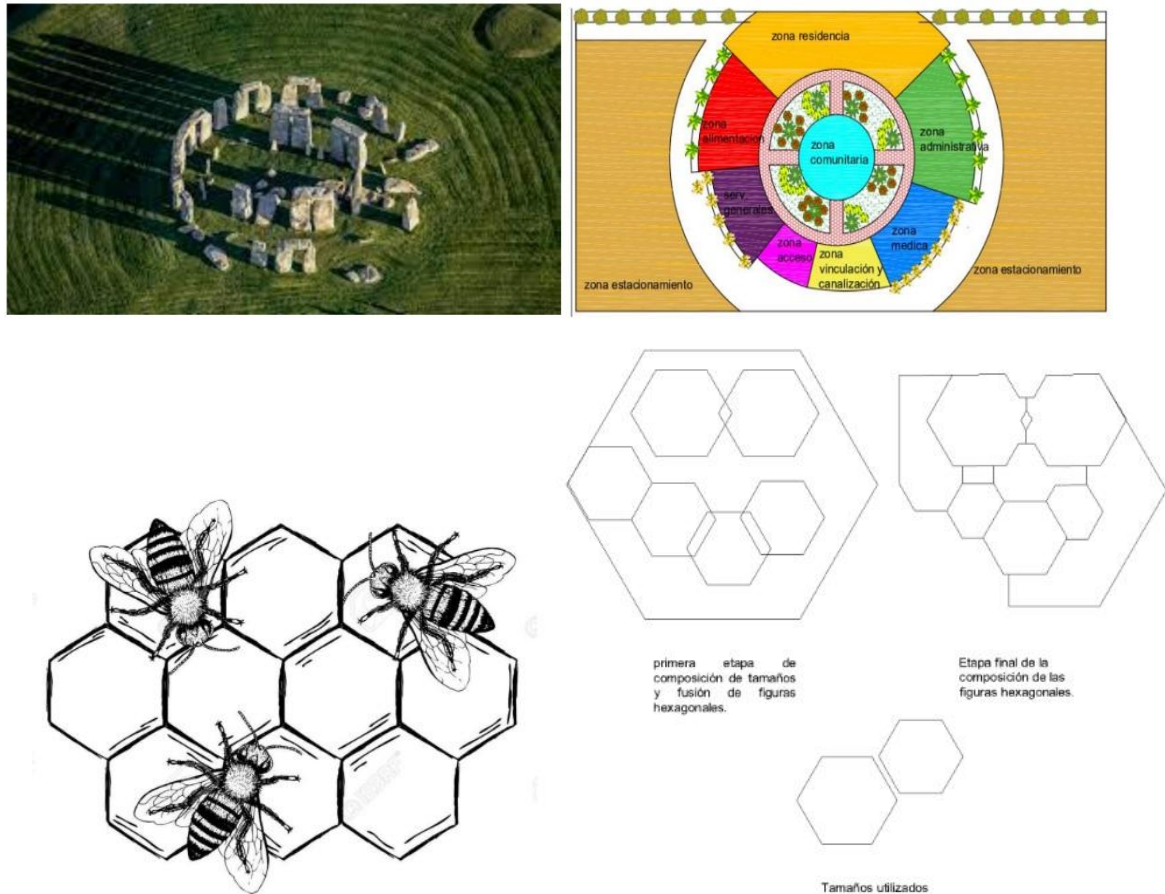
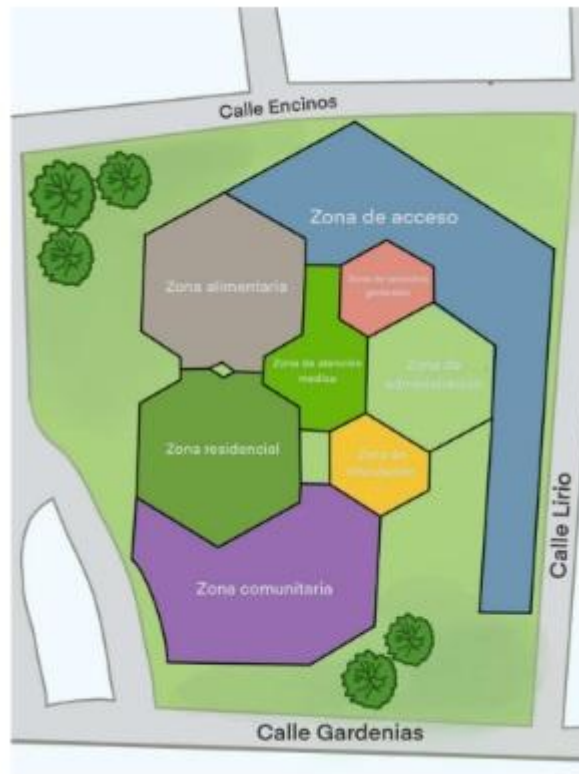


Figure 4

An architectural project based on analogical conceptualization takes up a natural element to project and distribute an architectural project, it is a guide that through its abstraction and total or partial geometrization gives guidelines to the integration of zones, inserting corridors, gardens and open-air spaces to link a functional architectural complex

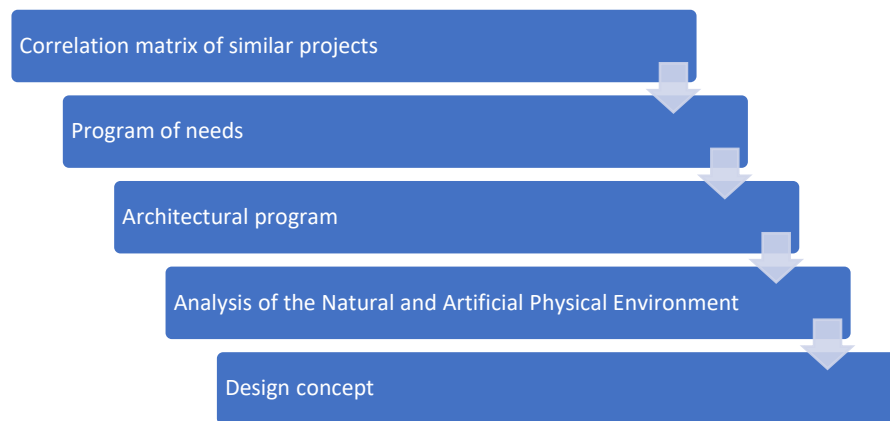


3 RESULTS

The methodology for the architectural design of a Social Assistance Center includes among its main phases:

Figure 5

The five phases presented are a guideline for implementing them in the methodology of any other architectural project

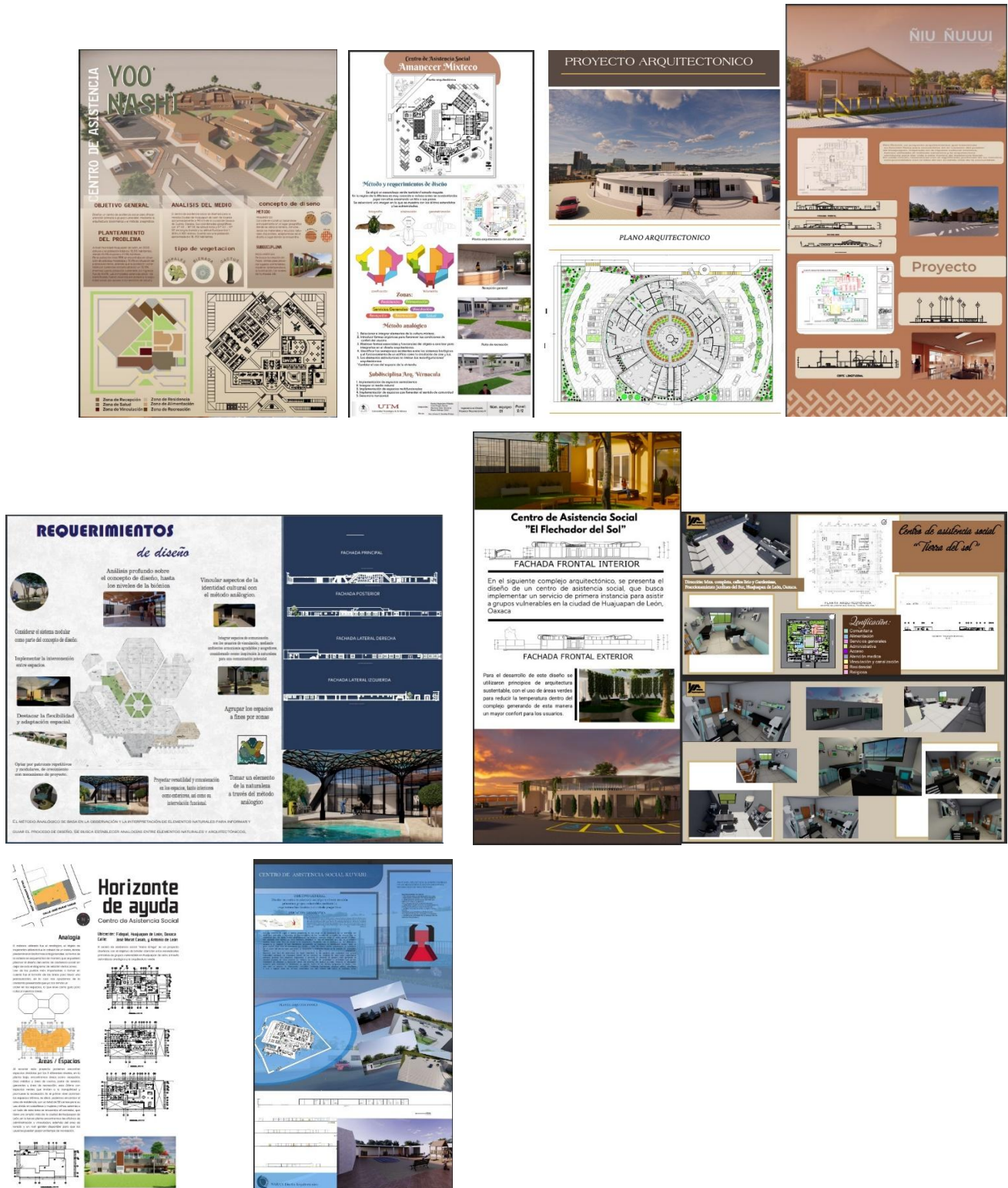


The integration of a methodology for the design of an architectural complex is not finite, it requires a prior and thorough analysis of the scope of the project, the target groups to be served, the radius of action, the area of location, the social and urban context, the geographical conditions and the natural and artificial physical environment within various factors. Sánchez-Platas, L., Sánchez-Luqueño, J. (2016)

It is also necessary to integrate other phases to support the methodology, such as the identification and definition of users, breaking down the activities of the main users through flow diagrams, the integration and constant updating of the study of minimum areas, the analysis of the interrelation of areas and spaces, general and specific operating diagrams and any other phase that allows the integration of a logical and clear file of the project of design.

Figure 6

As a result, nine architectural projects of Social Assistance Centers were integrated to meet the basic and complementary needs of migrants, people with addiction problems, people in street situations, people who have been abused, displaced persons, etc



Finally, nine architectural projects of Social Assistance Centers were integrated to meet the basic and complementary needs of migrants, people with addiction problems, people in street situations, people who have been abused, displaced persons, etc.

As a result of the research phase of the Social Framework, it was determined to integrate the following areas: reception, administration, recreation, food, general services, medical care, linkage and channeling, residence, religious and loading and unloading area.

The natural physical environment addressed the analysis of climate, soil, geological conditions, relief, water and vegetation. Schjetnan, M. Calvillo, J. Peniche, M. (2004)

The artificial physical environment determined the potential for urban development at the housing and commercial level, proximity to the city center, vehicular accessibility, infrastructure, security services, pollution, use of the landscape, paving conditions, among others. Cabeza Pérez, A. (1993)

Nine architectural projects of Social Assistance Centers were generated using iconic, canonical, pragmatic and analog architectural conceptualization.

4 CONCLUSIONS

It is necessary to generate architectural design solutions that address urban and rural equipment projects that consider the social, environmental, landscape, ecological and socioeconomic spheres.

It is convenient to reflect on the architectural design process which is not a finite and established process, each architectural project requires a different methodology.

The methodology for integrating architectural complexes that serve different social groups requires a thorough and exhaustive investigation that allows the integration of a Social Framework to provide a precise solution to basic and complementary needs.

The analysis of the Natural Physical Environment contemplates a review of at least six elements (climate, soil, geology, relief, water and vegetation), at the site, district and/or city level, conditioning the design of the architectural space. Schjetnan, M. Calvillo, J. Peniche, M. (2004)

The analysis of the Artificial Physical Environment contemplates an identification of parameters of the area in which the property is located in relation to the requirements of the Architectural Projects, previously designing a tabulator (correlation matrix), which allows an impartial evaluation of the available properties.

The design of architectural space is not only a creative process, it is a process of research, analysis and synthesis which forges a Design Engineer in his architectural work, and which is perfected over time but mainly with the tenacity to delve into each project in its research phase to obtain an excellent result in each architectural match.

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THE FAMILY–SCHOOL INTERFACE IN STRENGTHENING THE EDUCATIONAL PROCESS

A INTERFACE FAMÍLIA–ESCOLA NO FORTALECIMENTO DO PROCESSO EDUCATIVO

LA INTERFAZ FAMILIA–ESCUELA EN EL FORTALECIMIENTO DEL PROCESO EDUCATIVO

 <https://doi.org/10.56238/sevened2025.036-110>

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ABSTRACT

The study aimed to analyze central aspects of the interface between family and school in strengthening the educational process, based on a bibliographic review. The results indicate that both institutions are indispensable partners for the student's integral development, sharing responsibility for creating conditions that foster learning and citizenship formation. For this interface to produce significant effects, it is essential that family and school organize environments consistent with the values they aim to promote. Among these values, the need to provide children with concrete opportunities for democratic experience stands out, encouraging the expression of ideas, dialogue, and the collective construction of knowledge. Likewise, welcoming environments that promote respect, emotional security, and individual appreciation are essential conditions for school development. In this process, it is the school's role to establish and strengthen continuous partnerships with families, seeking communication, cooperation, and participation strategies that broaden students' understanding of themselves and the world. This articulation contributes to shaping individuals capable of acting critically, transforming their realities, and fully exercising their citizenship.

Keywords: Family. School. Socialization Agents. Social Function.

RESUMO

O estudo teve como objetivo analisar aspectos centrais da interface entre família e escola no fortalecimento do processo educativo, a partir de uma pesquisa bibliográfica. Os resultados apontam que ambas as instituições constituem parceiras indispensáveis para o desenvolvimento integral do aluno, sendo corresponsáveis pela criação de condições que favoreçam a aprendizagem e a formação cidadã. Para que essa interface produza efeitos

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significativos, é fundamental que família e escola organizem ambientes coerentes com os valores que desejam promover. Entre esses valores, destaca-se a necessidade de oferecer às crianças oportunidades concretas de vivência democrática, estimulando a expressão de ideias, o diálogo e a construção coletiva do conhecimento. Da mesma forma, o acolhimento em espaços que promovam respeito, segurança emocional e valorização individual é condição essencial para o desenvolvimento escolar. Compete à escola, nesse processo, estabelecer e fortalecer relações de parceria contínua com as famílias, buscando estratégias de comunicação, cooperação e participação que ampliem a compreensão que os alunos têm de si mesmos e do mundo. Essa articulação contribui para formar sujeitos capazes de atuar de maneira crítica, transformando suas realidades e exercendo plenamente sua cidadania.

Palavras-chave: Família. Escola. Agentes de Socialização. Função Social.

RESUMEN

El estudio tuvo como objetivo analizar aspectos centrales de la interfaz entre la familia y la escuela en el fortalecimiento del proceso educativo, a partir de una investigación bibliográfica. Los resultados señalan que ambas instituciones constituyen socios indispensables para el desarrollo integral del alumno, siendo corresponsables de crear condiciones que favorezcan el aprendizaje y la formación ciudadana. Para que esta interfaz genere efectos significativos, es fundamental que la familia y la escuela organicen ambientes coherentes con los valores que desean promover. Entre esos valores, se destaca la necesidad de ofrecer a los niños oportunidades concretas de vivencia democrática, estimulando la expresión de ideas, el diálogo y la construcción colectiva del conocimiento. Del mismo modo, la acogida en espacios que promuevan el respeto, la seguridad emocional y la valoración individual es una condición esencial para el desarrollo escolar. Compete a la escuela, en este proceso, establecer y fortalecer relaciones de asociación continua con las familias, buscando estrategias de comunicación, cooperación y participación que amplíen la comprensión que los estudiantes tienen de sí mismos y del mundo. Esta articulación contribuye a formar sujetos capaces de actuar de manera crítica, transformando sus realidades y ejerciendo plenamente su ciudadanía.

Palabras clave: Familia. Escuela. Agentes de Socialización. Función Social.

1 INTRODUCTION

The family is a fundamental resource in the educational context, because, unlike other social instances, it invests more time, affective dedication and commitment in the care and education of children. In contemporary times, it becomes evident that the school cannot do without the family, just as the family cannot do without the school. Both are interdependent and complementary institutions, whose articulation is decisive for the strengthening of the educational process.

The school, as an institution that also performs socio-affective functions, complements the role played by the family. Without this expanded understanding, it becomes unfeasible to train subjects capable of learning, acting and transforming society, applying the knowledge constructed in their daily lives. Learning initiated in the family and community environment needs to find continuity in school, so that school content is constituted as instruments for the ethical, cognitive and social formation of the future citizen.

Teaching students to live in society and to fully exercise their citizenship requires a consistent integration between family and school. The incentive to the child's educational process is directly related to the family's expectations, the stimuli offered and the way the family recognizes its influence on the children's development. As Silva and Lima (2009) state, family involvement depends essentially on the value that parents attribute to education and the perception they have of the impact of their performance on the children's performance and academic trajectory.

The developmental potential of an environment, as Well (2002) argues, is amplified to the extent that there are solid support bonds between different life contexts. Environments that are weakly linked or devoid of supplementary relationships configure less favorable conditions for human development. In this sense, the strengthening of developmental potential occurs when the support relationships include people with whom the child establishes stable primary dyads, which refers to the notion of continuity. Such continuity presupposes a joint construction between family and school, offering consistent support to the child's academic and socio-emotional development.

Given the relevance of the theme, this study is justified by adopting an integrative perspective on the family-school relationship, evidencing the need for parents and the school institution to act in an articulated way in the educational process. Thus, the objective of this research is to analyze central aspects of the performance of the family and the school in the teaching and learning process, based on a bibliographic investigation.

In this article, the family and school environments are understood as fundamental contexts of human development, emphasizing the importance of qualified relationships between them. Initially, the role of the family and its space as a socializing agent is discussed, with emphasis on contemporary family configurations, support networks and affective bonds that influence child development and learning. Next, the social function of the school is addressed, highlighting its complementarity in relation to the family and its responsibility in the development process. Finally, the family-school interface is analyzed, seeking to understand the similarities, specificities and responsibilities attributed to these instances in the development and learning process.

2 FAMILY AND SCHOOL as Socialization Agents

2.1 FAMILY FUNCTION

The concept of family has been transformed throughout the history of humanity (ALMEIDA; MEDEIROS, 2010). However, in its conceptual aspect, it is understood as a system of affective bonds that generates the process of humanization. The historical transformation of the sociocultural context is the result of a continuous process of evolution in the face of which the family structure is shaped.

Traditionally, when talking about family, especially a so-called "structured" family, there was the vision of a couple united by marriage and living in the same house with their children. Today, however, it is necessary to take a new look at this organization. A family can be considered harmonious and structured regardless of its constitution; and it can be unstructured even when formed by father, mother and children. This is because the structure does not necessarily define the relationship between the people who form a family (SOUZA; LOCH, 2008, p. 10).

The family environment is the first space for the establishment of affective and social relationships, a place for learning to live together and interact with others, a space constituted to learn to seek other spaces for socialization, preparing the human being to act in the social, political and ethical spheres.

Dessen and Poland (2007) state that the family plays an essential role in the transmission of values and behaviors in different social classes, enabling the incorporation of the primary *habitus*. The affective bond found in the family context can be understood as a necessary factor for the operations of the cognitive structure, exerting influence on the agility with which knowledge is constructed.

Nascimento (2011) points out that the family is responsible from birth for the physical, psychological, emotional, moral and cultural development of the child. The author adds that the child fulfills his basic needs, starting the process of construction of his perceptual, motor, cognitive, linguistic and affective schemes, through the first contact with family members. The family is understood as the first mediator between man and culture, therefore:

It constitutes the dynamic unit of affective, social and cognitive relations that are immersed in the material, historical and cultural conditions of a given social group. It is the matrix of human learning, with its own meanings and cultural practices that generate models of interpersonal relationships and individual and collective construction. Family events and experiences provide the formation of behavioral repertoires, actions and problem solving with universal (child care) and particular (perception of the school for a given family) meaning. These experiences integrate the collective and individual experience that organizes, interferes and makes it a dynamic unit, structuring the forms of subjectivation and social interaction (DESSEN; POLÓNIA, 2007, p. 22).

Thus, the family has an important role in the construction of the individual, because, as the primary space of socialization, it influences the "basis of personality", favoring physical growth and emotional development. As a source of human socialization, in the family space, the child experiences the first rewards and punishments, building his self-image and modeling his behavior. All this, when inscribed in his innermost self, starts to configure his individual world, coming to function as a determining factor in his social interactions.

Vygotsky (2000), in his work "The Construction of Thought and Language" makes it evident that learning precedes development, that is, for the development of Higher Psychological Functions (FPS) to⁶ occur, subjects need to appropriate cultural goods.

With this view, family life is essential to transform the subject from being biological into a social human being. For Vygotsky (1998, p. 75), the child's learning and development occur at two levels:

First at the social level, and then at the individual level; first between people (interpsychological), and then within the intrapsychological child). This applies equally to voluntary attention, logical memory, and concept formation. All higher functions originate from the real relationships between human individuals (VYGOTSKY, 1998, p. 75).

⁶The functioning of FPS such as attention, memory, imagination, thought and language are organized into functional systems, whose purpose is to properly organize the mental life of the subject in his environment comes from the social life of the young. Such interactions have the intellectual precise (VYGOTSKY, 2000). interaçõescriançacomadultosdesdeefeitossobre desenvolvimento

This means that all FPS lack the mediation of other more experienced subjects or the instruments to be developed. In this way, the family influences the child's relationship with the internal and external world, and can contribute negatively or positively to a healthy relationship with the society that surrounds him.

According to Sousa and José Filho (2008, p. 3), the family functions as the first and most important agent of socialization, helping the child in the construction and development of his or her apprentice model. All the knowledge acquired during your primary life experience will be reflected in your life in society, because:

It is through family interactions that transformations in societies are materialized, which, in turn, will influence future family relationships, characterized by a process of bidirectional influences between family members and the different environments that make up social systems, including school, constitute a preponderant factor for the development of the person (DESSEN; POLÓNIA, 2007, p. 22).

Considering that the child's performance is related to the different aspects of the family environment, Campos (2011) states that those who receive help regularly at home are more subject to better school performance, when compared to those who do not receive help at home.

Until the seventeenth century, a large part of the values and knowledge linked to professional actions was transmitted by family groups. The older members had the role of taking their knowledge to the younger ones as a way of ensuring the development of practices of survival and perpetuation of groups (CAMPOS, 2011).

However, currently, not only family members, but also the child's surroundings, such as the school context, friends, the church, among other spaces and people, exert influence on the understanding of the world, contributing to the transmission of knowledge and values that little by little form the character and personality of the citizen.

2.2 THE SOCIAL FUNCTION OF THE SCHOOL

In the current context, Brazilian education has the challenge of promoting the learning of all students and ensuring them a trajectory of school success. This trajectory becomes possible when the pedagogical aspect becomes part of a consolidated practice that prioritizes the premanence and appropriation of school scientific knowledge by children. For Saviani (2000), it is through the mediation of the school that the subjects make the transition from spontaneous knowledge to systematized knowledge.

According to Saviani (2000, p. 15), "education is a phenomenon of human beings. Therefore, the understanding of the nature of education passes through the understanding of human nature." The author understands that what is not produced by human nature needs to be historically produced by men, because,

Human nature is not given to man, but is produced by him on the basis of bio-physical nature. Consequently, educational work is the act of producing, directly and intentionally, in each individual. Thus, the object of education concerns, on the one hand, the identification of the cultural elements that need to be assimilated by individuals of the human species in order for them to become human and, on the other hand and concomitantly, the discovery of the most appropriate ways to achieve this objective (SAVIANI, 2000, p. 17).

For this reason, education understood as a mechanism of socialization and social insertion is pointed out by Saviani (2000) as the path to the development of human capacities. The author understands that only a non-alienating education contributes to the integral formation of man, so that he can carry out the social transformations necessary for his humanization, seeking to break with the systems that prevent his free development.

Facci (2004, p. 175) states that education is connected to the development process since "it can only be defined as a rational, planned, premeditated and conscious action, therefore, a form of intervention in the processes of natural growth of individuals".

The use of strategies must be adapted "to the different realities of students and teachers, to the demands of the community and to the available resources, taking into account the conditions and peculiarities of each era or historical moment" (DESSEN; POLÓNIA, 2007, p. 26).

The school is a place that is influenced by the socio-cultural conditions of the community in which the child is inserted, constituting the socializing space of all who live there, thus enabling the exchange of experiences and learning. Hence the importance of verifying the evolutionary conditions of the school segments, including teachers, students, parents and the community as a whole, in order to plan activities in the school context (DESSEN; POLONIA, 2007).

According to Vygotsky (2000), education plays a central role in the transformation of men in the path of their social formation. For the author, subjects are historical and learning arises from social relations, mediated by other subjects who help in the appropriation of knowledge that supports development. The author pointed out that the origins of the higher

forms of conscious behavior arise from the social relations that the subject maintains with the outside world in his practical activity. In this sense, the school has a prominent role.

According to Oliveira (1997), it is from the school's knowledge of the student's zone of proximal development (ZDP) that he will be able to develop an education that provides learning for the future, teaching what he does not yet know and not what he already knows. For the author, it is learning that determines development.

Through the concept of ZDP, Vygotsky (2000) explains how the influence between learning and development happens. To justify this concept, the author considers two levels of development: the first refers to the effective development, the one already accomplished (real development zone) which can be measured, for example, through psychological tests; the second is the zone of potential development, which refers to the development that is in the process of being achieved, that is, which is not yet part of the child's own repertoire, but is focused on his future.

According to Vygotsky (2000), the expansion of the zone of potential development occurs as the subject performs appropriate activities. This development is only effective in the social environment. It is at school that the child comes into contact with more structured activities.

At school, children invest their time and get involved in differentiated activities linked to formal tasks (research, directed reading) and informal learning tasks (recess time, excursions, leisure activities). However, in this environment, the attendance to cognitive, psychological, social and cultural needs is carried out in a more structured and pedagogical way than at home. School educational practices also have an eminently social nature, since they allow the expansion and insertion of individuals as citizens and protagonists of history and society. Education in its broad sense becomes a very important instrument to face the challenges of the globalized and technological world (DESSEN; POLÓNIA, 2007, p.29).

At school, the child has the opportunity to live unique experiences, expanding his repertoire as a subject of learning and development, especially with regard to the acquisition of culturally organized knowledge in his different areas of knowledge.

In this sense, the social function of the school is expanded, in order to become a privileged nucleus of education as a universal form of human development. As an institution capable of mediating between everyday and scientific concepts, the school together with the family is the main space for the integral formation of man.

2.3 FAMILY AND SCHOOL INTEGRATION

Studies and research on the family-school relationship, according to Silva and Lima (2009) have pointed out that the greater the bond that parents and/or guardians establish with the schooling process of their children, the greater the chances of these subjects obtaining a good school performance.

The integration between family and school is fundamental for the child's development and school learning, because,

The school space has many similarities with the family space, fundamentally because both are imbued with the task of educating. However, the dimension of education present in the school has singularities, mainly because it deals, above all, with formal education, systematized through the transmission of epistemological dimensions of knowledge throughout the curriculum (SILVA; LIMA, 2009, p. 242).

The school is a complementary institution to the family in terms of education, and should be a pleasant and affective space for children in the process of formation. According to Silva and Lima (2009), the school and the family as educational institutions need to act together in order to promote complementary and significant learning situations.

Although the roles of each are different, there are similar responsibilities and objectives between them. When the family works in partnership with the school, the child wins. The possibility of being able to count on the participation of the family in the school daily life is "a privilege for both institutions. It cannot be denied that the protagonists of this process are the students and teachers and, of course, the teaching-learning process" (SILVA; LIMA, 2009, p. 246).

According to Tiba (1988), in order to act democratically, the school needs the support of the family, to know its dynamics, to be able to respect, guide and understand it. Open and frank dialogue contributes to the most effective interventions in accordance with the real educational needs of children.

The Law of Guidelines and Bases of National Education (LDB), Law No. 9,394, of 1996, in Art. 12, paragraphs VI and VII, when referring to the process of integration between schools and families, exposes the need to articulate with families and the community, creating processes of integration of society with the school (BRASIL, 1996).

Gadotti and Romão (2004) share the understanding that the school-family partnership is a challenge that needs to be assumed by the entire school community. The school is also a place of meeting and coexistence between parents, students and managers, who must act

in groups in search of favorable conditions for the cognitive, affective, emotional, motor, social and professional development of their students. By working together, family and school can help the student to acquire personal security, helping him to overcome the insecurities of each phase, to feel valued in his qualities and in the changes that may occur, learning to organize himself internally and with the external environment.

However, this integration is not easy and requires a lot of dialogue. For Souza and Loch (2008), the relationship between family and school is the product of a sum of actions that lead the family, managers (principal, pedagogue, teacher, secretaries, among others), to practice continuous dialogue, in an attempt to overcome differences of opinion and understand the role of each one in the educational process.

The family and the school are understood as the two main spaces of human development in contemporary Western societies. Therefore, it is necessary to implement viable policies to bring the two contexts closer together, in order to recognize their singularities and similarities, especially with regard to "the development and learning processes, not only in relation to the student, but also to all the people involved" (DESSEN; POLÓNIA, 2007, p. 29).

The opening of the school to the entry of family members is a central aspect in the process of educational formation. Thus, the participation of the family in the school context is understood as an essential factor in the child's development and learning process, making the space more egalitarian in conditions to be shared by all through open dialogue. When mediated by dialogue, participation takes place in all spaces of the school: in school councils, in assemblies, in the classroom, in the library, among other spaces.

The partnership between family and school makes the school space democratic (LIBÂNEO; OLIVE TREE; TOSCHI, 2007). For these authors, the dialogue between family members and the school contributes to the construction and reorientation of decision-making, serving as a guide for the actions of the subjects, with a view to welcoming all those who are part of the school context.

The valorization of the school and families as instruments of knowledge is necessary to suppress social selectivity. The school and the family are integral parts of society. Thus, for Libâneo, Oliveira and Toshi (2007), acting together with these instances implies the preparation of students to act in the adult world with its contradictions, providing them with tools, through the acquisition of content and socialization, an organized and more active participation in the democratization of society.

The school space has many similarities with the family space, fundamentally because both are imbued with the task of educating. However, the dimension of education present in the school has singularities, mainly because it deals, above all, with formal education, systematized through the transmission of epistemological dimensions of knowledge throughout the curriculum.

As a social institution, the school suffers and exerts influence on what happens around it, preparing the child to act in contemporary society. As the school organizes itself together with the family to promote activities that facilitate growth and development in the various dimensions of the human being, it becomes interesting, alive and dynamic for those who attend it. In this way, learning becomes more effective for the student, who may feel more motivated to acquire practical knowledge and apply it in daily life (DESSEN; POLONIA, 2007).

By interacting with family members, the school can become an engaging place for students. As historical subjects, students need care and a good social interaction for their psychosocial development, as learning requires successive and shared movements (ALMEIDA; MEDEIROS, 2010). For the authors, the school is not only a physical space, but a project of education for citizenship. It is necessary for the school to have pedagogical projects that complement the role of the family, providing students with access to scientific knowledge and progress in the social and personal aspects.

By seeking in the family an ally to instrumentalize learning, the school will be building a motivating teaching procedure, strengthening the most complex processes of knowledge, helping in the construction of a more democratic system, thus favoring the link between social actions and writing. The interaction takes place between the individual and the environment. However, the one who imposes the forms and limits of assimilation is the individual himself, in whom the presence of the environment is necessary for the construction of knowledge whose social and cultural value cannot be forgotten.

According to Campos (2011), the family-school interaction aims to provide the responsible parents with knowledge about the pedagogical proposal developed by the school, with a view to discussing it with the team. In addition, this interaction complements the work carried out in the school context with the children, enabling unique knowledge about the different contexts of life, customs and family cultural values, as well as the possible differences and/or similarities between them in relation to the pedagogical proposal. Still, according to the author, there are social and cultural factors that interfere in the family-school relationship that contribute to the establishment of different conflicts. Attitudes of demand and

accusations on the part of the school are common and, at the same time, relationships of apathy, residence or even revolt on the part of the families.

On the one hand, some families, especially from the urban area, which due to the very complexity of life predominant in large centers; and due to the conditions of their family context, they usually exempt themselves from flaunting their role, incumbent on the school to act alone in the formation of habits, values, health, among other factors from which the family cannot exempt itself. On the other hand, there are specific aspects related to daily life, which bring obstacles, although they can be overcome to a greater interaction between parents and the pedagogical team. The father or mother may be working hours that do not allow him or her to come to school to bring or pick up his or her child, or even that make it difficult for him or her to attend meetings (CAMPOS, 2011).

In this way, the participation of parents that begins in the family environment extends to the school. Thus, school proposals should be aimed at maintaining a cooperative relationship between families in matters related to the child's learning.

3 FINAL CONSIDERATIONS

It is observed that the joint work between school and family constitutes one of the greatest challenges of any pedagogical proposal. This difficulty reflects a broader social problem, marked by social and political factors that directly influence the educational context. Therefore, instead of looking for culprits, it is essential to focus efforts on building solutions that bring the family closer to the school's pedagogical proposal.

The school objectives resulting from the partnership with families are achieved more effectively when an education focused on citizenship is sought. For this, different strategies of articulation between family, teachers and students must be planned and implemented. The involvement of the family in the teaching process is essential, as the educational objectives will only be fully achieved when there is a continuous and significant interrelationship between both parties.

Knowledge is built in a process of interaction between family and school, sustained by dialogue, sharing of ideas and collective work. In this perspective, the teacher acts as a mediator, relating to the student from his daily reality and promoting connections between school knowledge and the family context.

Parents, in turn, should be guided to encourage and stimulate their children, transmitting security to them and valuing their school career. The presence of the family in

the school should be welcomed and encouraged, recognizing it as a co-author of the educational process. Thus, the importance of the partnership between school and family is reinforced as a path to a truly transformative pedagogical practice.

The construction of this interaction requires a willingness to work collectively and to jointly define the objectives and means necessary to achieve them. However, the effective participation of parents is only materialized in a management that values democracy and recognizes the family as a fundamental partner in the action of educating.

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CERTIFICATION OF BRAZILIAN ARTISANAL CHEESE: CHALLENGES AND PERSPECTIVES OF THE ARTE SEAL

CERTIFICAÇÃO DO QUEIJO ARTESANAL BRASILEIRO: DESAFIOS E PERSPECTIVAS DO SELO ARTE

CERTIFICACIÓN DEL QUESO ARTESANAL BRASILEÑO: DESAFÍOS Y PERSPECTIVAS DEL SELLO ARTE

 <https://doi.org/10.56238/sevened2025.036-111>

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ABSTRACT

The central question of this study was to explore and understand the dynamics that permeate the certification of Brazilian artisanal cheese, focusing on the application of the Art Seal, evaluating the effects on producers and the consumer market based on the literature on the subject. Thus, the present study aimed to understand the approaches to the certification of Artisanal Cheese and Art Seal based on a systematic review of the literature. The methodology adopted for the present study can be classified as bibliographic and descriptive research, conducted through a systematic approach to literature. A research protocol was created for data collection, processing and analysis. Sources consulted include Periodicals Capes, Google Scholar and Scientific Electronic Library Online (SciELO). The research was carried out between May 23 and 24, 2024, where the selection of articles included searches with the key expressions: “artisan cheese” and “art seal”, totaling 23 scientific articles. The results showed that the B1 classification configured as the Qualis Capes classification of the journals for the majority of selected articles. The year 2023 represented the year with the most publications. Bibliographic and documentary research were the main methodologies adopted, secondly the use of experimental studies and then qualitative research, the latter two being approaches with primary data collection. The objects of study cover several regions of Brazil, with emphasis on Minas Gerais, Paraná and areas of the Northeast, whose investigation focused on certification of artisanal cheeses, analysis of good manufacturing practices and legislation. The analysis of documents and bibliographic sources made it possible to identify the main theoretical currents and the challenges faced by producers in obtaining certification. The analysis categories Geographical Indication (GI), Culture and Regionalism, Legislation and Regulation, and Good Manufacturing Practices and Food Safety were created, which presented a synthesis of the approaches of the selected articles. The study concludes that, although Art Seal promotes cultural recognition and the competitiveness of products in the market, it is essential to implement measures that simplify legal requirements and offer support to small producers in their formalization.

Keywords: Artisanal Cheese. Art Seal. Certification. Craft Production. Food Legislation.

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RESUMO

A questão central deste estudo foi explorar e compreender as dinâmicas que permeiam a certificação do queijo artesanal brasileiro, com foco na aplicação do Selo Arte, avaliando os efeitos para os produtores e para o mercado consumidor a partir da literatura sobre a temática. Desta forma, o presente estudo teve como objetivo conhecer as abordagens sobre a certificação do Queijo Artesanal e Selo Arte a partir da revisão sistemática da literatura. A metodologia adotada para o presente estudo pode ser classificada como pesquisa bibliográfica e descritiva, conduzida por meio de uma abordagem sistemática da literatura. Foi criado um protocolo de pesquisa para a coleta, tratamento e análise dos dados. As fontes consultadas incluem Periódicos Capes, Google Acadêmico e Scientific Electronic Library Online (SciELO). A pesquisa foi realizada entre os dias 23 e 24 de maio de 2024, na qual, a seleção dos artigos incluiu buscas com as expressões-chave: “queijo artesanal” e “selo arte”, totalizando 23 artigos científicos. Os resultados mostraram que a classificação B1 configurou como a classificação Qualis Capes dos periódicos da maioria dos artigos selecionados. O ano de 2023 representou o ano com a maioria das publicações. A pesquisa bibliográfica e documental foram as principais metodologias adotadas, em segundo lugar o uso de estudos experimentais e na sequência pesquisas qualitativas, pois estas duas últimas abordagens com coleta de dados primários. Os objetos de estudo abrangem diversas regiões do Brasil, com destaque para Minas Gerais, Paraná e áreas do Nordeste, cuja investigação focou em certificação de queijos artesanais, análise das boas práticas de fabricação e legislação. A análise de documentos e fontes bibliográficas possibilitou a identificação das principais correntes teóricas e dos desafios enfrentados pelos produtores na obtenção da certificação. Foram criadas as categorias de análise Indicação Geográfica (IG), Cultura e Regionalismo, Legislação e Regulamentação, e Boas Práticas de Fabricação e Segurança Alimentar, que apresentaram a síntese das abordagens dos artigos selecionados. O estudo conclui que, apesar do Selo Arte fomentar o reconhecimento cultural e a competitividade dos produtos no mercado, é imprescindível implementar medidas que simplifiquem as imposições legais e ofereçam suporte aos pequenos produtores em sua formalização.

Palavras-chave: Queijo Artesanal. Selo Arte. Certificação. Produção Artesanal. Legislação Alimentar.

RESUMEN

La cuestión central de este estudio fue explorar y comprender las dinámicas que rodean la certificación del queso artesanal brasileño, con énfasis en la aplicación del Sello Arte, evaluando sus efectos para los productores y para el mercado consumidor a partir de la literatura existente. De este modo, el presente estudio tuvo como objetivo examinar los enfoques sobre la certificación del Queso Artesanal y el Sello Arte mediante una revisión sistemática de la literatura. La metodología adoptada puede clasificarse como investigación bibliográfica y descriptiva, conducida a través de un enfoque sistemático de la literatura. Se elaboró un protocolo de investigación para la recopilación, el tratamiento y el análisis de los datos. Las fuentes consultadas incluyeron Periódicos CAPES, Google Académico y Scientific Electronic Library Online (SciELO). La búsqueda se realizó entre los días 23 y 24 de mayo de 2024, y la selección de los artículos incluyó búsquedas con las palabras clave “queso artesanal” y “sello arte”, totalizando 23 artículos científicos. Los resultados mostraron que la mayoría de los artículos seleccionados fueron publicados en revistas clasificadas como B1 en el sistema Qualis Capes. El año 2023 representó el período con mayor número de publicaciones. La investigación bibliográfica y documental fueron las metodologías predominantes, seguidas de estudios experimentales y de investigaciones cualitativas, ya que estas dos últimas implican la recolección de datos primarios. Los objetos de estudio

abarcaron diversas regiones de Brasil, con énfasis en Minas Gerais, Paraná y zonas del Nordeste, centrados en la certificación de quesos artesanales, el análisis de buenas prácticas de fabricación y la legislación. El análisis de documentos y de fuentes bibliográficas permitió identificar las principales corrientes teóricas y los desafíos enfrentados por los productores para obtener la certificación. Se crearon categorías de análisis—Indicación Geográfica (IG), Cultura y Regionalismo, Legislación y Reglamentación, y Buenas Prácticas de Fabricación y Seguridad Alimentaria—que sintetizaron los enfoques presentes en los artículos seleccionados. El estudio concluye que, aunque el Sello Arte fomenta el reconocimiento cultural y la competitividad de los productos artesanales en el mercado, es imprescindible implementar medidas que simplifiquen las exigencias legales y brinden apoyo a los pequeños productores en su proceso de formalización.

Palabras clave: Queso Artesanal. Sello Arte. Certificación. Producción Artesanal. Legislación Alimentaria.

1 INTRODUCTION

This work has as its central theme the certification of artisanal cheese. Recently, there has been an increase in the appreciation of artisanal products by consumers, motivated by the desire to consume foods that have a cultural identity, that are produced in a sustainable way and that have a superior quality (MARTINELLI; ANJOS, 2023; GEORGE; PINTO, 2023). In addition, certification is crucial to ensure the origin and food safety of these products, complying with market demands and the sanitary standards in force (SILVA *et al.*, 2022; PORTO *et al.*, 2022).

In addition, the rural producer can obtain gains from this process by adapting to the legislation, providing quality and authenticity to the products, gaining trust with consumers, enriching reputation and appreciation in the market.

The certification allows the expansion of product sales opportunities, reaching new market niches, including at an international level. As a result, there has been an increase in Brazilian exports of artisanal cheeses, reflecting the growing appreciation of the quality and reliability of this product in global markets (FERREIRA; COSTA, 2021; MATOS, 2023). This growth is driven by the demand for traditional gastronomic products and by consumers' search for unique culinary experiences, in addition to the appreciation of artisanal and sustainable production, showing that the quality standards required by regulatory agencies are being met (PENA *et al.*, 2022; MARTINELLI; ANJOS, 2023).

Artisanal cheeses have several ways to be used in cooking, which directly impacts their acceptance by the public. They can be enjoyed as part of a quick snack, in desserts or as an appetizer, it is quite common to combine cheeses with drinks such as wine, cachaça and beer. In addition, these artisanal cheeses can be incorporated into the preparation of savory and sweet dishes, as well as in the production of cheese bread, cakes and even as a filling for pasta, among other culinary options (MINISTRY OF AGRICULTURE, LIVESTOCK AND SUPPLY - MAPA, 2021).

The per capita consumption of milk and dairy products in Brazil increased by 5.1% in 2023, due to the growth in citizens' income and the drop in dairy prices. The supply of milk in the country grew 5.6% compared to the previous year, resulting in an increase of 1.409 million liters, of which 63% came from the increase in imports (EMBRAPA, 2024). In 2022, the per capita consumption of UHT milk in Brazil was 123.5 liters, which represents the lowest amount since 2013, showing a decrease compared to 2021, but still 52.7% higher than what was observed in 2004 (EMBRAPA, 2023).

According to the Confederation of Agriculture and Livestock of Brazil - CNA (2022), between 2017 and 2021, the value of Brazilian exports of dairy products grew by 50%. In the same period, world exports rose 11% and countries that have a more relevant share than Brazil, such as Switzerland and Uruguay, recorded a drop in sales, of 12% and 18% respectively. First place in the *ranking*, the European Union grew proportionally smaller than Brazil with 11%.

The Minas Gerais Institute of Agriculture - IMA (2019), with the creation of Decree No. 9,918, of 07/18/2019, which regulated Law No. 13,680, of 07/14/2018, establishes guidelines for granting the Art Seal by IMA, allowing handicraft products of animal origin to be marketed interstate, as long as they are subject to sanitary inspection. Cheese producers must be registered with the state inspection service, carried out by the IMA, and comply with the standards of good agricultural practices and good artisanal manufacturing practices. In addition to creating the Artisanal Cheese seal, the objective of the new decree is to clarify inspection powers, regulate the broad national commercialization of products and ensure the provision of adequate information to consumers, especially on the health and safety of food products of animal origin produced in an artisanal way (IMA, 2019).

There are several difficulties that producers face in the production and legalization of artisanal cheese for commercialization. Cheese producers must be registered with the state inspection service, carried out by the IMA, and comply with the standards of good agricultural practices and good artisanal manufacturing practices (IMA, 2019).

According to the Ministry of Agriculture, Livestock and Supply (MAPA, 2022), among the benefits of the regulation is the stimulus to formalize more producers in Brazil. A canastra cheese producer, for example, who already has the Art Seal may receive the Artisanal Cheese seal, that is, he can choose to use both or use only one. This is because it is a cheese linked to the territory, produced by a specific region. In the case of some seasoned cheeses, which can be produced independently of the region, they are eligible to receive the Art Seal, but cannot receive the Artisanal Cheese seal.

The Art Seal is a certificate that ensures that the food product of animal origin was made in an artisanal way, with a recipe and process that have its own, traditional, regional or cultural characteristics. It can be granted to dairy products, meat, fish and its derivatives and bee products. The Artisanal Cheese Seal, on the other hand, is a certificate that ensures that artisanal cheeses were made by traditional methods with territorial, regional or cultural

attachment and appreciation (MINISTRY OF AGRICULTURE, LIVESTOCK AND SUPPLY - MAPA, 2022).

Certifications ensure that products have unique, differentiated organoleptic properties inherent to the "artisanal making" of a particular region, tradition or culture. The two seals lead to the addition of value to products of animal origin and allow free commercialization in the national territory. With the new Decree and the inclusion of Mapa as the granting body of the Seals, the possibility of recognizing Brazilian artisanal products in other countries is envisaged, reaffirming the quality and value of these products, already recognized in international competitions (FEDERAÇÃO DA AGRICULTURA E PECUÁRIA DO ESTADO DE SÃO PAULO - FAESP, 2022).

On December 4, 2024, the United Nations Educational, Scientific and Cultural Organization (UNESCO) officially gave the title of Intangible Cultural Heritage of Humanity to the "Ways of Making Artisanal Minas Cheese". This honor underlines the significant historical and cultural importance of artisanal cheese production in Minas Gerais, highlighting the transmission of knowledge over generations and the relevance of the product to the local identity and economy. This international recognition provides Artisanal Minas Cheese with greater visibility in the world, creating new opportunities for its appreciation and promoting gastronomic tourism in the region. In addition, this validation encourages the preservation of traditional practices and fosters the creation of public policies aimed at the protection and sustainability of artisanal production (UNESCO, 2024).

The panorama of artisanal cheese certification in Brazil, especially with regard to the Art Seal, proves to be an aspect of great importance, both for the recognition of producers and for ensuring the quality and authenticity of the product. However, the certification process faces challenges and particularities, ranging from compliance with legal standards to the preservation of the traditional and regional characteristics of the cheese. Thus, the central issue of this study was to explore and understand the dynamics that permeate the certification of Brazilian artisanal cheese, focusing on the application of the Art Seal, evaluating the effects for producers and the consumer market from the literature on the subject.

This work is relevant due to the need for a more in-depth evaluation of the panorama of artisanal cheese certification in Brazil, specifically through the Art Seal. Certification has been the subject of considerable discussion, being seen as crucial for the appreciation and sale of handicraft products, in addition to promoting their entry into broader markets (SILVA *et al.*, 2022; MARTINELLI; ANJOS, 2023). Recent studies have explored the obstacles that

producers face in obtaining these certifications, emphasizing the sanitary requirements and bureaucracy that surround them (FERREIRA; COSTA, 2021; ROCK; CALDAS, 2023).

In this way, this research is integrated with these analyses by deepening the reflection on the norms of the Art Seal and its consequences for the commercialization of artisanal cheese in Brazil. In addition to enriching the academic debate, the findings of this research can be of great help to producers and those responsible for formulating public policies, offering information to improve and increase access to the seal, ensuring its role in cultural preservation and economic growth.

Finally, by examining the certification process of artisanal cheese, this study seeks to reinforce the identity and competitiveness of Brazilian cheese in the market, favoring the sustainability of small rural properties and the preservation of cheesemaking traditions in the country. Thus, this work has as its general objective to know the approaches to the certification of Artisanal Cheese and Art Seal from the systematic review of the literature. Specifically, the study aimed to characterize the articles selected for the study in relation to the Qualis Capes classification of the journals, the years of publication, methodologies adopted and objects of study investigated; to ascertain the approach present in the theoretical foundations of the articles participating in this study and; to create categories of analysis from the content of the selected articles on artisanal cheese and to present the synthesis of the approaches of the articles under study.

2 THEORETICAL FOUNDATION

In the Brazilian context, artisanal cheeses have their origins in the Portuguese influence, which brought to Brazil the production of cheeses with raw milk (BORELLI³ *et al.*, 2016 *apud* ARAÚJO *et al.*, 2020; CAMPELLO *et al.*, 2021). This practice was incorporated into the Brazilian territory and was consolidated in several regions, with Minas Gerais standing out as an important center for the production of artisanal cheese.

In Minas Gerais, cheese is not just a food, but a cultural and economic symbol. The cheese tradition began with the arrival of cattle during the colonial period, as a solution to food shortages, and quickly became integrated into the local diet and the region's economy (TAVARES, 2022).

³ BORELLI, B.M.; LACERDA, I.C.A.; PENIDO, F.C.L.; ROSA A.C. Traditional Cheeses Produced in Brazil: Characterisation, Production Technologies and Health Implications. *In*: PERKINS, E. (Ed.). **Food microbiology fundamentals, challenges and health implications**. New York: Nova Science Publishers, Inc., 2016. chap.7, p.161-189.

Today, dairy farming is consolidated as a vital activity for the State, influencing both economic and cultural aspects. The milk produced in Minas Gerais is essential not only for direct consumption, but also for the production of various derivatives, such as cheese, yogurt, and cottage cheese (MATOS, 2023).

The state of Minas Gerais is recognized as one of the most important centers for the elaboration of artisanal cheeses in Brazil, with several areas that have historically been dedicated to the production of these items, which combine ancient knowledge and methods passed down from generation to generation. The most relevant regions in the manufacture of Minas Artisanal Cheese (QMA) are Araxá, Campos das Vertentes, Cerrado, Serra da Canastra, Serra do Salitre, Serro, Triângulo Mineiro, Serras da Ibitipoca, Diamantina and Entre Serras da Piedade ao Caraça, all of which are notable for their specific production characteristics and the unique sensory qualities of the cheeses produced in these locations (COSTA *et al.*, 2022).

2.1 LEGISLATION AND CERTIFICATION STANDARDS

The production of Artisanal Cheese was directly impacted due to government actions, including the creation of laws and the implementation of public policies. This scenario intensified from the 2000s onwards, with the revision of the criteria for sanitary standards for products of animal origin in the country. The new regulations stipulated that Artisanal Minas Cheese (QMA) could only be marketed if it followed standards similar to those of industrial production (GIÁCOMO, 2022).

In 2000, French technicians visited Minas Gerais to improve the quality and income of the producers of Minas Artisanal Cheese (QMA) through international cooperation. They observed production in the regions of Serra da Canastra, Serra do Salitre and Serro, identifying the need to improve food safety and sanitary issues. Although the QMA had a market, there were concerns about the pasteurization of raw milk, which could alter its characteristics, in addition to problems such as lack of sanitary control and falsification regarding the geographical origin of the cheese (TAVARES, 2022).

Law No. 13,860, of July 14, 2018, defines artisanal cheese in its Article 1 as that produced by traditional methods, which values and is linked to a certain territorial, regional or cultural area. This type of cheese must follow a specific elaboration protocol for each type and variety, and must be manufactured with good agricultural and production practices (BRASIL, 2018).

According to Monteiro and Matta (2018), artisanal cheeses need to be processed in the rural establishments where the milk is produced. The maturation of the cheese must take place in a room with adequate humidity and temperature control, as well as enough space for the storage of the pieces.

Given the economic and cultural relevance of artisanal cheeses, producers sought to formalize production to meet legal requirements and preserve traditional characteristics. In response, the Art Seal was instituted by Law 13.680/2018, regulated by Decree 9918/2019. This decree allows states and the Federal District, with approved regulations, to grant the registration of handicraft products in accordance with federal legislation, promoting regional development, the expansion of local businesses and combating the illegal market (CAMPELLO *et al.*, 2021).

2.1.1 The Art Seal

The Art Seal, established by Law 13,680/2018 and regulated by Decree 9,918/2019, aims to ensure the genuineness and excellence of artisanal foods, enabling their sale throughout the Brazilian territory. This certification validates traditional production techniques and ensures that the products comply with sanitary standards, fostering the cultural and economic appreciation of local producers (BRASIL, 2018; BRAZIL, 2019).

The certification strengthens the identity of artisanal products and enables greater competitiveness in the formal market, in addition to allowing states and the Federal District to grant the seal according to local regulations, promoting the decentralization of the process and the autonomy of producers in the commercialization of their products (CAMPELLO *et al.*, 2021).

Certified products must comply with specific requirements, such as the use of their own raw material or of known origin, and the implementation of mostly manual processes. This certification not only guarantees the credibility of the product, but also allows its sale without limitations linked to the region of production or the type of sanitary inspection in force (MAPA, 2020).

The Art Seal plays a crucial role in the formalization of producers and the appreciation of artisanal products at the national level, enabling their growth in the consumer market and encouraging the maintenance of regional culinary traditions (MAPA, 2020).

The Art Seal plays a fundamental role in validating the quality of artisanal products, facilitating the adequacy of inspection processes for food of animal origin produced in an

artisanal way. These products, which are mostly made with their own or specific raw material, have their quality guaranteed by inspection agencies. This provides greater food confidence and security, while preserving the culinary and cultural traditions of each region. In addition, the Art Seal increases access to authentic and unique products, promoting the appreciation of local practices, income generation and the strengthening of traditional communities in Brazil (SEBRAE, 2020).

In order to be considered artisanal, within the scope of the Art Seal, food products must meet seven requirements:

- I - Raw materials of animal origin must be processed on the property where the processing unit is located or must have a determined origin;
- II - The techniques and utensils adopted that influence or determine the quality and nature of the final product must be predominantly manual at any stage of the production process;
- III - The production process must adopt good practices in the manufacture of artisanal products with the purpose of ensuring the production of safe food for the consumer;
- IV - The raw material production units and the units of determined origin must adopt good agricultural practices in artisanal production;
- V - The final product of manufacture must be individualized, genuine and maintain the uniqueness and traditional, cultural or regional characteristics of the product, allowing sensory variability between batches;
- VI - The use of industrialized ingredients must be restricted to the minimum necessary, and the use of dyes, flavorings and other additives considered cosmetic is prohibited; and
- VII - Processing should be done primarily from a traditional recipe, which involves techniques and domain knowledge of the manipulators (GOV, BR, 2021).

The eligible establishment must contact the state inspection body to request the Art Seal (EMBRAPA, 2021).

2.2 LABELING

According to the National Health Surveillance Agency (ANVISA, 2005), the relevance of nutritional labeling of food products to encourage a healthy diet and ensure strategies to prevent chronic diseases is highlighted in several studies and research in the area of nutrition. The inclusion of nutritional information on the labels of packaged foods has been mandatory

in Brazil since 2001. In order to create a single regulation for MERCOSUR countries, there was a need to review Brazilian standards and adapt them to global trends. In October 2020, ANVISA approved new nutritional labeling standards, whose implementation began in October 2022 (ANVISA, 2025).

According to Machado (2018), IMA Ordinance No. 1,261 of 11/09/12, Artisanal Minas Cheese, in registered cheese dairies, must include the information indicated in Table 1 on the labeling.

Table 1

Labeling identifications

Identification of the cheese factory or warehouse: (IMA Ordinance no.1.261/12). Corporate name or name of the producer. Complete address of the establishment with the inclusion of the telephone number and zip code. Classification of the establishment: CHEESE FACTORY or DAIRY WAREHOUSE (State Decree No. 38,691/97). The expression REGISTRATION IN IMA/GIP UNDER No. ..., (IMA Ordinance no. 1.261/12). CNPJ and STATE REGISTRATION, in the case of legal entities. CPF and IEPR, in the case of an individual and establishment located on rural property. The expression BRAZILIAN INDUSTRY in capital letters
Product sales denomination: ARTISANAL MINAS CHEESE in bold upper case, with at least 1/3 of the dimensions of the largest inscription on the label, affixed to the main panel. (MAPA Normative Instruction No. 22/05).
Commercial brand of the product, if any, affixed to the main panel.
Microregion of origin in uppercase. MICROREGION:.....
The phrase: PRODUCT MADE WITH RAW MILK, in upper case and bold, bets on the main panel.
Ingredients: Raw milk, salt, drip and rennet (in that order)
DATE OF MANUFACTURE/BATCH: (MAPA Normative Instruction No. 22/05), in capital letters.
VALIDITY:..... (MAPA Normative Instruction No. 22/05).
The phrases: MUST BE WEIGHED IN THE PRESENCE OF THE CONSUMER and WEIGHT OF THE PACKAGE: g, in integers and in grams (Inmetro Ordinance No. 25/86). Both sentences must be declared in the same font size and in capital letters
The expression KEEP COLD FROM 1 TO 10°C, in capital letters. (When recommended by the warehouse or cheese dairy).
ONCE OPENED, CONSUME WITHIN X DAYS (maximum time that the warehouse or cheese shop guarantees the quality of the product).
The phrase DOES NOT CONTAIN GLUTEN (Federal Law No. 10.674/03), in capital letters and in bold.
Official imprint of the IMA, (IMA Ordinance No. 1,261/12).
SISBI logo (Normative Instruction Map No. 2/09) inserted below the IMA stamp.
Nutritional Information Table. (ANVISA RDC Resolutions no. 359/03 and no. 360/03). Use Vertical Model A of Annex B of Resolution RDC No. 360/03. The layout must be obeyed as to the number of rows and columns.
"ALLERGIC: CONTAINS MILK" (ANVISA RDC Resolution No. 26/15)
CONTAINS LACTOSE (Decree - Law 13.305/16) and RDC no. 136/2017

Source: MACHADO, 2018.

In 2018, new laws were approved that brought changes to the labeling standards applied to artisanal cheeses in Minas Gerais. At the national level, according to Law No. 13,680, of June 14, 2018 (known as the Art Seal Law), artisanal cheeses must be marked throughout the Brazilian territory with a single seal indicating ARTE, as established in the specific regulation. In relation to the state of Minas Gerais, Law No. 23,157, of December 18, 2018, establishes that the labels of Minas Artisanal Cheeses must contain, at least, information such as the description of the type or variety, registration number, registration or title of the producing establishment, and municipality of origin.

The creation of the brand is essential, ensuring the proper positioning of all components of the ARTE Seal on the label. This ensures a cohesive and standardized presentation across the entire product line. This zeal not only enriches the identity of the artisanal product, but also favors the recognition and trust of consumers (MINAS GERAIS, 2018).

The elaboration of the brand is crucial, ensuring the correct placement of all elements of the Art Seal on the label. This ensures a unified and uniform presentation across the entire product range. This care not only enhances the identity of the handmade product, but also promotes customer recognition and trust, as shown in Figure 1 – Art Seal Grid (Minas Gerais, 2018).

Figure 1

Art Stamp Grid



Source: MAPA, 2020.

In addition, Minas Gerais legislation also allows the commercialization of cheeses without packaging, as long as identification methods such as bas-relief printing, stamps with non-toxic inks are used, or other forms authorized by current regulations (MINAS GERAIS, 2018).

The Art Seal mark obeys a set of specific guidelines, ensuring its proper application in certified products. The standardization of these components facilitates the identification of the seal by customers and ensures its authenticity.

In Table 2, the main elements of the Art Seal are highlighted. The seal structure is arranged in a grid of 6x6 squares inclined at 45°, which act as a foundation for the placement of the other components. The title "Handicrafts of Brazil" is printed in the four central squares of the upper ends of the stamp, with a Montserrat Regular font, with no changes in size between the words. The stamp's graphics, composed of stylized letters, must be centered, ensuring that it touches, but does not invade the squares that make up the text (MAPA, 2020).

Table 2

Elements of the Art Seal

3.2.1 The Grid	3.2.2 Text "Artesanal do Brasil"	3.2.3 The "Art" Graphics
The elements of the ARTE Seal will be arranged in a grid of 6x6 squares, inclined at 45°.	The text "Artesanal do Brasil" will be arranged in the four central squares of the upper sides, occupying its entire width the text must be written in the Montserrat Regular font, with no variations in its size between the excerpts "Artesanal" and "do Brasil". So that both parts completely occupy the width of four squares, the space between letters varies between the passages.	The graphics (stylized letters) that give the name to the ARTE Seal should be as centered as possible on the grid, with due attention to always touching, but never invading, the squares of the text present.

Source: MAPA, 2020.

As presented in Table 2 - Elements of the Art Seal, these guidelines ensure a uniform use of the seal in handicraft products, encouraging its appreciation and reliability in the consumer market (MAPA, 2020).

2.3 ECONOMIC AND SOCIAL IMPACT OF CERTIFICATION

The challenges faced by artisanal cheese producers are significant and reflect the complexities of current legislation. According to a study carried out by Matos (2023), respondents from Geographical Indications (GIs) reported several difficulties related to sanitary requirements, especially considering the particularities of artisanal cheese, such as the use of raw milk and the time required for maturation.

Maintaining traditional manufacturing methods is key to preserving the unique characteristics of the products, but Brazilian legislation is predominantly focused on industrial cheeses, which creates a challenge for artisanal producers. The comparison between industrial and artisanal production practices reveals a significant discrepancy in production patterns, making the legislation inadequate for the specific needs of artisanal cheeses (MATOS, 2023). In addition, the current legislation prevents the export of artisanal cheeses, allowing these products to obtain only the Art Seal, which is not sufficient for export (MATOS, 2023).

Traceability and certification of the origin of artisanal cheeses are essential to ensure the veracity of products and to combat counterfeiting. In Brazil, one of the methods used for this control is the implementation of casein labels, especially for the manufacture of cheeses with Geographical Indication (GI). APROCAN (Association of Canastra Cheese Producers) began to use these labels as a direct identification badge on the product. This system was implemented after an exchange of experiences with French producers, and was later approved by ANVISA and the Ministry of Agriculture, Livestock and Supply between 2015 and 2016. Casein brands ensure that only cheeses made in accordance with the guidelines defined by the Canastra GI obtain this certification, reducing unfair competition and promoting the strengthening of the market for authentic artisanal cheeses.

In addition, the traceability that this method offers allows for more effective control over the quantity of production of the members, ensuring adherence to regulatory requirements (MUÝLDER *et al.*, 2022). Matos (2023) points out that, due to the difficulties imposed by sanitary requirements, many producers sought to form associations and register their productions with a geographical indication to highlight the quality and differentials of the products. However, these associations face high costs and challenges related to legislation that regulates the production of artisanal cheeses and prevents export. The reality of many small producers, who have difficulties in making large investments, further complicates the situation.

In a study conducted by Silva *et al.* (2022), the analysis of the results indicates that most small producers are unable to comply with legal standards due to the high costs involved. There is an urgent need to adapt legislation to facilitate the entry of small enterprises into the formal market and to implement a training plan that ensures greater product safety.

3 METHODOLOGY

This study, from the methodological perspective, can be defined as a bibliographic research carried out through a systematic approach to the literature. According to Lakatos and Marconi (2003), scientific investigation is a formal and meticulous procedure that seeks the acquisition of knowledge, based on logical and systematic principles. Thus, more than simply collecting data, research seeks to establish a path to understand reality and discover solutions to specific issues, employing appropriate scientific methods. The implementation of this rigorous method ensures the reliability and validity of the analyses conducted during the research.

For the construction of the present study and formulation of results, a systematic review of the literature was carried out. According to the authors Galvão and Ricarte (2020), conducting a systematic review of the literature goes beyond the common procedure of conducting a review as part of an academic research.

Systematic review is a research method that adopts specific protocols and seeks to organize a vast set of documents in a logical way. After defining the concept and presenting the different types of systematic review, the stages of this process are discussed, which include the definition of the research problem, the choice of databases, the formulation of the search strategy, the selection of documents and the organization of the results. Finally, aspects related to the dissemination and publication of systematic literature reviews are addressed. Understanding these aspects is essential not only for researchers who carry out this type of investigation, but also for reviewers and editors of academic journals from different fields of knowledge.

This study is also structured as a descriptive study, as outlined by Prodanov and Freitas (2013), when the researcher limits himself to recording and describing the phenomena he observes, without intervening in them, seeks to detail the characteristics of a specific population or phenomenon, in addition to establishing links between different variables. This process uses standardized data collection techniques, such as questionnaires and systematic observation, usually taking the form of a survey.

3.1 DATA COLLECTION, PROCESSING AND ANALYSIS

Information was obtained through a literature review in several academic databases. The sources consulted include Capes Journals, Google Scholar and *Scientific Electronic Library Online* (SciELO). The research was carried out between May 23 and 24, 2024,

through a simple search, using the key expressions: "artisanal cheese" and "art seal", from which 215 documents were found, namely: scientific articles, dissertation, electronic books, monographs, report, abstracts, academic journal, doctoral thesis, course completion works (TCC). In addition, relevant legislation on the subject was analyzed on the official platforms of the Brazilian Institute of Geography and Statistics (IBGE), the Minas Gerais Institute of Agriculture (IMA) and the Ministry of Agriculture, Livestock and Supply (MAPA).

For the treatment of the collected data and the appropriate organization by platform, a spreadsheet was created in which each tab created referred to the platforms chosen for the study. And in each tab there were the following columns: number, type of work, title, citation, type of work, year, journal/journal, abstract of the article, topics of the theoretical framework, category of analysis to be created from the keywords of the article, conclusion obtained and the *link* to access the work. Articles published in English and Portuguese that are related to the theme were selected. However, all the articles found were in Portuguese.

Thus, the research protocol created aimed to select the works participating in this research and established the parameters for inclusion and exclusion of these articles. The parameters for the protocol have been detailed below:

- Parameter for inclusion of the works resulting from the protocol: carried out from the detailed reading of the abstract of each document, containing the key expressions, *artisanal cheese* and *Art Seal*.
- Exclusion of articles that did not contain the theme *artisanal cheese* and *Art Seal*.
- Any works that are not articles from journals/magazines (TCC, dissertation, thesis, specialization monograph, abstracts, event articles and books may be excluded).
- Deletion of repeated articles on the same platform and on different platforms.
- Deletion of articles that are not complete or that do not open or the page is no longer available.

The research protocol is summarized in Table 3, which details how the investigation was conducted and the systematic review carried out.

Table 3

Research protocol

Platform	SciELO	Google Scholar	Capes Journals
Date	23/05/2024	24/05/2024	23/05/2024

Search term	"Artisanal cheese" and "Art seal"	"Artisanal cheese" and "Art seal"	"Artisanal cheese" and "Art seal"
Language	Portuguese	Portuguese	Portuguese
Specific period	No time frame to know the time history of publications	No time frame to know the time history of publications	No time frame to know the time history of publications
Overall search result on the platforms based on the search terms	0	159	3
Articles chosen after refinement with the application of the search protocol with inclusion and exclusion parameter	0	23	0

Source: Prepared by the authors, 2024.

The search carried out in the SciELO data platform resulted in no article that met the parameters established for the study. As for the articles excluded based on the exclusion criteria, it was found that none focused only on the theme of artisanal cheese or the Art Seal, without addressing both simultaneously. All articles were in the stipulated languages (Portuguese and English), and there were no duplicate articles on the same platform or between the different search platforms. In addition, no article was excluded because it was incomplete, that is, containing only the abstract, and no article was discarded due to inoperative links or inaccessible content.

The search on the Google Scholar data platform resulted in 115 articles. Of these, 44 articles were selected because they met the parameters determined for the study. Of the excluded articles, 21 addressed only artisanal cheese or the Art Seal, but not both topics simultaneously. There were no articles outside the established languages (Portuguese and English). Two duplications were identified on the same platform and 53 articles could not be accessed due to inoperative links or unavailable content.

The search carried out in the CAPES Periodicals data platform resulted in three articles, which did not comply with the parameters established for the study, and there were no selected articles. Of the excluded articles, none addressed exclusively artisanal cheese or the Art Seal simultaneously. All articles were in the established languages (Portuguese and English) and there were no duplications on the same platform or among other search platforms. In addition, no article was excluded because it was incomplete, that is, containing only the abstract, and there were no inaccessible articles due to *inoperative* links.

Thus, a total of 23 scientific articles were selected after refinement and application of the research protocol, based on the inclusion and exclusion criteria. None of the articles came from SciELO or the CAPES Journals platform, and all 23 came from the Google Scholar platform. The selected articles were analyzed together and summarized in Table 4.

Table 4

Articles selected from the applied research protocol

No.	Quote	Title
01	Araújo <i>et al.</i> (2020)	A historical-critical analysis of the development of Brazilian standards related to artisanal cheeses
02	Campello <i>et al.</i> (2021)	The ways to obtain the Art Seal in Rio de Janeiro
03	Azenha e Silva (2021)	Contamination by <i>L. Monocytogene</i> in cheese
04	Silva e Melo (2020)	Macururé cheese made from men's alligator, AL: physicochemical, microbiological and production characteristics
05	Martinelli and Angels (2023)	Valorization of Brazilian artisanal cheeses: Applicability of three distinctive quality signs for curd cheese from the perspective of experts
06	Cislaghi and Badaró (2021)	Dilemmas of the production of artisanal colonial cheese in the southwest of Paraná
07	Porto <i>et al.</i> (2022)	Microbiological quality of curd cheese produced in salt pans, MG: a case study
08	Silva <i>et al.</i> (2022)	Good practices in the production of artisanal cheeses: a systematic review of the literature
09	Ströher <i>et al.</i> (2024)	Evaluation of good agricultural practices (GAP) and manufacturing practices (GMP) of an artisanal serrano cheese (QAS) agroindustry in Rio Grande do Sul (RS)
10	Faria and Aveni (2023)	The institute of geographical indication in Brazilian law and the tolerance of the word "type" on the label
11	Ferreira e Costa (2021)	The protection of the cultural heritage of Minas Gerais by regulating the production and commercialization of artisanal cheeses
12	Goulart and Pinto (2023)	Brazilian artisanal and authorial cheeses: what is said about these products in the media and in the scientific community?
13	Rocha and Caldas (2023)	A study of the cottage cheese of Santa Bárbara-BA for the recognition of Geographical Indication (GI)
14	Benincá <i>et al.</i> (2020)	Raw milk cheese: case studies with agro-industries and health surveillance in the Department of Sarthe, France

15	Cruz <i>et al.</i> (2020)	Social networks and preservation of artisanal cheese production methods on Marajó Island, PA
16	Braccini <i>et al.</i> (2022)	Legality versus informality in the commercialization of colonial cheeses in southern Brazil: the consumer at the center of the debate
17	Souza and Borges (2023)	The regional culture in the production of cabacinha cheese: a study based on subjects from Goiás and Mato Grosso
18	Ströher, Silva and Nunes (2023)	Microbiological quality of colonial artisanal cheese (QAC): impact of good manufacturing practices - a systematic review
19	Silva <i>et al.</i> (2022)	Obstacles and challenges for the implementation of a geographical indication: the case of the curd cheese of Jaguaribe-CE
20	Ragazzon and Marconato (2023)	The Socioeconomic Impact of SUSAF-PR on Cheese Dairies in the Southwest Region of Paraná
21	Silva and Borelli (2020)	The importance of lactic acid bacteria in the safety and quality of artisanal Minas cheeses
22	Costa <i>et al.</i> (2022)	Artisanal Minas cheeses – a brief review
23	Pena <i>et al.</i> (2022)	Gastronomic know-how in Brazil: intangible heritage and Geographical Indication as resources for its protection

Source: Prepared by the authors, 2024.

The analysis of the collected data involved a critical and comparative reading of the identified legislation and standards, as well as the evaluation of the challenges and legal requirements that artisanal cheese producers face. The main points of compliance and the bureaucratic obstacles that impact the legalization and certification of artisanal products were identified. The analysis also included the verification of the differences between state and federal regulations, with a particular focus on the specificities of the state of Minas Gerais.

The 23 articles selected for content analysis were read in depth and completely. According to Bardin (1977), this process aims to structure in an appropriate way and present information in a different way, using transformation processes. The objective is to store information in a varied way and facilitate access to the observer, allowing him to extract the maximum amount of data (quantitative aspect) and relevance (qualitative aspect).

The content analysis allowed thematic categorization of the articles, divided into three large groups, based on their contents and the keywords of each article: 1) Geographical Indication (GI), Culture, Regionalism and Appreciation of Brazilian Artisanal Cheeses; 2) Legislation and Regulation and; 3) Physicochemical and Microbiological Characteristics, Good Manufacturing Practices and Food Safety. This classification was crucial to organize the analysis and understand the main areas of interest addressed in the articles.

The distribution of articles by groups addressed a view of the most recurrent approaches in the literature. The next section presents the results of the systematic review carried out.

4 RESULTS AND DISCUSSION

This section addressed the results of the studies presented in this research. Initially, it discussed the general characterization of the articles selected for the study in relation to the years of publication, the Qualis Capes classification of the journals, the methodologies adopted and the objects of study investigated. Next, he presented the theoretical foundations and the main works used in the selected articles of this study. And, finally, he explained about the categories of analysis created from the content of the selected articles on artisanal cheese, synthesizing the approaches of the articles under study.

4.1 GENERAL CHARACTERIZATION OF THE ARTICLES

In this section, the characterization of the 23 articles selected for analysis was presented. The approach showed the Qualis classification of these articles, the years of publication, the methodologies used in the studies and the objects of investigation analyzed. The objective was to provide a broad and detailed view of the characteristics of the selected articles. Table 5 presents the Qualis Capes classification of the journals whose selected articles were published.

Table 5

Qualis Capes classification of journals

No.	Title	Journal/Magazine	Qualis Capes Classification
1	A historical-critical analysis of the development of Brazilian standards related to artisanal cheeses	Periodicals Brazilian Archives of Veterinary Medicine and Animal Science (Arq. Bras. Med. Vet. Zootec.)	B1
2	The paths to obtain the Art Seal in Rio de Janeiro	Food Magazine: Science, Technology and Environment	C
3	L. Monocytogenes <i>contamination</i> in cheese	Brazilian Journal of Animal and Environmental Research	B4
4	Macuriré cheese manufactured in Jacaré dos Homens, AL: physicochemical,	Cândido Tostes Dairy Institute Magazine	C

	microbiological and production characteristics		
5	Valorization of Brazilian artisanal cheeses: applicability of three distinctive quality signs for curd cheese from the perspective of experts	Memória em Rede Magazine	B1
6	Dilemmas of the production of artisanal colonial cheese in the southwest of Paraná	Faz Ciência Magazine	B2
7	Microbiological quality of curd cheese produced in Salinas, MG: a Case Study	Cândido Tostes Dairy Institute Magazine	C
8	Good practices in the production of artisanal cheeses: a systematic review of the literature	Revista Diversitas Journal	B2
9	Evaluation of good agricultural practices (GAP) and manufacturing practices (GMP) of an artisanal serrano cheese (QAS) agroindustry in Rio Grande do Sul (RS)	Agricultural Science Magazine	C
10	The institute of geographical indication in Brazilian law and the tolerance of the word "type" on the label	JRG Journal of Academic Studies	C
11	The protection of the cultural heritage of Minas Gerais by regulating the production and commercialization of artisanal cheeses	Prisma Legal Magazine	A4
12	Brazilian artisanal and authorial cheeses: what is said about these products in the media and in the scientific community?	Concilium Magazine	A4
13	A study of the cottage cheese of Santa Bárbara-BA for the recognition of Geographical Indication (GI)	Journal of Management and Secretariat	B1
14	Raw milk cheese: case studies with agro-industries and health surveillance in the Department of Sarthe, France	Cândido Tostes Dairy Institute Magazine	C
15	Social networks and preservation of artisanal cheese production methods on Marajó Island, PA	Redes Magazine (Santa Cruz do Sul, Online)	A3

16	Legality versus informality in the commercialization of colonial cheeses in southern Brazil: the consumer at the center of the debate	Journal of Social Studies	B4
17	The regional culture in the production of cabacinha cheese: a study based on subjects from Goiás and Mato Grosso	Building the Way Magazine	B4
18	Microbiological quality of colonial artisanal cheese (QAC): impact of good manufacturing practices - a systematic review	Journal of Nutrition and Health Surveillance	C
19	Obstacles and challenges for the implementation of a geographical indication: the case of the curd cheese of Jaguaribe-CE	Economic Journal of the Northeast	A4
20	The Socioeconomic Impact of SUSAF-PR on Cheese Dairies in the Southwest Region of Paraná	Paranaense Development Journal	B1
21	The importance of lactic acid bacteria in the safety and quality of artisanal Minas cheeses	Journal of the Cândido Tostes Dairy Institute	C
22	Artisanal Minas cheeses – a brief review	Research, Society and Development Journal	A3
23	Gastronomic know-how in Brazil: intangible heritage and Geographical Indication as resources for its protection	Cultural Confluences Magazine	A4

Source: Prepared by the authors, 2024.

The analysis of Table 5 revealed that there are no articles (0%) classified in categories A1 and A2, which pointed to the inexistence of journals with greater academic repercussion among the selected articles. It is observed that 8.7% of the articles are in category A3 and 17.4% in A4, resulting in a total of 26.1% of publications in journals with significant academic impact. In group B, 17.4% are classified as B1, 8.7% as B2 and 13% as B4, adding up to 39.1% in intermediate-level journals. Finally, 34.8% of the articles belong to classification C, evidencing a higher frequency of publications in journals with less academic impact.

Regarding the years of publication, it can be observed that the articles analyzed are distributed in a varied way over time. In 2020, five articles were identified, while in 2021, there was a slight decline to four. In 2022, there was an increase, with six articles published. In

2023, the highest number was recorded, totaling seven articles. Finally, in 2024, only one study was found. This distribution shows a growing trend of interest in the topic until 2023, with a slight reduction in the last year analyzed, as shown in Table 6, below.

Table 6

Year of publication of the selected articles

Year	Absolute value	Relative Value (%)
2020	5	21,74
2021	4	17,39
2022	6	26,09
2023	7	30,43
2024	1	4,35
Total	23	100,00

Source: Prepared by the authors, 2024.

It should be noted that the research protocol was carried out without a time frame to know the time history of the publications. What can be verified in relation to this point is that the first published articles date from 2020, converging with the moment when the subject begins to be discussed in academia. The Art Stamp Law was enacted in 2018 (Law 13.680/2018 and regulated by Decree 9918/2019). It should also be added that the Minas Gerais Institute of Agriculture - IMA (2019) regulated this law with the creation of Decree No. 9,918, of 07/18/2019, which established guidelines for granting the Art Seal by the IMA, allowing handicraft products of animal origin to be marketed interstate, as long as they are subject to sanitary inspection.

In addition, the association of the subject of artisanal cheese certification related to the Art Seal took place two years after the publication of Law No. 13,860, of July 14, 2018, which defined in its first article artisanal cheese as that produced by traditional methods, which values and is linked to a certain territorial area, regional or cultural.

The methodology or material and methods of a study describes the process of development of the research, including the typology of the investigation carried out and details about the collection, analysis and treatment of the data obtained. Next, in Table 7, the methodological approach of the selected articles was presented, which deal with the certification of artisanal cheese and the art seal.

Table 7

Methodologies adopted

No.	Quote	Methodology	Data collection
01	Araújo <i>et al.</i> (2020)	Bibliographic research with critical analysis considering: 1) the main types of artisanal cheeses produced in Brazil and their characteristics, 2) a historical presentation of the standards related to the production and commercialization of Brazilian artisanal cheeses and 3) critical discussion about the challenges and perspectives for the development of new standards and their potential impacts on identity, quality and harmlessness of these products.	Primary sources: official legislation; Secondary sources: reviews of scientific literature and databases.
02	Campello <i>et al.</i> (2021)	Qualitative approach with a bibliographic and documentary review to examine the legislation that regulates the production of artisanal cheese in Brazil.	Documents and scientific literature.
03	Azenha e Silva (2021)	The Federal Official Gazette was used as the main reference, the search tool "Google Scholar" with the keywords "Listeriosis", "Cheese" and "Listeria", and books such as " <i>Modern Food Microbiology</i> " and " <i>The Microbiology of Safe Food</i> " for the development of the work.	Secondary sources: books, scientific articles, and government data.
04	Silva e Melo (2020)	Experimental research. Four technical visits were carried out between August and November 2018, where all manufacturing stages were monitored and described in detail through direct observation, audiovisual records and dialogue with the producer throughout manufacturing. The acidity (% lactic acid) of the dough was also monitored from its obtaining to the final shaping process (by direct titration with NaOH 0.1 mol/L). Another parameter monitored throughout the process was the temperature of scalding/washing and cooking the dough. Physicochemical, microbiological and cheese production analyses.	Primary sources: interviews with producers and laboratory data; Secondary sources: revision of legislation.
05	Martinelli and Angels (2023)	This is a qualitative study, with data collection through semi-structured interviews with specialists. Case study, with content analysis.	Primary sources: qualitative interviews; Secondary sources:

			review of academic literature and institutional data.
06	Cislaghi and Badaró (2021)	Qualitative research. Case study. This article reports the main actions already carried out by some projects developed on artisanal Colonial cheese from the Southwest of PR, such as the mapping of producers, preparation and publication of didactic materials, qualification actions carried out with producers, description of the production process, water and milk analysis, in addition to the physical-chemical, microbiological and sensory characterization of the cheeses. It presents a brief history of the creation of the Association of Artisanal Cheese Producers of Southwest Paraná (APROSUD) and also describes the legal issues involving the production of artisanal cheeses, as well as the challenges that still need to be faced to legitimize artisanal Colonial cheese from Southwest Paraná.	Primary sources: interviews, laboratory analyses and on-site visits. Secondary sources: historical data and teaching materials.
07	Porto <i>et al.</i> (2022)	Experimental research. This was a case study that evaluated the microbiological quality of brown cottage cheese commercialized in the city of Salinas, MG, and tested the efficiency of different processes with varying levels of adoption of safety practices in the pathogenic microbiota of brown cottage cheese.	Primary sources: laboratory microbiological analyses of experimental and commercial samples. Secondary sources: legislation and quality standards.
08	Silva <i>et al.</i> (2022)	A systematic review of the literature was conducted. To obtain the works, a search was made in the databases of Scielo, <i>Scopus</i> , <i>Web Of Science</i> and Database of Theses and Dissertations (BDTD).	Secondary sources: scientific articles, dissertations and theses reviewed in databases.
09	Ströher <i>et al.</i> (2024)	It presents an evaluation of the good practices applied in an agroindustry producing QAS in this region. On the occasion, the tools of good practices of the agroindustry installed on the property were	Primary sources: technical visits and <i>checklists</i> in certified property.

		evaluated, as well as the milking of the animals and the manufacture of the QAS.	Secondary sources: legislation and technical manuals.
10	Faria and Aveni (2023)	The work explores the legislation in the case of tolerance to the "type", and proposes to bring cases and examples that deal with such tolerance. It is, therefore, a bibliographic and internet research in the search for cases of use of the word "type" in labeling.	Secondary sources: national and international legislation, case analysis, and examples of labels collected online.
11	Ferreira e Costa (2021)	It used the legal-theoretical methodology, as well as deductive reasoning and transdisciplinary bibliographic research addressing reflections that permeate environmental and constitutional law, with an interface in anthropology, in addition to analysis in the legislative field.	Secondary sources: legal texts, legislative analyses and transdisciplinary studies.
12	Goulart and Pinto (2023)	A search was carried out on the Web of <i>Science</i> and <i>Scopus</i> search platforms using the terms "artisanal cheese" and "authorial cheese". Alerts were also received from Google with internet news on these two topics. It was observed that scientific research has as its main theme, when it comes to artisanal and authorial cheeses, the microbiological quality of these foods. The internet news broadcast to the population has as its main focus an event that took place in São Paulo, where the world cheese contest was held.	Secondary sources: data from scientific publications and news alerts categorized and statistically analyzed.
13	Rocha and Caldas (2023)	The methodology used consists of the use of bibliographic research procedures, through physical and virtual collections, with documentary, normative analysis and field survey. In addition, the perceptions obtained from visits to the municipality of Santa Bárbara-BA are added, in order to obtain information about the chosen object of study regarding its representativeness for the place, as well as the processes and technological innovations involved in its manufacture, and the challenges encountered for its recognition as a Geographical Indication (GI).	Primary sources: field survey and visits to local producers; Secondary sources: legislative analysis and institutional publications.

14	Benincá <i>et al.</i> (2020)	It is characterized as a qualitative research with a triangulated, exploratory and descriptive-interpretative study based on interviews with two owners of French agroindustries in the Department of Sarthe, France, in December 2019. The data collection instrument was a semi-structured interview questionnaire with guiding questions.	Primary sources: interviews and <i>on-site</i> observations. Secondary sources: bibliographic review and French and European legislation.
15	Cruz <i>et al.</i> (2020)	Using a qualitative approach, through semi-structured interviews and thematic oral history, it was sought to analyze and understand the social networks developed around the production and consumption of different types of cheeses from Marajó, the impacts on production and marketing, their characteristics considered essential in the maintenance and preservation of their quality, producers' view of changes in the production process, its difficulties, forms of resistance and permanence over time.	Primary data: interviews. Secondary data: scientific and historical literature.
16	Braccini <i>et al.</i> (2022)	The study appropriated a descriptive, exploratory and quantitative approach, as it seeks to reflect on the data recruited, seeking to outline the reality, through an exposition based on works and authors in the area. The data for this study come from a convenience sample of 121 consumers of Colonial Cheese (QC) in Santa Maria, Rio Grande do Sul State, Brazil.	Primary data: structured questionnaires. Secondary data: scientific literature.
17	Souza and Borges (2023)	In the study approach, qualitative research was defined. We studied aspects of the way of making cabacinha cheese, the regionalization and the identity of the artisanal product, especially with a couple of producers from Santa Rita do Araguaia (GO) and with a producer from Alto Araguaia (MT).	Primary data: interviews and field observation. Secondary data: cultural and historical literature.
18	Ströher, Silva and Nunes (2023)	Literature search was conducted in three databases, Google Scholar, <i>Scopus</i> , and <i>Web of Science</i> , using the following keywords: "colonial artisanal cheese" or "good manufacturing practices" or "colonial cheese" "microbiological analysis" using Boolean operators and quotation marks.	Secondary data: scientific articles on microbiological quality and food safety.

19	Silva <i>et al.</i> (2022)	In this study, a descriptive and exploratory research was used, based on a qualitative approach and focus on a case study, with the objective of understanding the challenges for the implementation of the GI of Jaguaribe Curd Cheese in Ceará. For a study of this nature, multiple and varied sources of evidence are needed.	Primary data: semi-structured interviews and direct observation. Secondary data: documentary analysis.
20	Ragazzon and Marconato (2023)	The field research was exploratory (since it aims to bring the researcher closer to the researched object) and descriptive, as it proposes to collect and analyze data, in order to identify whether SUSAF-PR contributed to improve the socioeconomic conditions of cheese producers in the Southwest region of the state.	Primary data: online questionnaires. Secondary data: legislation and technical literature.
21	Silva and Borelli (2020)	The following review presents information on the antagonistic activity of lactic acid bacteria and their ability to ensure the safety and quality of artisanal cheese.	Secondary data: scientific literature on lactic acid bacteria and microbiological safety.
22	Costa <i>et al.</i> (2022)	The work was carried out through a bibliographic review in different indexing databases to collect information on artisanal Minas cheeses. The main electronic databases used were <i>Scopus</i> , <i>Scielo</i> , <i>Science Direct</i> , <i>Web of Science</i> , <i>Wiley Online Library</i> and <i>Google Scholar</i> . The search was carried out using the keywords: "artisanal cheese", " <i>artisanal cheese</i> ", " <i>artisanal Minas cheese</i> ", "pingo", "sano-fermento", "rala", " <i>endogenous starter culture</i> ".	Secondary data: scientific, legislative and historical bases.
23	Pena <i>et al.</i> (2022)	Documentary and bibliographic review, with analysis of the resources for the protection of traditional knowledge in artisanal food production interpreted based on scientific production on the subject, published in the last five years. The resources analyzed in the study were: the registration of intangible assets of IPHAN, under Decree No. 3,551, of August 4, 2000; and the Geographical Indications (GI) granted by the BPTO, with the legal framework of Law No. 9,279, of May 14, 1996.	Secondary data: national legislation and recent scientific productions.

Source: The authors, 2024.

The data described in Table 6 show that of the 23 articles examined, 43.5% were dedicated exclusively to bibliographic or documentary research, using secondary data. This indicates a predominance of approaches based on theoretical review and document analysis. On the other hand, 26.1% of the studies were categorized as experimental research, in which primary data were collected, evidencing an expressive application of practical methods and the direct collection of information. Finally, 30.4% of the articles opted for a qualitative approach, with the collection of primary data through interviews or questionnaires, which highlights the importance of interpretative and exploratory analyses on the topic in question.

This distribution reveals the variety of methodological approaches used in research related to the certification of artisanal cheese. It combines the theoretical robustness of literature reviews with practical and qualitative studies, providing important insights for understanding the phenomenon.

With regard to the objects of study, the analysis addressed the geographic regions investigated in the selected articles. The studies covered a variety of locations, with an emphasis on rural areas involved in artisanal cheese production in Minas Gerais, highlighting the micro-regions of Cerrado and Serra da Canastra, as well as other parts of Brazil that face similar challenges, such as Goiás, Jacaré dos Homens (AL), Jaguaribe (CE), Marajó (PA), Mato Grosso, Nordeste, Rio de Janeiro, Salinas (MG), Southwest of Paraná and São Francisco de Paula (RS). A study was also carried out on cheese production in Le Mans, France. It is noteworthy that eight articles did not specify the region of the objects of study. Table 8 illustrates the objects of study and the regions investigated in each of the selected articles.

Table 8

Objects of study and region researched

No.	Quote	Objects of Study	Region
01	Araújo <i>et al.</i> (2020)	Bibliographic research on artisanal cheeses without defined location.	-
02	Campello <i>et al.</i> (2021)	Bibliographic research, focusing on the municipality of RJ. The objective is to verify the demand for the sale of raw milk and artisanal cheeses, through informal trade; the need to regulate the artisanal cheese market, especially in the state and municipality of Rio de Janeiro and the adherence to inspection	Rio de Janeiro-RJ

		systems by small producers, as a way to mitigate risks to public health.	
03	Azenha e Silva (2021)	Bibliographic research on artisanal cheeses without a defined object of study.	-
04	Silva e Melo (2020)	Macururé cheese has been produced for about 100 years by a single family, in the village of Caititu, located in the city of Jacaré dos Homens, AL.	Jacaré dos Homens-AL
05	Martinelli and Angels (2023)	Artisanal curd cheese for the northeast region.	Northeast
06	Cislaghi and Badaró (2021)	Artisanal Colonial Cheese from the Southwest of PR.	Southwest of PR
07	Porto <i>et al.</i> (2022)	Brown cottage cheese sold in the city of Salinas-MG.	Salinas-MG
08	Silva <i>et al.</i> (2022)	To investigate whether the production of artisanal cheeses meets the requirements established by the legislation in force in Brazil. For this, a systematic review of the literature was carried out.	-
09	Ströher <i>et al.</i> (2024)	A dairy farm located in the municipality of São Francisco de Paula-RS was chosen as the object of investigation for the evaluation of the GAP applied in the rural property and the GMP implemented in the agroindustry.	São Francisco de Paula-RS
10	Faria and Aveni (2023)	The work explores how Brazil faces challenges in the protection of Geographical Indications in light of new international agreements, especially in relation to the current tolerance of products without GIs, but marketed in a misleading way.	-
11	Ferreira e Costa (2021)	This work analyzes the importance of cultural heritage as a way of preserving the identity of a collectivity, focusing on the artisanal production of cheese in the state of Minas Gerais.	Minas Gerais
12	Goulart and Pinto (2023)	This study identifies the main interests of the scientific community and the population in relation to artisanal and authorial cheeses.	-
13	Rocha and Caldas (2023)	The object of study chosen concerns its representativeness for the place, as well as the processes and technological innovations involved in its manufacture, and the challenges encountered for its recognition as a Geographical Indication (GI).	-

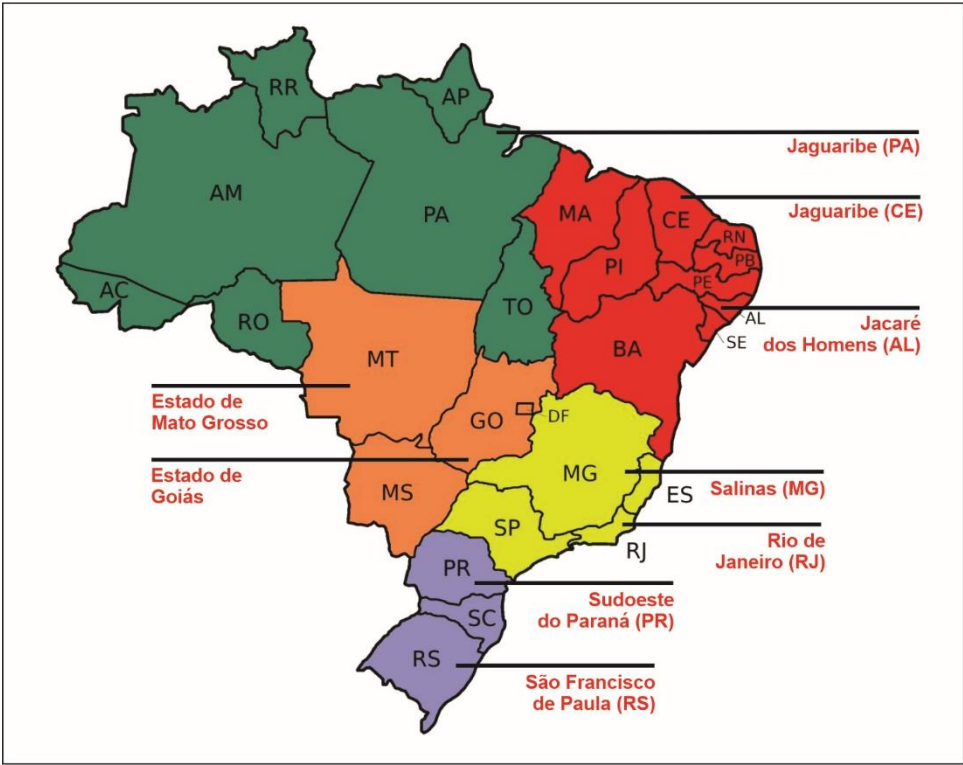
14	Benincá <i>et al.</i> (2020)	The work evaluates the perception of cheese producers and veterinary technicians through interviews in Le Mans, in the Department of Sarthe, France, according to the social and sanitary aspects in relation to the production and commercialization of this product.	Le Mans, in the Sarthe department, France
15	Cruz <i>et al.</i> (2020)	It reflects on social networks developed throughout the cheese production system (butter and cream types) in Marajó/PA, Brazil.	Marajó-PA
16	Braccini <i>et al.</i> (2022)	This study explores the level of importance attached to sociocultural aspects, beliefs and preferences, food safety, and state regulation in the purchase of Colonial Cheese (QC).	-
17	Souza and Borges (2023)	It briefly addresses the history of cabacinha cheese, produced in two neighboring states: Goiás and Mato Grosso.	States of Goiás and Mato Grosso
18	Ströher, Silva and Nunes (2023)	It addresses the production and commercialization of colonial artisanal cheeses, with emphasis on microbiological parameters.	-
19	Silva <i>et al.</i> (2022)	It analyzes the process of implementation of the Geographical Indication of Curd Cheese from Jaguaribe-CE, pointing out the role of the agents involved, the main obstacles and challenges that prevent the advancement towards its implementation.	Jaguaribe-CE
20	Ragazzon and Marconato (2023)	To collect and analyze data, in order to identify the contribution of SUSAF-PR to improve the socioeconomic conditions of cheese producers in the Southwest region of the state.	State of Paraná - PR
21	Silva and Borelli (2020)	It is the analysis of the characteristics and benefits of the lactic acid bacteria present in artisanal Minas cheese, especially in relation to its antagonistic activity against pathogenic microorganisms.	Minas Gerais
22	Costa <i>et al.</i> (2022)	To present a literature review, contemplating the main characteristics of the producing regions and the aspects of each cheese produced.	-
23	Pena <i>et al.</i> (2022)	It addresses the issue of the protection and enhancement of cultural elements, which make up a food system, with a specific focus on food products produced under signs of cultural distinction. The article investigates how these foods, elaborated based on ancestral and geolocated knowledge, are perceived	-

		as important alternatives in a global market, where food culture may be becoming homogenized and questionable.	
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Source: The authors, 2024.

The evaluation of the geographical dispersion of the chosen research shows a significant concentration of studies in certain areas of Brazil, evidencing the importance of the production of handmade cheese in these areas. Figure 2 illustrates in detail the areas analyzed, highlighting the federative units and micro-regions where the investigations took place, making it possible to observe the geographic extent of the research and detect trends in the location of producers and the difficulties encountered to certify artisanal cheese.

Figure 2
Map of the regions studied



Source: The authors, 2024.

The presentation of the regions studied is complemented by an illustrative image (Figure 2), which highlighted the geographical distribution of the objects of study and provided a visual and contextualized synthesis of the areas analyzed by these studies chosen for this research.

4.2 THEORETICAL APPROACHES TO ARTISANAL CHEESE AND THE ARTE SEAL IN THE WORKS INVESTIGATED

This second part of the results presented the theoretical foundations and main works used in the articles participating in this study in order to theoretically know the approach of these articles.

Table 9

Theoretical foundations of the articles studied

No.	Quote	Topics of the theoretical framework
01	Araújo <i>et al.</i> (2020)	Historical data related to cheese production in Brazil are controversial, both in relation to the period and the regions in which this practice was initiated. Minas Gerais was the first to develop its own legislation that enabled the artisanal production of cheeses with raw milk. The artisanal cheese production chain in Brazil has not been adequately regulated for decades, due to scarce, evasive or inefficient legislation. With the update of the Regulation of Industrial and Sanitary Inspection of Products of Animal Origin (Riispoa) (Brazil, 2017) and the regulation of the Arte seal (Brazil, 2018; 2019a), a series of state and municipal standards related to artisanal products, including cheeses, began to be developed and implemented. Theoretical critical foundation on: 1) the main types of artisanal cheeses produced in Brazil and their characteristics, 2) a historical presentation of the standards related to the production and commercialization of Brazilian artisanal cheeses and 3) a critical discussion on the challenges and perspectives for the development of new standards and their potential impacts on identity, quality and harmlessness of these products.
02	Campello <i>et al.</i> (2021)	2.1 Milk production and informal trade 2.2 The artisanal cheese market in Brazil and its regulation 2.3 Regulation of artisanal cheeses in the state of Rio de Janeiro 2.4 Adhesion to inspection seals
03	Azenha e Silva (2021)	Reasons why half-ripened cheese is considered susceptible to listeria <i>monocytogenes contamination</i> . About Listeriosis: mortality, incubation period, risk population and diagnosis.
04	Silva e Melo (2020)	Description of the Macururé cheese manufacturing process. Collection and transport of samples. Physicochemical analysis Microbiological analyses. Experimental design and statistical analysis of the data.
05	Martinelli and Angels (2023)	Digging up the roots of artisanal curd cheese. Potentialities of Brazilian valorization and safeguard devices. Expert reports on recovery and safeguard

		devices. Perceptions about intangible cultural heritage. Perceptions about the labels of differentiation of agri-food products. Perceptions about geographical indications. Perceptions about the Arte label
06	Cislaghi and Badaró (2021)	Artisanal colonial cheese manufacturing technology. Physicochemical parameters of artisanal Colonial cheese from Southwest Paraná. Sensory characteristics of artisanal Colonial cheese and consumer perception. Microbiological quality of artisanal Colonial cheese from the Southwest of Paraná. Legislation for artisanal Colonial cheese Main difficulties in the production of artisanal Colonial cheese.
07	Porto <i>et al.</i> (2022)	Verification of the microbiological quality of brown cottage cheeses. Detection of <i>Salmonella sp.</i> Coagulase-positive staphylococci determination. Determination of total and thermotolerant coliforms.
08	Silva <i>et al.</i> (2022)	Brazilian legislation for the production of artisanal cheeses. There are several laws regulating production in the country, which undergo constant changes over time in order to ensure a product of excellent quality.
09	Ströher <i>et al.</i> (2024)	The Serrano Artisanal Cheese (QAS) has great economic, social and environmental importance in the northeast region of Rio Grande do Sul (RS), being a bicentennial and traditional product to the point of undergoing few changes over the years. And when adopted, good agricultural practices (GAP) and good manufacturing practices (GMP), together, make artisanal activity safer for consumers of these products. Thus, the GAPs on the property and the GMPs in the cheese factory end up providing refrigerated raw milk and artisanal cheese, respectively of good quality according to regulatory specifications.
10	Faria and Aveni (2023)	Tolerance in Brazilian law to foods that do not use the Geographical Indication seal, but continue to be marketed as long as they are under the nickname of the word "type" added to the name of the legitimate Geographical Indication. Ordinance No. 146 of March 7, 1996 published by the Brazilian Ministry of Agriculture, which regulates the production of cheese in the country, as well as Normative Instruction No. 22 of November 24, 2005, which allows products of animal origin manufactured according to technologies characteristic of different geographical places. In order to obtain products of animal origin with sensory properties similar or similar to those that are typical of certain recognized areas, the name of the product of animal origin must include the expression "type", with letters of the same size, prominence and visibility as those corresponding to the name approved in the regulation in force in the country of consumption, in violation of international treaties.
11	Ferreira e Costa (2021)	The manufacture of artisanal cheeses in Brazil, with emphasis on Minas Gerais, constitutes a valuable intangible cultural heritage, closely linked to

		traditional knowledge and regional identity. This process uses raw milk and manual maturation techniques that have been passed down from generation to generation. In the past, the absence of adequate regulation brought difficulties to the formalization of this practice, leading many producers to operate clandestinely. The evolution of legislation, especially with the introduction of the Art seal and state and federal regulations, sought to balance cultural preservation with sanitary requirements, promoting economic viability and ensuring the continuity of artisanal production.
12	Goulart and Pinto (2023)	Main interests of the scientific community and the population in relation to artisanal and authorial cheeses.
13	Rocha and Caldas (2023)	Definitions and legislation involved with Geographical Indication (GI), which is a distinctive sign of Intellectual Property, for collective use, and refers to the recognition of a place that has become known for offering a unique product or service.
14	Benincá <i>et al.</i> (2020)	The production of artisanal cheeses, especially those made with raw milk, still remains a problem around the world. The analysis and understanding of the functioning of the production and market of these products in countries where they are traditional can be an important tool for the reproduction of know-how in other cultures. Current Brazilian legislation on the regulation for the production and commercialization of traditional cheeses made from raw milk and questions about the safety of consumption of these artisanal foods.
15	Cruz <i>et al.</i> (2020)	Production systems and product classification criteria. Criteria for evaluating food quality, reflecting in public policies and legislation that assume a "quality" based on conventional metric criteria, linked to industrial production, leaving small production in the background or even in informality. Process of (re)valorization and resignification of the rural and its products, connoting these meanings of reliability, healthiness and transparency in relation to the techniques used and, therefore, capable of providing safe and healthy food, leading to the construction of demands, new markets and consumption patterns with a strong territorial and cultural connection. Development of trusted social networks that strengthen and support local products and producers, enabling the continuity and preservation of differentiated and unique knowledge, production techniques, ways of life and products, aspects that have generally been neglected by official inspection and inspection standards.
16	Braccini <i>et al.</i> (2022)	The theoretical framework of the New Institutional Economics was used to examine sociocultural factors, beliefs and preferences, food security, and state

		regulation. The institutional environment. Informal and formal rules. Sanitary regulations for cheeses in Brazil.
17	Souza and Borges (2023)	The identities, the origin of cabacinha cheese and the regionalization of production in Brazilian culture.
18	Ströher, Silva and Nunes (2023)	Production and marketing of artisanal colonial cheeses, with emphasis on microbiological parameters. Good manufacturing practices.
19	Silva <i>et al.</i> (2022)	Geographical Indications (GI) and their importance. The process of implementing a GI. Main obstacles and challenges to the process of institutionalization / implementation of Geographical Indications in Brazil. Geographical Indication (GI) in Brazil and the potential of the State of Ceará.
20	Ragazzon and Marconato (2023)	Family agribusiness has transformed the rural environment in several aspects, bringing advantages in the social and economic area to producing families. Food legislation at the municipal, state and federal levels began to look at colonial and artisanal products as being traditional and began changes in the legislation, differentiating large and small foods, as is the case of family agribusiness. To support the agro-industrialization process, the state of Paraná, through the Secretariat of Agriculture and Supply (SEAB), established new regulations that instituted the Unified System of Attention to Agricultural Health, Family and Small Farming in the State of Paraná (SUASA-SUSAF-PR), and introduced the concept of uniformity, harmonization and equivalence between the inspection services of the municipalities of the territory of Paraná, in the inspected establishments.
21	Silva and Borelli (2020)	The artisanal Minas cheeses. Microbiological safety. Lactic acid bacteria. Antagonistic compounds produced by BAL (Lactic Acid Bacteria). Antagonistic activity. Resistance of pathogenic bacteria to the maturation process of cheeses.
22	Costa <i>et al.</i> (2022)	Characteristics of the manufacturing process of Minas Artesanal cheese. Pingo used in the manufacture of QMA. QMA producing regions: Araxá, Campos das Vertentes, Cerrado, Serra da Canastra, Serra do Salitre, Serro, Triângulo Mineiro, Serras da Ibitipoca, Diamantina and Entre Serras da Piedade ao Caraça.
23	Pena <i>et al.</i> (2022)	Intangible cultural heritage: the safeguard proposed by Iphan for the traditional know-how of food. The Geographical Indication as an instrument of intellectual property for the preservation of intangible heritage. Protection of the know-how of artisanal food products in Brazil: possible articulations.

Source: The authors, 2024.

The concepts and definitions related to artisanal cheeses emerge as a frequent theme in the academic literature, highlighting cheese as an intangible cultural heritage. The manufacture of artisanal cheeses in Brazil, exemplified by the Artisanal Minas Cheese (QMA), represents traditional knowledge, passed down from generation to generation, associated with regional identity and the use of raw milk, in addition to manual techniques for maturation. These activities maintain a deep connection with the local culture, as pointed out by Ferreira and Costa (2021), who underline the cultural and economic importance of cheeses made in Minas Gerais. Another fundamental aspect is legislation and certification, especially the Art Seal. The Industrial and Sanitary Inspection Regulation (RIISPOA) together with the Art Seal marked significant achievements in the regulation of artisanal cheeses, allowing their sale between states without compromising traditional practices.

According to Araújo *et al.* (2020), these regulations brought modernization to the production chain, raising quality and safety. However, research points to the obstacles faced by small producers to adapt to legal requirements without compromising the cultural authenticity of their products.

The Geographical Indication (GI) emerges as a crucial instrument to protect and enhance artisanal cheeses, ensuring their genuineness and connection to specific regions. Examples such as Artisanal Minas Cheese, recognized by IPHAN, demonstrate the positive effect of this certification on the strengthening of local economies and the preservation of traditional know-how (ROCHA; CALDAS, 2023). However, as pointed out by Silva *et al.* (2022), there are still difficulties and challenges in the institutionalization of GIs in Brazil.

Issues related to health and microbiology have been widely debated, focusing on the dangers linked to the consumption of raw milk and contamination by pathogens, such as *Listeria monocytogenes* and *Salmonella*. Research indicates that the adoption of good manufacturing practices (GMP) and good agricultural practices (GAP) is essential to ensure product safety and meet established standards, without compromising artisanal techniques (STRÖHER *et al.*, 2024; PORTO *et al.*, 2022).

In addition, the social and economic effects of artisanal production were highlighted as significant aspects. Family agribusiness has promoted transformations in the rural environment, boosting the local economy and valuing both culturally and territorially handicraft products. Ragazzon and Marconato (2023) point out that the creation of specific regulations for small producers was an important advance to ensure their sustainability and continuity.

4.3 CATEGORIES OF ANALYSIS AND SYNTHESIS OF THE ARTICLES UNDER STUDY

This section covered the analysis categories created from the content covered in the selected articles. It should be noted that many contents are related and the categorization sought to compile the themes involved in the studies, considering the complete content of each article. In all, three broad categories of analysis were created, namely: 1) Geographical Indication (GI), Culture, Regionalism and Appreciation of Brazilian Artisanal Cheeses; 2) Legislation and Regulation and; 3) Physicochemical and Microbiological Characteristics, Good Manufacturing Practices and Food Safety. Table 10 describes the numbers and titles of articles included in each category.

Table 10

Analysis categories created

Category		Article No.	Title
1	Geographical Indication (GI), Culture, Regionalism and Appreciation of Brazilian Artisanal Cheeses	19	Obstacles and challenges for the implementation of a geographical indication: the case of the curd cheese of Jaguaribe-CE
		17	The regional culture in the production of cabacinha cheese: a study based on subjects from Goiás and Mato Grosso
		13	A study of the cottage cheese of Santa Bárbara-BA for the recognition of Geographical Indication (GI)
		23	Gastronomic know-how in Brazil: intangible heritage and Geographical Indication as resources for its protection
		5	Valorization of Brazilian artisanal cheeses: Applicability of three distinctive quality signs for curd cheese from the perspective of experts
		6	Dilemmas of the production of artisanal colonial cheese in the southwest of Paraná
		20	The Socioeconomic Impact of SUSAF-PR on Cheese Dairies in the Southwest Region of Paraná
		22	Artisanal Minas cheeses – a brief review

		15	Social networks and preservation of artisanal cheese production methods on Marajó Island, PA
2	Legislation and Regulation	1	A historical-critical analysis of the development of Brazilian standards related to artisanal cheeses
		2	The paths to obtain the Art Seal in Rio de Janeiro
		10	The institute of geographical indication in Brazilian law and the tolerance of the word "type" on the label
		11	The protection of the cultural heritage of Minas Gerais by regulating the production and commercialization of artisanal cheeses
		16	Legality versus informality in the commercialization of colonial cheeses in southern Brazil: the consumer at the center of the debate
3	Physicochemical and Microbiological Characteristics, Good Manufacturing Practices and Food Safety	18	Microbiological quality of colonial artisanal cheese (QAC): impact of good manufacturing practices (GMP) - a systematic review
		12	Brazilian artisanal and authorial cheeses: what is said about these products in the media and in the scientific community?
		7	Microbiological quality of curd cheese produced in Salinas, MG: a Case Study
		3	Contamination by <i>L. Monocytogenes</i> in cheese
		21	The importance of lactic acid bacteria in the safety and quality of artisanal Minas cheeses
		9	Evaluation of good agricultural practices (GAP) and manufacturing practices (GMP) of an agroindustry of Artisanal Serrano Cheese (QAS) in Rio Grande do Sul (RS)
		14	Raw milk cheese: case studies with agro-industries and health surveillance in the Department of Sarthe, France
		4	Macururé cheese manufactured in Jacaré dos Homens, AL: physicochemical, microbiological and production characteristics

		8	Good practices in the production of artisanal cheeses: a systematic review of the literature
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Source: The authors, 2024.

The articles examined were classified into three main categories, which summarize the most common topics in research related to artisanal cheeses in Brazil: (1) Geographical Indication (GI), Culture, Regionalism and Appreciation of Brazilian Artisanal Cheeses; (2) Legislation and Regulation; and (3) Physicochemical and Microbiological Characteristics, Good Manufacturing Practices and Food Safety. The category Geographical Indication (GI), Culture, Regionalism and Appreciation of Brazilian Artisanal Cheeses is the one that contains the largest number of articles. These investigations emphasize the relevance of GI as an instrument to protect and enhance artisanal cheeses, ensuring their authenticity and their connection with specific regions.

In addition, the cultural and economic effects of regional production are discussed, highlighting how traditional knowledge expresses the identity of the producing communities. Objects of study of the selected articles included the curd cheese from Jaguaribe-CE and research on the local culture in the manufacture of cabacinha cheese in Goiás and Mato Grosso.

With regard to Legislation and Regulation, the articles analyze the challenges and progress of legal standards related to the production and sale of artisanal cheeses. The creation of the Art Seal and the regulation of Geographical Indications are considered relevant milestones for the formalization of this sector, although problems such as informality and the difficulty of following regulations persist. This category demonstrates the search for balancing technical and sanitary requirements with cultural preservation, with Minas Artesanal cheese being a significant example in this discussion.

Finally, the section that deals with Physico-Chemical and Microbiological Characteristics, Good Manufacturing Practices and Food Safety focuses on the microbiological safety and physicochemical parameters of artisanal cheeses. The investigations examine the presence of pathogens, such as *L. monocytogenes*, and highlight the relevance of good manufacturing practices (GMP) and agricultural practices (BPA) to ensure the quality and safety of products.

In addition, they address the influence of lactic acid bacteria on the safety and flavor of cheeses, in addition to the particularities of regional products, such as Macururé cheese, produced in Alagoas.

This investigation highlights the emphasis on themes related to cultural appreciation and regulation, while technical-scientific and sanitary issues emerge as a fundamental basis to ensure the quality and sustainability of artisanal production.

Each of these themes was explored independently, aiming to deepen the understanding of the contributions, difficulties and impacts on the scenario of artisanal cheese production in the country. This approach enabled a more detailed investigation of each category, highlighting the subtleties that define research in this area.

4.3.1 Geographical Indication (GI), Culture, Regionalism and Appreciation of Brazilian Artisanal Cheeses

The Geographical Indication (GI) stands out as one of the most relevant mechanisms for the appreciation of artisanal cheeses in Brazil, ensuring their authenticity and link with specific areas. As pointed out by Silva *et al.* (2022), the implementation of the GI faces considerable bureaucratic obstacles, but its potential to leverage the regional economy is indisputable. The study deals with the curd cheese of Jaguaribe-CE, where the certification aims to reinforce the cultural identity and increase the value of the product.

Comparatively, Rocha and Caldas (2023) underline that GI acts as a tool for collective intellectual protection by recognizing regional products for their unique characteristics, as well as the quality linked to the place of origin. The research explores the cottage cheese of Santa Bárbara-BA, illustrating how GI can transform the local economy and preserve traditional knowledge, in addition to facing both technical and institutional challenges.

Souza and Borges (2023) comprehensively address the cultural and regional dimension when studying the production of cabacinha cheese in Goiás and Mato Grosso. The authors emphasize that this product represents an icon of the cultural identity of these locations, reflecting a historical heritage, passed down through the generations. Similarly, Pena *et al.* (2022) emphasize that gastronomic knowledge should be considered an intangible heritage, subject to protection through the Geographical Indication (GI), which strengthens both the culture and the economy of the regions involved.

In addition, the appreciation of artisanal cheeses, by distinctive signs of quality, is a prominent theme. Martinelli and Anjos (2023) investigate the effect of seals, such as the Art Seal and the GI, on curd cheese, pointing out the positive view of experts about the cultural and commercial advantages that these certifications offer. The authors state that such

initiatives not only ensure the protection of products, but also sustain the economic viability of the communities that produce them.

Social networks were identified as an important element in the preservation of production practices. Cruz *et al.* (2020) examine the influence of these platforms on cheesemaking on Marajó Island-PA, highlight how they help to preserve traditions and build trust between producers and consumers. This type of interaction is essential to reinforce the connection between the product and its place of origin.

In addition, studies on regional appreciation emphasize the socioeconomic impact of artisanal cheese production. Ragazzon and Marconato (2023) analyze the transformations resulting from SUSAF-PR in cheese dairies in southwestern Paraná, showing that differentiated regulation promotes local development and protects small producers. Costa *et al.* (2022) carry out a review of Minas Artesanal cheeses, highlighting the importance of certifications in the preservation of traditions and economic strengthening.

Thus, the articles examined show that the Geographical Indication works as an effective tool for the protection and appreciation of artisanal cheeses, uniting cultural, regional and economic dimensions. In addition, this approach proves to be a competent strategy to ensure the sustainability of these traditions and reinforce the identity of the producing communities.

4.3.2 Legislation and Regulation

The category referring to legislation and regulation underlined the relevance of legal standards and certifications, including the Art Seal and the Geographical Indication (GI), for the organization and development of the artisanal cheese market. While the greatest emphasis is on the cultural and economic aspects of artisanal cheese, regulations have played a crucial role in the formalization and growth of the sector. According to Campello *et al.* (2021), the Art Seal has proven to be an essential instrument to enable the commercialization of handicraft products between states, as evidenced in the case of Rio de Janeiro. The study points out that, despite significant achievements, adherence to the Art Seal still faces administrative and bureaucratic obstacles.

A relevant aspect discussed concerns the use of the term "type" on product labels that seek to refer to Geographical Indications (GIs). As noted by Faria and Aveni (2023), this practice can cause confusion among consumers, as it insinuates a connection with the quality

and authenticity of products with GIs, even if they do not meet the strict criteria required for certification.

The study criticizes this approach as an attempt to take advantage of the prestige of GIs, which weakens the valuation of truly certified products and compromises the credibility of the GI protection system in Brazil. Thus, the urgency of more intense control and specific regulations that prohibit the inappropriate use of terms that may deceive the consumer and discredit producers who comply with certification standards is highlighted.

Furthermore, Faria and Aveni (2023) address the legislation that regulates the use of the term, underlining its importance to distinguish products with certification of origin from those that only refer to tradition. This analysis emphasizes the need for stricter control in order to avoid confusion among consumers and ensure the protection of local producers.

Araújo *et al.* (2020) also highlight the evolution of legal norms by outlining a historical overview of Brazilian regulations related to artisanal cheese. The authors point out that, for decades, the sector has faced difficulties due to ambiguous and inconsistent legislation. However, significant advances, such as the Industrial and Sanitary Inspection Regulation (Riispoa) and the Art Seal, have brought significant improvements. Despite this, there are still challenges for small producers to adapt to the standards without compromising the authenticity of their products.

The regulation of Minas Artesanal cheese was addressed by Ferreira and Costa (2021), who emphasize the importance of balancing sanitary requirements with the preservation of traditional practices. The study proposes that legislation be adjusted to take into account regional and cultural particularities, favoring the inclusion of small producers in the formal market.

In addition, Braccini *et al.* (2022) draw attention to the duality between legality and informality in the commercialization of colonial cheeses in southern Brazil. The survey indicates that many producers still face difficulties in complying with legal standards, which limits their presence in the market and decreases their growth potential. This situation is compounded by the lack of institutional support and the complexity of regulations.

The five articles examined demonstrate that, despite the importance of legislation and regulation to ensure the quality and safety of artisanal cheeses, these aspects also impose considerable challenges on small producers. While initiatives such as the Art Seal represent significant progress, there are still opportunities for enhancements that favor greater inclusion and access within the sector.

4.3.3 Physicochemical and Microbiological Characteristics, Good Manufacturing Practices and Food Safety

The physicochemical and microbiological properties of artisanal cheeses are essential to ensure food safety and product quality. As presented by Porto *et al.* (2022), the brown cottage cheese from Salinas, MG, faces challenges related to microbiological contamination, especially with pathogens such as *Salmonella sp.* and *coagulase-positive staphylococci*. This study highlights the need to monitor these conditions in order to ensure the safety of the product.

Similarly, Silva and Melo (2020) emphasize the physicochemical and microbiological characteristics of Macuré cheese, produced in Jacaré dos Homens, AL. The research highlighted the importance of adopting good manufacturing practices to reduce the risks of contamination and maintain the sensory and nutritional qualities of the cheese.

Within the scope of good manufacturing and agricultural practices, Ströher *et al.* (2024) highlight that the implementation of GMP and BPA in an agroindustry that produces Serrano Cheese (QAS) in Rio Grande do Sul resulted in notable improvements in product quality and safety. These protocols ensured high-quality refrigerated raw milk, in addition to promoting the sustainability of artisanal practices in the region.

In addition, research has examined the effect of lactic acid bacteria on the microbiological safety of cheeses. As mentioned by Silva and Borelli (2020), these bacteria have antagonistic properties that fight pathogens and favor both the maturation and quality of Minas Artesanal cheeses. These compounds are essential to ensure the safety of products and enhance their sensory characteristics.

Finally, Silva *et al.* (2022) conducted a systematic analysis of best practices in artisanal cheese production, highlighting the importance of regulations that ensure product quality and reduce public health risks. The implementation of strict protocols has been linked to a substantial drop in contamination and increased competitiveness in the market.

These researches show that the combination of good manufacturing practices, microbiological monitoring and control of physicochemical characteristics are essential to ensure the quality and safety of artisanal cheeses. In addition, these measures help to maintain the cultural authenticity of the products and strengthen consumer confidence.

5 FINAL CONSIDERATIONS

The conclusions were formulated based on the objectives defined in this study, taking into account the results of the systematic review of the literature regarding the certification of Artisanal Cheese and the Art Seal. The comprehensive evaluation of the selected articles shows that most of the publications are in journals in categories A4 and B1, followed by categories B2 and C. The trend of publications over time shows that, even without a specific time frame, studies on the certification of artisanal cheese and the Art Seal began to grow from 2020 onwards, with 2023 presenting the highest number of publications among the articles participating in this study. The data showed that bibliographic and documentary research, based on secondary sources, were the most used methods in the articles examined. Qualitative research, which included interviews, and experimental studies also showed relevance.

The research themes cover several regions of Brazil, with emphasis on Minas Gerais, Paraná and areas of the Northeast. The main theoretical bases discussed the cultural importance of artisanal cheese, legal and regulatory difficulties, as well as good manufacturing practices and microbiological safety. These elements emphasize the relevance of certification in strengthening and protecting traditional knowledge associated with production.

Three categories of analysis were established to better organize the related subjects: (1) Geographical Indication (GI), Culture, Regionalism and Appreciation of Brazilian Artisanal Cheeses; (2) Legislation and Regulation; and (3) Physicochemical and Microbiological Characteristics, Good Manufacturing Practices and Food Safety. The distribution of studies among these categories was balanced, with a slight predominance of the first two.

In category (1), it was possible to conclude that the Geographical Indication plays a crucial role in the appreciation of artisanal cheeses, ensuring their authenticity and promoting the preservation of local traditions, in addition to strengthening the economies of the regions.

Category (2) revealed that, although the regulation has advanced with initiatives such as the Art Seal, there are still obstacles for small producers, who face difficulties in complying with the standards without compromising the authenticity of their products.

Finally, category (3) showed that the adoption of good manufacturing and agricultural practices, combined with microbiological control, are essential to ensure the quality and food safety of artisanal cheeses, contributing to greater competitiveness in the market.

The considerations on the certification of Artisanal Cheese and the Art Seal allowed an in-depth understanding of the theme, highlighting the cultural, economic and regulatory relevance linked to this practice. Moreover, this research offers significant practical contributions, particularly with regard to the consequences for public policy makers and policymakers. The evaluation highlights the need for actions that simplify access to certification, reduce bureaucratic obstacles, and provide technical and financial assistance to smallholder farmers. Likewise, the considerations presented can contribute to the creation of more efficient public policies, ensuring both the recognition of artisanal products and food security and competitiveness in the market.

The present study found limitations, such as the scarcity of comprehensive primary data, the dependence on secondary sources, and the concentration of research in certain regions of Brazil.

It is recommended for future research to explore how certification affects the view of consumers and to analyze the feasibility of modifications in regulatory rules that promote the insertion of small producers in the formal market. In addition, the evaluation of the export of certified artisanal cheeses can be vital to enhance the economic effect of this practice.

It is also suggested to expand the research universe through access to global databases and the execution of studies in other languages, particularly in nations with a tradition in the manufacture and certification of artisanal cheeses. In addition, future research may focus on primary studies, such as interviews with producers and consumers, experimental evaluations of the quality of certified cheeses, and case studies in regions with varying levels of regulation. The application of comparative methods between the effects of certification in Brazil and in other nations can also help in a more complete understanding of the problem.

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EVALUATION OF PATHOLOGICAL MANIFESTATIONS AND CONSERVATION STATUS OF REINFORCED CONCRETE VIADUCTS IN THE MUNICIPALITY OF LUANDA

AVALIAÇÃO DAS MANIFESTAÇÕES PATOLÓGICAS E DO ESTADO DE CONSERVAÇÃO DE VIADUTOS EM BETÃO ARMADO NO MUNICÍPIO DE LUANDA

EVALUACIÓN DE LAS MANIFESTACIONES PATOLÓGICAS Y DEL ESTADO DE CONSERVACIÓN DE VIADUCTOS DE HORMIGÓN ARMADO EN EL MUNICIPIO DE LUANDA

 <https://doi.org/10.56238/sevened2025.036-112>

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ABSTRACT

This study aimed to evaluate the pathological manifestations and conservation status of four reinforced concrete viaducts in the Municipality of Luanda, aged over 21 years. The methodology was based on detailed visual inspections and the application of the DNIT evaluation method, which assigns scores from 1 to 5 to structural and non-structural elements. The results indicated that all viaducts received a final score of 3, corresponding to "apparently good stability conditions". The main pathologies identified include cracking, concrete delamination, exposure of reinforcements, degradation of expansion joints, deficiencies in signaling and drainage, among others. It is concluded that, although the viaducts are in acceptable conditions, preventive and corrective maintenance interventions are necessary to ensure their durability and safety. The study reinforces the importance of patrimonial management systems for special works of art, aligning with international best practices.

Keywords: Viaducts. Reinforced Concrete. Pathological Manifestations. Inspection. Conservation Status. DNIT Method.

RESUMO

O presente estudo teve como objetivo avaliar as manifestações patológicas e o estado de conservação de quatro viadutos em betão armado no Município de Luanda, com idade superior a 21 anos. A metodologia baseou-se em inspeções visuais detalhadas e na aplicação do método de avaliação do DNIT, que atribui notas de 1 a 5 aos elementos estruturais e não estruturais. Os resultados indicaram que todos os viadutos apresentaram nota final de classificação 3, correspondente a "condições de estabilidade boa

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aparentemente". As principais patologias identificadas incluem fissuração, delaminação do betão, exposição de armaduras, degradação de juntas de dilatação, deficiências na sinalização e drenagem, entre outras. Conclui-se que, embora os viadutos se encontrem em condições aceitáveis, são necessárias intervenções de manutenção preventiva e corretiva para garantir a sua durabilidade e segurança. O estudo reforça a importância de sistemas de gestão patrimonial para obras de arte especiais, alinhando-se com as melhores práticas internacionais.

Palavras-chave: Viadutos. Betão Armado. Manifestações Patológicas. Inspeção. Estado de Conservação. Método DNIT.

RESUMEN

Este estudio tuvo como objetivo evaluar las manifestaciones patológicas y el estado de conservación de cuatro viaductos de hormigón armado en el Municipio de Luanda, con más de 21 años de antigüedad. La metodología se basó en inspecciones visuales detalladas y en la aplicación del método de evaluación del DNIT, que asigna puntuaciones de 1 a 5 a los elementos estructurales y no estructurales. Los resultados indicaron que todos los viaductos obtuvieron una puntuación final de 3, correspondiente a "condiciones de estabilidad aparentemente buenas". Las principales patologías identificadas incluyen fisuras, deslaminación del hormigón, exposición de armaduras, degradación de juntas de dilatación, deficiencias en señalización y drenaje, entre otras. Se concluye que, aunque los viaductos se encuentran en condiciones aceptables, son necesarias intervenciones de mantenimiento preventivo y correctivo para garantizar su durabilidad y seguridad. El estudio refuerza la importancia de los sistemas de gestión patrimonial para obras de arte especiales, alineándose con las mejores prácticas internacionales.

Palabras clave: Viaductos. Hormigón Armado. Manifestaciones Patológicas. Inspección. Estado de Conservación. Método DNIT.

1 INTRODUCTION

Special engineering works (SSOs), such as bridges and viaducts, are vital elements in the transport infrastructure of any country, ensuring regional connectivity and socio-economic development (DEBS & TAKEYA, 2007). In the Municipality of Luanda, the rapid post-conflict urban growth, from 2002 onwards, resulted in the accelerated construction of a considerable park of these infrastructures. Many of them, with more than two decades of service, are beginning to show signs of degradation, highlighting the need for effective asset management, based on periodic inspections and proper maintenance (JESUS, 2015).

The degradation of reinforced concrete structures is a complex process, influenced by intrinsic (quality of materials, construction details) and extrinsic (environmental actions, overloads, maintenance) factors (HELENE, 1993). Systematic inspection is, therefore, the fundamental tool for diagnosing the real state of these works, allowing the early identification of pathologies and the programming of interventions (DNIT, 2004; RYALL, 2010).

In this context, this article presents a detailed evaluation of four reinforced concrete viaducts located in Luanda, Angola. The study aims to: (i) identify and characterize the main pathological manifestations; (ii) apply the evaluation method proposed by DNIT (2004) to classify the conservation status; and (iii) discuss the probable causes of the pathologies and propose mitigating measures, contributing to the preservation of the existing heritage and the safety of users.

2 THEORETICAL FRAMEWORK

2.1 PATHOLOGIES IN REINFORCED CONCRETE STRUCTURES

The pathological manifestations in reinforced concrete structures can be classified according to their origin in: defects in design, materials, execution and use (SOUSA & RIPPER, 1998 apud GIOVANNETTI, 2014). For bridges and viaducts, the combined action of cyclic loads, aggressive environmental agents (such as chlorides from salt spray or anti-ice) and carbonation of concrete are the main deterioration mechanisms, often culminating in reinforcement corrosion (MEHTA & MONTEIRO, 2014).

Corrosion is an electrochemical process that causes the expansion of the volume of the steel, generating internal stresses that lead to cracking, peeling and, finally, delamination of the covering concrete. This phenomenon, in addition to compromising aesthetics and durability, significantly reduces the resistant capacity of the cross-section of structural elements (ANDRADE, 1993).

2.2 INSPECTION AND EVALUATION OF BRIDGES AND VIADUCTS

Inspection is defined as a set of technical procedures carried out according to prior planning, which provides information about the work at a given time (GIOVANNETTI, 2014). The DNIT Road Bridge Inspection Manual (2004) establishes a robust methodology, classifying inspections as: cadastral, routine, special, extraordinary and intermediate.

The DNIT evaluation method is based on the attribution of grades (from 1 to 5) for each component element of the work, considering the severity and extent of the pathologies. The final grade of the structure corresponds to the lowest grade assigned to one of its elements with a structural function, adopting a conservative approach that prioritizes safety (DNIT, 2004). This system allows an objective quantification of the conservation status, facilitating the prioritization of interventions and the allocation of resources. Similar systems are used internationally, as proposed by the COST 345 report (2007) in Europe and the Bridge Inspection Manual (BIRM) in the USA.

3 METHODOLOGY

The research is characterized as applied, with a qualitative-quantitative approach and exploratory-descriptive objectives (SILVA & MENEZES, 2005). The multiple case study was conducted on four viaducts (OAE) built in 2001, located in the Municipality of Luanda, Angola, and aged over 21 years at the time of inspection (2023):

- OAE 1: 4 de Fevereiro International Airport Viaduct
- OAE 2: Cassenda Viaduct
- OAE 3: Zamba 2 Viaduct
- OAE 4: Underpass of the Portuguese Embassy

The selection of the sample was based on the criterion of homogeneity in terms of age and construction material (reinforced concrete), allowing a comparative analysis of the degradation patterns.

The detailed visual inspection, in line with the procedures for a "Special Inspection" according to the DNIT (2004), was carried out with equipment that included a digital camera, drone for access to hard-to-reach areas, a tape measure, a laser meter and a fissurometer. The following components were systematically evaluated:

- *Carriageway and platform elements*: accesses, expansion joints, protective barriers (New Jersey), guardrails, wheel guards, drainage devices, signaling and lighting.
- *Superstructure*: support equipment (neoprene), deck and public pipes.

- *Mesostructure*: wall pillars.
- *Infrastructure*: abutments and slope protection.

Each element was classified with a score from 1 to 5, according to the severity and extent of the pathologies observed, following the scale of the DNIT (2004):

- 5 (Excellent): No or insignificant defects.
- 4 (Good): Minor defects, no significant affectation.
- 3 (Regular): Moderate defects, requiring medium-term intervention.
- 2 (Poor): Serious defects, requiring priority intervention.
- 1 (Very Poor): Critical defects, with imminent risk of collapse.

The final grade of the work corresponded to the lowest grade attributed to one of its elements with a structural function, ensuring a conservative and safe evaluation.

4 RESULTS AND DISCUSSIONS

4.1 CHARACTERIZATION OF THE MAIN PATHOLOGICAL MANIFESTATIONS

The detailed inspection revealed a consistent pattern of pathologies on the four viaducts, indicating systemic problems related to environmental exposure, the quality of execution and, above all, the lack of scheduled maintenance. The most significant manifestations were:

- *Runway*: Widespread presence of sinking, exudation, slipping and inadequate punctual repairs (patches), which compromise the comfort and safety of the roll. These defects are often associated with compaction problems of the access embankment and the degradation of the pavement layers (Figure 1a).
- *Expansion joints*: Elastomer and steel monobloc joints showed debris accumulation, loss of sealing capacity, and edge damage (Figure 1b). This situation compromises watertightness, allowing the infiltration of water and aggressive agents on the support devices and lower structural elements, a problem widely documented in the literature (VITÓRIO, 2002).
- *Safety and security elements*: The New Jersey barriers, metal guardrails, and wheel guards exhibited cracking, delamination of the concrete, exposure and severe corrosion of the reinforcements, and deteriorated paint (Figures 1c and 1d). Corrosion of reinforcement, triggered by the carbonation of concrete and/or the penetration of chlorides, is the predominant pathological mechanism (HELENE, 1993).

- *Signage and lighting:* There was a near absence or severe degradation of vertical and horizontal signage, as well as public lighting. This condition poses a high risk to road safety, especially at night or in adverse weather conditions.
- *Structural Elements:* In the pillars and abutments, cracking, peeling of the concrete, dark spots due to humidity and, in some cases, the presence of efflorescence were identified (Figure 1e). The misuse of infrastructure, such as the occurrence of physiological needs at the base of the pillars, introduces aggressive chemical agents that accelerate degradation.

Figure 1

Examples of pathological manifestations identified: (a) Pans and sinkings in the roadway (OAE 4); (b) Damaged expansion joint (OAE 1); (c) Wheel guard with severe reinforcement corrosion (OAE 2); (d) New Jersey Barrier (OAE 3); (e) Cracking and peeling of concrete in a column (SO 1)



Bad patch and/or pans

(a) Pans and sinks on the raceway (OAE 4)



Sags



Stormwater runoff

Absence of clamping sockets and slit in the finial between the joint and the transition layer

(b) Damaged expansion joint (OAE 1)



Exposure and corrosion of reinforcements Partial disintegration

(c) Wheel guard with severe reinforcement corrosion (OAE 2)



(d) Delaminated New Jersey Barrier (OAE 3)



(e) Cracking and peeling of concrete in a column (SO 1)

Source: Author (2025).

4.2 EVALUATION AND CLASSIFICATION BY THE DNIT METHOD

The application of the evaluation method resulted in the attribution of the final grade 3 (Regular) to all the viaducts studied. Table 1 summarizes the classification by main component, showing the homogeneity of the conservation status of the sampled park.

Table 1

Classification of viaducts by main structural component

Component	OAE 1	OAE 2	OAE 3	OAE 4
Runway and platform	3	3	3	3
Superstructure	3	3	3	3
Mesostructure (Columns)	3	3	3	3
Infrastructure (Meetings)	3	3	3	3
Final Note of the Work	3	3	3	3

Source: Author (2025).

4.3 CRITICAL DISCUSSION OF RESULTS

The uniformity in the final classification (Note 3) reflects not only the constructive and age similarity of the viaducts, but also the exposure to analogous environmental and traffic conditions. The "Regular" grade indicates that the structures still have apparent global stability, but have a moderate state of degradation that, if not stopped, will progress in an accelerated way, and may evolve to "Bad" or "Very Bad" conditions in a short period of time (JESUS, 2015).

The pathologies observed are, for the most part, the consequence of a combination of factors:

1. *Deficiencies in the Execution Phase*: The poor vibration of the concrete, the insufficient covering of the reinforcements and the inadequate construction details, identified in various elements (e.g., wheel guards), are failures at the origin that compromise the long-term durability (HELENE, 1993).
2. *Absence of Preventive Maintenance*: The lack of routine inspections and conservation interventions, such as cleaning joints and drains, applying protective paints, and punctual repairs, allowed small defects to evolve into significant pathologies. This is perhaps the most critical cause identified, and it is a common problem in contexts where wealth management is not fully implemented (GIOVANNETTI, 2014).

3. *Environmental and Exploration Actions*: Exposure to the tropical climate, heavy traffic and, possibly, the circulation of vehicles with loads higher than those foreseen in the project, contributed to the acceleration of the fatigue process and degradation of materials.

The case study corroborates Reis' (2006) view that intuition in design should always be accompanied by strict supervision in execution and active management during the exploration phase. The situation found in Luanda is a warning of the urgent need to implement a management system for OAE, as recommended by DNIT (2004) and authors such as Ryall (2010), which allows a systematic control of the state of these critical infrastructures.

5 CONCLUSION

The present study allowed us to conclude that the four reinforced concrete viaducts in the Municipality of Luanda, with more than 21 years of service, have a state of conservation classified as "Regular" (Note 3) according to the DNIT method. This condition is characterized by the generalized presence of moderate pathological manifestations, which do not compromise global stability imminently, but which signal the urgent need for maintenance interventions.

The application of DNIT's inspection and evaluation methodology proved to be an effective and practical tool for the objective quantification of conservation status, allowing the prioritization of interventions based on technical criteria.

As recommendations, it is proposed:

- *Immediate Interventions*: Execution of corrective maintenance on the most critical elements, namely: cleaning and replacement of expansion joints; repair and corrosion protection of guardrails and wheel guardrails; and repair of drainage and signaling systems.
- *Medium and Long Term Management*: Implementation of a permanent program of routine (biannual) and special (five-yearly) inspections, using a property management system (e.g., specific software) for data storage and evolutionary analysis.
- *Future Research*: Conducting non-destructive tests (e.g., sclerometry, potentiostat) for a more accurate quantification of the strength of the concrete and the corrosion state of the reinforcements, complementing the visual inspections.

The preservation of this infrastructural heritage is crucial not only for the safety of users, but also for the economic sustainability of Luanda, ensuring the flow of traffic and avoiding costs associated with deep repairs or premature reconstructions in the future.

ACKNOWLEDGMENT

We thank the Integrated Center for Public Security (CISP) for the logistical support, and the Administration of the Municipality of Luanda for access to the works of art studied.

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THE AECO INDUSTRY AND INFRASTRUCTURE IN AFRICA: CHALLENGES AND OPPORTUNITIES IN A DIGITAL TRANSFORMATION CONTEXT

A INDÚSTRIA AECO E AS INFRAESTRUTURAS EM ÁFRICA: DESAFIOS E OPORTUNIDADES NUM CONTEXTO DE TRANSFORMAÇÃO DIGITAL

LA INDUSTRIA AECO Y LAS INFRAESTRUCTURAS EN ÁFRICA: DESAFÍOS Y OPORTUNIDADES EN UN CONTEXTO DE TRANSFORMACIÓN DIGITAL

 <https://doi.org/10.56238/sevened2025.036-113>

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ABSTRACT

This article analyzes the Architecture, Engineering, Construction, and Operation (AECO) Industry and the development of infrastructures in Africa, identifying the main challenges and opportunities related to the sustainable transformation of the sector. The research assumes that infrastructure is the foundation of economic and social progress, being essential for competitiveness and quality of life. However, the African continent faces a severe structural deficit across all subsectors—transport, energy, water, sanitation, telecommunications, and housing—which limits its productive integration and ability to attract foreign direct investment. The study is based on documentary and descriptive analysis, complemented by data from international organizations such as the World Bank, the African Development Bank (AfDB), the UN, and Deloitte, to understand the dynamics of financing, innovation, and sustainability in the AECO industry within the African context. The results show that the infrastructure deficit reduces Africa's economic growth by around 2% per year and company productivity by up to 40%, reflecting technological and financial dependence on external sources. Conversely, significant opportunities emerge from construction digitalization, circular economy principles, the use of local materials, and energy transition. It concludes that integrated public policies, combined with technical capacity building and technological innovation, are crucial to boost the AECO sector as a driver of sustainable development in Africa.

Keywords: AECO Industry. Infrastructure. Africa. Sustainability. Circular Economy.

RESUMO

O presente artigo analisa a Indústria da Arquitetura, Engenharia, Construção e Operação (AECO) e o desenvolvimento de infraestruturas em África, identificando os principais desafios e oportunidades associados à transformação sustentável do setor. A investigação parte da premissa de que a infraestrutura é o alicerce do progresso económico e social, sendo indispensável à competitividade e à qualidade de vida das populações. No entanto, o continente africano enfrenta um défice estrutural acentuado em todos os subsectores — transportes, energia, água, saneamento, telecomunicações e habitação — o que limita a sua integração produtiva e a sua capacidade de atrair investimento direto estrangeiro. O estudo baseia-se numa análise documental e descritiva, complementada por dados de organismos internacionais como o Banco Mundial, o Banco Africano de Desenvolvimento (AfDB), a ONU e a Deloitte, para compreender as dinâmicas de financiamento, inovação e sustentabilidade

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da Indústria AECO no contexto africano. Os resultados demonstram que o défice de infraestrutura reduz o crescimento económico do continente em cerca de 2% ao ano e a produtividade das empresas até 40%, refletindo-se numa dependência tecnológica e financeira externa. Por outro lado, emergem oportunidades significativas associadas à digitalização da construção, à economia circular, ao uso de materiais locais e à transição energética. Conclui-se que a implementação de políticas públicas integradas, associadas à capacitação técnica e à inovação tecnológica, é fundamental para impulsionar o setor AECO como motor do desenvolvimento sustentável africano.

Palavras-chave: Indústria AECO. Infraestruturas. África. Sustentabilidade. Economia Circular.

RESUMEN

Este artículo analiza la Industria de Arquitectura, Ingeniería, Construcción y Operación (AECO) y el desarrollo de infraestructuras en África, identificando los principales desafíos y oportunidades relacionados con la transformación sostenible del sector. La investigación parte del supuesto de que la infraestructura constituye la base del progreso económico y social, siendo esencial para la competitividad y la calidad de vida. Sin embargo, el continente africano enfrenta un grave déficit estructural en todos los subsectores —transporte, energía, agua, saneamiento, telecomunicaciones y vivienda— que limita su integración productiva y su capacidad para atraer inversión extranjera directa. El estudio se basa en un análisis documental y descriptivo, complementado con datos de organismos internacionales como el Banco Mundial, el Banco Africano de Desarrollo (AfDB), la ONU y Deloitte, para comprender las dinámicas de financiación, innovación y sostenibilidad de la industria AECO en el contexto africano. Los resultados muestran que el déficit de infraestructura reduce el crecimiento económico del continente en aproximadamente un 2% anual y la productividad empresarial hasta un 40%, reflejando una dependencia tecnológica y financiera externa. Por otro lado, surgen oportunidades relevantes derivadas de la digitalización de la construcción, la economía circular, el uso de materiales locales y la transición energética. Se concluye que la implementación de políticas públicas integradas, junto con la capacitación técnica y la innovación tecnológica, es fundamental para impulsar el sector AECO como motor del desarrollo sostenible africano.

Palabras clave: AECO. Infraestructuras. África. Sostenibilidad. Economía Circular.

1 INTRODUCTION

Infrastructure development is one of the key pillars for sustainable economic growth and the reduction of social inequalities in any region of the world. In the African context, the issue acquires particular relevance, given the magnitude of the structural deficit that affects essential sectors such as energy, transport, water supply, sanitation, telecommunications and housing. The Architecture, Engineering, Construction and Operation (AECO) industry plays, in this sense, a strategic role as a vector of economic transformation and social modernization, as it materializes the physical infrastructure on which the continent's productivity, mobility and connectivity are based.

According to the African Development Bank (AfDB, 2023), the annual infrastructure financing gap in Africa is estimated at between US\$68 and US\$108 billion, reflecting a historical gap that limits the competitiveness and well-being of populations. The World Bank (2022) reinforces that the low quality of infrastructure reduces the continent's economic growth by about 2 percentage points per year, and decreases business productivity by up to 40%, becoming one of the biggest obstacles to industrialization and regional integration. This reality is compounded by rapid population growth — Africa's population is expected to double by 2050 — which puts increased pressure on already saturated urban systems and natural resources.

AEC Industry, as a multidisciplinary field that integrates the planning, design, construction, operation and maintenance of physical assets, is both part of the problem and part of the solution. On the one hand, the sector is responsible for about 40% of global carbon emissions and the consumption of approximately 50% of the planet's natural resources (UNEP, 2022); on the other hand, it is an essential engine of the economy, generating millions of direct and indirect jobs and promoting technological innovation and industrialization. The need for a transition to sustainable practices, based on principles of circular economy, digitalization and climate resilience, is today recognized as a strategic imperative for the future of African construction.

The global context of energy and technological transformation directly influences the prospects of the AEC sector in Africa. The implementation of decarbonization policies, the emergence of digital twins, Building Information Modeling (BIM) and Smart Infrastructure solutions create unprecedented opportunities to overcome historical limitations in productivity, transparency and efficiency. However, the adoption of these technologies faces

significant challenges related to the initial cost, the lack of standardization, the shortage of skilled labor, and the insufficiency of integrated public policies.

On the socio-economic front, the fragility of Africa's infrastructure translates into persistent inequalities. Data from the United Nations (UN, 2023) indicate that only 38% of the African population has access to electricity, less than 10% to the internet, and only a quarter of the continental road network is paved. These figures illustrate the urgency of structural investment and infrastructure management policies that combine technological innovation with environmental sustainability and social inclusion.

Thus, understanding the challenges and opportunities of the AEC Industry in Africa is essential to outline sustainable development strategies that unite economic growth, social equity and environmental protection. The approach of this study aims to contribute to the academic and technical debate on how to structure and operationalize policies, technologies and management models capable of transforming the African infrastructure deficit into an engine of development.

Thus, this article aims to critically analyze the challenges and opportunities of the AEC Industry in the context of African infrastructure, highlighting the dynamics of sustainability, innovation and financing. As specific objectives, it is intended to:

- a) to identify the main structural and institutional constraints that condition the AEC sector on the African continent;
- b) examine emerging trends related to circular economy, digitalisation and climate resilience;
- c) to propose strategic lines for strengthening the technical and technological capacity of African infrastructures.

2 THEORETICAL FRAMEWORK

The theoretical framework is structured around four fundamental axes that underpin the analysis of AEC Industry and infrastructure in Africa: (i) the conceptual framework of AEC Industry and its relationship with sustainable development; (ii) the structural deficiencies of the African continent in the field of infrastructure; (iii) the need to transition to a circular and low-carbon economy; and (iv) the incorporation of digital and smart technologies as catalysts for efficiency and innovation.

2.1 AEC INDUSTRY AND SUSTAINABLE DEVELOPMENT

The AEC (Architecture, Engineering, Construction and Operation) industry covers the entire life cycle of buildings – from design and planning to the execution, operation, maintenance and decommissioning of infrastructures. It is an interdisciplinary sector, which integrates the domains of civil engineering, architecture, economics, management and technology, playing a vital role in urban and regional development (Andrade & Silva, 2020).

Contemporary literature recognizes that the construction sector is both one of the largest global economic engines and one of the main emitters of greenhouse gases. According to the United Nations Environment Programme (UNEP, 2022), the built environment is responsible for about 37% of global CO₂ emissions and consumes approximately 36% of the world's final energy. In Africa, although the level of industrialization is still low, the trend of accelerated urbanization — which is expected to reach 60% by 2050 — puts unprecedented pressure on building and infrastructure systems (AfDB, 2023).

The concept of sustainable development, enshrined in the Brundtland Report (World Commission on Environment and Development, 1987), states that economic progress must meet present needs without compromising the capacity of future generations. Applied to the AEC sector, this implies adopting construction practices that minimize the consumption of non-renewable resources, reduce waste, promote energy efficiency, and prioritize the life cycle of materials and buildings.

According to Gibb and Isack (2019), the transition to a sustainable construction model requires "structural changes in the processes of design, planning and execution of works, including digital integration and the circular economy as guiding principles of the construction value chain".

In this way, the AEC Industry in Africa presents itself as a strategic vector for the achievement of the United Nations Sustainable Development Goals (SDGs), especially SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action).

2.2 INFRASTRUCTURE SHORTAGES IN AFRICA

Africa's infrastructure deficit is one of the main obstacles to economic growth and regional integration. According to World Bank estimates (2022), only 38% of the African population has access to electricity, less than 10% to the internet, and only 25% of the continental road network is paved. The cost of infrastructural inefficiency translates into an

average loss of 2% of annual GDP and a reduction of up to 40% in business productivity (World Bank, 2022).

The African Development Bank (AfDB, 2023) estimates that US\$93 billion per year would be needed over the next decade to address infrastructure deficiencies in sub-Saharan Africa. Of this total, US\$ 60 billion is earmarked for the construction of new infrastructure and US\$ 30 billion for the maintenance of existing ones. The following table summarizes the main sectoral shortcomings:

Table 1

Top infrastructure shortages in Africa (2023)

Sector	Current Situation	Economic and Social Impact
Electrical energy	38% population access	Low industrialization and limitations to productivity
Water and sanitation	30% adequate coverage	Public health problems and regional inequalities
Road transport	25% of paved roads	Increases logistics costs by 30–40%
Telecommunications	<10% internet penetration	Limits innovation and digital inclusion
Urban housing	50 million units in deficit	Informal sprawl and urban degradation

Source: World Bank (2022); AfDB (2023); UN-Habitat (2022).

Infrastructural fragility is linked to multiple factors, including:

- a) excessive dependence on external financing;
- b) absence of maintenance and preventive rehabilitation policies;
- c) insufficient regional integration and logistics; and
- d) lack of technical and governance skills.

In addition, the infrastructure deficit exacerbates the continent's climate vulnerability. Climate change increases the frequency of floods, droughts, and coastal erosion, directly affecting energy, road, and water infrastructure (IPCC, 2022). Thus, resilient and sustainable construction emerges as a priority need.

2.3 CIRCULAR ECONOMY AND DECARBONIZATION

The traditional model of construction — linear, resource- and emissions-intensive — is unsustainable in the long term. The transition to a circular economy proposes a systemic approach based on three principles: reduce, reuse and recycle (Ellen MacArthur Foundation, 2021). In AEC Industry, this translates into the design of buildings and infrastructures that

maximize durability, allow dismantling and incorporate recyclable materials.

According to Deloitte (2022), the construction industry is responsible for 40% of global solid waste and 12% of the world's drinking water consumption. In Africa, where waste management systems are fragile, this statistic is critical. Embedding circular practices – such as the use of low-impact, local materials, recycling of construction waste and modular production – can reduce the total life-cycle cost of infrastructure by up to 30% (UNEP, 2022).

The concept of circular construction also involves the integration of Environmental Performance Indicators (PPEs) in the planning and operation of assets. Emerging examples include the use of ecological blocks produced from recycled plastic waste, as in the experience of the company Nelplast, in Ghana, whose products are 30% cheaper and more durable than conventional ones, in addition to promoting social inclusion and reducing emissions (Economic Forum, 2022).

Overall, the targets of carbon neutrality by 2050 put the AEC sector under pressure to adopt low-carbon materials, renewable energies and digitalised processes that optimise energy efficiency. The concept of green and resilient infrastructure therefore becomes a central element of African competitiveness.

2.4 DIGITALIZATION AND TECHNOLOGICAL INNOVATION

Digitalization is recognized as the main driver of transformation of the AEC Industry in the 21st century. Technologies such as Building Information Modeling (BIM), Digital Twins, Internet of Things (IoT) and Artificial Intelligence (AI) are redefining the planning, construction and management of infrastructures on a global scale (KPMG, 2021).

The McKinsey Global Institute (2020) estimates that the adoption of digital technologies can increase the productivity of the construction sector by up to 60% and reduce design and operating costs by between 10% and 20%. In Africa, this transformation is still in its infancy, but with high potential, especially in countries that invest in national BIM and Smart Infrastructure strategies.

The integration of digital platforms allows the management of the life cycle of assets, optimizing maintenance costs, safety and structural performance. In addition, the use of drones, laser scanners, sensors, and infrared thermography has revolutionized the inspection and monitoring of bridges, roads, and buildings, increasing the reliability of engineering decisions.

The African Development Bank (2024) underlines that the digital transition in

construction is an essential condition for increasing transparency, reducing corruption and improving public governance in the sector. The combination of technological innovation and environmental sustainability thus forms the new paradigm of African infrastructure development.

3 METHODOLOGY

The methodology adopted in this study aims to ensure the scientific consistency and replicability of the results, based on principles of applied research and interdisciplinary approach. The analysis of AEC Industry and infrastructure in Africa requires a methodological framework that articulates economic, technological, environmental and institutional dimensions, in view of the systemic complexity of the topic.

3.1 TYPE AND NATURE OF RESEARCH

This is a qualitative and quantitative research (mixed method), with descriptive, exploratory and analytical-comparative characteristics. The qualitative approach allowed us to understand the political-economic and institutional contexts of African infrastructure, while the quantitative approach provided empirical support through statistical data from recognized sources.

According to Gil (2019), descriptive research seeks to "describe the characteristics of a given phenomenon or the relationship between variables", and is suitable for studies in which it is intended to identify causes and consequences of a complex reality. In this article, the reality analysed is the current state of AEC infrastructure and industry on the African continent, as well as the prospects for technological and sustainable evolution.

The research also assumes a bibliographic and documentary character, based on the critical review of reports, scientific articles and databases of international organizations, including:

- African Development Bank (AfDB);
- World Bank;
- United Nations (UN and UNEP);
- Deloitte, McKinsey, KPMG and OECD;
- UN-Habitat;
- Technical reports from African engineering and construction institutions.

3.2 METHODOLOGICAL PROCEDURES

The procedures adopted comprised four main steps:

- a) *Bibliographic and documentary survey*: A systematic analysis of the academic and technical literature on AEC Industry, infrastructure development and sustainability in Africa was carried out. Sources included databases such as Scopus, ScienceDirect, SpringerLink and African Journals Online, as well as public policy documents and sector performance reports.
- b) *Secondary data analysis*: Statistical data on macroeconomic indicators, levels of access to basic services, investment volumes, and environmental performance indicators were compiled and interpreted. The integration of data from different bodies allowed a comparative and transversal view of the continent.
- c) *Analytical structuring*: A thematic analysis matrix with three central axes — Structural Challenges, Strategic Opportunities and Technological Trends — was used, which served as the basis for the critical synthesis presented in the Results and Discussion section.
- d) *Conceptual validation*: Source triangulation was employed to ensure the coherence and reliability of the findings, as recommended by Yin (2021) in studies of an interpretative nature.

3.3 UNIT OF ANALYSIS AND DELIMITATION

The unit of analysis of this study is the African continent, considered as a whole, with no emphasis on specific national cases. The choice for a continental approach is justified by the need to understand the common structural patterns, regional gaps and converging trends that characterize African infrastructural development.

The time limit covers the period from 2015 to 2024, corresponding to the implementation of the African Union's Agenda 2063 and the intensification of international commitments to the Sustainable Development Goals (SDGs). This time frame allows us to analyze recent changes in infrastructure policies and the adoption of sustainable construction technologies.

3.4 ANALYSIS TOOLS AND TECHNIQUES

The data were analyzed using two complementary techniques:

- a) Thematic content analysis, applied to literature and technical reports, in order to identify the most recurrent categories of challenges and opportunities in the African AEC Industry. This technique followed the guidelines of Bardin (2016), allowing the grouping and interpretation of qualitative evidence in a structured way.
- b) Comparative analysis and descriptive statistics, used to organize and synthesize quantitative data on access to infrastructure, investment and emissions. These data were presented in tables and tables prepared according to ABNT standards, with indication of primary sources.

3.5 ETHICAL CONSIDERATIONS AND LIMITATIONS

The research respected the ethical principles of scientific integrity, according to the UNESCO Code of Ethics (2021), ensuring transparency in the citation of sources and reliability of interpretations. No confidential data was used, limited to public and official information.

Among the limitations of the study, the following stand out:

- the heterogeneity of statistical sources among African countries, which makes direct comparisons difficult;
- the scarcity of specific data on technology adoption in the African AEC sector;
- the absence of complete historical series for some sustainability indicators.

Despite these restrictions, methodological triangulation and the cross-referencing of international sources provided a comprehensive, rigorous, and up-to-date view on the subject.

4 RESULTS AND DISCUSSIONS

The analysis of data and specialized literature allowed the identification of a set of persistent structural challenges and emerging opportunities that shape the future of AEC Industry and infrastructure in Africa. This section presents the synthesis of these results, supported by empirical evidence and a critical reading of continental trends.

4.1 STRUCTURAL CHALLENGES OF AEC INDUSTRY AND INFRASTRUCTURE IN AFRICA

Africa's infrastructure is characterized by multidimensional shortcomings, which go beyond physical insufficiency and include gaps in planning, management, capacity building, and financing. The analysis highlights five central dimensions of challenge: structural, economic, institutional, technological and environmental.

4.1.1 Structural deficit and infrastructure obsolescence

The deficit of basic infrastructure is the most limiting factor of African development. It is estimated that around 600 million Africans lack access to electricity, 400 million lack adequate access to clean water, and more than 60% of the urban population lives in informal settlements (UN-Habitat, 2023).

Transport, energy and communications networks are, in many countries, in a state of obsolescence. Only 25% of African roads are paved, which increases the logistics costs of goods by 30 to 40% (World Bank, 2022). The poor integration between national and regional infrastructures prevents the consolidation of production chains and the efficient circulation of goods and services.

Table 2

Critical Infrastructure Indicators in Africa (2023)

Indicator	Continental average value	World average
Access to electricity	38% of the population	90%
Internet access	9,8%	65%
Paved roads	25%	55%
Annual investment in infrastructure	\$93 billion (required)	—
Percentage of urbanization	45% (in 2024)	56%

Sources: AfDB (2023); World Bank (2022); UN-Habitat (2023).

Chronic underinvestment in maintenance exacerbates the problem. The AfDB (2023) estimates that one third of existing infrastructure is severely structurally degraded, requiring urgent rehabilitation. The lack of preventive maintenance policies leads to accelerated loss of assets and increased reconstruction costs.

4.1.2 Financial and investment challenges

Financing is one of the biggest obstacles to African infrastructure development. According to the Global Infrastructure Hub (2023), only 12% of financing for African infrastructure comes from domestic sources (governments and the local private sector), while 88% depends on external capital, mostly from China, the World Bank, and multilateral funds.

The main financial constraints include:

- high public debt and low credit rating;
- lack of risk mitigation instruments for private investment;
- political and exchange rate instability;
- absence of regional development banks with high leverage capacity.

In addition, existing funding is mainly focused on transport and energy megaprojects, neglecting areas such as maintenance, affordable housing and urban sanitation, which perpetuates territorial inequalities.

4.1.3 Institutional deficit and governance

African infrastructure governance is often characterized by institutional fragmentation, corruption, and low transparency in public procurement processes. Transparency International (2023) points out that construction is the second most vulnerable sector to corruption in Africa, after the exploitation of natural resources.

Institutional weaknesses include:

- absence of integrated urban and territorial planning policies;
- deficiencies in the regulation and technical inspection systems;
- lack of performance standards and technical standardization (particularly in public works);
- scarce culture of facility management and post-construction maintenance.

These gaps reduce the efficiency of investments and compromise the sustainability of public assets.

4.1.4 Technological and capacity building challenges

African AEC Industry is still based on traditional construction methods, with low productivity and reduced technological integration. The McKinsey Global Institute (2020) shows that construction productivity in Africa is about 40% lower than the world average.

Key technological limitations include:

- low adoption of BIM (Building Information Modeling) and Digital Twins;
- absence of technical standards and data interoperability;
- insufficient training in digital engineering, automation and sustainability.

The shortage of skilled labor is another relevant obstacle: according to the African Union Commission (2022), only 1 in 10 engineering professionals in Sub-Saharan Africa have received formal training in digital tools applied to construction.

4.1.5 Environmental and climate impacts

The AEC sector is responsible for approximately 40% of global carbon emissions, with infrastructure alone responsible for 53% of these emissions (UNEP, 2022). The African challenge is particularly sensitive, as local infrastructure is highly vulnerable to extreme weather events — floods, droughts, and storms — exacerbated by climate change (IPCC, 2022).

In addition, the use of energy-intensive materials (cement, steel and concrete) increases the ecological footprint of construction. The transition to low-carbon materials and circular economy practices is, therefore, essential to mitigate the sector's environmental impacts.

4.2 STRATEGIC OPPORTUNITIES OF AEC INDUSTRY AND INFRASTRUCTURE IN AFRICA

Despite the structural challenges identified, Africa presents a robust set of strategic opportunities that can transform the AEC sector into a catalyst for sustainable growth, social inclusion and technological innovation. These opportunities are aligned with the African Union's Agenda 2063 and the Sustainable Development Goals (SDGs).

4.2.1 Urban growth and industrialization potential

Accelerated urbanization is both a challenge and an opportunity. The African continent will have 1.3 billion urban dwellers by 2050, which will require urban infrastructure, housing, mobility and basic services on an unprecedented scale (UN-Habitat, 2023). This growth creates a continuous demand for the AEC sector, stimulating employment, local industrialization and innovation in construction materials and technologies.

The industrialisation of the sector can be supported by regional value chains, encouraging local production of cement, steel and modular components, which would reduce import costs and increase economic resilience.

4.2.2 Innovation and digitalisation of construction

The digitalization of the AEC sector is considered one of the most promising vectors of transformation. The use of BIM, Digital Twins (Figure 1), IoT and Artificial Intelligence allows integrated planning, reduction of design errors, cost control and real-time performance monitoring.

Studies by KPMG (2021) and McKinsey (2020) indicate that the adoption of digital tools can reduce the cost of operating and maintaining infrastructures by up to 25% and increase construction productivity by 60%. Countries such as Morocco, Egypt, Kenya and South Africa have already started national programs for the implementation of BIM and smart infrastructures, with positive results in transparency and public efficiency.

Figure 1

Digital twins



Source: Image taken from the internet

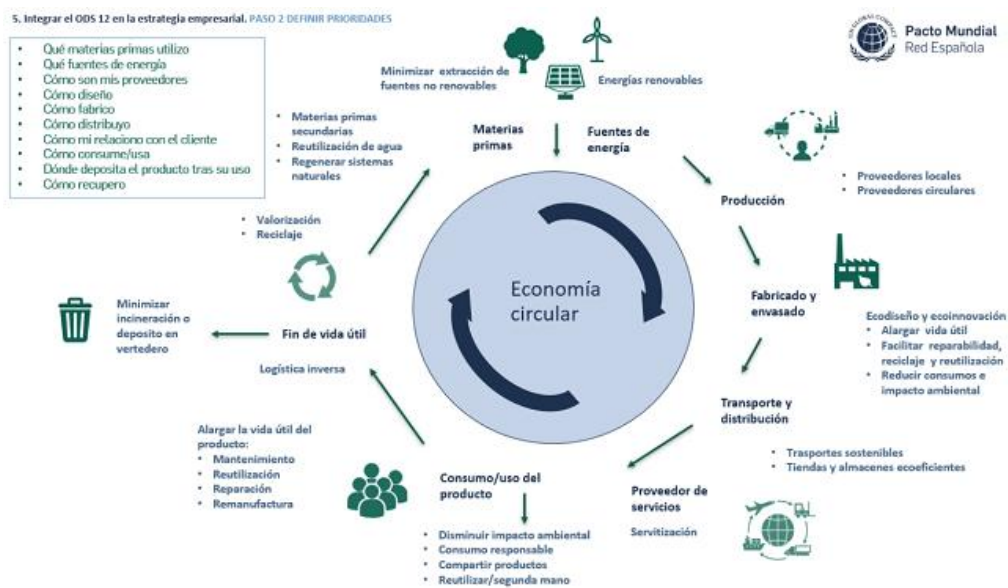
4.2.3 Circular Economy and Material Innovation

The circular economy offers opportunities for a more efficient and inclusive construction model, Figure 2. Experiences such as that of the company Nelplast Eco, in Ghana, which converts plastic waste into paving blocks and ecological bricks, demonstrate the potential of local and sustainable solutions. These materials reduce production costs by 30% and are more durable and waterproof (World Economic Forum, 2022).

Promoting production chains of sustainable materials — expanded clay, bamboo, natural fibers, and recycled aggregates — can generate endogenous innovation, local employment, and a reduction in the ecological footprint.

Figure 2

Circular economy cycle



Source: Image taken from the internet

4.2.4 Green finance and public-private partnerships

The transition to a sustainable economy drives new sources of financing, such as Green Bonds, Climate Funds and Public-Private Partnerships (PPPs). The African Development Bank (2023) highlights that the continent raised more than US\$20 billion in green bonds between 2019 and 2023, with a growing share of the sustainable construction and renewable energy sector.

PPPs, when well structured, can leverage private investment and transfer execution risks, as long as they are accompanied by adequate regulation and transparency guarantees.

4.2.5 Technical training and institutional strengthening

Strengthening local technical capacities is key to ensuring the sustainability and independence of the African AEC sector. Initiatives such as the African Infrastructure Fellowship Program (AIFP) and the Pan-African University Institute for Water and Energy Sciences (PAUWES) already train engineers and public managers in topics such as resilient infrastructure, digitalization, and project governance.

The creation of regional centers of excellence and integrated public innovation policies is essential to consolidate technical knowledge, normative standardization, and technological diffusion in the continent.

4.2.6 Climate resilience and sustainability

The incorporation of green infrastructure and nature-based solutions is another strategic opportunity. These solutions – such as sustainable drainage, urban reforestation and permeable pavements – contribute to mitigating flooding, improving environmental quality and increasing the resilience of African cities (UNEP, 2023).

Sustainable infrastructure, when associated with digital monitoring mechanisms and intelligent management, constitutes a new paradigm of African engineering, capable of simultaneously responding to the needs of development, climate mitigation and social inclusion.

5 CONCLUSION

This study has provided a comprehensive understanding of the challenges and opportunities of AEC Industry and infrastructure in Africa, in a context marked by deep structural asymmetries and the imperative of sustainable transformation. The results show that Africa's infrastructure deficit — estimated at about US\$ 93 billion annually — is one of the main obstacles to the continent's economic and social development. This deficit manifests itself in severe shortages in the energy, transport, sanitation, housing and telecommunications sectors, affecting the competitiveness, productivity and quality of life of the population.

The study also showed that institutional and financial weaknesses, low technological integration and climate vulnerability increase the complexity of the African infrastructure problem. The lack of preventive maintenance policies, the dependence on external financing

and the insufficiency of technical standards and effective supervision limit the efficiency of investments and perpetuate the degradation of assets.

However, the African scenario is equally fertile in structuring opportunities. The rapid process of urbanization, increasing industrialization, and the expansion of new green financing mechanisms offer the potential for an unprecedented qualitative leap. The adoption of digital technologies – such as BIM, digital twins and smart sensors – combined with the circular economy and the use of sustainable local materials, can reduce costs, increase productivity and mitigate the environmental impact of the AEC sector.

Sustainable and digital construction thus represents the new frontier of African engineering. For the continent to capitalize on these opportunities, integrated public policies, institutional strengthening and systematic investment in technical training are necessary. The creation of regional innovation centres, the harmonisation of construction standards and the encouragement of applied research in sustainable technologies are essential pillars for strengthening African technological autonomy.

It is concluded that the future of AEC Industry in Africa depends on the collective capacity to articulate governance, innovation and sustainability. The challenge is no longer just to build more, but to build better, with efficiency, equity and environmental respect.

The integration between the public, private and academic sectors will be decisive in transforming the infrastructure deficit into an engine of inclusive and resilient development, consolidating the role of the AEC sector as the structuring axis of the 2063 Agenda and the Sustainable Development Goals on the continent.

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**KNOWLEDGE MANAGEMENT IN THE AMAZON REGION: INTEGRATING
TRADITIONAL KNOWLEDGE, DIGITAL INNOVATION, AND PUBLIC POLICIES
FOR SUSTAINABLE DEVELOPMENT**

**GESTÃO DO CONHECIMENTO NO CONTEXTO AMAZÔNICO: INTEGRAÇÃO
ENTRE SABERES TRADICIONAIS, INOVAÇÃO DIGITAL E POLÍTICAS
PÚBLICAS DE DESENVOLVIMENTO SUSTENTÁVEL**

**GESTIÓN DEL CONOCIMIENTO EN EL CONTEXTO AMAZÓNICO:
INTEGRACIÓN ENTRE CONOCIMIENTOS TRADICIONALES, INNOVACIÓN
DIGITAL Y POLÍTICAS PÚBLICAS PARA EL DESARROLLO SOSTENIBLE**

 <https://doi.org/10.56238/sevened2025.036-114>

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ABSTRACT

Knowledge Management (KM) has increasingly consolidated as a strategic approach to sustainable development and innovation across regional contexts. In the Amazon region, characterized by vast biodiversity and sociocultural complexity, KM plays a crucial role in integrating traditional and scientific knowledge, promoting environmental conservation, and fostering sustainable socioeconomic development. This article discusses key challenges and opportunities for KM in Amazonia, focusing on the interfaces among science, technology, public policy, and local communities. Accordingly, the study examines how KM can be applied to preserve, systematize, and valorize Amazonian traditional knowledge while promoting innovation oriented toward sustainable development. It also identifies knowledge co-construction practices, challenges related to the inclusion of Indigenous peoples and local communities, and the political and institutional implications for territorial and environmental governance. The methodology combines a bibliometric review, interviews with KM researchers working in Amazonian contexts, government reports, an analysis of the trajectories of research groups, and a review of the scientific literature on KM in Amazonia. The results highlight the need for participatory conceptual models, transparency in data governance, and the institutionalization of inclusive dialogue channels. Recommendations are also presented for public policy and research practice.

Keywords: Knowledge Management. Amazon Region. Innovation. Sustainable Development Goals. Regional Development.

RESUMO

A Gestão do Conhecimento (GC) tem se consolidado como uma abordagem estratégica para o desenvolvimento sustentável e a inovação em diversos contextos regionais. Na Amazônia, território caracterizado por vasta biodiversidade e complexidade sociocultural, a GC assume papel crucial para integrar saberes tradicionais e científicos, promover a conservação ambiental e estimular o desenvolvimento socioeconômico sustentável. Este artigo discute os desafios e oportunidades da GC na Amazônia, abordando as interfaces entre ciência, tecnologia, políticas públicas e comunidades locais. Portanto, este estudo busca

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compreender como a GC pode ser aplicada para preservar, sistematizar e valorizar os saberes tradicionais da Amazônia, promovendo inovação com foco no desenvolvimento sustentável. Busca identificar as práticas de co-construção de conhecimento, os desafios de inclusão dos povos indígenas e comunidades locais, e as implicações políticas e institucionais para governança territorial e ambiental. A metodologia combina revisão bibliométrica, entrevistas com pesquisadores de GC no contexto amazônico, relatórios governamentais, trajetória de grupos de pesquisa e análise de produção científica sobre GC no contexto amazônico. Como resultados, destaca-se a necessidade de modelos conceituais participativos, transparência na governança de dados e institucionalização de canais de diálogo inclusivos. Aponta ainda recomendações para políticas públicas e para práticas de pesquisa.

Palavras-chave: GC. Amazônia. Inovação. Objetivos do Desenvolvimento Sustentável. Desenvolvimento Regional.

RESUMEN

La Gestión del Conocimiento (GC) se ha consolidado como un enfoque estratégico para el desarrollo sostenible y la innovación en diversos contextos regionales. En la Amazonía, un territorio caracterizado por una vasta biodiversidad y complejidad sociocultural, la GC desempeña un papel crucial en la integración de conocimientos tradicionales y científicos, la promoción de la conservación ambiental y el impulso del desarrollo socioeconómico sostenible. Este artículo analiza los desafíos y las oportunidades de la GC en la Amazonía, abordando las interfaces entre ciencia, tecnología, políticas públicas y comunidades locales. Por lo tanto, el estudio examina cómo la gestión del conocimiento puede aplicarse para preservar, sistematizar y valorar los conocimientos tradicionales amazónicos, promoviendo la innovación orientada al desarrollo sostenible. Además, identifica prácticas de co-construcción del conocimiento, desafíos para la inclusión de pueblos indígenas y comunidades locales, y implicaciones políticas e institucionales para la gobernanza territorial y ambiental. La metodología combina revisión bibliométrica, entrevistas con investigadores en GC en el contexto amazónico, informes gubernamentales, análisis de la trayectoria de grupos de investigación y revisión de la producción científica sobre GC en la Amazonía. Como resultados, se destaca la necesidad de modelos conceptuales participativos, transparencia en la gobernanza de datos e institucionalización de canales de diálogo inclusivos. También se formulan recomendaciones para políticas públicas y prácticas de investigación.

Palabras clave: Gestión del Conocimiento. Amazonía. Innovación. Objetivos de Desarrollo Sostenible. Desarrollo Regional.

1 INTRODUCTION

The Brazilian Amazon, recognized worldwide for its vast biodiversity and cultural diversity, faces complex socio-environmental challenges that require innovative and integrated solutions (Fearnside, 2018; Barlow, 2018; Artaxo, 2021). In this context, KM emerges as a strategic tool to organize, share and apply available knowledge, promoting both economic development, innovation and environmental sustainability (Nonaka; Takeuchi, 1997; Rezende, 2017; Olive tree; Saints; Martins, 2022)

The Amazonian context faces severe environmental challenges such as deforestation and economic pressure, which requires integrated management strategies and joint public policies between different government entities, according to studies by Fearnside (2005) and Ferreira, Venticinque; Almeida (2010). In the same vein, Barlow (2018) demonstrates the global relevance of Amazonian biodiversity and the growing challenges arising from human factors, agricultural expansion, mining, and climate change. It is evident that Amazonian challenges can only be faced with integrated approaches, involving science, communities, industries, and public policies (Brondizio, 2018; Almeida; Szwarcwald, 2020).

The study of Brondízio; Moran (2012) highlights cultural diversity and the need to integrate scientific and traditional knowledge in socio-environmental solutions. The importance of the cultural and historical diversity of the Amazonian peoples and their role in the ecological management of the region should be emphasized (Clement, 2015). Thus, it becomes relevant to implement the need for coordinated and transdisciplinary actions to face complex socio-environmental challenges, as highlighted by Nascimento (2015) and Artaxo (2021).

In this sense, the Amazonian context, due to its unique and peculiar characteristics, faces complex challenges that require innovative approaches to promote sustainable development (Brondízio; *et al.*, 2016; Silva; *et al.*, 2017; Fleury, Lobato; Dantas, 2019). Thus, KM and its foundation in an interdisciplinary science that permeates different scientific areas, becomes a strategy to integrate knowledge from traditional native peoples, advances in scientific knowledge with a focus on sustainability, promote regional technological advancement and provide opportunities for innovation in the industrial ecosystem (Bentes-Gama, 2012; Foster; Zaninelli, 2024; Castanha, 2025), strengthening local governance and driving adaptive solutions in the face of climate change and socio-environmental pressures, improving the performance of the industry and promoting an impact on society (Lima; Pozzobon, 2005; Silva, 2017; Mello-Théry; Fearnside, 2020)

It should be considered that the Amazon is one of the richest regions in biodiversity and cultural diversity on the planet, playing an essential role in global climate regulation and in the preservation of strategic natural resources (Lima; Pozzobon, 2005; Matos, Barroso Tenazor; Lopes, 2022). However, it faces historical challenges related to predatory exploitation, social inequalities and lack of integration between scientific, technological and traditional knowledge (Brondízio; Moran, 2012; Saints; Costa, 2021). It is relevant to highlight and highlight that the Brazilian Amazon is a complex space for the production, circulation and appropriation of knowledge, whether scientific, technological, community, social, indigenous, economic and ancestral (Fernandes; *et al.*, 2025; Magalhães, 2025). This knowledge coexists in a territory marked by structural asymmetries and intense sociocultural and immaterial diversity (Miranda; Schwaninger; Lucena, 2023). It can be said that it is essentially the sharing of tacit knowledge, passed from generation to generation or between subjects chosen by the leaders, so there is a challenge to the construction of collective knowledge (Chaves, Barbosa; Clement, 2018; Santos, *et al.*, 2023).

The notion of KM, originally developed in the business and organizational field (Nonaka; Takeuchi, 1997), has been gradually reinterpreted for contexts of territorial development, environmental conservation, and social innovation (Müller, 2024; Fonseca, 2024). It is clear that there is still an embryonic movement to transform this tacit knowledge into explicit knowledge. In this sense, scientific research and KM have much to contribute to the sustainable development of the Amazon region (Arruda Filho, 2019; Foster; Zaninelli, 2024; Castanha, 2025)

In this context, KM emerges as an instrument for integrating and valuing local knowledge, capable of guiding public policies and sustainable innovative practices (Ribeiro; Leite, 2021; Santos, *et al.*, 2023).

However, KM can contribute significantly to the construction of an Amazonian development model based on knowledge, innovation and sustainability, as described in the studies by Bentes-Gama, (2012); Silva, (2017) and Fleury, Lobato; Dantas (2019). This approach implies recognizing the plurality of actors such as universities, research centers, indigenous communities, indigenous peoples, government institutions, and companies articulating processes of creation, sharing, and application of knowledge focused on the Amazonian reality (Freire; Lima, 2020; Foster; Zaninelli, 2024; Castanha, 2025).

The present study is justified due to the integration between different forms of knowledge, being essential to strengthen public policies, innovation strategies and socio-

environmental governance mechanisms in the search to protect, preserve and seek a sustainable development plan (Freire; Lima, 2020; Mello-Théry; Fearnside, 2020; Saints; Costa, 2021). Another relevant point that justifies the study is that the Amazon, with its immeasurable environmental and sociocultural diversity, constitutes one of the most complex ecosystems of knowledge on the planet (Margulis, 2003; Porto-Gonçalves, 2006; Clement, 2015; Barlow, 2018).

In this context, KM assumes a strategic role by integrating scientific, technological and traditional knowledge in favor of sustainable development and social innovation (Leite; Marly 2019; Geraldo; Pinto, 2019; Silva; Bittencourt, 2021; Geraldo, Pinto; Duarte, 2022; Barbalho, *et al.*, 2023). Recent productions on the subject highlight the importance of thinking about KM in the Amazon from collaborative, interdisciplinary and territorially situated approaches (Ribeiro; Leite, 2021; Magalhães, 2025).

Some initial scientific research in the Amazonian context deals with the theme KM in the legal Amazon is characterized by a multidisciplinary and interdisciplinary field of study that ranges from organizational practices to traditional indigenous knowledge (Leite; Marly 2019; Silva; Bittencourt, 2021 Barbalho, Inomata; Fernandes, 2021; Geraldo; Dick; Duarte, 2022; Yanai, *et al.*, 2024).

Studies on the KM theme in the Amazonian context and in the northern region of Brazil are recent. In the study by Brito, *et al.*, (2016) a study was prepared in which it analyzes how credit unions in the Amazon apply KM practices, considering cultural and regional specificities.

The study by Souza, Barros and Gomes (2020) developed a bibliometric study that analyzes the works published on KM in university libraries in the Amazon, using the Web of Science database. The study by Fonseca (2024) explored initiatives of conceptual models of indigenous KM within the scope of Information Science, highlighting traditional practices and their contemporary application (Leite; Marly 2019; Silva; Bittencourt, 2021 Barbalho; Inomata; Fernandes, 2021).

Thus, no studies were found that connect KM to sustainable development, preservation, systematization and valorization of traditional knowledge of the Amazon based on the Sustainable Development Goals (SDGs) (Leite; Marly 2019; Silva; Bittencourt, 2021 Barbalho; Inomata; Fernandes, 2021; Geraldo; Dick; Duarte, 2022; Fonseca, Zaninelli; Simonetti, 2024).

A relevant and innovative question reinforces that KM in the Amazonian context is considered an interdisciplinary field that seeks to promote the creation, sharing, and efficient application of knowledge in organizations and communities (Davenport; Prusak, 1998). In the Amazonian context, however, knowledge is not limited to scientific or technological production, but includes traditional knowledge rooted in cultural, spiritual, and ecological practices (Fleury; Lobato; Dantas, 2019; Barreto; Freitas, 2020; Arreto; Brazil, 2021; Foster; Zaninelli; Simonetti, 2024). This knowledge is transmitted orally, sustaining ways of life and sustainable management strategies that have resisted for centuries (Diegues, 2000).

From this perspective, the Amazon constitutes a hybrid informational ecosystem, in which traditional knowledge and scientific systems coexist and, in many cases, are tensioned. KM in the region is not limited to technology transfer or data digitization, but involves valuing local practices, information governance, and the integration of diverse actors such as indigenous people, riverside communities, universities, public agencies, and companies and social organizations (Barreto; Freitas, 2020; Castro, Lima; Zucarelli, 2021; Arreto; Brazil, 2021; B; Inomata; Fernandes, 2021).

The Amazon, as a territory of biodiversity and sociocultural plurality, presents unique challenges and opportunities for KM (Santos, *et al.*, 2023; Foster; Zaninelli, 2024; Castanha, 2025). The integration between KM and traditional knowledge becomes, therefore, a strategic and ethical issue. Recognizing this knowledge as legitimate forms of scientific production broadens the notion of innovation, favoring intercultural dialogue and sustainability (Santos, 2007; Brook; Leite, 2021; Fernandes, *et al.*, 2025; Magalhães, 2025). Thus, this article seeks to understand how KM can be applied to preserve, systematize and value the traditional knowledge of the Amazon, promoting innovations focused on sustainable development without decontextualizing them or reducing them to mere scientific data.

2 THEORETICAL FRAMEWORK

The theoretical contribution of this study is structured and interrelated in the dialogue of classical and contemporary authors. When structuring the theoretical foundation of the study, it was understood that it would be innovative to present in the text the theoretical and scientific relevance establishing the interlocution of national and international articles given the complexity of *the locus* of study, the Amazonian context.

Thus, the theoretical framework is structured in four chapters. The first deals with the fundamentals and different approaches to KM. The second chapter addresses KM in the

Amazonian context, discussing its different characteristics. The third chapter addresses the Amazon as an ecosystem of knowledge, discussing its sociocultural, environmental and epistemological dimensions. The fourth chapter articulates KM integrated with traditional knowledge, dialoguing with digital innovation.

2.1 GC: FUNDAMENTALS, APPROACHES AND CONCEPTUAL EVOLUTION

KM has been consolidated, over the last three decades, as one of the pillars of organizational competitiveness, innovation and informational sustainability (Angeloni, 2008; Terra, 2013; Barbosa; Schneider, 2015; Baptist; Quandt, 2016; Pear tree; Angeloni, 2020; Geraldo; Dick; Duarte, 2022).

In the Brazilian context, the field of KM studies has taken on its own characteristics, influenced by institutional diversity, the public innovation agenda, the emergence of digital technologies, and the challenges imposed by complex territories such as the Amazon (Rosenberg; Ohayon; Batista, 2008; Alfenas, *et al.*, 2021; Bike; Fernandes; Angels, 2021; Müller; *et al.*, 2024). Thus, KM in Brazil has developed its own characteristics, especially in the public sphere, due to institutional diversity, the adoption of a governmental innovation agenda, and territorial particularities (Pinheiro; Araújo, 2023; Coast; Almeida, 2023; Pacheco; Yamaguchi; Madeira, 2023).

National studies show that KM in the public sector is still in the consolidation phase and requires contextual adaptations according to studies by Santos, (2022) and Cunha; Meirelles, (2022). The study by Alfenas *et al.* (2021) who conducted a literature review from 2008–2017 concluded that Brazilian public organizations need to establish specific KM models adapted to their reality. Conclusions from more recent scientific studies advance to consider KM stages adapted to complex regional realities, such as in the Amazon and in the Northeast region according to Pacheco, Yamaguchi; Madeira, (2023) and de Müller, *et al.*, (2024).

In the Brazilian context, KM has been researched and discussed in different areas such as Information Science, Administration, Production Engineering, Information Systems, People Management and Organizational Studies according to Ziviani, *et al.*, (2025). In this way, the KM theme becomes relevant when relating it to open access policies, data governance, digital repositories, social innovation, and traditional knowledge (Barbalho, 2022; Tartarotti; 2023). At the same time, international studies reinforce the centrality of

knowledge flows as essential mechanisms for continuous learning, strategic renewal, and dynamic capacity building (Wiig, 1997; Davenport; Prusak, 1998).

KM in the scientific field has been discussed in universities, public and private companies, government entities and social organizations as an interdisciplinary field (Ziviani; Corrêa; Muylder, 2019; Would; Costa, 2020). Its evolution is directly linked to the transformation of knowledge into a central economic resource, as emphasized by Drucker (1993, p.83), when he states that "knowledge has become the main economic resource of modern organizations".

In this way, KM consolidates itself as a field of science, being one of the strategic areas for public, private, academic and community organizations in the twenty-first century (Francini, 2002; Souza; Corrêa, 2018; Silva; Menezes, 2013; Fialho; Barbosa; Santos, 2018). Inserted in a global context of digital transformations, intensification of information flows, and growing valuation of intangible assets, KM has become fundamental for innovation, process improvement, competitiveness, and decision-making (Batista; Quandt, 2016; Rezende, 2017; Olive tree; Santos, 2022).

Classic authors in the field of KM such as Nonaka; Takeuchi (1997) states that, in contemporary societies, knowledge constitutes the basis of economies, representing the main strategic resource of organizations. Thus, "the ability to create knowledge, disseminate it and incorporate it into products, services and systems is the most important source of competitive advantage" (Nonaka; Takeuchi, 1997, p. 13).

In this sense, Batista and Quandt (2016) argue that KM becomes essential for innovation and organizational competitiveness by allowing information to be systematized and transformed into action (Ziviani; et al, 2025; Correa; *et al.*, 2025). Terra (2019) argues that KM practices strengthen collaborative environments and contribute to the creation of public and social value.

In the contemporary scenario, characterized by dynamics of continuous innovation, technological advances, and growing organizational complexity, KM is now considered a strategic element for creating value, sustaining competitiveness, and promoting continuous learning (Correa; *et al.*, 2025; Ziviani; *et al.*, 2024). Davenport and Prusak (1998, p. 5) add that knowledge is "a fluid mixture of condensed experience, values, contextual information, and specialized insight."

In Brazil, the debate on KM has been expanded since the 2000s, when authors such as Fleury and Fleury (2000), Batista (2004), Valentim (2004) and Terra (2005), began to

articulate international theories with the reality of local organizations. Terra (2005) observes that KM in the country needs to consider cultural, institutional and structural specificities, especially in organizational environments marked by inequalities, discontinuity of policies and lack of informational integration.

Still within the Brazilian context, studies such as those by Angeloni (2008) and Batista; Quandt (2016) indicate that the adoption of KM practices is growing progressively, although it still faces structural, cultural and managerial limitations. Angeloni (2008, p. 27) highlights that "Brazilian organizations are still maturing their KM processes", emphasizing the need to consolidate incentive policies, learning structures and institutional recognition. Increasing digitalization has brought new challenges and opportunities for strengthening KM in the Amazonian context (Stradioto; Frazzon, 2023; Silva; File; Silva, 2025).

Davenport; Prusak (1998) point out that the growing volume of data and information does not necessarily translate into useful knowledge: it is necessary to interpret, contextualize, validate and apply this information. KM emerges exactly as a field capable of transforming dispersed data into strategic knowledge, favoring organizational learning, continuous improvement and adaptive capacity (Sá, *et al.*, 2018; Belinski; Martins, 2020; Klein; Azevedo; Silva, 2021).

Thus, understanding knowledge not only as an input, but as a dynamic process, becomes fundamental for the understanding of KM, with knowledge being the most relevant resource for organizations (Gonzalez; Martins, 2017; Pear tree; Macieira, 2020; Ziviani; *et al.*, 2025). Nonaka and Takeuchi (1995) argue that organizational knowledge results from the continuous interaction between tacit and explicit dimensions, operating in a cyclical and spiral process capable of promoting innovation. For the authors, "knowledge is created in a spiral process, which expands both at the individual and collective levels" (Nonaka; Takeuchi, 1995, p. 25).

Wiig (1997) reinforces this conception by arguing that KM involves systematic practices aimed at identifying, constructing and applying knowledge in order to improve organizational performance. In his perspective, "KM exists to ensure that the organization can act intelligently" (Wiig, 1997, p. 92), revealing the strategic character of this field.

On the international scene, Yu; *et al.*, (2022) and Pereira (2025), argue that KM should be understood as a multidimensional phenomenon, involving technology, social structures, and cognitive processes. According to the authors, knowledge is an intangible asset whose

effectiveness depends mainly on sharing mechanisms, collaborative culture and appropriate systems.

To contextualize this study, it is necessary to define CG. Therefore, KM constitutes an organized and intentional set of processes to create, capture, systematize, share and apply knowledge, whether tacit or explicit, in scientific organizations and institutions, with the purpose of transforming internal knowledge into strategic assets that promote innovation, organizational learning, institutional preservation and competitive advantage (Silva, 2004; Milk; Costa, 2007; Bike; Kobashi; Bettencourt; Cianconi, 2012; Correa, *et al.*, 2024; Ziviani; *et al.*, 2025a).

Table 1 presents the definition of KM discussed by different classical and contemporary authors and elucidates the concept of KM for this study.

Table 1

Definitions of KM

Author(s)	Year	Definition/Approximation of GC
Nonaka; Takeuchi	1997	KM as "a process of continuous creation of new knowledge, disseminating it widely throughout the organization and quickly incorporating it into new products/services, technologies and systems".
Davenport; Prusak	1998	KM is the "collection of processes that aim to govern the creation, dissemination, and use of knowledge to achieve organizational objectives."
Sveiby	2000	KM understood as the "art of creating value from the leverage of an organization's intangible assets", involving internal/external structure and employee competence.
Choo	2006	KM involves processes of knowledge creation, generation of meaning, and decision-making — that is, in addition to manipulating information, the focus is on how the organization generates meaning and decides based on knowledge.
Valentine	2008	KM is a set of activities that aims to work on the organizational/informational culture and institutional communication to provide a favorable environment for the generation, acquisition, sharing and use of knowledge. It focuses on transforming tacit knowledge into explicit knowledge to support ideas, problem solving, and organizational decision-making.
Corrêa, Ziviani; Muylder	2019	They propose a "holistic approach" to KM, highlighting that existing models are parsimonious and suggesting that effective KM should consider multiple dimensions of the organization (people, processes, culture, technology, etc.).

Source: survey data, 2025.

The literature presents a diversity of KM definitions: with approaches more centered on processes, capture and use of knowledge according to Davenport; Prusak (1998) and Sveiby (2000). It is also noted that integrated/holistic models (Corrêa, Ziviani; Muylder, 2019) value culture, technology, structure, and people simultaneously. The holistic approach of Corrêa, Ziviani; Muylder (2019) can serve as a modern and systemic reference, especially if his study addresses KM in companies/organizations that deal with sustainability, innovation,

and green technology focused on areas that require integration between processes, people, and technology.

For Nonaka; Takeuchi (1997, p. 83), "knowledge is created through the continuous interaction between tacit and explicit knowledge", articulated in the SECI model, which has become a world reference. Davenport; Prusak (1998) reinforce that knowledge is a strategic resource, stating that "valuable knowledge derives from experience, interpretation and reflection" (Davenport; Prusak, 1998, p. 5).

In addition to the corporate context, KM can also be applied to the academic and research environment: scientific KM involves practices of organization, communication, and dissemination of scientific knowledge, with a view to facilitating the production, exchange, and preservation of knowledge produced in teaching and research institutions. Scientific communication, documentation, recording of data and results, as well as the dissemination of knowledge are seen as essential elements for this type of KM (Leite; Costa, 2007; Sampaio; Menezes, 2021; Baptist; Farias, 2023).

It is important to highlight that, although there are several definitions and conceptual approaches to KM, there is a consensus among researchers and authors that KM is not reduced to the management of data or information. KM presupposes a mature organizational strategy, technology infrastructure, and organizational, socio-technical, and cultural culture that allows transforming knowledge into intellectual capital, that is, into a strategic resource (Menezes; Rodrigues, 2023; Correa, *et al.*, 2024; Ziviani; *et al.*, 2025a).

Finally, KM presents itself as a solid, dynamic and multidimensional field. The integration between technology, social processes, collaborative culture and ethics is indispensable. In Brazil, the relationship between KM and complex territories, such as the Amazonian context, is a strategic and little explored area, demanding critical, participatory approaches that are sensitive to epistemological diversity (Souza; Corrêa, 2018; Barbalho, 2023; Yanai, *et al.*, 2024).

2.2 KNOWLEDGE MANAGEMENT IN THE AMAZONIAN CONTEXT

The Brazilian Amazon is a territory of great socio-environmental and cultural complexity, home to a unique diversity of ecosystems, indigenous peoples, traditional communities, and teaching and research institutions. (Arruda Filho, 2019; Artaxo, 2019; B; Inomata, 2021). This scenario presents unique challenges for KM, especially with regard to the integration between scientific and traditional knowledge, the preservation of strategic

information and the promotion of sustainable innovation (Brito, *et al.*, 2016; Cardoso; Pimenta, 2019; Yanai, *et al.*, 2024; Fonseca, 2025)

According to Müller, Arruda; Vilches (2024, p. 12), "KM consists of a set of processes aimed at creating, organizing, disseminating and applying knowledge, considering it as strategic assets". In the Amazonian context, this definition requires expansion, given that the knowledge produced is not only technical or scientific, but also cultural, ancestral and collective (Castro; File; Zucarelli, 2021; Coast; Almeida, 2023). Thus, KM in the region should be thought of in an interdisciplinary way, incorporating social, environmental and epistemological dimensions specific to the Amazon territory (Chaves; Barbosa; Clement, 2018; Fleury; Lobato; Dantas, 2019; Castro; File; Zucarelli, 2021)

KM is a field that emerged at the end of the twentieth century, with the aim of organizing and maximizing the use of information within organizations and communities (Nonaka; Takeuchi, 1997). According to Müller, Arruda, and Vilches (2024), KM processes include: knowledge identification, creation, storage, distribution, application, and evaluation. Such processes make it possible to transform information into strategic assets capable of generating innovation and competitive advantage (Stewart, 1997; Sveiby, 1998).

However, in regional contexts such as the Amazon, the application of these concepts needs to be adapted and contextualized to the scenario and field of study (Fonseca; Zaninelli, 2022; Foster; Zaninelli; Simonetti, 2024; Magalhães, 2025). Researcher Fonseca (2024, p. 45) points out that "traditional KM models, usually developed in urban or corporate environments, do not always apply to the Amazonian reality, where oral, collective knowledge and linked to specific territorial and cultural practices predominate". This perspective shows that KM in the Amazon must incorporate not only technology and scientific documentation, but also practices of preservation and transmission of community knowledge (Little; Barreto Filho, 2012; Martins; Silva, 2019; Matos; Barroso Tenazor; Lopes, 2022).

The classic KM literature is not limited to the management of information or data, it involves the coordination of knowledge flows, the promotion of organizational learning, and the creation of cooperation networks that facilitate the production and exchange of knowledge (Davenport; Prusak, 1998). In regions of high cultural and environmental diversity, such as the Amazon, these elements assume strategic relevance (Moraes; Birth, 2021; Pine; Araújo, 2023; Pacheco; Yamaguchi; Madeira, 2023).

The Amazon is characterized by a mosaic of cultures, languages, and forms of knowledge. Indigenous and riverine knowledge, for example, has spiritual and collective

dimensions that make it difficult to codify it in traditional KM systems (Silva; Oliveira, 2021; Saints; Costa, 2021; Barbalho, 2022; Fonseca, 2024). Decoloniality and Traditional Knowledge in Scientific Practices in the Amazon argues that non-Western knowledge should be treated as legitimate epistemology, requiring KM models that respect their own logics (Silva; Saints; Ferreira, 2022; Schott; Steinmueller, 2023).

According to Fonseca (2024, p. 32), "indigenous knowledge is dynamic, collective, and deeply linked to the territory, and it is essential to ensure its preservation and transmission in an ethical and culturally sensitive way". Thus, the integration between scientific and traditional KM requires attention to ethical, legal, and cultural aspects, avoiding the misappropriation of local knowledge (Barbalho, 2022; Yanai; *et al.*, 2024)

Research carried out in cooperatives and institutions in the Amazon points to significant gaps in KM infrastructure. According to Brito, *et al.*, (2016), despite recent advances, the adoption of KM systems is still incipient, with a lack of adequate technologies for organizing, storing, and sharing information.

In addition, the lack of interoperability between different information systems prevents the efficient circulation of knowledge (Valentim, 2008; Martin; Nascimento, 2021). Fonseca (2024) highlights that Amazonian museums and libraries face challenges related to the standardization of vocabularies, cataloguing, and digital access, limiting the dissemination of scientific and cultural knowledge (Bernard; Jorgensen, 2022; Souza; Oak; Mendes, 2022; Yanai, *et al.*, 2024)

One of the greatest challenges is to reconcile traditional and scientific knowledge in a collaborative way (Silva; Oliveira, 2020; Silva; Bittencourt, 2021). According to Fonseca (2024), the creation of specific conceptual models, such as those developed for indigenous communities, allows for more ethical and effective knowledge management. Such models value orality, ancestry and the immaterial dimension of knowledge, integrating them with practices of social and technological innovation (Machado; Carvalho, 2019; Freire; Lima, 2020; Foster; Zaninelli; Simonetti, 2024).

Decoloniality and traditional knowledge reinforce that the dialogue between different knowledge regimes requires rethinking methodologies, indicators, and evaluation metrics (Battiste, 2019; Schott; Steinmueller, 2023). The simple transfer of urban or corporate KM techniques to Amazonian contexts is insufficient, as it ignores the cultural, social and environmental specificities of the territory (CASTRO, 2010; Foster; Zaninelli, 2022; Barbalho, 2023).

Fonseca (2024) proposes a conceptual model of KM for indigenous communities that values collectivity, orality, and connection to the territory. This model allows for the recording of knowledge in an ethical manner, ensuring intergenerational transmission and cultural protection. The integration of such practices with academic and technological initiatives strengthens the dialogue between science and tradition, promoting social innovation and territorial sustainability (Silva; Barreto, 2020; Wikepena, 2021).

In the context of indigenous peoples, knowledge is not just a set of information, but a historical and cosmological construction linked to the territory, community relations, spirituality and environmental practices (Arreto; Brazil, 2021; Bernard, 2022). In this sense, Berkes (2012, p.4) states that traditional ecological knowledge constitutes "a complex, adaptive, and cumulative system transmitted between generations," which implies understanding indigenous knowledge as living and dynamic systems. In addition, Almeida (2014, p. 90) highlights that indigenous territories are spaces for the production of identities and specific knowledge, constituting "territories of knowledge", a view that goes against the study of Carvalho, Pires; Ribeiro (2021). Thus, applying KM models to these contexts requires expanding epistemological references, avoiding colonizing and reductionist approaches (Battiste, 2019; French; Oliveira, 2020).

From the perspective of cognitive justice, Santos; Meneses (2019) argues that there is a long history of subordination of indigenous epistemologies in the Western scientific field. For the authors, recognizing indigenous knowledge implies adopting epistemologies from the South, which presuppose "the coexistence of different forms of knowledge and the refusal of epistemological hierarchization" (Santos; Meneses, 2019, p. 8). This view dialogues with Smith (2012), for whom indigenous knowledge is intrinsically linked to cultural sovereignty, and should be treated ethically and with respect for community protocols. The author states that "researching or recording indigenous knowledge is always a political act" (Smith, 2012, p. 59), reinforcing the need for collaborative approaches and free and informed consent.

From the point of view of documentation and preservation, Brazilian authors have highlighted the importance of participatory processes (Freitas; Oliveira, 2020; Weitzel, 2021; Souza; Oak; Mendes, 2022). Freitas and Oliveira (2020) point out that the preservation of indigenous intangible heritage requires methodologies that consider oralities, rituals, and community dynamics, avoiding decontextualization. Likewise, Silva; Barreto (2020) discusses KM practices in Brazilian villages, emphasizing that oral transmission remains

central to the maintenance of knowledge, although digital tools can support registration processes when used under the governance of the community itself.

Another relevant axis is the role of indigenous knowledge in sustainability (Geraldo; Pinto, 2019; Geraldo; Dick; Duarte, 2022; Ziviani; *et al.*, 2025b). Nakashima *et al.* (2020), in a study published in *Science*, demonstrate that traditional knowledge is fundamental for global biodiversity conservation strategies, reinforcing its direct relationship with the territory and with ancestral sociocultural practices. In this sense, Diegues (2000, p. 21) states that this knowledge offers "singular interpretations of nature and its cycles", constituting references that complement modern science.

The integration between scientific institutions and indigenous peoples has demanded new KM practices based on collaboration. Carvalho, Pires; Ribeiro (2021) analyze partnerships between indigenous communities and research centers, emphasizing the importance of social innovation and the recognition of collective intellectual property. Similarly, Bernard; Jorgensen (2022) propose collaborative research models that include co-authorship, joint planning, and benefit-sharing.

In the methodological field, Kovach (2020) argues that indigenous epistemologies and methodologies should guide any KM process involving this knowledge, as they represent "ways of knowing based on relationship, territory, and belonging" (Kovach, 2020, p. 52).

From a critical perspective, Agrawal (2002) warns that many processes of recording indigenous knowledge carry logics of Western classification that disregard the proper ways of organizing knowledge. He argues that, without reflection, KM can reproduce epistemic inequalities. This leads to the contemporary challenge of developing intercultural KM practices, capable of integrating digital technologies, participatory methodologies, and principles of self-determination (Almeida, 2014; Oak; Saucer; Ribeiro, 2021; McGrew; *et al.*, 2023).

In this context, the ethical dissemination of indigenous knowledge requires intellectual protection policies, shared governance, and community control mechanisms over the use of information (Souza; Gomes, 2019; Nakashima; *et al.*, 2021). Souza; Gomes (2019) highlight that safeguard policies should ensure that the circulation of knowledge occurs according to cultural, legal and ethical principles agreed with the communities. Thus, KM applied to indigenous peoples cannot be limited to techniques for capturing and recording knowledge. It must involve active participation, reciprocity, respect and recognition of different ways of existing and knowing (Kovach, 2020; Wikepena, 2021; Bernard; Jorgensen, 2022)

In general, KM in indigenous contexts demands a plural epistemology, sensitive to the territory, oral narratives, community technologies, and spiritual relations that structure traditional knowledge (Barbalho, 2022; B; *et al.*, 2023; Fonseca, 2024). It is a field that expands the frontiers of KM, allowing the construction of more inclusive, ethical, and multicultural models of knowledge production and circulation. The preservation and dissemination of indigenous knowledge, therefore, can only occur legitimately when guided by the autonomy of peoples, by cognitive justice, and by collaborative processes that respect their complexity and historical depth (Freire; Lima, 2020; Foster; Zaninelli, 2022).

KM in the Amazon is also directly related to innovation and sustainable development policies (Lima; Pozzobon, 2005; Little; Barreto Filho, 2012; Matos; Barroso Tenazor; Lopes, 2022). Schott; Steinmueller (2023) highlight that integrative KM models can contribute to contextualized science, technology, and innovation (ST&I) policies, considering axes of territorial governance, environmental sustainability, social innovation, and informational sovereignty.

In this way, KM becomes a strategic tool for sustainable regional development, promoting not only the appropriation of scientific knowledge, but also the appreciation and protection of local knowledge (Rezende, 2017; Pear tree; Angeloni, 2020; Martin; Nascimento, 2021).

KM in the Amazonian context presents some fundamental and relevant guidelines. The first point is the epistemological plurality, which is essential when recognizing and integrating different types of knowledge such as scientific, technological, indigenous and community in management models that respect their specificities (Fonseca, 2024). Another issue is related to ethics and cultural preservation in which KM processes must ensure that traditional knowledge is used ethically, preserving cultural and territorial rights (Schott; Steinmueller, 2023).

The study by Brito, *et al.*, (2016) describes the need for institutional adaptation when implementing KM practices that must consider the particularities of Amazonian institutions, including technological, structural, and human resource limitations. In another sense, the integration with innovation and sustainability stands out. In this sense, KM must be articulated with social, technological and environmental innovation policies, contributing to the sustainable development of the region (Schott; Steinmueller, 2023).

The adoption of these guidelines implies rethinking traditional KM models, promoting flexible, interdisciplinary approaches that are sensitive to cultural and environmental diversity

(Santos; Costa, 2021; Silva; Bittencourt, 2021; Saints; *et al.*, 2023; Yanai; *et al.*, 2024a). In addition, the dialogue between modern science and traditional knowledge can generate social and technological innovation adapted to local realities. KM, in this sense, becomes a means of community empowerment, allowing Amazonian peoples to define their own sustainable development strategies (Silva; Barreto, 2021; Bernard; Jorgensen, 2022; Yanai, *et al.*, 2024b)

2.3 THE AMAZON AS AN ECOSYSTEM OF KNOWLEDGE: SOCIOCULTURAL, ENVIRONMENTAL AND EPISTEMOLOGICAL DIMENSIONS

The Amazon region concentrates one of the greatest biodiversity on the planet and, at the same time, a diversity of indigenous peoples, riverside dwellers, quilombolas and traditional communities that produce, transmit and resignify knowledge in close relationship with the environment (Fearnside, 2005; Brondízio; Moran, 2012; Fernandes; *et al.*, 2025). This knowledge, often referred to as traditional ecological knowledge (TEK), constitutes complex systems of observation, experimentation and classification of nature, which guide practices of use, management and conservation of natural resources (Hanazaki *et al.*, 2018).

Hanazaki *et al.* (2018) define traditional and local knowledge as a set of knowledge and practices that guide the sustainable use of biodiversity and that are fundamental to achieving global conservation goals, such as the Global Strategy for Plant Conservation (Becker, 2002; Barlow; *et al.*, 2018; Almeida; Szwarcwald, 2020; Artaxo, 2021). For the authors, "traditional ecological knowledge and local ecological knowledge are central to sustainable harvest and biodiversity conservation" (Hanazaki *et al.*, 2018, p. 1592), emphasizing that such knowledge is not a remnant of the past, but an active component of contemporary sustainability strategies.

In the Brazilian Amazon, Galvão *et al.* (2024), when studying the use of mangrove wood in coastal communities, show that the TEK organizes vocabularies, classifications, and practices of use of species such as *Rhizophora mangle* and *Avicennia germinans*, articulating technical, family, and intergenerational dimensions. The authors point out that local knowledge about wood has been validated by scientific research, which reinforces the idea of complementarity between traditional and academic knowledge (Galvão *et al.*, 2024). In this sense, the TEK studies go against the fundamental concepts of KM that defines tacit and explicit knowledge according to Nonaka; Takeuchi (1997).

In this way, the Amazon can be understood as an ecosystem of knowledge in which biodiversity and sociodiversity are mutually reinforcing: biological wealth feeds multiple knowledge systems, while these systems are crucial for the maintenance of cultural and ecological landscapes (Lima; Pozzobon, 2005; Brondizio, 2016; Arreto; Brazil, 2021; Assad, 2022). In this sense, KM as a science assumes a strategic position in the Amazonian context (Machado; Oak. 2019; Mello-Théry; Fearnside, 2020; Matos; Barroso Tenazor; Lopes, 2022)

Amazonian knowledge is inseparable from the historical trajectories and forms of social organization of the peoples who inhabit the region (Santos; Costa, 2021; Silva; Bittencourt, 2021; Pine; Araújo, 2023). Fernandes; Moser (2021), when analyzing riverside communities, show that the socio-historical formation of the Amazon was marked by processes of colonization, forced migration, economic cycles, and public policies that, to a large extent, made the social and political place of these groups invisible (Silva; Oliveira, 2020; Fernandes; Moser, 2021; Silva; Saints; Ferreira, 2022).

These communities build a way of life in which territory, identity, and knowledge are intertwined. Padovani (2022), when presenting the Encyclopedic Atlas of Traditional Knowledge of the Amapá Amazon, highlights that traditional populations are groups "culturally established in a geoFigureical space, having intrinsic and interdependent connections with it", and that their knowledge involves practices, spiritual connections, and collective memories transmitted between generations (Padovani, 2022, p. 36).

In this sense, Amazonian knowledge is not limited to the "use of resources", but is structured in a) forms of community education (learning by observation, orality, rituals); b) local governance systems (assemblies, community councils, traditional leaders); and c) ethical values linked to reciprocity, care for the river, the forest, and non-human beings (Matheus, 2019; Alves; *et al.*, 2022; Souza; Oak; Mendes, 2022).

Araújo (2025), dialoguing with the Epistemologies of the South in rural education in the Amazon, argues that the ancestral knowledge of rural peoples can challenge hegemonic curricular logics and propose intercultural and democratic pedagogical practices, in which knowledge is not just content, but situated experience (Araújo, 2025). In this way, it is verified that knowledge in the Amazonian context is tacit essential (Sell; Gregori, 2018; Fernandes; Moser, 2021; Saints; *et al.*, 2023).

Thus, the sociocultural dimension of Amazonian knowledge shows that: a) the ways of life (riverside, quilombola, indigenous, extractivist) are matrices of knowledge; b) collective identities are built in the relationship with rivers, streams, forests and seasonal cycles; and c)

traditional knowledge is dynamic, resignified in the face of new technologies, public policies and markets (Arreto; Brazil, 2021; Castro; File; Zucarelli, 2021; Barbalho, 2022).

In order to understand the Amazon as an ecosystem of knowledge, numerous authors articulate the discussion with the Epistemologies of the South, formulated by Boaventura de Sousa Santos and collaborators (Santos, 2011; Santos; Meneses, 2019). Santos (2014) criticizes hegemonic Western reason, responsible for producing a true "epistemicide", that is, the disqualification and destruction of non-Western knowledge, considered backward, superstitious or unscientific (Santos, 2014).

In place of a monoculture of scientific knowledge, Santos (2014) proposes an "ecology of knowledge", understood as a practice of horizontal dialogue between scientific and non-scientific knowledge, in which no knowledge is a priori superior to another. This perspective is particularly fruitful for thinking about the Amazon, where the following coexist: a) indigenous, riverside, quilombola and other traditional peoples' knowledge; b) scientific knowledge produced by universities, research institutes and government agencies; and c) technical knowledge of public policy agents, NGOs and companies (Sell; Gregori, 2018; Matheus, 2019; Fernandes; Moser, 2021; Padovani, 2022).

In the Amazonian context, Gebara *et al.* (2023) explicitly dialogue with the Epistemologies of the South when discussing epistemic justice and bioeconomy, arguing that the construction of policies needs to recognize the pluriversality of epistemologies and ontologies present in the region, under penalty of deepening forms of biopiracy and biocolonialism (Gebara; Ramcilovic-Suominen; Schmidlehner, 2023; Galvão; *et al.*, 2024).

Casino; *et al.* (2025, p. 10), in turn, propose "thinking with Amazonian indigenous peoples" to expand knowledge systems, arguing that indigenous epistemologies should not only be "data sources" for science, but epistemic partners in processes of co-production of knowledge and socio-environmental governance (Almeida, 2014; Oak; Saucer; Ribeiro, 2021; B; *et al.*, 2023)

In the field of education, Araújo (2025) shows how the Epistemologies of the South can guide a reinvention of rural education in the Amazon, in dialogue with ancestral knowledge and with the experiences of historically subalternized peoples. For the author, curricula that ignore this knowledge reproduce colonial hierarchies; on the contrary, when traditional knowledge is recognized as legitimate, paths are opened for intercultural and democratic pedagogical practices (Souza; Oak; Mendes, 2021; Schott; Steinmueller, 2023; Araújo, 2025).

From this perspective, the Amazon ceases to be just an "object" of research and becomes an epistemic subject: a space for the production of theories, concepts, and categories capable of tensioning the scientific canon. The idea of the Amazon as an ecosystem of knowledge implies: a) recognizing the epistemic authority of indigenous peoples and traditional communities (Nakashima; *et al.*, 2020; McGrew; *et al.*, 2023); b) to practice an intercultural translation between scientific and traditional languages, without subordination (Brondízio; Moran, 2012; Chaves, 2018; Matos; Barroso Tenazor; Lopes, 2022); and c) to build research agendas and public policies anchored in cognitive justice, that is, in the right of different peoples to produce, validate and transmit their own knowledge (Bentes-Gama, 2012; Brondízio; *et al.*, 2016; Battiste, 2019).

Finally, the Amazon needs to be understood as an ecosystem of knowledge. Recent literature shows that the Amazon should be understood, simultaneously, as:

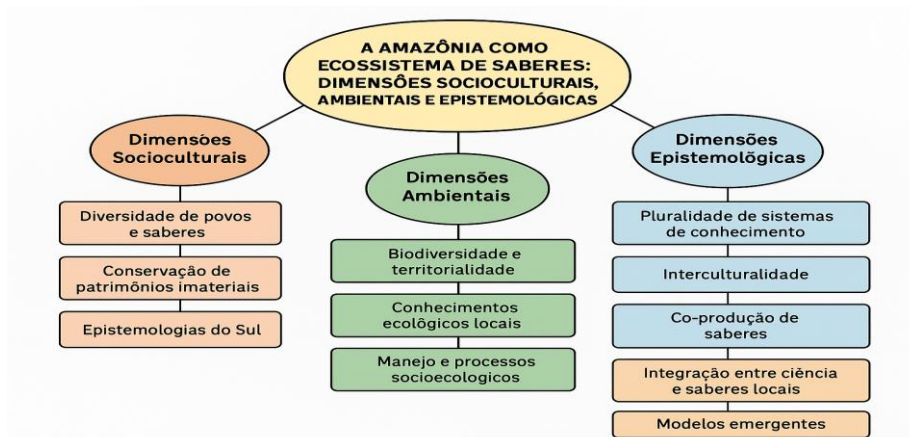
- Socio-environmental ecosystem in which biodiversity and sociodiversity are intertwined, and where TEK guides management and conservation practices (Hanazaki *et al.*, 2018; Galvão; *et al.*, 2024).
- A complex sociocultural space marked by trajectories of resistance, specific territorialities, and its own forms of education, work, and governance (Fernandes; Moser, 2021; Padovani, 2022; Alves; *et al.*, 2022).
- A field of political-legal disputes in which the rights of peoples and communities, intellectual property regimes, and bioeconomy strategies are confronted, often marked by asymmetries and risks of bioepistemicide (Matheus, 2019; Sell; Gregori, 2018; Gebara; *et al.*, 2023).
- A privileged place for epistemological reflection – which dialogues with the Epistemologies of the South and with the notion of ecology of knowledges, challenging the exclusive centrality of Western scientific knowledge (Santos, 2014; Araújo, 2025; Casino; *et al.*, 2025).

This understanding broadens the horizon of environmental management, public policies, and scientific research itself, by shifting the Amazon from the place of a "resource frontier" to that of an ecosystem of knowledge, in which different rationalities and ontologies cohabit and dispute meanings of development, sustainability, and justice (Padovani, 2022; Gebara; Ramcilovic-Suominen; Schmidlehner, 2023; Galvão; *et al.*, 2024)element.

Contextualizing the theoretical discussion about the Amazon as an ecosystem of knowledge, it is assumed that the Amazonian context constitutes a *multilayered* space in which different knowledge systems are articulated in a dynamic, relational and historically constructed way (Porto-Gonçalves; 2006; Noble; Borma, 2009; Casino; *et al.*, 2025). Figure 1 presents a synthesis of these interactions, organizing them into three major dimensions, sociocultural, environmental and epistemological that, although analytically highlighted, operate in an integrated and synergistic way in the territory.

Figure 1

The Amazon as an ecosystem of knowledge: sociocultural, environmental and epistemological dimensions



Source: prepared by the authors, 2025.

Figure 1 systematizes an expanded view of the Amazon as an ecosystem of synergistic knowledge, in line with the conception of Santos (2018), for whom "all knowledge is situated, contextual and relational" (Santos, 2018, p. 47). Thus, understanding the region requires recognizing that its knowledge emerges from the continuous interaction between peoples, environments and sociocultural practices in a web of networks, cooperation, interactions and transfers of multiple knowledge (knowledge) relevant to society and organizations.

The first dimension highlighted refers to the sociocultural diversity of the Amazon, marked by the presence of indigenous peoples, riverside communities, quilombolas, and traditional populations that produce and preserve their own knowledge. Figure 1 highlights elements such as the diversity of peoples and knowledge, the conservation of intangible heritage, and the epistemologies of the South. These epistemologies, according to Santos

(2019), "affirm the legitimacy of historically subordinated knowledge" (Santos, 2019, p. 112), as opposed to the monoculture of scientific knowledge.

The second dimension refers to the role of Amazonian ecosystems as a basis for the production of local knowledge. Figure 1 presents elements such as biodiversity and territoriality, local ecological knowledge and socio-ecological management practices. Berkes (2015) calls this knowledge *traditional ecological knowledge*, defined as "bodies of adaptive knowledge derived from experience and transmitted culturally" (Berkes, 2015, p. 27).

The third dimension encompasses the plurality of knowledge systems present in the Amazon and the processes of intercultural dialogue that emerge from this encounter. Figure 1 highlights elements such as epistemological plurality, interculturality, co-production of knowledge, and integration between science and local knowledge.

Not to conclude, the articulation of the three dimensions reveals a web of knowledge networks in the Amazon as an ecosystem of deeply interconnected and interrelated knowledge. This view confirms the argument of Porto-Gonçalves (2017), who considers the region "a territory of epistemic insurgency and the invention of new possible futures" (Porto-Gonçalves, 2017, p. 203). Thus, any public policy, academic research, or KM initiative in the Amazon must recognize the inseparability between culture, environment, and epistemology.

2.4 INTEGRATION BETWEEN TRADITIONAL KNOWLEDGE, DIGITAL INNOVATION AND GC: MODELS, TENSIONS AND POTENTIALITIES

Traditional and indigenous knowledge have been understood as complex systems of production, circulation and use of knowledge, deeply rooted in specific territorial, cosmological and socio-political contexts (Becker, 2005; Assad, 2022; Coast; Almeida, 2023). The literature emphasizes that such knowledge cannot be reduced to a set of "local information", but constitutes "ways of knowing, doing and existing", articulating their own practices, values, narratives and technologies (Cunha, 2007, p. 25).

In this sense, researchers in Information Science and related areas have been advocating a broader reading of the concept of traditional knowledge, which encompasses knowledge about land management, biodiversity, medicinal plants, agroforestry systems, healing practices, and forms of social organization, often transmitted by orality and performance (Pereira; Espírito Santo, 2020; Foster; Zaninelli, 2025). As one of these studies summarizes, traditional knowledge "brings with it a broader element than the notion of

continuity", as it articulates collective memories, identity bonds and strategies of sociocultural reproduction in the long term (Pereira; Espírito Santo, 2020, p. 89.).

In the Amazonian context, documents from universities and scientific institutions emphasize that "traditional knowledge is inspiration for the decisions we need to make and to them are added the science we need to produce", pointing to the region as a strategic space for dialogue between local epistemologies and modern science (UFPA, 2023, p. 121). This perspective reinforces the Amazon as a privileged territory for experimenting with models of integration between scientific knowledge, indigenous knowledge and sustainable development policies (Porto-Gonçalves; 2006; Saints; Meneses, 2019; Pine; Araújo, 2023).

At the same time, critical authors warn of the risks of homogenization and "flattening" of internal differences when one speaks generically of "traditional knowledge", without considering the diversity of peoples, histories and cosmologies involved. Foster; Zanelli (2024), show that the tendency to treat indigenous knowledge as a single block, directly comparable to Western scientific knowledge, constitutes "a way to better homogenize it" and make its epistemological incommensurability invisible (Fonseca; Zaninelli, 2024, p. 29).

KM has emerged, in recent decades, as an interdisciplinary field that seeks to understand and structure processes of creation, organization, sharing and use of knowledge in different types of organizations, according to Correa, *et al.*, (2023) and Ziviani, *et al.*, (2025a). In a classic work, Davenport; Prusak (1998) defines knowledge as a fluid mixture of experience, values, contextualized information, and intuition, which provides a framework for evaluating and incorporating new experiences. For the authors, "Knowledge is a fluid mixture of interpreted experience, values, contextual information, and expert insight (Davenport; Prusak, 1998, p. 5), which implies recognizing the human, relational and situated dimension of knowledge.

In the debate on innovation, Nonaka; Takeuchi (1997) highlight the SECI dynamics (socialization, externalization, combination and internalization) as the engine of organizational knowledge creation, articulating tacit and explicit dimensions. The authors' perspective is relevant to thinking about the integration between traditional knowledge and digital innovation, as it emphasizes the procedural, collective, and historical character of knowledge production, central elements in indigenous and community contexts according to studies by Machado (2020).

In Brazil, KM has been appropriated and redefined by authors who situate it in public, academic and territorial contexts. Valentim (2010, 2008) argues that information

management and KM should occur in an articulated way, in order to promote behaviors of searching, sharing and using information aligned with the organizational culture. For the author, "information management in the organizational context occurs in a specific way and depends on the way knowledge is being managed" (Valentim, 2010, p. 42).

Batista (2023) reinforces this view by proposing a "simplified" KM, centered on accessible languages and practical tools for public administration, without losing sight of the complexity of organizational learning processes (Batista, 2023; Correa, *et al.*, 2023; Ziviani; *et al.*, 2025b). These contributions are important to contextualize, in Brazilian terms, the discussion on KM as a conceptual and operational infrastructure to integrate traditional knowledge, digital technologies and innovation policies (Cardoso; Pimenta, 2019; Belinski; Martins, 2020; Mark; Rodrigues, 2023)

More specifically, Fonseca; Santos (2023), when discussing "KM and traditional knowledge: an innovation proposal for indigenous organizations", propose the Collaborative Creativity Centers (NCC) as a KM model oriented to the valorization of indigenous knowledge. According to the authors, the NCC seek to foster a culture of innovation based on "the knowledge derived from the traditional knowledge of these peoples", articulating informational flows, KM practices and organizational innovation in companies and collectives linked to indigenous communities (Fonseca; Santos, 2023, p. 11.).

The expansion of digital technologies has profoundly reconfigured the ways of recording, storing, communicating, and appropriating traditional knowledge (Fleury; Lobato; Dantas, 2019; Costa, 2022; Oak; Saucer; Ribeiro, 2023). Steeves (2015) shows that, in various Indigenous contexts, digital technologies such as video, audio, photoFigurey, and online platforms have been appropriate to record, preserve, and share aspects of culture and knowledge with other Indigenous groups, the world, and future generations, while producing new challenges to cultural identity. In this sense, the author, "some digital technologies are helping Aboriginal groups record and share their traditional knowledge with other Aboriginal groups, the wider world, and future generations" (Steeves, 2015, p. 13).

Recent studies on "*indigenous knowledge management*" emphasize the role of technologies such as databases, RFID, GIS, 3D scanners, smartphones, and digital repositories to support the documentation, organization, and circulation of local knowledge, especially in the post-pandemic period (Matheus, 2019; Ajani, 2023). These works point out that digital innovation is not limited to the digitization of content, but involves the design of

socio-technical infrastructures sensitive to the community logics of ownership, access and use of knowledge (Pereira; Angeloni, 2020; Martin; Birth, 2021; Pine; Araújo, 2023).

From the point of view of sustainability, Anti (2025) discusses the challenges of preserving traditional knowledge in the digital age, highlighting that modernization and globalization have interrupted the intergenerational transmission of knowledge, putting its continuity at risk. The study emphasizes that "Accelerated modernization and globalization have disrupted the intergenerational transmission of this knowledge, putting it at risk of disappearing.", and that digital strategies need to be accompanied by robust ethical guidelines (Anti, 2025, p. 18).

In the same direction, Bellini; Raglianti (2025) analyze tensions and opportunities at the intersection between indigenous knowledge and digital technologies, showing that the introduction of platforms and information systems can both empower communities and reinforce power asymmetries and technological dependence if they are not co-designed with indigenous peoples themselves (Carvalho; Saucer; Ribeiro, 2021; Pine; Araújo, 2023). Studies focused on the Sustainable Development Goals also highlight that aligning traditional knowledge and digital technologies is strategic for goals such as climate action, biodiversity protection and quality education (Arvanitidis *et al.*, 2024; Fonseca, 2025).

In the Amazonian context, reports and case studies show experiences in which blockchain, big data, Internet of Things (IoT), and artificial intelligence have been used to support socio-bioeconomy chains, ensure traceability of forest products, monitor deforestation, and strengthen business models based on traditional knowledge (Santos; Costa, 2021; NESsT, 2025). These initiatives reinforce the potential of digital innovation as a mediator between local knowledge, global markets, and public policies for sustainable development (Souza; Gomes, 2019; Silva; Barreto, 2020; Saints; *et al.*, 2023)

Recent literature has advanced in the formulation of conceptual models of indigenous KM (GCI) and integration between traditional knowledge and contemporary KM approaches. Foster; Zaninelli (2024), carry out a review of international models of GCI, identifying different structures, varying according to geoFigureic location, community, and objectives of each initiative. The authors conclude that "the identified Indigenous KM models have different characteristics, structures, and approaches, according to the location, the community, and the proposed objectives", and point to the absence of models developed in Brazil as a research gap (Fonseca; Zaninelli, 2024, p. 19).

In a subsequent study, Fonseca; Zaninelli (2025) analyze African models of indigenous KM and show how ethno-knowledge systems articulate spiritual, environmental, and community dimensions in their own structures of classification and transmission, distinct from Western information systems. The study concludes that the integration between these systems and contemporary approaches requires recognizing "distinctive characteristics, sociocultural contexts and practical applications" of indigenous models, avoiding their mere translation into Eurocentric categories (Fonseca; Zaninelli, 2025, p13.).

In the Brazilian context, Fonseca; Santos (2023) proposes the aforementioned Collaborative Creativity Centers (NCC) as a KM model aimed at indigenous organizations, based on Choo's (2003) hypertext organization model. The NCC articulate three axes, namely, KM, innovation and traditional knowledge, and position indigenous knowledge as a central asset in the organizational innovation process (Fonseca; Santos, 2023).

The integration between traditional knowledge, digital innovation and KM is not without conflicts. The literature highlights different orders of tension: epistemological, political, legal, technological and institutional (Santos; Meneses, 2019; Freire; Lima, 2020; French; Oliveira, 2020). From the epistemological point of view, authors such as Cunha (2007) and Machado; Carvalho (2019), point out that traditional systems of classification and organization of information, based on Western logics, tend to exclude or distort indigenous knowledge.

On the technological level, there is a risk that digitization processes will reinforce "data colonialism", appropriating traditional knowledge without guaranteeing mechanisms of consent, community control and benefit sharing. Studies on indigenous databases and digital repositories insist on the need for governance models in which communities define the levels of access, use, and circulation of content, as well as criteria for contextualization and protection of sensitive knowledge (Steeves, 2015; Ajani, 2023).

Tensions related to intellectual property and traditional knowledge protection regimes are also at stake. Research on Amazonian socio-bioeconomy chains and on the use of traditional knowledge in technological innovation processes point to the importance of intellectual property policies that do not individualize collective knowledge, nor encourage its commodification without safeguards of cognitive justice and fair sharing of benefits (NESsT, 2025).

In the institutional dimension, authors who analyze KM in the public sector show that cultural factors such as resistance to change, power relations and forms of communication – constitute important obstacles to the implementation of collaborative KM practices (Batista;

Quandt, 2015; Silva; Barreto, 2020). Such challenges tend to intensify when it comes to incorporating traditional knowledge into institutions historically structured from Eurocentric epistemologies, such as universities, development agencies, and environmental agencies.

Finally, there are tensions within the communities themselves, related to generational, gender, and authority disputes over who can speak, record, and share certain knowledge, which requires KM and digital innovation models to be co-constructed in a way that is sensitive to local dynamics (Fonseca; Zaninelli, 2025).

Despite the tensions, the literature points to a wide range of potentialities in the integration between traditional knowledge, digital innovation and KM. Studies on the Amazonian socio-bioeconomy show that the articulation between traditional knowledge and emerging technologies has contributed to strengthening sustainable production chains, ensuring traceability of forest products, expanding access to markets, and fostering business models rooted in indigenous and community territories (NESsT, 2025)

On the scientific and technological level, initiatives coordinated by institutions such as RNP, universities and ST&I bodies have emphasized the construction of digital biodiversity management platforms that combine scientific data with traditional knowledge, providing for specific KM components and the development of open digital solutions (RNP, 2025; MCTI, 2025).

International authors highlight that aligning traditional knowledge and digital technologies contributes directly to several Sustainable Development Goals, especially those related to climate action, the protection of life on land, and the promotion of inclusive education (Arvanitidis; *et al.*, 2024). At the same time, workshops, networks, and international programs have been discussing models of research governance and rematriation of indigenous knowledge that use artificial intelligence and digital platforms to strengthen the rights, languages, and knowledge systems of indigenous peoples.

In the field of KM, these movements point to the need for more relational and ecosystemic models, which go beyond the view of knowledge as an exclusively organizational resource and recognize the existence of "knowledge ecosystems" marked by interdependencies between communities, scientific institutions, companies, technologies, and territories (Fonseca; Santos, 2023; Bellini; Raglianti, 2025).

Table 2

Theoretical synthesis: integration between traditional knowledge, digital innovation and KM

Dimension	Core elements	Main authors	Essential contributions
Traditional knowledge	Indigenous epistemologies; Territoriality; oral transmission; sociocultural complexity	Cunha (2007); Pear tree; Espírito Santo (2020); Foster; Zaninelli (2025); Smith (2012)	Smith (2012) demonstrates that indigenous epistemologies are often framed in inappropriate Western categories, generating invisibilizations. Cunha (2007) points out that traditional knowledge constitutes complex systems rooted in their own cosmologies.
GC	Processes of creation, organization, socialization and application of knowledge; tacit and explicit dimensions	Davenport; Prusak (1998); Nonaka; Takeuchi (1997); Valentim (2008, 2010); Baptist (2023)	Davenport and Prusak (1998) define knowledge as a fluid mixture of experience and contextualized information. Nonaka; Takeuchi (1997) propose the SECI model, integrating tacit and explicit dimensions in the creation of knowledge.
Digital innovation	Digitization of collections; data governance; platforms, AI, blockchain, GIS	Steeves (2015); Ajani (2023); Bawack (2025); Arvanitidis <i>et al.</i> (2024)	Steeves (2015) shows that digital technologies allow the recording and transmission of indigenous knowledge, while Bawack (2025) warns of the risks of data colonialism without community governance.
Integration Models	Indigenous GC (GCI); Collaborative Creativity Centers; Knowledge ecosystems	Foster; Santos (2023); Foster; Zaninelli (2024, 2025); Bellini; Raglianti (2025)	Fonseca and Santos (2023) propose the NCC, articulating KM, innovation, and traditional knowledge. Foster; Zaninelli (2024, 2025) evidence international diversity of GCI models.
Tensions and dilemmas	Epistemological colonialism; data governance; PI; Western frameworks; Institutional challenges	Smith (2012); Ajani (2023); Bawack (2025); Teixeira (2020); Santos <i>et al.</i> (2024)	Smith (2012) discusses colonial methodologies that distort indigenous knowledge. Teixeira (2020) highlights cultural barriers in public KM. Santos <i>et al.</i> (2024) show tensions in the appropriation of traditional knowledge (Baniwa peppers).
Potential	Sustainable innovation; socio-bioeconomy; digital ecosystems; informational sovereignty	NESsT (2025); Bioeconomy of Restoration (2024); RNP (2025); MCTI (2025)	NESsT (2025) shows how technologies can strengthen production chains based on traditional knowledge. RNP (2025) shows digital integrations between science and indigenous knowledge.

Source: survey data, 2025.

Table 2 shows that the integration between traditional knowledge, digital innovation, and KM requires the recognition of the complexity and epistemic autonomy of indigenous peoples. Cunha (2007) and Pereira; Espírito Santo (2020) show that traditional knowledge constitutes territorial and pluriepistemic systems, while Smith (2012) warns that Western categories tend to distort these epistemologies.

In GC, authors such as Davenport; Prusak (1998), Nonaka; Takeuchi (1997) and Valentim (2008; 2010) demonstrate that knowledge is relational and depends on structured processes of creation and circulation, favoring its articulation with indigenous epistemologies. In the digital field, Steeves (2015), Ajani (2023) and Bawack (2025) highlight that technologies can support cultural preservation, but also generate risks of data colonialism. Models such as the Collaborative Creativity Centers (Fonseca; Santos, 2023) and the studies on indigenous GC of Fonseca; Zaninelli (2024; 2025) show paths for sociotechnical integrations.

Finally, studies such as Santos *et al.* (2024) show ethical tensions and misappropriation. On the other hand, initiatives such as NESsT (2025), Bioeconomy of Restoration (2024) and RNP (2025) show that this integration has strong potential for sustainable innovation and the strengthening of Amazonian ecosystems.

Not to conclude, the theoretical review indicates that:

- traditional knowledge constitutes complex knowledge systems, which challenge Western models of information and KM;
- KM, by articulating processes of creation, organization and sharing, offers a fertile conceptual basis to model the integration between different epistemologies;
- digital innovation introduces opportunities and risks, requiring socio-technical infrastructures co-governed by indigenous communities and partner institutions;
- the emerging models of ICM and knowledge ecosystems point to ways to integrate traditional knowledge, digital technologies, and sustainable development policies, as long as they are attentive to the ethical, political, and epistemological tensions involved.

3 METHODOLOGY

The present research is characterized as a qualitative, exploratory and descriptive study, aimed at understanding KM in the preservation, systematization and valorization of traditional knowledge of the Amazon, promoting innovation with a focus on sustainable development. According to Gil (2019), the exploratory study aims to provide greater familiarity with the problem, making it more explicit or building hypotheses based on a set of preliminary observations.

The choice for a qualitative approach is justified by the interest in dialoguing with different interfaces of the regional context, with traditional knowledge, science, technology, innovation, public policies and sustainability. The qualitative approach allows the investigation

of complex phenomena, capturing meanings, perceptions and social practices in depth (Gil, 2008; Minayo, 2017).

A descriptive study is a type of research whose main objective is to describe characteristics, phenomena or relationships observable in a given context, without necessarily establishing cause and effect relationships or testing hypotheses. It seeks to organize, systematize and analyze data in detail, providing an in-depth overview of the object of study (Gil, 2008; Santos, 2014).

The study is based on interdisciplinary theoretical contributions from Information Science, Administration, Education, Sociology, Technology, Education, Production Engineering and anchored in the KM literature, which offer conceptual tools to analyze the processes of production, organization, sharing and use of knowledge in the academic sphere.

Information Science, according to Borko (1968) and Le Coadic (2004), is concerned with the informational cycle and the role of information and knowledge as strategic resources for decision-making and innovation. KM, on the other hand, according to Nonaka and Takeuchi (1997), involves processes of creation and dissemination of knowledge in organizations, favoring collective learning and continuous innovation.

The methodological approach was structured in five complementary axes: a) integrated literature review; b) survey of empirical data with KM researchers in the Amazonian context; c) documentary and institutional analysis of government agencies and social institutions; d) analysis of the activities of research groups in KM in the Amazonian context; and e) collection of secondary data from institutional websites of different actors that discuss KM in the Amazon. Each axis contributes to understanding different dimensions of KM in the regional context.

In the first phase, an Integrated Literature Review was carried out with the objective of mapping the scientific production on KM in the Amazon, identifying trends, research gaps, authors and institutions most active in the theme. National and international databases were consulted: Scielo, Web of Science, Scopus, Spell and Google Scholar.

The selection criteria included: i) Publications between 2000 and 2025; b) Language: Portuguese or English; and c) Content related to KM, integration of traditional knowledge and technological innovation. It should be inferred that this first phase of the research did not consider the methodological aspects and scientific rigor required for a Systematic Review of the Literature. Therefore, the studies highlighted in the research results were selected for the

convenience of researchers based on the scientific production of Brazilian research groups that deal with KM themes in the Amazon context.

The review aimed to map authors, concepts, theoretical approaches and research gaps, as advised by Tranfield, Denyer; Smart (2003) in conducting systematic reviews. The descriptors used included: GC, Amazon, traditional knowledge, sustainable innovation, public policies, and regional development. The data were analyzed through metrics such as annual volume of publications, frequency of keywords, enabling the identification of the main concepts and approaches (Bornmann; Daniel, 2008). Finally, the information was organized in Figures, tables and figures, being discussed and analyzed based on the discussions and foundations described in the theoretical framework.

The survey of empirical data with the purpose of understanding KM practices in the Amazon was carried out with data collection through semi-structured interviews with KM researchers in the Amazonian context. Two semi-structured interviews were conducted, as it allows flexibility and depth in the answers, as recommended by Triviños (2015). The interviews were conducted online (via Teams), lasting 60 minutes each, through a Free and Informed Consent Form (ICF). The participants were informed about the objectives of the research and consented to the recording and use of data, following ethical standards (BRASIL, 2016).

The data collection instrument was elaborated from the theoretical foundation discussed in the previous chapter, addressing the trajectory of scientific research in KM in the Amazon, understanding of research projects developed or in progress, scientific production in KM, training of human resources and understanding of themes such as knowledge of native peoples and the understanding of the role of KM in the context of economic development, technological and social aspects of the Amazon. Topics such as community participation, preservation of knowledge, technological innovation and territorial governance were addressed, allowing for deepening according to the answers (Gil, 2008).

The selection of the interviewed researchers was intentional and non-probabilistic, selected based on the following criteria: a) Work in graduate programs recognized by CAPES; b) Participation in projects or research groups with a KM focus in the Amazonian context; and c) Recent scientific production on KM in the Amazon. Table 3 presents the profile of the researchers interviewed. The data were recorded, transcribed and organized into thematic categories.

Table 3

Profile of the Interviewed Researchers

Interviewed	University	Training	Research Group	Years as a researcher
BETWEEN 1	UFAM UFPA	PhD in Information Science. Bachelor of Library Science	GICA	15
BETWEEN 2	UFAM	PhD in Communication and Semiotics. Degree in Library Science.	GICA	33

Source: survey data, 2025.

The transcripts of the interviews resulted in a volume of approximately 30 (thirty) pages of qualitative text. Only part of this volume of data was used in this study. Therefore, a vast and rich material in the development of scientific research in KM in the Amazon is still available for other analyses. A relevant strategy for future studies may be to use qualitative data analysis software NVIVO, MAXDATA or ATLAS TI.

In the analysis of government reports, institutional guidelines and official documents, technical and institutional documents dealing with Amazonian development and policies related to KM and the protection of traditional knowledge were examined. The analysis included:

- reports from federal and state agencies linked to territorial, socio-environmental management and regional development of the Amazon;
- public policies for science, technology and innovation, with a focus on guidelines for open data, protection of traditional knowledge and encouragement of sustainable innovation;
- regulations and regulatory frameworks aimed at safeguarding traditional knowledge, including guidelines related to the rights of indigenous peoples and traditional communities;
- institutional documents from BNDES, MCTI, CNPq, IBAMA and indigenous organizations, which offer strategic guidelines, development programs and ongoing projects in the region.

This documentary analysis allowed us to identify guidelines, institutional actors, regulatory weaknesses, and structural gaps that affect the implementation of KM practices in the Amazon, especially with regard to interinstitutional collaboration, data governance, and social participation.

The research also involved mapping the trajectory of groups registered in the Directory of Research Groups of Brazil (DGP/CNPq) that develop studies on the Amazon, traditional knowledge, sustainable innovation and KM. The following elements were analyzed: a) lines of research and their thematic evolution; b) scientific production (articles, theses, dissertations, books and technical reports); c) collaboration networks between researchers, institutions, traditional communities and government organizations; and d) scientific and community partnerships aimed at the collective construction of knowledge and innovation in the Amazonian context.

The findings were integrated into the results of the literature review, making it possible to identify emerging trends, conceptual centralities, research gaps, and potential interdisciplinary convergences.

The qualitative data from the interviews, institutional documents and bibliographic reviews were submitted to thematic content analysis, according to the procedures of Bardin (2016). This technique allowed the organization and interpretation of the textual corpus in analytical axes, such as: a) integration of knowledge (traditional and scientific); b) sociopolitical challenges of KM in the Amazon; c) governance of local information and knowledge; d) sustainable innovation and social technologies; and e) inclusion of indigenous peoples and local communities.

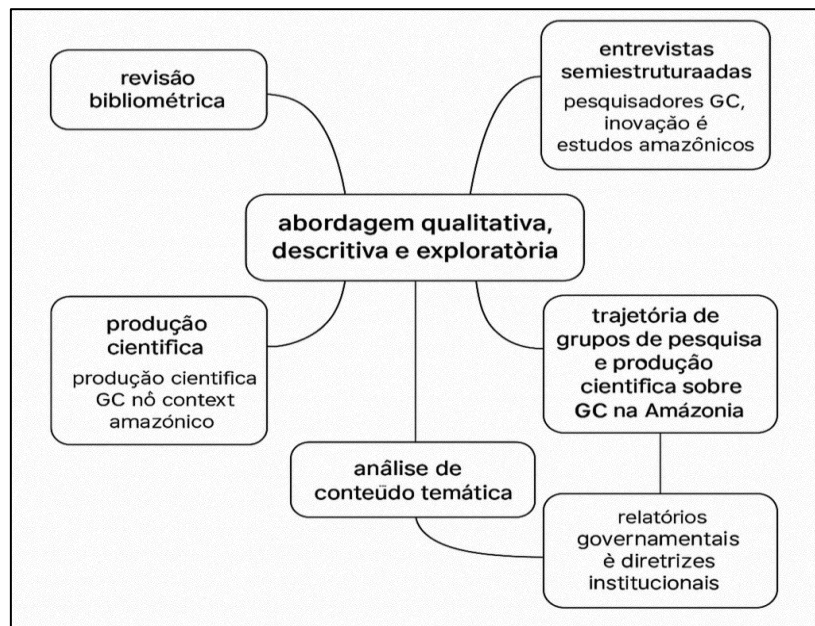
Combining bibliometric methods, document analysis and qualitative interviews, the methodology adopted enabled a comprehensive view of the state of the art of KM in the Amazon. The results made it possible to highlight the need for participatory models, transparent governance mechanisms and integrated policies that value both traditional knowledge and scientific and technological innovations.

As procedures for analyzing the collected data, we opted for data triangulation between bibliometric review, interviews and document analysis, ensuring reliability and robustness in the results (Triviños, 2011). The emerging categories were organized in tables and concept maps, facilitating the visualization of the relationships between actors, KM practices, public policies and promotion of innovation with a focus on sustainable development.

The conceptual map of the methodological path presented in figure 1 was elaborated to visually organize the relationships between the actors (local communities, researchers and government), the KM processes (co-creation, documentation, sharing) and the expected results (sustainable development, environmental preservation and innovation).

Figure 2

Conceptual Map of the Methodological Path



Source: survey data, 2025.

Finally, it should be noted that the research respected the ethical principles defined by Resolution No. 510/2016 of the National Health Council (2016), ensuring the anonymity of the participants and the use of the data exclusively for scientific purposes. All interviewees agreed to the Informed Consent Form (ICF).

The combination of methods such as: bibliometric review, document analysis and qualitative interviews made it possible to build a comprehensive understanding of KM in the Amazonian context. The results showed:

- the need for participatory KM models, which articulate scientific knowledge and traditional knowledge;
- the importance of transparent data governance mechanisms that are sensitive to territorial and identity agendas;
- the urgency of integrated public policies, capable of strengthening collaborative networks, ensuring respect for the rights of indigenous peoples and fostering innovations aligned with sustainable development.

4 PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS

Section 4 presents, analyzes and discusses the results in the light of the central objective of the study, which is to understand how KM can be mobilized to preserve,

systematize and value traditional knowledge in the Amazon and, simultaneously, guide innovation committed to sustainable development. It is based on the assumption, consolidated in the classic literature, that KM constitutes a framework for the creation, sharing and application of knowledge in socio-technical organizations and networks (Davenport; Prusak, 1998; Nonaka; Takeuchi, 2008). However, when shifted to a socio-ecological and epistemically plural territory such as the Amazon, this agenda tends to be tensioned by dimensions that conventional organizational models often deal with in a peripheral way, such as territoriality, historical asymmetries, collective regimes of knowledge ownership, and ethical safeguards against misappropriation (Berkes, 2015; Saints; Meneses, 2010). Thus, in this section, it is argued that the results should not be read only as a description of the state of the art, but as evidence of a field in dispute, in which KM is reconfigured as a socio-territorial practice, simultaneously cognitive, political and institutional. The presentation of the findings is organized on three methodologically complementary fronts: (i) results of the integrated literature review, which outline trends, semantic nuclei, actors and gaps; (ii) qualitative analysis of interviews with reference researchers, which explains convergences and tensions between theory and situated experience; and (iii) documentary analysis of reports, guidelines, and regulatory frameworks, which allows us to observe how policies and institutions condition, enable, or block inclusive knowledge ecosystems. By articulating these layers, it is intended to highlight implications for research and public policies, with an emphasis on participatory models, transparency in information governance, and institutionalization of effectively inclusive dialogue channels (Whittemore; Knafl, 2005; Tranfield; Denyer; Smart, 2003).

4.1 RESULTS OF THE FIRST PHASE OF THE RESEARCH: INTEGRATED LITERATURE REVIEW

The first phase of the research consisted of conducting an Integrated Literature Review (RIL), whose objective was to map the scientific production on KM in the Amazonian context, identifying trends, recurrences and research gaps. This type of review allows you to analyze and synthesize existing knowledge in a broad and flexible way, especially when it comes to complex and multifaceted phenomena. As Whittemore and Knafl (2005) point out, the integrated review is particularly useful when the literature is heterogeneous, as it "allows the combination of theoretical and empirical studies, enabling a more complete understanding of the phenomenon investigated" (Whittemore; Knafl, 2005, p. 547).

To search for the studies, recognized national and international databases such as: SciELO, Web of Science, Scopus, Spell and Google Scholar were consulted, considering publications between 2000 and 2025, in Portuguese or English and related to KM, the integration between traditional and scientific knowledge and technological innovation aimed at Amazonian development.

However, unlike a Systematic Review of the Literature (RSL), this stage did not follow strict protocols, such as PRISMA. RSL is characterized by standardized, reproducible procedures guided by methodological rigor. For Tranfield, Denyer and Smart (2003), the systematic review works as a structured investigation process, as it "follows a robust, transparent and replicable method to identify, evaluate and synthesize existing evidence" (Tranfield; Denyer; Smart, 2003, p. 209). Thus, the absence of these protocols implies that the results obtained here are exploratory, not exhaustive within the methodological parameters.

In this study, the integrated approach was intentionally chosen, due to the particularities of the theme. As Botelho, Cunha and Macedo (2011) point out, the integrated review "enables the inclusion of different methodologies, expanding the analytical scope and favoring critical and reflective syntheses" (Botelho; Wedge; Macedo, 2011, p. 126).

Thus, it should be inferred that the selection of studies was not intended to be exhaustive or replicable, typical characteristics of the RSL, but was guided by convenience and thematic relevance, considering the production of Brazilian research groups that stand out in discussions on KM in the Amazon, traditional knowledge, innovation and public policies in the Amazonian context. As Cooper (1988) points out, integrative reviews are appropriate when the objective is to "synthesize existing knowledge, identify patterns and propose new directions of research", especially in developing fields.

The adoption of this approach proved to be pertinent to the purpose of this exploratory phase, allowing to map the state of the art, organize relevant contributions, and subsidize subsequent more in-depth analyses, including epistemological, bibliometric, and political discussions related to KM in the Amazonian context.

The results are organized into seven sections: (i) temporal evolution, (ii) frequency of themes and keywords, (iii) co-authorship networks and clusters, (iv) outstanding authors and institutions, (v) thematic synthesis, (vi) gaps, and (vii) implications for public policies and future research.

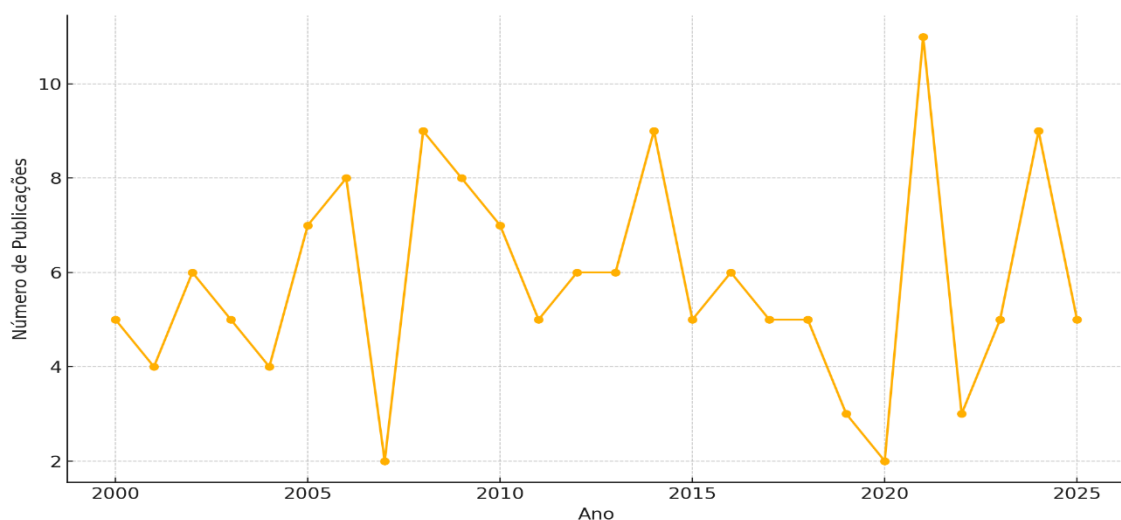
4.1.1 Overview of Scientific Production (2000–2025)

The search carried out in the SciELO, Web of Science, Scopus, Spell and Google Scholar databases initially resulted in 1,147 studies related to the established descriptors. After applying the inclusion criteria (period 2000–2025; Portuguese/English languages; thematic adherence to KM, traditional knowledge, sustainable innovation, or the Amazon), 178 articles were selected for full reading and 92 articles for detailed analysis.

The breadth of the time frame allowed us to observe the gradual consolidation of the theme, especially from 2010 onwards, when interest in sustainable innovation, public ST&I policies and integration between traditional and scientific knowledge grew.

Figure 3

Temporal distribution of publications on KM in the Amazon (2000–2025)



Source: survey data, 2025.

The literature analyzed reveals a significant increase in studies after 2010, coinciding with the expansion of government agendas aimed at promoting innovation, science and technology in the Amazon. From 2015 onwards, there has been a greater density of studies on bioeconomy, governance of common goods, intercultural education, digital documentation systems, and management of traditional knowledge.

Silva and Gomes (2021) emphasize that "understanding the Amazon as a complex system requires KM approaches capable of integrating plural and technological epistemologies". Likewise, Santos (2010) argues that the ecology of knowledges is fundamental to address historical epistemic inequalities between scientific knowledge and traditional knowledge.

Figure 1 shows important oscillations, with production peaks in 2008, 2014, 2021, and 2024, suggesting key moments in which themes related to the Amazon, GC, bioeconomy, and traditional knowledge gained prominence in public and scientific agendas.

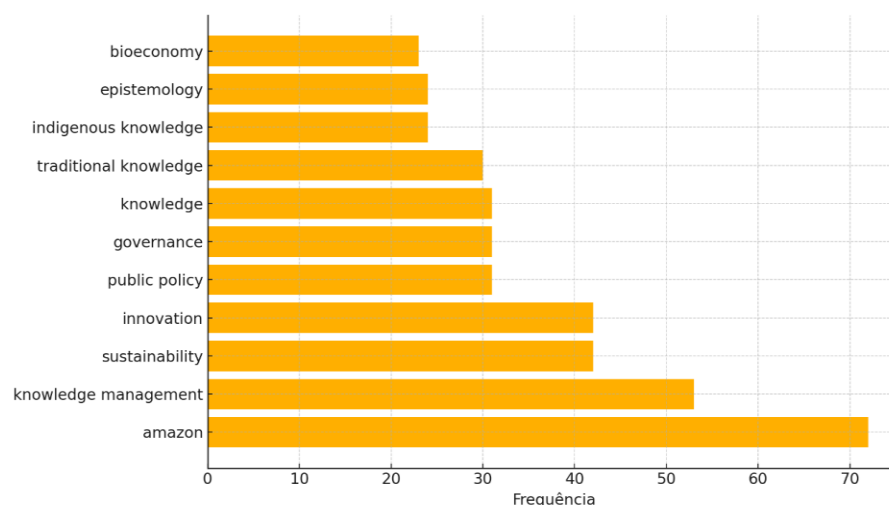
Main possible interpretations:

- The increase after 2015 coincides with the advancement of the discussion on PPCDAm, territorial governance and international agendas (SDGs).
- The jump in 2021–2024 may be associated with the rise of the Amazon bioeconomy, digitalization, and research on traditional knowledge.
- The occasional drops indicate periods of lower public funding or national thematic reorientation.

Figure 4 of keyword frequency reveals that the dominant terms are: Amazon, knowledge management, Sustainability and innovation. The central themes that articulate KM and sustainable development. Emerging terms linked to the identity agenda include: traditional knowledge, indigenous knowledge and epistemology. By analyzing the key words, a growing appreciation of Amazonian epistemologies and local knowledge can be perceived. Finally, a political-institutional axis is contacted, such as: public policy, governance. It shows that part of the literature analyzes KM as an instrument of territorial management and public policies.

Figure 4

Keyword Frequency



Source: survey data, 2025.

The analysis of keyword frequency reveals five central semantic cores: a) GC (*Knowledge Management*); b) Traditional Knowledge / Indigenous Knowledge; c) Innovation and Digital Transformation; d) Bioeconomy and Sociobiodiversity; and e) Regional Development / Territorial Governance.

This set suggests a field guided by hybrid approaches, which articulate organizational knowledge (Sveiby, 1998; Nonaka; Takeuchi, 2008;), epistemologies of the South (Santos, 2011, 2014) and socio-ecological systems (Brondízio *et al.*, 2016).

Table 4

Institutions with the highest production related to KM in the Amazon (2000–2025)

Institution	Predominant themes	Evidence from the literature
UFPA	Territorial information systems, socio-biodiversity	Lima (2018), Farias (2017)
INPA	Ethnoknowledge, biodiversity, documentation	Menezes (2020)
UFAM	S,T policies; I, digital governance	Braga (2022)
UFOPA	Traditional and riverine communities	Santos (2019)
FIOCRUZ Amazon	Traditional knowledge in health	Rocha (2019)

Source: survey data, 2025.

The predominance of Amazonian institutions (UFPA, INPA, UFAM, UFOPA) confirms the thesis of Barbalho *et al.* (2023) that the production of traditional knowledge and KM must emerge from the territory, avoiding decontextualized readings of hegemonic centers of the Global South or South-Southeast axis

Authors such as Farias (2017), Lima (2018) and Menezes (2020) reinforce the role of sociobiodiversity and traditional ecological knowledge in territorial governance. These productions respond to Berkes' (2015) warning about the urgency of integrating scientific knowledge and local knowledge for resilient adaptive systems.

The growing presence of research on innovation and social technologies (D'Ávila; Moreira, 2020 and Braga, 2022;) shows the region's alignment with global Industry 4.0 trends, but with an Amazonian reading — inclusive, communitarian and relational (Stradioto; Frazzon, 2023).

The interpretative analysis allowed us to identify five structuring thematic trends in the literature, presented in Table 5.

Table 5

Thematic trends identified in the literature on KM in the Amazon

Tendency	Description	Author contributions
Integration of knowledge	Articulation between scientific and traditional knowledge	Santos (2010), Rocha (2019)
Technological innovation	Digital platforms, GIS, databases	Braga (2022)
Territorial governance	Public policies, planning and management	Acselrad (2015)
Sociobiodiversity	Sustainable production chains	Lima (2018)
Education and broadcasting	Youth training and intergenerational practices	Menezes (2020)

Source: survey data, 2025.

The theme of integration of knowledge in literature highlights the centrality of indigenous, quilombola, and riverine epistemologies (Almeida, 2014; Battiste, 2019; Santos; Meneses, 2019). On the other hand, the "ecology of knowledges" of Santos (2010) is the main theoretical lens highlighted here. In Santos' view, (2011, p.13), "There is no cognitive justice without the recognition of multiple ways of knowing."

This perspective dialogues with Toledo's ethnoecology; Barrera-Bassols (2009) and with Agrawal's (2002) critique of the fragmentation between indigenous knowledge and Western knowledge.

Regarding technological innovation, Ferreira; Mendes (2019), Braga (2022) and Schott; Steinmuller (2023) articulates with Bellini's vision; Raglianti (2025) on digital knowledge ecosystems, in which digitalization does not replace, but enriches traditional systems.

The emergence of documentation and digital preservation platforms (Steeves, 2015; McGrew *et al.*, 2023; NESsT, 2025) reinforces opportunities and risks, namely: the opportunities: visibility, registration, legal protection and the risks: misappropriation, digital colonialism, bioepistemicide (Gebara *et al.*, 2023).

The governance of these systems is highlighted by RNP (2025), which defends ethical protocols for sensitive data.

Regarding the territorial governance trend, Acselrad (2015), Cardoso; Pimenta (2019) and Castro, Lima; Zucarelli (2021) argue that KM in the Amazon is inseparable from environmental management, land conflicts, and social participation. This view is reinforced by Brondizio *et al.* (2016), who describe the Amazon as a socio-ecological complex, in which territorial decisions depend on situated knowledge flows.

Amazonian Sociobiodiversity and Bioeconomy, according to Schmitz (2020) and EMBRAPA (2021) needs KM models capable of documenting, tracking, and protecting

knowledge associated with biodiversity. In this sense, Silva's criticism; Oliveira (2020) to biopiracy reinforces the need for KM that respects collective rights, as provided for in the Nagoya Protocol.

Gebara; *et al.* (2023) warn of the risk of bioepistemicide, when production chains ignore traditional knowledge. Thus, KM is not mere "registration", but protection, recognition and fair redistribution of benefits.

Finally, with regard to education and intergenerational transmission Rocha (2019), Loureiro; Almeida (2022) and Menezes (2020) argue that Amazonian knowledge is transmitted through community immersion, orality, and bodily practices. Therefore, KM in the Amazon needs a people-centered approach, not only in databases (Polanyi, 1966; Wenger, 1998).

4.1.2 Shortcomings identified – critical comments

From the integrated literature review, it was possible to identify some theoretical, methodological and contextual gaps. Thus, it can be highlighted as the main critical points evidenced in the literature.

- Absence of Amazonian theoretical models

Confirmed by Fonseca; Zaninelli (2024; 2025), who propose models of indigenous KM.

- Deficit of longitudinal studies.

Barbalho (2021) argues that there are many descriptive analyses and few impact assessments.

- Lack of university-community integration.

Almeida; Szwarcwald (2020) highlights sociopolitical barriers that hinder the inclusion of traditional populations.

- Fragility of ethical digital platforms

Teeves (2015) and McGrew *et al.* (2023) show risks of leakage of sensitive data.

- Little articulation between KM and public policies

Teixeira (2020) and Santos; Costa (2021) reinforce this gap.

These gaps are not only scientific, but structural and linked to the limited historical recognition of Amazonian populations in science and technology policies.

4.2 QUALITATIVE ANALYSIS OF INTERVIEWS WITH KNOWLEDGE MANAGEMENT RESEARCHERS IN THE AMAZONIAN CONTEXT

KM has evolved, in recent decades, from a field guided by organizational models related to business strategy such as those defined by Alavi and Leidner (2001), Davenport and Prusak (1998) and Nonaka; Takeuchi (2008) and for a more diverse field of study, capable of dialoguing with different epistemologies, cultural realities and modes of knowledge production. In the Amazonian context, this transition becomes even more evident, as territorial dynamics, traditional knowledge regimes, sociocultural diversity, and the history of structural inequalities impose unique challenges and possibilities, as highlighted by the researchers interviewed.

The empirical corpus used for this analysis consists of qualitative interviews with Profa. Célia Regina Simonetti Barbalho, a pioneer in KM research in the Amazon, and Profa. Danielly Oliveira Inomata, a researcher at UFAM and UFPA whose contemporary work articulates KM, sustainability and information flows in the Amazonian context.

The analysis was conducted according to the methodology of Content Analysis (Bardin, 2011), with thematic categorization and critical interpretation of the corpus, confronting it with contemporary literature on a) integration of knowledge (traditional and scientific); b) sociopolitical challenges of KM in the Amazon; c) governance of local information and knowledge; d) sustainable innovation and social technologies; e) inclusion of indigenous peoples and local communities; f) trajectory of KM research in the Amazonian context; g) KM research groups in the Amazon; and h) ongoing and future research agenda of KM in the Amazon.

From the interviews and literature, it is possible to outline a robust contemporary agenda on the KM theme in the Amazonian context.

The research agenda on KM in the Amazon has as its starting point studies on indigenous KM and intellectual protection. As highlighted in the studies by Fonseca (2024) who studies the conceptual modeling of indigenous KM and studies by Gebara, et.al., (2023) who deals with analyses on bioepistemicide and the National Observatory of Indigenous Production.

The researcher ENTRE 1 highlights GC research, information flows, and climate change as an agenda. According to the researcher ENTRE 1, research on climate disinformation and organizational resilience in the face of environmental effects in the Amazon is underway.

Castro Studies; Zucarelli, (2021) deal with integrated information governance. Focused on building systems that unite scientific, socio-environmental and traditional data.

On the other hand, Cardoso; Pimenta (2019) discuss KM and bioeconomy/sociobioeconomy when developing studies on sociobiodiversity production chains and social technologies.

Finally, studies such as Correa, *et al.*element. (2023) put KM in public organizations in the Amazon on the research agenda. Contributing to this agenda Cunha; Meirelles, (2022) deal with innovation mechanisms for public policies in the Amazon context.

Summarizing the current and future agenda of KM research in the Amazon, Table 6 presents the foundations for understanding and substantiating the studies.

Table 6

Current and Future Agenda for KM Research in the Amazon

Line of Research	Researchers/Evidence	Scientific developments
Indigenous GC	The researcher ENTRE 2 reports that the formation of a network of researchers is essential to strengthen research in the Amazonian context; It reinforces the need to investigate epistemological models.	Conceptual models (Fonseca, 2024) and intellectual protection.
Climate Misinformation	The researcher ENTRE 1 coordinates studies on information flows.	GC-climate articulation; evidence-based decision-making.
Bioeconomy and social technologies	Research on Baniwa Pepper and sustainable chains.	GC Integration – Territorial Innovation (EMBRAPA, 2023).
Information Governance	Integrated repository projects and Amazonian thesauri.	Knowledge ecosystems (Bellini, 2025).

Source: survey data, 2025.

4.2.1 Integration of Knowledge (Traditional and Scientific)

The integration between traditional and scientific knowledge emerged, in the interviews, as one of the central axes of the resignification of KM in the Amazonian context. The literature also points to this movement as essential to face socio-environmental challenges and build sustainable development alternatives (Berkes, 2015; Escobar, 2016; Leff, 2021)

ENTRE 2 stresses that indigenous knowledge operates through dynamics that completely challenge traditional KM models. In his words: "It deconstructs absolutely all concepts" of KM by observing the relational, ritualistic and cosmological logic that governs indigenous knowledge

This view dialogues with Agrawal (2002), who argues that Western classifications tend to reduce the complexity of traditional knowledge, and with Battiste (2019), who defends epistemological decolonization as a condition for understanding indigenous knowledge systems.

Table 7 below was elaborated considering the qualitative data collected in the interviews and their relationship with the theoretical framework and the authors on which this study is based.

Table 7

Integration of Knowledge (Traditional and Scientific) in the Amazon GC

Dimension	Corpus Evidence	Relationship with Literature
Nature of traditional knowledge	Knowledge transmitted by rites, coexistence, collective practices and spiritual choices; "deconstructs absolutely all the classic concepts" of KM as stated by ENTRE 2.	Berkes (2015) on sacred ecology; Agrawal (2002) on the classification of knowledge; Foster; Zaninelli (2024) on indigenous GC.
Science-tradition co-production	Amazonian GC should incorporate local values and knowledge into organizations, according to reports from ENTRE 1.	Jasanoff (2004) and Cassino; <i>et al.</i> (2025) on co-production of knowledge systems.
Epistemological tensions	Need to abandon rigid Western categories to understand indigenous cosmologies according to ENTRE 2.	Leff (2021) and Escobar (2016) on territorial and decolonial epistemologies.

Source: survey data, 2025.

The interviewed researcher (ENTRE 2) reinforces that "knowledge management in the Amazonian context means incorporating values and knowledge into the organizational culture" and recognizing that Amazonian institutions already assume elements of sustainability and tradition in their missions and institutional practices. This understanding is close to Jasanoff (2004), for whom scientific and social knowledge are co-produced; and Casino; *et al.* (2025), who argue that thinking with the peoples of the Amazon can expand contemporary knowledge systems

In this sense, the interviewed researcher ENTRE 2 explains that, among indigenous peoples, socialization occurs: a) by rites; b) dances; c) coexistence in the preparation of food; d) community crops; and e) spiritual choice of apprentices, as in the case of shamans.

Therefore, these results contrast with Nonaka's SECI cycles; Takeuchi (2008), based on tacit-explicit conversion. As Polanyi (1966) points out, tacit knowledge is always greater than explicit knowledge and in the Amazon, it remains primarily tacit for cultural, spiritual and collective protection reasons, according to the researchers interviewed.

4.2.2 Sociopolitical Challenges of Knowledge Management in the Amazon

Sociopolitical challenges form a cross-cutting category, articulating historical inequalities, institutional barriers, environmental pressures, and geopolitical disputes. According to a report by ENTRE 1, it can be said that researchers from the North live with "the asymmetry of graduate studies", which requires interstate partnerships and the strengthening of regional programs such as UFAM and UFPA

This asymmetry has been widely documented by Bentes-Gama (2012) and Bursztyn (2015) who describe the historical marginalization of the Amazon in science and technology policies

As highlighted by ENTRE 2, research with indigenous peoples requires multiple authorizations, such as FUNAI and the Ethics Committee, making the process "extremely complex" and bureaucratic, especially in ethnoFigureic approaches. CNS Resolution 510/2016 reinforces the need for ethical care in research with vulnerable populations, also foreseen by Diegues (2000) and Bernard; Jorgensen (2022) in the discussion of collaborative ethics in traditional knowledge.

ENTRE 1 reports that it has been investigating information flows and disinformation related to climate change, a critical issue in a region that lives under ecological "tipping points", an issue also reported in Nobre's studies; Borma (2009) and political tensions associated with environmental disinformation. Therefore, KM thus becomes a mechanism of cognitive governance in the face of narrative conflicts about climate, forest, and territory.

One should reflect on the economic exploitation of knowledge. ENTRE 2 warns of the vulnerability of traditional knowledge in the face of the interest of pharmaceutical and biotechnology industries, stating: "Imagine the pharmaceutical industry crazy to get their hands on the pile of knowledge they have".

This concern is corroborated by Matheus (2019) and Gebara *et al.* (2023), which discuss the threat of bioepistemicide, that is, the appropriation and erasure of indigenous knowledge systems by the global biotechnology economy.

Table 8 summarizes the sociopolitical challenges of KM in the Amazon and relates the challenges to the literature.

Table 8

Sociopolitical Challenges of KM in the Amazon

Category	Interview Evidence	Dialogue with Scientific Studies
Academic and regional asymmetries	ENTRE 1 reports the historical disparities between the North and other regions related to the training of human resources. It reinforces the need to strengthen regional graduate studies.	Bursztyn (2015); Bentes-Gama (2012) on inequality of scientific infrastructure.
Bureaucracy and ethics in research with indigenous people	Need for multiple authorizations (BETWEEN 2).	Bernard; Jorgensen (2022); CNS Resolution 510/2016.
Economic exploitation of knowledge	"Pharmaceutical industry eager to get its hands on knowledge" (ENTRE 2)	Matheus (2019); Gebara <i>et al.</i> (2023) on bioepistemicide.
Climate misinformation	This is a central theme of projects coordinated by ENTRE 1.	Noble; Borma (2009); Brondízio <i>et al.</i> (2016).

Source: survey data, 2025.

4.2.3 Governance of Information and Local Knowledge

The theme of governance of information and local knowledge, described in Table 9, emerges as a strategic axis for integrating data, protecting traditional knowledge and structuring information ecosystems.

Table 9

Governance of Information and Local Knowledge

Dimension	Corpus Situations	Theoretical Framework
Informational fragmentation	Lack of an integrated system on the Amazon; projects for unified repositories (ENTRE 2).	Castro; Zucarelli (2021); Freire; Lima (2020).
Intellectual protection	Demand for access and safeguard restrictions (ENTRE 2).	McGrew <i>et al.</i> (2023); Matos; Tenazor (2019).
Community governance	Collective and non-commodified knowledge (ENTRE 2).	Almeida (2014); Cunha (2007) on traditional collectivities.

Source: survey data, 2025.

The researcher ENTRE 2 argues that there is a lack of a "large referential system of integrated information about the Amazon" and that her projects seek precisely to "structure a unified repository" that connects scientific, socio-environmental and traditional data.

This gap is recognized by authors such as Freire; Lima (2020) and Castro, Carvalho; Zucarelli (2021) and that highlight the need for integrated informational governance for environmental and territorial policies in the Amazon context.

It becomes evident that it is necessary to safeguard and protect the intellectual territory of the Amazon. Study by McGrew *et al.*, (2023), points out that traditional knowledge requires

specific protection mechanisms, such as: a) adequate licensing; b) legal protection; c) specific metadata; and d) ethical governance of information.

The researcher and interviewee ENTRE 2 who has been working since CBA and PROFNIT with intellectual property issues and states that GC in the Amazon needs to consider access restrictions, as certain knowledge cannot be widely opened without risk of external exploitation.

Indigenous governance systems are not based on Western notions of property, but on collectivity, reciprocity, and territoriality, as highlighted in the studies of Cunha (2007) and Almeida (2014).

Therefore, the practice of governance directly implies KM strategies that must respect: a) distributed decision-making; b) cultural and spiritual authority and c) cosmological protection of knowledge.

4.2.4 Sustainable Innovation and Social Technologies

KM is recognized as a structuring resource for sustainable innovation, as ENTRE 1 points out when it states that KM can "direct knowledge aligned with sustainability in the cultural, economic, environmental and technological dimensions"

This view corresponds to the notion of informational sustainability highlighted in Barbosa's studies; Schneider (2015) and in the seminal studies of Geraldo, Pinto; Duarte (2022). Also discussed in the approaches to knowledge ecosystems by Bellini; Raglianti (2025).

By highlighting social technologies as an Amazonian solution, ENTRE 2 highlights the production of baniwa pepper as an example of KM in social technology: community production, traditional division of roles and innovation oriented to indigenous economic autonomy.

In this sense, authors such as Fleury, Lobato; Dantas (2019) and D'Ávila (2020) argue that social technologies are more effective in Amazonian territories because they respect local traditions, collectivities, and ecological systems

Reflecting on academic and technological innovation, it was evident that ENTRE 2's performance in the CBA, implementing KM structures, competitive intelligence and intellectual property, demonstrates a pioneering model of institutional innovation oriented to the bioeconomy. The literature on Amazonian bioeconomy (EMBRAPA, 2021; Coast;

Almeida, 2023) reinforces this articulation between science, territory, and traditional knowledge.

4.2.5 Inclusion of Indigenous Peoples and Local Communities

Indigenous KM as an epistemological rupture is discussed in the reports of the researcher ENTRE 2 when she states that working KM with native peoples requires "detaching oneself from many concepts of knowledge management" because indigenous knowledge has a cosmological, spiritual and relational nature.

This understanding dialogues with Fonseca; Zaninelli (2024), who propose conceptual models of indigenous KM, and with Escobar's (2016) approach to "feeling-thinking with the Earth".

The researcher ENTRE 2 mentions the creation of a national observatory of the production of indigenous academics, which seeks to map intellectual trajectories and strengthen the epistemological autonomy of these groups.

In this sense, the researcher ENTRE 1 reinforces that her UFAM-UFPA work contributes to expanding indigenous and regional participation in graduate programs, reducing historical inequalities in the regional context.

4.2.6 Trajectory of KM Research in the Amazon Context

The genesis of KM research in the Amazonian context has as its starting point studies based on the field of librarianship and management. The researcher ENTRE 2 reports that she began her research in the 1990s, when she was still "the only doctor in the library science course for almost 20 years" and began investigating library management and technological diagnoses at UFAM.

The turning point was the performance of ENTRE 2 in the field of biotechnology. Thus, his work at the Amazon Biotechnology Center (CBA) for 12 years marks a significant turning point that positioned GC as a strategic tool to support the nascent biobusiness hub in the region. This phase anticipated current trends in the territorial bioeconomy, as evidenced in Fernandes' studies; *et al.*, (2025).

Table 10 summarizes the trajectory of KM research in the Amazon.

Table 10

Groups and Trajectories of KM Research in the Amazon

Theme	Interview Evidence	Interpretative Synthesis
Origin of studies	Initial research by ENTRE 2 in the 1990s in librarianship and organizational diagnoses.	The Amazonian GC was born within information science, with a strong institutional look.
Biotechnological turn	12 years of experience at CBA structuring KM, innovation and intellectual property. (OF 2)	Framework that links KM to the bioeconomy and regional industrial policy.
Network expansion	Simultaneous performance UFAM-UFPA and expansion of graduate studies (ENTRE 1).	Institutional strengthening and new lines of research in sustainability and information flows.
GICA	Structuring of lines focused on KM; Inclusion of GC in the name of the group and Amazon focus.	Consolidation of the GC research ecosystem in the North.

Source: survey data, 2025.

Finally, in 2019, the reformulation of the research group culminated in the creation of GICA, definitively inserting KM as a central research axis at UFAM and strengthening studies of traditional knowledge, women in science and intellectual protection as reported by the researchers.

4.2.7 Research Groups in Knowledge Management in the Amazon

This study sought to understand the KM strategy in the Amazonian context. In this sense, the researcher ENTRE 1 describes GICA as a continuation of the historical NEPCI, aimed at studying characteristics of information and knowledge as managerial elements, with "special focus on the Amazonian context".

Under the coordination of the researcher and interviewee ENTRE 2, GICA began to develop research on: a) indigenous knowledge; b) GC in public organizations; c) social technologies; d) informational sustainability; and e) bioeconomy.

The researchers' reports reinforce And highlight some emerging national networks such as the observatory of indigenous academics and national partnerships reflect the maturation of KM in the Amazon as a relevant field of research.

Table 11 summarizes the KM research groups in the Amazon, the lines of research and the main contributions to the regional context.

Table 11

KM Research Groups in the Amazon

Group / Institution	Interview Evidence	Line of Action	Contributions to the Amazon GC
GICA – Research Group on Information and Knowledge Management in the Amazon (UFAM)	Reformulated in 2019; Includes CG in the name of the group as reported in ENTRE 1.	Information, GC, innovation, sustainability.	It integrates teaching, research and extension; history of training regional staff.
DICA – Development, Information, Knowledge and the Amazon (UFAM)	Structured by the researcher and interviewee ENTRE 2; Strong performance in ICTs, indigenous KM and intellectual property.	Traditional knowledge, governance, bioeconomy.	Pioneer in the discussion of indigenous KM and safeguarding knowledge..
PPGIC – Graduate Program in Information and Communication (UFAM)	Created with the participation of the researcher and interviewee ENTRE 1; interdisciplinary focus.	Interdisciplinarity, culture and KM.	It expands epistemological and theoretical boundaries of KM.
PPGCI – UFPA	Simultaneous performance of the researcher (ENTRE 1) strengthens UFAM-UFPA integration.	KM, sustainability, information flows.	It reduces regional asymmetries and strengthens Amazonian scientific production.
National Networks/Observatory of Indigenous Scholars	Initiative coordinated by the researcher ENTRE 2 in a multidisciplinary network.	Indigenous epistemologies and critical open science.	It promotes visibility and autonomy of indigenous researchers.

Source: survey data, 2025.

4.2.8 Ongoing and Future Research Agenda of KM in the Amazon

From the interviews and literature, it is possible to outline a robust contemporary agenda on the KM theme in the Amazonian context.

The research agenda on KM in the Amazon has as its starting point studies on indigenous KM and intellectual protection. As highlighted in the studies by Fonseca (2024) who studies the conceptual modeling of indigenous KM and studies by Gebara, et.al., (2023) who deals with analyses on bioepistemicide and the National Observatory of Indigenous Production.

The researcher ENTRE 1 highlights GC research, information flows, and climate change as an agenda. According to the researcher ENTRE 1, research on climate disinformation and organizational resilience in the face of environmental effects in the Amazon is underway.

Castro Studies; Zucarelli, (2021) deal with integrated information governance. Focused on building systems that unite scientific, socio-environmental and traditional data.

On the other hand, Cardoso; Pimenta (2019) discuss KM and bioeconomy/sociobioeconomy when developing studies on sociobiodiversity production chains and social technologies.

Finally, studies such as Correa, *et al.* (2023) put KM in public organizations in the Amazon on the research agenda. Contributing to this agenda Cunha; Meirelles, (2022) deal with innovation mechanisms for public policies in the Amazon context.

Summarizing the current and future agenda of KM research in the Amazon, Table 12 presents the foundations for understanding and substantiating the studies.

Table 12

Current and Future Agenda for KM Research in the Amazon

Line of Research	Researchers/Evidence	Scientific developments
Indigenous GC	The researcher ENTRE 2 reports that the formation of a network of researchers is essential to strengthen research in the Amazonian context; It reinforces the need to investigate epistemological models.	Conceptual models (Fonseca, 2024) and intellectual protection.
Climate Misinformation	The researcher ENTRE 1 coordinates studies on information flows.	GC-climate articulation; evidence-based decision-making.
Bioeconomy and social technologies	Research on Baniwa Pepper and sustainable chains.	GC Integration – Territorial Innovation (EMBRAPA, 2023).
Information Governance	Integrated repository projects and Amazonian thesauri.	Knowledge ecosystems (Bellini, 2025).

Source: survey data, 2025.

4.2.9 Convergences Between Interviews and KM Theories

KM has been consolidated as a strategic field for private, public, and social organizations since the 1990s. Authors such as Davenport and Prusak (1998), Nonaka; Takeuchi (2008) and Choo (2006) established theoretical frameworks that define knowledge as an essential organizational asset for innovation, competitive advantage, and continuous learning.

However, when analyzing specific contexts, especially the Amazon, marked by sociocultural diversity, traditional knowledge, its own cosmologies, complex ecosystems and unique territorial dynamics, it is observed that the classical models do not fully account for reality. It is at this point that fundamental contributions emerge from the interviews conducted with Prof. Dr. Célia Regina Simonetti Barbalho and Prof. Dr. Danielly Oliveira Inomata, pioneering researchers at the interface between GC, the Amazon and traditional knowledge.

The researcher (ENTRE2) points out that, in the case of indigenous peoples and other Amazonian communities, it is necessary to "deconstruct absolutely all [traditional] concepts of knowledge management," given the way knowledge circulates, is shared, and protected in these contexts. On the other hand, researcher ENTRE 1, in turn, highlights that the Amazon GC must incorporate contextualized values, knowledge, and practices, integrating sustainability, institutional mission, and territoriality.

This chapter deepens these convergences, articulating them with the conclusions of the Integrated Literature Review on KM in the Amazon (2000–2025), prepared by the research project to which this work is linked. Thus, the central objective is to demonstrate how interviews and theories complement each other, tension and generate new understandings about KM in the Amazonian context.

The convergence between interviews and KM theories points to KM as a social and cultural practice. Both the literature and the interviewees converge on the idea that knowledge is socially constructed. Brown and Duguid (2001) state that KM should be understood as a social practice, not as a mere technical process. This understanding appears strongly in the statements of the researcher ENTRE 2.

Researcher ENTRE 2 points out that "Socialization [among indigenous people] is much broader. It occurs through rites, dances, daily coexistence." The researcher ENTRE 1 adds that, in Amazonian organizations, KM depends on the incorporation of regional values into the organizational culture. Thus, he states: "To think about knowledge management in the Amazon is to incorporate values and knowledge into the culture of organizations."

Table 13

Theoretical and Empirical Convergences between Interviews and KM Classics

Dimension	Classical theories	Interview – ENTRE 2	Interview – ENTRE 1	Convergence
Nature of knowledge	Tacit and explicit (Nonaka; Polanyi)	Indigenous knowledge is mostly tacit and non-externalizable	Knowledge must incorporate regional values	Knowledge is social and contextual
Socialization	Interaction and learning	Rituals, dances, expanded coexistence	Amazonian organizational culture	Expanded socialization
KM as a strategy	Innovation and advantage	Cultural safeguarding and protection	Sustainability and SDGs	KM as a socio-territorial practice
Public management	Moderate role	GC in libraries	KM in universities and public agencies	Expanding the KM Field

Source: survey data, 2025.

Traditional knowledge challenges the SECI model. Classical literature assumes that knowledge tends to be transformed into explicit for management purposes. However, ENTRE 2 clarifies: "They are not concerned with transforming tacit knowledge into explicit knowledge". This statement converges with Berkes (2015) and Battiste (2019), who argue that indigenous knowledge is holistic, contextual, and not reducible to formal records.

The interviews converge with recent literature linking KM and sustainability (LEITE; BAPTISTA, 2019). Researcher ENTRE 1 emphasizes: "Our research is directly related to the SDGs, especially sustainability, climate change, and organizational resilience."

This perspective dialogues with authors who highlight the Amazon as an essential ecosystem for global climate balance (Artaxo, 2019; Brondizio *et al.*, 2016).

The researcher ENTRE 1 states that a large part of her scientific production involves KM in public management, especially universities and research bodies. "We have many projects focused on knowledge management in public organizations, including organizational maturity and innovation."

The literature confirms the historical gap in studies on KM in public institutions in the Amazon (Alfenas *et al.*, 2021; Baptist; Quandt, 2015).

KM contributes to the preservation of knowledge and generational continuity. In this sense, ENTRE 2 reports the implementation of KM in the UFAM Library System to avoid loss of critical knowledge with retirements: "Several people had mastery of the system's knowledge and this could be lost."

Davenport; Prusak (1998) already emphasized the importance of retaining organizational knowledge, but in the Amazonian context this dimension acquires more urgent contours due to regional asymmetries, an issue emphasized by ENTRE 2.

Table 14

Convergences between Interviews and KM Theories

Concept	Interview BETWEEN 2	Interview BETWEEN 1	Literature
Tacit knowledge	Indigenous knowledge is not easily converted into explicit; are culturally protected.	GC must recognize territorialities and subjectivities.	Polanyi (1966); Nonaka; Takeuchi (2008).
KM and sustainability	KM applied to the protection of traditional knowledge.	Projects aligned with the SDGs and climate resilience.	Barbosa; Schneider (2015); Geraldo; Pinto (2019).
Social innovation	Traditional production chains as social technologies.	KM as a driver of sustainable innovative practices.	Fleury <i>et al.</i> (2019); D'Ávila (2020).

Source: survey data, 2025.

4.3 DOCUMENTARY ANALYSIS OF GOVERNMENT REPORTS, INSTITUTIONAL GUIDELINES AND REGULATORY FRAMEWORKS IN THE AMAZON

The analysis of government reports, institutional guidelines, and normative documents allowed us to deepen the understanding of the policies that guide Amazonian development and their relationship with KM. Technical documents from federal and state agencies linked to territorial, socio-environmental and regional development management were examined, including environmental monitoring reports, strategic plans for sustainable development and territorial planning instruments. Public policies for science, technology, and innovation were also analyzed — especially those aimed at promoting open data, protecting traditional knowledge, and stimulating sustainable innovation, which make up the normative framework for KM practices in the Amazonian context.

In addition, regulatory and normative frameworks related to the safeguarding of traditional knowledge were considered, including guidelines related to the rights of indigenous peoples and traditional communities, with emphasis on benefit-sharing mechanisms, access to genetic heritage, and shared governance of knowledge. Institutional documents from agencies such as BNDES, MCTI, CNPq, IBAMA and indigenous organizations were also included, since they present strategic guidelines, development programs and structuring projects being carried out in the region.

This documentary analysis made it possible to identify key guidelines, institutional actors involved, normative weaknesses and structural gaps that directly affect the implementation of KM practices in the Amazon. Among the main challenges identified, the following stand out: low interoperability between government information systems; the fragmentation of initiatives for the production and circulation of knowledge; insufficient interinstitutional articulation; and limited social participation in decision-making processes. Such elements reinforce the need for collaborative governance models and robust data management and openness policies that strengthen the integration between science, traditional knowledge, and sustainable innovation in the region.

Reports from federal and state institutions responsible for territorial and environmental management and regional development were examined, including:

- State Master Plans and Economic-Ecological Zoning (ZEE);
- Environmental monitoring reports from IBAMA and ICMBio;
- Strategic plans for sustainable development linked to SUDAM and the Ministry of Integration and Regional Development;

- Evaluation reports on bioeconomy policies and Amazonian production chains.

These documents provide an overview of the use of socio-environmental data, territorial information infrastructure, and shared governance challenges, which are fundamental to KM.

Regulations and guidelines of Science, Technology and Innovation (ST&I) policies were also analyzed, especially those related to:

- data openness and interoperability (Federal Government Open Data Policy);
- protection and sustainable use of genetic heritage and traditional knowledge (Law No. 13,123/2015);
- encouragement of applied research in bioeconomy;
- digital governance and integration of information systems.

These policies are directly related to the ability to produce, manage and share knowledge strategically.

The analysis included regulatory frameworks such as:

- National System for the Management of Genetic Heritage and Associated Traditional Knowledge (SisGen);
- Guidelines of the Convention on Biological Diversity (CBD);
- Norms on the territorial rights of indigenous peoples and traditional communities (FUNAI, ILO Convention 169);
- Community protocols for consultation and prior consent.

These instruments regulate the use, recognition, and protection of traditional knowledge—an essential element of KM in the Amazon.

Institutional documents were also analyzed from:

- BNDES (funds for bioeconomy, innovation notices and resources for sustainable production chains);
- CNPq (research calls, scholarships for traditional knowledge, INCTs focused on the Amazon);
- MCTI (National Innovation Strategy, National Open Science Policy);
- IBAMA and ICMBio (management of conservation units and environmental data policies);

- Indigenous organizations (consultation protocols, territorial and environmental management plans – PGTAs).

These documents reveal how different institutions produce and circulate knowledge, with varying degrees of integration.

Table 16

Institutional actors and their functions in the GC of the Amazon

Actors	Main functions	Contributions to KM	Weaknesses identified
MCTI / CNPq / CAPES	ST&I policy formulation; Promotion of research	Scientific production, research networks, data infrastructure	Low integration with traditional knowledge; Fragmentation between bases
BNDES / Finep	Economic and technological development	Supporting sustainable innovation and the bioeconomy	Few actions integrated with territorial governance
IBAMA / ICMBio	Environmental inspection and management	Large environmental databases	Systems not interoperable with universities and local organizations
SUDAM / State Governments	Regional planning	Territorial and socio-economic plans	Lack of informational standardization and KM mechanisms
Indigenous organizations	Territorial management, advocacy	Consultation protocols and safeguarding of knowledge	Poor integration with government systems
Universities / INCTs	Research and training	Scientific production and dissemination	Difficulty accessing up-to-date government data

Source: survey data, 2025.

5 FINAL CONSIDERATIONS

KM in the Amazon presents itself as a crucial tool for sustainable development, capable of integrating traditional and scientific knowledge, strengthening local governance and promoting innovation. The strengthening of these practices contributes to the preservation of biodiversity and the improvement of the socioeconomic conditions of Amazonian communities.

The Amazonian context, due to its vast biodiversity and cultural diversity, faces complex challenges that require innovative approaches to promote sustainable development. In this sense, KM emerges as a strategic tool to integrate traditional and scientific knowledge, strengthen local governance and drive adaptive solutions in the face of climate change and socio-environmental pressures seeking sustainable development and committed to the UN Sustainable Development Goals (SDGs).

KM in the Amazon is essential for building sustainable solutions that respect the cultural and environmental diversity of the region. Integrating traditional and scientific knowledge, strengthening local governance, and promoting innovation are essential steps to ensure a sustainable future for the Amazon and its peoples.

KM in the Amazon represents a strategic path to integrate science, technology and traditional knowledge in favor of a sustainable and innovative development model. Valuing cognitive diversity and creating collaborative networks are essential for the knowledge produced in the region to effectively contribute to global solutions to environmental, social, and economic challenges.

When applied ethically and interculturality, KM can strengthen the appreciation of traditional knowledge from the Amazon, promoting cognitive justice and sustainability. The articulation between scientific and traditional knowledge requires institutional, political and cultural mediations that respect the rights of communities and recognize epistemic plurality.

The preservation of this knowledge is not only a matter of memory, but of environmental and cultural survival. Thus, integrating KM into the protection of traditional knowledge represents a promising path for the future of the Amazon and humanity.

Among the main challenges are the asymmetry of power between social actors and the risk of misappropriation of traditional knowledge. The implementation of policies for the protection and recognition of collective intellectual rights is indispensable. In addition, KM in the Amazon must be based on ethical, collaborative, and intercultural principles that recognize epistemological diversity and strengthen the autonomy of local peoples (Barreto; Freitas, 2020).

The advancement of information and communication technologies can enhance the sharing and integration of knowledge, but it requires adequate infrastructure and cultural mediation to avoid exclusions (Moraes; Birth, 2021; Mark; Rodrigues, 2023).

KM in the Amazon represents a fertile field for social and environmental innovation. Knowledge dialogues between local and scientific knowledge are essential pillars for participatory and sustainable governance. Thus, the integration of KM practices can contribute not only to the strengthening of public policies, but also to the appreciation of cultural diversity and the protection of the forest and its peoples.

The Amazon presents complex challenges, but also unique opportunities for the implementation of innovation and sustainability strategies. The integration between bioeconomy, technology, environmental conservation, and inclusive socioeconomic

development is essential to ensure the preservation of the biome and the well-being of local populations. Robust public policies, investments in research, and the active participation of communities are essential to transform potential into concrete and lasting results.

KM in the Amazonian context is a challenging field, but strategic for sustainable development and for the valorization of local knowledge. The integration of scientific and traditional KM practices requires adapted models that respect cultural plurality, the collectivity of indigenous knowledge, and the institutional specificities of the region.

The literature shows that KM can serve not only as a tool for organizing and disseminating knowledge, but also as an instrument for social, technological and environmental innovation. The Amazon, therefore, should not be seen only as an object of study or a source of natural resources, but as a strategic space for the production of plural, ethical, and sustainable knowledge, capable of contributing to regional and global science, technology, and innovation policies.

The application of KM in the Amazon has proven to be essential to strengthen social inclusion and regional sustainability. According to Brito, Lima and Oliveira (2016), KM practices in credit unions in the states of Rondônia, Acre and Amazonas allowed the dissemination of knowledge to local communities, expanding opportunities for socioeconomic development.

Studies such as the one by Brito *et al.* (2016) analyze KM practices in credit unions in the states of Rondônia, Acre and Amazonas, highlighting the importance of disseminating knowledge for social inclusion and income distribution in the region.

In addition, citizen science projects, such as ForestEyes, use KM tools to monitor deforestation and generate data in real time, allowing for more efficient decision-making by public and private managers (Silva *et al.*, 2022).

KM is understood as the systematic process of creating, storing, sharing and using knowledge to generate value and innovation (Davenport; Prusak, 1998). In the territorial context, especially in regions such as the Amazon, knowledge management needs to go beyond traditional corporate models, incorporating sociocultural, environmental, and cultural dimensions (Martins; Silva, 2019).

The main challenges for KM in the Amazon involve the lack of technological infrastructure, limited connectivity, scarcity of incentive policies, and the difficulty of legal recognition of traditional knowledge. However, there are promising prospects with the

advancement of digital transformation, the expansion of research networks, and the strengthening of the bioeconomy (Menezes; Rodrigues, 2023).

The articulation between GC and SDGs represents a promising path for sustainable development, especially in megadiverse and socio-culturally rich regions such as the Amazon. From the interviews analyzed, it is observed that For Barbalho, the Amazonian KM requires alternative conceptual frameworks and respect for the cosmologies of the original peoples, deconstructing classical models. For Inomata, KM in the Amazon must integrate knowledge, sustainability and organizational mission, strengthening institutions and innovating in social and environmental practices.

Thus, the KM Research Agenda must be plural, ethical, inclusive, and territorially situated, contributing to addressing global and regional challenges, and consolidating KM as an instrument for social and environmental transformation in alignment with the SDGs.

KM in the Amazonian context is today a unique field, which requires epistemological decolonization, respect for territorialities, integration between science and tradition, and strengthening of governance structures. More than adapting classic models, it is necessary to create new paradigms that reflect the complexity of the region, as Célia and Danielly defend in their trajectories and productions.

The convergence between traditional and scientific knowledge, social technologies, bioeconomy, and informational governance points to a future in which KM can contribute decisively to the cognitive, cultural, environmental, and political sustainability of the Amazon.

The bibliometrics carried out point to a promising and consolidating field: KM in the Amazon is currently articulated with central themes of the socio-environmental agenda (bioeconomy, governance, traditional knowledge and digital innovation). However, there is an urgent need for sensitive methodological models, applicable metrics and ethical protocols for KM to contribute in a fair and sustainable way to regional development and the protection of Amazonian epistemological heritage.

The literature analyzed demonstrates that KM in the Amazon: a) is emergent, interdisciplinary and politically situated; b) it requires articulation between science and traditional epistemologies; c) it is deeply linked to environmental governance, bioeconomy and cognitive justice; and d) it requires its own conceptual models, ethically sustainable and digitally integrated.

As Escobar (2016), Santos (2018) and Leff (2021) argue, the future of the region depends on post-decolonial approaches, capable of respecting Amazonian ways of producing knowledge.

This study has some limitations that can be observed in the results, such as: a) Many studies are qualitative, focusing on specific cases or restricted communities, which may make generalizations difficult; b) the availability of public data, validated models or specific "Knowledge Management" metrics in the Amazonian context is still limited; c) the practical implementation of KM models adapted to the Amazon encounters logistical, cultural, and financial barriers many studies point to the challenges, but even fewer show models widely implemented and evaluated with robust quantitative data; and d) There is a risk of applying imported models without adaptation to the Amazonian context, which can lead to failures in adaptation or local rejection.

ACKNOWLEDGEMENTS

The authors would like to thank the Minas Gerais Research Foundation (FAPEMIG), the National Council for Scientific and Technological Development (CNPq) for funding the Postdoctoral Fellowship Abroad to one of the researchers who authored this study, and the Coordination for the Improvement of Higher Education Personnel (CAPES), the Catholic University of Brasília, the Catholic University of Brasília UEMG Institutional Research Support Program (PAPq/UEMG) to the Federal Institute of Minas Gerais and the Federal University of Rondônia.

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THE ROLE OF CIVIL SOCIETY IN CREATING INCLUSIVE CITIES

O PAPEL DA SOCIEDADE CIVIL NA CONSTRUÇÃO DE CIDADES INCLUSIVAS

EL PAPEL DE LA SOCIEDAD CIVIL EN LA CONSTRUCCIÓN DE CIUDADES INCLUSIVAS

 <https://doi.org/10.56238/sevened2025.036-115>

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ABSTRACT

The purpose of this article is to analyze the relationship between the right to the city and housing policies in São Paulo, focusing on occupations promoted by housing movements in central areas. An interdisciplinary approach was adopted, combining normative analysis of urban and housing legislation with a bibliographical review of academic studies and official documents on social mobilization and participatory governance. The results showed occupations respond to a structural housing deficit resulting from historical processes of marginalization; that instruments of participatory democracy play a decisive role in the formulation and continuity of inclusive policies; and that the reuse of empty urban spaces for social housing strengthens the dialogue between civil society, public authorities and private initiative. In the end, we highlight the need to institutionalize participatory channels to ensure the continuity of these policies and propose investigating their applicability in other Brazilian metropolises.

Keywords: Right to the City. Housing Policies. Participatory Democracy. Social Housing.

RESUMO

Este artigo tem por objetivo analisar a relação entre o direito à cidade e as políticas habitacionais em São Paulo, com foco nas ocupações promovidas por movimentos de moradia nas áreas centrais. Adotou-se abordagem interdisciplinar, combinando análise normativa da legislação urbanística e habitacional com revisão bibliográfica de estudos acadêmicos e documentos oficiais sobre mobilização social e governança participativa. Como resultados, constatou-se que as ocupações respondem a um déficit estrutural de moradia decorrente de processos históricos de marginalização; que instrumentos de democracia participativa exercem papel decisivo na formulação e continuidade de políticas inclusivas; e que o reaproveitamento de espaços urbanos ociosos para habitação de interesse social fortalece a interlocução entre sociedade civil, poder público e iniciativa privada. Ao final, destaca-se a urgência de institucionalizar canais participativos para garantir a perenidade dessas políticas e propõe-se investigar sua aplicabilidade em outras metrópoles brasileiras.

Palavras-chave: Direito à Cidade. Políticas Habitacionais. Democracia Participativa. Habitação de Interesse Social.

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RESUMEN

El objetivo de este artículo es analizar la relación entre el derecho a la ciudad y las políticas de vivienda en São Paulo, centrándose en las ocupaciones promovidas por los movimientos de vivienda en las zonas céntricas. Se adoptó un enfoque interdisciplinario, combinando el análisis normativo de la legislación urbanística y de vivienda con una revisión bibliográfica de estudios académicos y documentos oficiales sobre movilización social y gobernanza participativa. Como resultados, se constató que las ocupaciones responden a un déficit estructural de vivienda derivado de procesos históricos de marginación; que los instrumentos de democracia participativa desempeñan un papel decisivo en la formulación y continuidad de políticas inclusivas; y que la reutilización de espacios urbanos ociosos para viviendas de interés social fortalece el diálogo entre la sociedad civil, el poder público y la iniciativa privada. Por último, se destaca la urgencia de institucionalizar canales participativos para garantizar la continuidad de estas políticas y se propone investigar su aplicabilidad en otras metrópolis brasileñas.

Palabras clave: Derecho a la Ciudad. Políticas de Vivienda. Democracia Participativa. Vivienda Social.

1 INTRODUCTION

This article will investigate how the dialogue between organized civil society and municipal administration can boost housing policies in large urban centers, taking the center of São Paulo as a case study, with the purpose of building more inclusive and sustainable cities. To ensure the effectiveness of these policies, they must be formulated in line with a vision of a modern and progressive city, which goes beyond the right to housing and the use of urban space, with a view to universalizing access to culture, leisure and sports.

From this analytical perspective, the present study proposes to address five fundamental issues: urban occupations are understood as forms of reaction to the socio-spatial segregation of peripheral populations; the institutional and social configuration of the municipalities contributes to the strengthening – or weakening – of the debate and the implementation of articulated housing policies; the articulation between different institutions has a direct impact on the reconfiguration of large urban centers; the institutionalization of democratic governance practices interferes with the representativeness and legitimacy of local governments; An integrative city-project acts as a potential tool in mitigating the urban deficit in a structuring way.

To this end, it will consolidate bibliographic research of normative documents - international treaties, Federal Constitution of 1988, infra-constitutional legislation, in comparison with quantitative data and vast specialized literature to demonstrate to what extent the reinforcement of local associative links and representative organizations influences the mobilized social capital and the consolidation of democratic practices.

2 THEORETICAL FRAMEWORK

The construction of inclusive cities requires an in-depth analysis of the theories that relate the right to the city, participatory democracy and housing policies. The concept of the right to the city, initially formulated by Henri Lefebvre (1968), has been expanded by contemporary authors such as Rolnik (2016) and Saule Júnior (2016), who understand it as a diffuse and collective right, capable of guaranteeing not only access to housing, but also to culture, leisure, transportation, and public services.

In this sense, the City Statute (Law No. 10,257/2001) represents, to this day, a fundamental legal framework by establishing guidelines for sustainable and inclusive urban development based on instruments such as the Special Zones of Social Interest (ZEIS) and the special urban adverse possession demonstrate how the legislation seeks to reconcile the

right to housing with the social function of property (Cafrune, 2016).

The literature also highlights the role of organized civil society in the formulation and implementation of public policies. Social housing movements, participatory councils, urban committees and conferences are examples of democratic governance practices that expand the representativeness and legitimacy of municipal decisions (Rubin, 1996; Amanajás; Klug, 2018).

These are mechanisms that reinforce the idea that the city must be built collectively, ensuring the inclusion of historically marginalized groups, such as homeless populations, women, the elderly, and LGBTQIAPN+ communities.

At the international level, documents such as the World Charter for the Right to the City (2005) and the Gwangju Principles (2015) consolidate the right to the city as an emerging human right, in line with the United Nations (UN) Sustainable Development Goals, especially Sustainable Development Goal (SDG) No. 11, which provides for inclusive, safe and sustainable cities.

Despite normative and institutional advances, authors such as Rolnik (2024) point out the persistent gap between legislation and urban reality, marked by real estate speculation, gentrification, and housing deficit. This contradiction highlights the need to seek ways to strengthen the channels of participation and to institutionalize democratic practices that ensure the continuity of social policies aimed at broad access to housing.

3 METHODOLOGY

This article proposes an integrative review of the literature aimed at understanding the relationship between organized civil society, housing policies and the right to the city, taking the city of São Paulo as a case study. The choice for this cut is justified by the leading role of the capital of São Paulo in the processes of urban occupation and the relevance of social mobilizations around decent housing.

The research is exploratory and descriptive to identify how normative instruments and participatory practices have been applied in the construction of inclusive cities, as well as to analyze the impacts of urban occupations in the center of São Paulo.

The sample comprises normative instruments, notably the Federal Constitution of 1988, the Statute of the City (Law No. 10,257/2001), complementary legislation and international treaties on the right to the city and housing; works by authors such as Lefebvre (1968), Rolnik (2016, 2024), Saule Júnior (1997, 2016), Cafrune (2016), among others that

discuss urbanization, housing policies, and participatory democracy; data collected from the repositories of the Institute of Applied Economic Research, João Pinheiro Foundation and international organizations such as UN-Habitat; case studies, such as programs and initiatives aimed at the rehabilitation of idle spaces and urban occupations in the center of São Paulo.

Despite the geographical restriction to the city of São Paulo and the use of secondary data, the analysis sought to highlight convergences and divergences between theory, legislation and social practice in the management of the housing deficit in the capital of São Paulo.

4 RESULTS AND DISCUSSIONS

4.1 THE RIGHT TO THE CITY AND THE EXERCISE OF DEMOCRACY

The housing deficit in one of the largest metropolises in the world, marked by miscegenation and multiculturalism, has long been discussed. Even so, the city is home to a growing number of homeless people, a trend that intensifies over the years and mandates. The challenges related to housing go beyond housing policies, as there is a structural factor that makes it impossible to continue public policies aimed at the socially vulnerable population: the city deficit, a term coined by Raquel Rolnik (2016).

As it is understood as a diffuse and collective right, the right to the city must be exercised in each metropolis, town or city institutionally organized as a district, municipal or metropolitan administrative local unit, covering the urban space, as well as the rural or semi-rural surroundings that are part of its territory (Saule Júnior, 2016, p. 75).

The definitions of this right were extended to encompass not only the mere exercise of a faculty, but the duty – also of the population itself – to think about fair, inclusive and sustainable cities. To this end, the right to the city began to reveal socioeconomic nuances, considered an essential common good for the quality of life, and which requires a positive conduct of the State.

The right to the city is free of any form of discrimination, strives for an inclusive citizenship, with greater political participation, which fulfills its social functions and is composed of founding elements for its conformation as a diffuse and collective good, namely, the presence of quality public spaces, with gender equality, cultural diversity, inclusive economies and a common ecosystem that respects rural-urban links (Ibid., p. 75).

The relevance of this theme is so significant that, at the international level, the right to the city is recognized in several documents essential for its understanding as an emerging human right within the new urban agenda. Among them, the World Charter on the Right to the City (2005), the European Charter of Human Rights in Cities (Saint-Denis, 2000), Human Rights in Cities – Global Agenda (United Cities and Local Governments – UCLG, 2009), the City Charter on the Right to the City (Mexico, 2009) and the Rio de Janeiro Charter on the Right to the City, of the World Urban Forum (2010).

In addition, documents such as For a World of Inclusive Cities, the UCLG Committee on Social Inclusion, Participatory Democracy and Human Rights (2013) and Social Inclusion and Participatory Democracy and the Gwangju Principles for a City of Human Rights (2015) reinforce this debate and its growing importance.

In Brazil it was no different, as the provisions on the subject gained space during the redemocratization of the country, when the right to the city was improved in the legal and institutional spheres. In the provisions relating to the right to housing, the right to the city is guaranteed, as a logical antecedent of the former.

In the Urban Policy Chapter, which aims to order the full development of the city's social functions and ensure the well-being of its inhabitants, arts. 182 and 183 served as inspiration for the formulation and implementation of urban policy.

This policy, consolidated in Law No. 10,257/2001 (City Statute), has as its fundamental principle the promotion of the dignity of the human person, guiding guidelines and actions aimed at sustainable and inclusive urban development, considered to this day as a legal framework in the face of urban ills, especially those related to irregular housing and the absence of basic sanitation. land regularization actions and urbanization of informal settlements.

The Statute begins with the discipline of the use of urban property of the artificial environment and lists as main guidelines to guarantee the right to sustainable cities, which today are a new role model for the achievement of plural, democratic and progressive cities, the right to urban land, housing, basic sanitation, urban infrastructure, to transport and public services, to work and leisure.

In order to achieve its desideratum, over the years, Law No. 10,257/2001 gave rise to the creation of tools aimed at favoring possession for housing purposes, for the sake of the permanent permanence of the occupants, through mechanisms for the regularization of real estate, legal and political institutes, among which the Special Zones of Social Interest (ZEIS)

stand out, the concession of the real right of use, the concession of special use, the special adverse possession and the right of surface (Cafrune, 2016, p. 192).

The ZEIS are a clear example of how the right to housing and the right to the city are umbilically intertwined, as they fulfill a double function: in addition to establishing special conditions for the land regularization of low-income settlements, they also boost the production of new social housing units by public and private agents.

The extravagant legislation was not restricted to the Statute. Eight years later, came the urban demarcation and the legitimization of administrative possession, with Federal Law No. 11,977/2009, which provides for the Minha Casa, Minha Vida Program (MCMV) and the land regularization of settlements located in urban areas. This law sought to streamline the procedure for recognizing the factual situation of urban settlements, as occurs with the acquisitive prescription by extrajudicial means and with concessions and surface rights.

All this normative framework allowed the instrumentalization of a better management of urban space, especially from the edition of the aforementioned master plan, a procedure that was accompanied by popular participation throughout the process of elaboration of urban policy, from the conception of urban policy management, to its implementation, through specific municipal legislation.

Over time, other valuable instruments have emerged to ensure the social management and strategy of urban spaces, aimed at the democratic administration of the territory, among which conferences, councils and public hearings stand out to promote dialogue between local governments and civil society and provide "the appropriation and institutional recognition of the local social and cultural reality for the constitution of the rules, procedures and instruments aimed at making the right to the city effective" (Saule Júnior, 1997, p. 42).

For these two poles to interact effectively, it is essential to strengthen communication channels, always the first step in this process. As Rubim (1996, p. 75) points out, living in large urban centers necessarily means being inserted in multiple communicative dynamics.

Thus, it is not enough just to give voice to local populations, it is essential to listen to them. The importance of interpersonal relationships within organized groups lies exactly in this, as they expand and strengthen territorialized coexistence in different spaces of the city, each with its own demands and specificities.

4.2 HOUSING POLICY COMBINED WITH URBAN MANAGEMENT

Chronologically, the Brazilian urbanization process accelerated from the second half of the twentieth century, anchored in an expressive population growth. According to studies carried out by the Institute of Applied Economic Research (IPEA), for the Brazilian Habitat III Report, between 1960 and 2010, urbanization grew 402%, from 32 million to 160 million people living in cities. Percentage-wise, in 1970, the urban population was 56%; in 1996, 78.4%; in 2010, 84.4% (IPEA, 2016).

But the rising urbanization, combined with the disorderly growth of cities, especially in developing countries, has generated consequences and challenges, especially in large centers, where segregation, informality and marginalization of some social strata have been observed, making the city a practically private environment for a very restricted layer of the population.

The rapid unplanned expansion of municipalities and cities means an increasing number of poor and vulnerable people living in precarious conditions, without adequate housing space or access to basic services such as water, sanitation, electricity and health services.

This means that the periphery accesses spaces of culture, leisure and sports, mostly, as service providers, or they cross these means on their way to work and from there to home. There is, therefore, no integration, belonging and participation for those who do not live in the city, but only work to keep it functioning for the benefit of a portion of society that effectively occupies and enjoys these spaces.

In an attempt to shorten the distances between the peripheral regions and the large centers, where the city actually takes place, during the 2000s, there was a reflection on the edition and execution of public policies for urban infrastructure in the country, especially to enable the exercise of the right to decent housing.

Large cities usually face different types of challenges to insert themselves in global economic spaces, to guarantee the population the minimum well-being, necessary for the consolidation of competitive democratic coexistence, as Borja (1996, p. 82) points out, namely, infrastructure, quality of life, social integration and governability.

This awareness leads economic agents to set objectives and carry out acts compatible with local government and of a collective nature. To be up to date with this requirement, it is necessary to have a city project, which can be designed from the transformation of urban infrastructure, which would facilitate the transition from the traditional industrial model to that

of a qualified tertiary center, so that local leadership, whether political or not, must be present and contribute to the construction of joint leadership.

4.3 HOUSING FOR THOSE WHO BUILD THE CITY

In the international sphere, the precursor document dealing with this matter appeared in 1948, the Universal Declaration of Human Rights (UDHR), which enunciates the right to housing, enunciated in paragraph 1 of article 25, according to which everyone has the right to a standard of living sufficient to ensure health and well-being for him and his family, especially with regard to food, clothing, housing, medical care and necessary social services, and has the right to security in the event of unemployment, sickness, disability, widowhood, old age or other cases of loss of means of subsistence due to circumstances beyond their control (United Nations, 1948).

In 1966, the International Covenant on Economic, Social and Cultural Rights (ICESCR) was adopted, whose article 11, § 1 enshrines the right to housing by recognizing the right of all people to an adequate standard of living and to the continuous improvement of their living conditions. Brazil internalized this commitment on July 6, 1992, through Decree No. 591.

Nationally, housing policy in the country was developed between the 1940s and 1960s, based on the Retirement and Pension Institutes, the Popular House Foundation and the creation of the National Housing Bank (Rubin; Bolfe, 2014).

The treatment of the housing issue, at the constitutional level, according to the 1988 Charter, is specifically provided for in article 6, specifically addressed, under the terms of article 23, item IX, which attributes to the Union, the States, the Federal District and the Municipalities, common competence for the promotion of housing construction programs and improvement of housing conditions and basic sanitation.

The importance of the right to housing, especially decent housing, has been among the social rights since Constitutional Amendment No. 26/2000, which added this subjective right to the category of social prerogative. Like the right to the city, the right to housing demands a positive attitude from the public entity as it appears as a prerogative of the private individual.

The enactment of the City Statute represented one of the great milestones in the consolidation of the right to the city, reaffirming its commitment to the right to housing as well. To implement the constitutional commandments, the Ministry of Cities was created in 2003,

with the mission of centralizing the financing and execution of essential policies for urban development. Among its main areas of activity, housing, land regularization, urban planning, transportation, mobility and sanitation, integrated city management and the promotion of decent living conditions for the population stand out.

In the same year that the Conferences of Cities and the Council of Cities were created, instruments for the strategic and democratic management of federal urban policies that also began to discuss the issue of housing, a process of strengthening social participation in the design of housing policies began.

This participatory framework was reinforced in 2005, with Law No. 11,124 (popular initiative), which established the National Social Interest Housing System (SNHIS) and the corresponding Fund (FNHIS), establishing guidelines and resources to guarantee decent housing and access to urbanized land for the low-income population.

Through this law, the National Housing Secretariat of the Ministry of Cities was established and coordinated the preparation of the National Housing Plan (PLANHAB), as an instrument for the implementation of the new National Housing Policy (PNH).

Regional and sectoral debates were also organized, including for direct monitoring by representatives of the Council of Cities and the Management Council of the National Fund for Social Interest Housing (CGFNHIS). PLANHAB represented not only a watershed in housing policy, but represented, for the time, a true exercise of social and political cooperation, structured with the contribution of various participatory bodies.

This process of institutional participation strengthened political dialogue and triggered structural changes in the Brazilian macroeconomic panorama: it raised average incomes, motivated federal actions to mitigate the effects of the global financial crisis, and leveraged the growth of credit and investments in the housing sector. These factors ensured the success of a long-term housing policy, aimed especially at low-income families through periodic reviews and articulation with the government's budgetary and financial planning instruments.

In 2007, it was the turn of Law No. 11,445/2007 to create the national guidelines for basic sanitation. In the same year, the Growth Acceleration Program (PAC) was launched, which included projects aimed at social and urban infrastructure, covering areas such as housing, sanitation, mobility, risk reduction and water resources.

In 2009, the Minha Casa, Minha Vida (MCMV) Program was implemented, reestablished by Law No. 14,620/2023, to expand the housing stock to meet housing needs, especially for low-income families; improve the conditions of existing housing, correcting

inadequacies related to property ownership, structure, sanitation, infrastructure and public services; encourage the modernization of civil construction and technological innovation, promoting cost reduction, environmental sustainability and the qualification of housing production to expand the reach of the Program; strengthen the institutions involved and train public and private agents; and encourage the participation of micro and small companies, individual microentrepreneurs in civil construction and private non-profit entities in the program's actions.

The following year, Law No. 12,305/2010 came into force, which instituted the National Solid Waste Policy, followed by Law No. 12,587/2012, responsible for the National Urban Mobility Policy. Together, these legislations made two important financing programs possible, allocating significant resources to the development of cities and the implementation of strategic actions for urban sustainability.

Despite the extensive legislative and operational apparatus, the urban reality remains far from meeting the needs of the population (Rolnik, 2016). Thus, this disconnection highlights the fragility of public policies and opens space for the rise of social organizations and housing movements, which demand structural changes in the way of living and occupying the city.

Cafrune (2016) points out that the appropriation of urban spaces by all inhabitants is not only a right, but an urgent need. These territories should be recognized as spaces of diversity, strengthening of community relations, leisure and full exercise of citizenship, not as mere scenarios of systematic exclusion.

It is in these spaces that those excluded from the process of planning and construction of cities, such as migrants and refugees, women, young people, the elderly and people with disabilities, homeless populations, indigenous people and the LGBTQIAPN+ population, exercise their citizenship and claim the right to the city (Amanajás; Klug, 2018).

The expectation is that by 2030 the design of socially inclusive and safe public spaces will contribute to the reduction of urban inequalities and crime. SDG No. 11 has precisely this desideratum, that is, the construction of inclusive, safe, resilient and sustainable cities and human settlements. However, with only five years to go, this timeline sounds more programmatic than feasible, especially because there is still a lack of practical answers on how to convert the excluded and invisible into full-fledged citizens.

At the same time that we agree on global goals, the challenge remains to translate these guidelines into concrete policies and projects that, in the city's daily life, promote the

effective participation and recognition of those who to this day live on the margins of the urban space.

4.4 LIVES ON THE MARGINS AND IDLE SPACES

The right to housing is much more than a simple shelter: it is the home where our dreams sprout, where we feel seen, safe and fully human. For methodological purposes, this article will be restricted to the municipality of São Paulo, which still faces severe and secular difficulties in the implementation of perennial housing policies, which is why it still concentrates a significant housing deficit.

For no other reason, it is one of the municipalities that has one of the highest coefficients of homeless people, very motivated by some factors in particular: gentrification, the criminalization of peripheral populations, real estate speculation, and still quite marked by a history of social exclusion whose factors already identified point to obstacles of the most diverse orders, associated with neoliberal macroeconomic policies and budget reserves, for example.

Faced with this scenario of social exclusion and structural challenges that profoundly mark the city of São Paulo, it has become urgent to adopt measures capable of reversing this situation and promoting more inclusive urban development.

It was in this context that, in November 2003, the Forum for Social and Economic Development of the Center of São Paulo and the Executive Coordination of Ação Centro were established, in partnership with the Municipal Urbanization Company (EMURB), which aimed at the general coordination of the actions of all sectors of the government, as well as the opening for a shared management with civil society in a broader way, and the Development Agency of the Center of São Paulo was created, linked to the Development Board of EMURB.

The structuring of the Ação Centro Rehabilitation Program started from the reading of the main axes of confrontation in terms of housing deficit in the city of São Paulo. In a study carried out in the early 2000s, when the Program was published, the first was the displacement of the elites and the popularization of the center, processes concomitant with the degradation of the constructed framework and the loss of the affective identity of the memory and history of São Paulo.

Over time, the inability of the center to offer tertiary spaces of the quality required by the market was verified, the disqualification of the public space and the deterioration of

historic properties reinforced the existence of empty buildings on the upper floors and occupied only on the ground floor.

For the time (2002), the agreement signed by the Ministry of Cities, Caixa Econômica Federal, Sinduscon (Union of the Civil Construction Industry of the State of São Paulo), Secovi (Union of Companies for the Purchase, Sale, Lease and Management of Residential and Commercial Properties of São Paulo), ASBEA (Brazilian Association of Architecture Offices), the IAB (Institute of Architects of Brazil), to produce social housing, as well as the use of resources from the Guarantee Fund for Length of Service (FGTS) intended to finance the renovation of buildings in the center for the production of apartments (Somekh, 2006, p. 268).

Subsequently, the Morar no Centro Program and the Integrated Habitat Recovery Perimeters (PRIH), developed by the Municipal Housing Secretariat, promoted the recovery of historic buildings and areas in the area. As a result, the socioeconomic profile of the population was transformed, which gave rise to the discussion between the public and private sectors about the guidelines for an economic strategy of the center.

Important legal institutions remained in the region, as well as popular commerce centers and specialized streets, and the seat of the Municipal Power was installed there, which gave impetus to the offer of leisure, culture and tourism services. Even so, in terms of habitability, there is a very significant shortage.

The most recent data from the João Pinheiro Foundation (FJP), from 2022, show that more than half of the housing deficit in the country, which totals 6,205,314 households, that is, 52% or 3,242,780 households, is directly related to the cost of rent. In the Metropolitan Region of São Paulo (RMSP), especially in the central region, this percentage reaches almost 70%, according to data released this year by the FJP.

Historically, housing policy in Brazil has focused on the construction of own homes, with subsidized interest, as in the case of Minha Casa, Minha Vida. However, even with subsidies that reach 95%, as in the case of Track 1 of the program, many social groups, living on the edge, are unable to pay the installments. These groups earn enough to survive on a day-to-day basis, but not to cover the costs of financed housing, which means that the programs end up benefiting higher income brackets (Rolnik, 2024).

This difficulty in paying rent is also reflected in the ability of families to keep paying the installments of financed properties. Among those included in the MCMV program, Track 1,

aimed at the population with a gross monthly income of up to R\$ 2,640.00 (two thousand six hundred and forty reais), many face major obstacles to honor financial commitments.

This shows that the housing problem is not limited to the scarcity of available units, but rather to the lack of conditions for these houses, whether produced by public policies or by the market, to be effectively accessible to the portion of the population that needs it most.

We understand that the market should be responsible for meeting the solvable demand, just as the low-income population should be served by the Government (Somekh, 2006, p. 268). Based on the understanding that urban legislation is disjointed, becoming a non-effective instrument of regulation.

In this context, social interest housing emerges, with the purpose of guaranteeing the right to housing for families living in urban areas and having a monthly income of up to R\$ 8,000.00 (eight thousand reais). In addition to meeting this fundamental need, housing is directly linked to economic development, job and income generation, and improved living conditions of the urban population (Brasil, 2023).

It should be recalled that the precursors of the initiatives for HIS programs, in addition to the MCMV Program, the Morar no Centro Program, aimed at guaranteeing social housing in the central area and attracting new middle-class residents to the place, was conceived in conjunction with the Ação Centro Program for the rehabilitation of downtown São Paulo, reorganizing the previous PROCENTRO, reformulated in 2001, which provided for defining general guidelines for the central area and which had been obtaining limited intervention results (Somekh, 2006, p. 266).

To ensure its objectives, the Morar no Centro program was divided into the following actions and subprograms: housing provision; renovation and recycling of buildings for housing; social leasing; improvements in tenements; the PRIH; special project Parque do Gato and application of new urban instruments.

The demand for housing provision was met through a partnership with the Municipal Housing Secretariat (SEHAB) in conjunction with the Metropolitan Housing Company of São Paulo (COHAB), Caixa Econômica Federal (CEF) and social movements active in the center. Considering, on the one hand, the small supply of land and, on the other hand, the large number of empty and abandoned buildings existing in the region, it was decided to renovate these buildings, preferably the construction of new ones.

The social movements had already been operating the CEF's Residential Lease Program (PAR) aimed at serving families with an income of up to six minimum wages, through

lease for 15 years, at the end of which the resident has the option to buy the property. To be able to serve lower-income families, SEHAB negotiated specific federal resources for subsidy, created fee exemptions and incentives to reduce costs.

SEHAB's actions in the center, organized by the PRIH, were not limited to the production of housing: they also promoted improvements in tenements, recovery of historical heritage and public spaces, and the provision of cultural, health, education, and income generation programs. This integrated model aimed to raise the quality of life and work of the poorest residents.

Joint action gives effectiveness to good ideas in terms of housing policies, most of which have already been thought of and already put into practice. On the other hand, what taints the effectiveness of these programs is precisely the discontinuity, the lack of commitment to the continuity and maintenance of urban policy, because it is known that many of these actions end up being used for the personal promotion of rulers who, at the end of their terms, only show that everything was a government project, not municipal. This factor contributes to the maintenance of the high rates of homeless people.

4.5 URBAN HOUSING POLICIES: BEING, BEING AND REMAINING

The value of the use of spaces, of the encounter, of and through simultaneities, of oneself and of the other, of living together (Oliveira; Neto, op. cit., p. 7). Recognized by several nations, this right is elevated to the universal category of the right of individuals, an innate characteristic of fundamental rights. Cities and homes shape our identity, being essential for access to education, employment opportunities, healthy living, and strengthening community engagement.

For this reason, adequate housing, as a universal human right, must be at the center of urban policy and be considered an integral part of the right to a decent standard of living, something that goes far beyond simply having four walls and a roof. For a house to be suitable, many factors need to be taken into account: where it is located, its accessibility, and the availability of basic services such as water, sanitation, and drainage.

There are countless obstacles to be overcome by the Administration, among which the need to find integrated and non-sectoral responses to housing problems stand out; the configuration of new spaces and mechanisms that stimulate political participation, facilitate the relationship between administrations and those administered, and promote the organization of social groups.

According to UN-Habitat's Global Urban Observatory, public housing accounts for less than 15% of total housing units, in both developed and developing countries. At the same time, over the past two decades, housing values have skyrocketed, pushing low-income families farther and farther to the peripheries in search of financially viable options. These indicators clearly demonstrate that the current real estate market model has not been able to offer affordable housing to the poorest.

In addition, accessing and securing well-located land, especially in large cities such as São Paulo, where vast urban areas have been systematically excluded from infrastructure development opportunities, also takes on special relevance from an environmental point of view as well.

Debates on decarbonization have highlighted the paramount need to move away from development patterns that promote carbon-intensive urban sprawl and generate dependence on fossil fuels (Frediani; Cociña, 2024). Urban sprawl can lead to increased emissions due to transportation and infrastructure construction, and can lead to water contamination and deforestation.

A study by the Inter-American Development Bank shows that, in Brazil, the average spending of families on items such as transportation and other services can be up to 45% higher for families living on the outskirts of cities than for those living in central areas. Housing relocation tends to be less sustainable than on-the-spot improvement programs, as well as worsening the social and economic conditions of displaced people (Duren, 2017).

In recent years, housing groups have developed projects to improve, regularize and guarantee the lease of occupied buildings in downtown São Paulo through modernization initiatives. These projects were conceived under the aegis of the MCMV program, which supported the development of self-managed housing projects led by social movements in collaboration with technical consultants.

In addition to modernization projects and new housing, to promote on-site improvement programs as a way to prioritize location, another collective strategy of social movements is the optimization of resources to promote clean energy and the more sustainable use of materials, in addition to reducing the cost of living and expenses for residents of social housing.

Research in low-income settlements shows that implementing healthy, low-cost energy efficiency initiatives (WHO, 2014) has not only reduced electricity consumption and

carbon dioxide emissions, but has also resulted in substantial annual savings for communities.

It is these experiences that contribute to broader efforts led by social housing movements and the technical consultants who work with them, who are constantly looking for ways to innovate with building materials and resources to make housing more affordable and sustainable.

5 CONCLUSION

Adequate housing is a universal human right, and should be at the center of urban and urban policies. Currently, more than half of the global population lives in urban areas, and it is estimated that approximately a quarter of these inhabitants reside in slums or informal settlements, regions marked by poor housing conditions.

In general, these people have not had access to decent work opportunities that would allow them to obtain an income compatible with the high costs of living in the center, where their respective workplaces are concentrated. As a result, this portion of the population becomes more vulnerable to forced removals, which can lead them to face homelessness.

One of the greatest challenges of our democracy may be related exactly to the institutional and social reality of the municipalities, either due to the fragility of local mechanisms for guaranteeing citizenship rights and the high degree of social inequalities, or due to the existing civic culture pattern, which blocks the conformation of public spheres and the participation of society. focusing, therefore, on the possibilities of interaction between government and society.

Democratic governance, the patterns of interaction between government institutions, market agents and social actors that coordinate and simultaneously promote social inclusion agendas expand social participation in decision-making processes in urban and housing policies, which require coherence and continuity to pursue accessibility, regardless of the price of land.

The transformation of urban centers emerges from the convergence of essential factors: the alignment and cooperation between public and private actors, the configuration of effective political and civic leadership, and the consensus among citizens to drive the socio-cultural progress of the city. In this way, the project not only presents itself as a response to social and humanitarian challenges, but also as a powerful instrument for local development.

It is likely that decisive issues that must be faced today by Latin American cities will be addressed and resolved with urban actors, i.e., articulation of public and private agents; creation of qualified public spaces; reconstruction of civic culture; political-administrative reform to make local governments more efficient and more participatory and, above all, modernization of urban infrastructure.

The institutionalization of democratic governance practices and the success of local experiences in the formulation of responsive public policies depend directly on the way in which institutional arrangements are structured, which should: (i) stop clientelism and the capture of public spheres by corporate and particularist interests, through transparent procedures and the propagation of a democratic culture capable of overriding non-democratic politics; (ii) foster horizontal participation structures, capable of generating social capital; (iii) empower groups in situations of vulnerability, reducing the impact of asymmetric power relations; (iv) strengthen associative links, mobilizations and local representative organizations, encouraging interaction between the various actors in the public sphere.

The definition of a strategic plan must build and/or modify the image that the city has of itself and that which is held of it abroad. To the extent that it is a response to a sense of crisis, which is the result of the desire to enter new global economic and cultural spaces and which intends to integrate a population that often feels excluded or little considered, the city-project is a project of communication and mobilization in the city and of internal and external promotion of the city.

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IMPORTANCE OF THE CHARACTERIZATION OF COAL-DERIVED ASH FOR APPLICATION IN THE ARCHITECTURE, ENGINEERING, AND CONSTRUCTION INDUSTRY

IMPORTÂNCIA DA CARACTERIZAÇÃO DE CINZA ORIUNDA DO CARVÃO MINERAL PARA APLICAÇÃO NA INDÚSTRIA DA ARQUITETURA, ENGENHARIA E CONSTRUÇÃO

IMPORTANCIA DE LA CARACTERIZACIÓN DE CENIZAS PROVENIENTES DEL CARBÓN MINERAL PARA SU APLICACIÓN EN LA INDUSTRIA DE LA ARQUITECTURA, LA INGENIERÍA Y LA CONSTRUCCIÓN

 <https://doi.org/10.56238/sevened2025.036-116>

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ABSTRACT

The growing demand for sustainable solutions in the Architecture, Engineering, and Construction (AEC) industry encourages the use of residues from industrial processes as alternative materials to Portland cement—whose production is highly CO₂-emissive—or in the manufacture of cementitious matrices. Among these residues, ashes resulting from the combustion of mineral coal in thermoelectric power plants stand out, as they represent a significant environmental liability. In this context, the present study aimed to chemically, mineralogically, and morphologically characterize bottom ash generated at the Pecém Thermoelectric Power Plant (Ceará, Brazil) after beneficiation, in order to identify potential applications for this processed residue. The methodological procedures included ash beneficiation through granulometric fragmentation and sieving; determination of chemical composition by X-ray fluorescence; identification of mineralogical composition by X-ray diffraction; and morphological analysis by scanning electron microscopy. The results showed that the beneficiated coal bottom ash is rich in SiO₂, Al₂O₃, and Fe₂O₃, meeting the chemical requirements of NBR 12653 for classification as a Class C pozzolan. In addition, the presence of an amorphous halo in the diffractogram and a spherical morphology with vitreous, friable particles confirmed its pozzolanic potential. Therefore, the beneficiated bottom ash presents suitable characteristics for partial replacement of Portland cement in mortars, concretes, and

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other cementitious matrices, contributing to the reduction of environmental impacts and to the achievement of sustainable production and consumption targets established in Sustainable Development Goal 12.

Keywords: Bottom Ash. Pozzolan Material. Sustainability in Civil Construction.

RESUMO

A crescente demanda por soluções sustentáveis na indústria da Arquitetura, Engenharia e Construção incentiva a utilização de resíduos oriundo de processos industriais como materiais alternativos ao cimento Portland, cuja produção é altamente emissora de CO₂, ou na confecção de matrizes cimentícias. Entre esses resíduos, destacam-se as cinzas advindas da queima do carvão mineral em usinas termelétricas, que representam um passivo ambiental significativo. Neste contexto, a presente pesquisa teve como objetivo caracterizar química, mineralógica e morfológicamente a cinza pesada gerada na Usina Termelétrica do Pecém/CE, após processo de beneficiamento, a fim de identificar quais usos podem ser dados a este resíduo beneficiado. Os procedimentos metodológicos adotados foram beneficiamento da cinza pelos processos de fragmentação granulométrica e peneiramento; determinação da composição química por fluorescência de raios X; obtenção da composição mineralógica por difração de raios X, e identificação da morfologia por microscopia eletrônica de varredura. Os resultados alcançados evidenciaram que a cinza de carvão mineral pesada beneficiada apresenta composição rica em SiO₂, Al₂O₃ e Fe₂O₃, atendendo aos requisitos químicos da NBR 12653 para classificação como pozolana Classe C, ademais a presença de halo amorfo no seu difratograma e a morfologia esférica com presença de partículas quebradiças vítreas confirmaram o seu potencial pozolânico. Então, a cinza pesada beneficiada possui características adequadas para ser usada em substituição parcial ao cimento Portland em argamassas, concretos e demais matrizes cimentícias, contribuindo para a redução de impactos ambientais e para o cumprimento das metas de produção e consumo sustentáveis previstas no Objetivo de Desenvolvimento Sustentável 12.

Palavras-chave: Cinza Pesada. Material Pozolânico. Sustentabilidade na Construção Civil.

RESUMEN

La creciente demanda de soluciones sostenibles en la industria de la Arquitectura, la Ingeniería y la Construcción (AIC) impulsa el uso de residuos provenientes de procesos industriales como materiales alternativos al cemento Portland—cuya producción es altamente emisora de CO₂—o en la elaboración de matrices cementicias. Entre estos residuos, se destacan las cenizas provenientes de la combustión del carbón mineral en centrales termoeléctricas, que representan un pasivo ambiental significativo. En este contexto, la presente investigación tuvo como objetivo caracterizar química, mineralógica y morfológicamente la ceniza pesada generada en la Central Termoeléctrica de Pecém (Ceará, Brasil), tras un proceso de beneficiamiento, con el fin de identificar los posibles usos de este residuo procesado. Los procedimientos metodológicos incluyeron el beneficiamiento de la ceniza mediante fragmentación granulométrica y tamizado; la determinación de la composición química por fluorescencia de rayos X; la obtención de la composición mineralógica por difracción de rayos X; y la identificación de la morfología mediante microscopía electrónica de barrido. Los resultados evidenciaron que la ceniza pesada de carbón mineral beneficiada presenta una composición rica en SiO₂, Al₂O₃ y Fe₂O₃, cumpliendo los requisitos químicos de la norma NBR 12653 para su clasificación como puzolana de Clase C. Además, la presencia de un halo amorfo en el difractograma y la morfología esférica con partículas vítreas frágiles confirmaron su potencial puzolánico. Por

lo tanto, la ceniza pesada beneficiada presenta características adecuadas para su uso como sustituto parcial del cemento Portland en morteros, hormigones y otras matrices cementicias, contribuyendo a la reducción de impactos ambientales y al cumplimiento de las metas de producción y consumo sostenibles previstas en el Objetivo de Desarrollo Sostenible 12.

Palabras clave: Ceniza Pesada. Material Puzolánico. Sostenibilidad en la Construcción Civil.

1 INTRODUCTION

The Architecture, Engineering and Construction (AEC) industry is one of the industries that consumes the most natural resources, including energy, soil and water, in addition to being responsible for significant generation of solid waste and emission of greenhouse gases [1,2]. The growing concern of this sector to become sustainable has driven the development of strategies such as the use of new technologies and sustainable materials, capable of reducing the consumption of these natural resources and promoting the proper management of the waste generated [2].

Portland *cement* is the raw material used in the manufacture of concrete, considered the most used construction material on the planet [3], consequently, cement becomes one of the most used inputs, corresponding to one of the materials that causes great negative impacts on the environment [4]. This corresponds to a hydraulic binder obtained by grinding Portland clinker, resulting from the burning at high temperatures of calcareous and clayey materials [5]. Therefore, its production method results in high carbon dioxide (CO₂) emissions, contributing to global warming and climate change. Corresponding to one of the biggest challenges for the AEC industry to become sustainable, as the need for a large amount of Portland cement goes against environmental sustainability, but the great demand for concrete production requires its use, and consequently CO₂ emissions.

In this sense, the partial replacement of Portland cement and the addition of alternative materials from the processing of solid waste to concrete is an effective strategy to reduce CO₂ emissions, as they reduce cement consumption, contributing to the AEC industry meeting Sustainable Development Goal (SDG) number 12 by 2030.

At the same time, thermoelectric plants that use coal as an energy source produce tons of waste from the combustion process of this fossil fuel and the improper disposal of this waste represents a relevant environmental problem, as it can cause contamination of soil and surface water, in addition to requiring large areas for deposition [6]. Among the residues are light ash captured in precipitation systems and heavy ash deposited at the bottom of boilers [7].

As these wastes generated by thermoelectric plants have potential for use in cement-based products [6], this research aimed to carry out the chemical, mineralogical and morphological characterization of the heavy ash generated by the Pecém Thermoelectric Power Plant, located in São Gonçalo do Amarante/CE, to identify which uses can be given to this processed waste. The relevance of this research stems from the need to demonstrate

that the techniques of characterization of materials are important to contribute to the AEC industry achieving SDG 12 regarding sustainable production and consumption, because the introduction of processed waste in new production chains only occurs correctly when its properties, determined through their characterization, contribute to the durability and technical performance of the alternative materials that will be developed with them.

2 THEORETICAL FOUNDATION

2.1 CHARACTERISTICS THAT MATERIALS MUST HAVE TO BE USED IN THE PRODUCTION OF CONCRETE TO REDUCE THE CONSUMPTION OF PORTLAND CEMENT

Materials used in the production of concrete, either as a partial replacement for *Portland* cement or incorporated directly into cement, should be classified as Supplementary Cementitious Materials (MCS). These materials consist of mineral additions that, when incorporated into *Portland* cement or employed in concrete as a partial substitute for cement, have the purpose of improving the technological performance of cementitious materials [8,9]. They must have adequate availability, economic viability and compatible technical performance, considering their chemical, mineralogical and hydration properties [10].

These materials can be classified as pozzolanic when they have pozzolanic activity, or as cementing, when they have their own hydraulic capacity, and also as *filler*, when the material does not have significant chemical activity [8]. It should be noted that limestone filler is used as MCS because it is a carbonate material chemically compatible with Portland cement, which can optimize the packaging of particles and reduce the water content, resulting in better mechanical properties of the composite [11]. Limestone *filler* falls under the definition of MCS because NBR 12653 [12] allows fine mineral materials, even without significant chemical reaction, to be used to supplement cement performance.

Table 1 presents the characteristics that MCSs may possess according to their classification.

Table 1

Characteristics of the different MCSs that are added to composite cement. Source: Adapted from Neville (2016)

Material	Cementitious Characteristic
Granulated blast furnace	Latent hydraulicity, sometimes hydraulic

slag	
Natural pozzolan (class N)	Latent hydraulicity with <i>Portland cement</i>
Siliceous flywheel ash (Pozzolan class F)	Latent hydraulicity with <i>Portland cement</i>
High limescale fly ash (Pozzolan class C)	Latent hydraulicity with <i>Portland cement</i>
Silica fume (Artificial Pozzolan)	Physical action, to a large extent, and latent hydraulicity with <i>Portland cement</i>
<i>Limestone filler</i> (Inorganic material)	Physical action but mild latent hydraulicity with <i>Portland cement</i>

Meanwhile, inert materials are not considered MCS [13], such as powdery waste generated in the extraction and processing of quartzite according to the parameters of NBR 12653 [12].

2.1.1 Pozzolans

Pozzolans are siliceous or silice-aluminous materials that, although they have little or no agglomeration capacity alone, when finely ground react chemically with lime in the presence of water, forming stable compounds with cementing properties, and materials that are by themselves binders are not included in this category [14].

Pozzolans are materials that have pozzolanic activity [8]. This activity refers to the ability of siliceous or silicoaluminous materials to react with calcium hydroxide (Ca(OH)_2) in the presence of water, forming hydrated calcium silicate (C-S-H), which are compounds with cementitious properties and contribute, for example, to the increase of compressive and flexural strength, to advanced ages, to the increase of resistance to sulfates and reduction of porosity and permeability, when added to concrete, mortars and pastes [12].

Several materials can present pozzolanic activity, such as silica fume, natural pozzolans and fly ash [8]. NBR 12653 [12] determines that in order to qualify as Class N (natural and artificial pozzolans), Class C (fly ash produced by the burning of mineral coal in thermoelectric plants) and Class E (any pozzolans, not included in classes N and C) the material must comply with the physical and chemical requirements established in Table 2.

Table 2

Chemical and physical requirements for pozzolanic materials

Chemical Requirements (%)	Pozzolanic Material Class		
	N	C	E
SiO ₂ +Al ₂ O ₃ +Fe ₂ O ₃	≥ 70	≥ 70	≥ 50
SO ₃	≤ 4	≤ 5	≤ 5
Moisture content	≤ 3	≤ 3	≤ 3
Loss to fire	≤ 10	≤ 6	≤ 6
Alkalis available in Na ₂ O	≤ 1.5	≤ 1.5	≤ 1.5
Physical Requirements (%)	Pozzolanic Material Class		
	N	C	E
Material retained in the sieve 45 µm	< 20 %	< 20 %	< 20 %
Performance index with <i>Portland cement</i> at 28 days, in relation to the control	≥ 90 %	≥ 90 %	≥ 90 %
Pozzolanic activity with lime at seven days	≥ 6 MPa	≥ 6 MPa	≥ 6 MPa

Source: Adapted from NBR 12653 (ABNT, 2014)

Because they are generally by-products of different industrial processes, pozzolanic materials such as silica fume and fly ash can present great variability in their characteristics, depending on the region of origin and production conditions [15].

2.1.2 Latent cementitious activity materials

Materials with latent cementitious activity, or cementing, are those that have the ability to form hydrated products, in a similar way to Portland cement [16]. One of the main materials of latent cementitious activity is blast furnace granulated slag, which is a by-product of the pig iron production process, obtained by sudden cooling that generates a glass phase composed mainly of calcium silicates and aluminosilicates [5].

The reactivity of blast furnace slag depends on its chemical composition, fineness, and vitreous phase content, as these are factors that control its solubility and the formation of hydrated products, characteristics necessary to promote some type of physical, chemical, or thermal activation capable of overcoming its naturally slow hydration and allowing its effective use as a cementitious material [17].

2.2 INERT MATERIALS – FILLER EFFECT

Filler is a finely divided material that does not have chemical activity, being inert, but promotes the physical effect of packaging, in which very fine particles fill the voids between the larger particles, favoring the densification of the cement paste and the nucleation of the hydration products [15,18].

According to Mehta and Monteiro, these materials cannot be used as a substitute for *Portland cement*, but they can be used in the manufacture of concrete as a partial substitute for fine aggregate, contributing to improve the packaging of the cementitious matrix and promoting better mechanical behavior [13].

Powdery materials that do not have pozzolanicity or cementing activity, but have sufficiently fine granulometry, can be used to promote the filler effect in concretes and mortars (cementitious matrices) [19]. The main result of this effect is the increase in the compactness of the mixture, promoted by the incorporation of fine and ultrafine particles, which optimize the particle size distribution and improve the densification of the cementitious matrix [9].

2.3 IMPORTANCE OF USING COAL ASH

The relevance of investigating and promoting the use of ash as a partial substitute for *Portland cement* lies in two crucial challenges: promoting industrial waste management and mitigating the carbon footprint of the AEC industry. According to Bertolini, the burning of fossil fuels generates carbon dioxide (CO₂), which, although not an immediate risk to human health, its large-scale release is a significant factor contributing to the worsening of the greenhouse effect [20].

Portland cement is produced from calcareous and clayey raw materials, and can incorporate additions, and its production involves high-temperature processes, reaching approximately 1450 °C [18]. In this context, the use of coal ash emerges as a relevant strategy, as it allows reducing the extraction of natural resources.

In addition, these ashes can be incorporated into new production chains, such as in the manufacture of bricks, paving, environmental barriers and ceramic products, as long as their properties are properly defined in the processing process. This is because, as highlighted by Mehta and Monteiro [13], the materials used in the production of concrete must be characterized, as the properties of concrete depend directly on the properties of its constituents. Therefore, characterizing each material is essential to predict the performance of concrete in the fresh and hardened state [19].

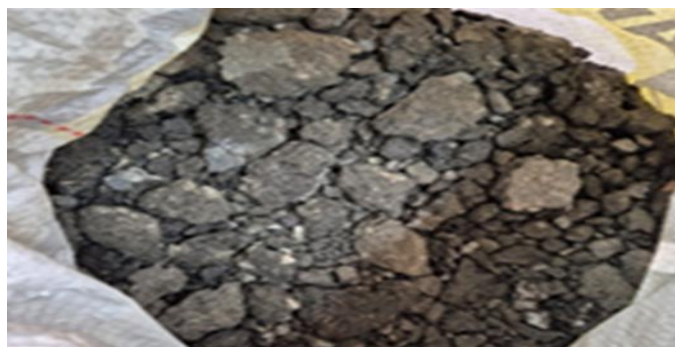
3 MATERIALS AND METHODS.

3.1 MATERIAL

The material used in this research was ash from the coal burning process at the Pecém Thermoelectric Power Plant (UTE Pecém), located in the municipality of São Gonçalo do Amarante/CE. Precisely, the bottom ash (Figure 1), which corresponds to the coarsest fraction of the waste generated in the combustion of coal. It is noteworthy that it receives this name because its granulometry does not allow them to rise with the gases and ends up accumulating at the bottom of the furnace because it is heavy.

Figure 1

Gray background generated by the Pecém TPP. (Authors, 2025)



3.2 METHODS

The methodology adopted in this research followed the workflow presented in Figure 2.

Figure 2

Workflow adopted in the research (Authors, 2025)



3.2.1 Processing

The coal ash collected at the Pecém TPP was benefited through: processes of reduction of the size of its particles and sieving in ABNT sieve number 200. The fragmentation of the particles occurred in the Los Angeles Abrasion machine of the Asphalt Mixtures Laboratory of the Federal Rural University of the Semi-Arid (UFERSA/Mossoró), using 12 spheres for an approximate period of 20 minutes. The processed ash remained in the granulometry of powdery material (Figure 3).

Figure 3

Pecém ash after processing in the laboratory. (Authors, 2025)



3.2.2 Chemical Characterization

The chemical composition of the processed ash was determined by X-ray fluorescence spectrometry (XRF), a technique that is based on the principle of X-ray absorption by the material, which causes the internal ionization of the atoms and generates a characteristic radiation known as "fluorescence". The test was carried out in a Universal Machine, a Shimadzu EDX 720 spectrometer, at the Materials Technology Laboratory (LTM) of the Federal University of Campina Grande (UFCG).

To determine the volatile material content of the processed waste, the *Loss on Ignition* test was carried out at a temperature of 1050 °C at a level of 2 hours, this took place at the Wood Technology Laboratory of UFERSA/Mossoró.

3.2.3 Mineralogical Characterization

The mineralogical characterization was obtained by means of the X-ray diffraction (XRD) technique. This technique is based on the interaction of X-radiation with the crystalline arrangement of the material, resulting in characteristic diffraction patterns that allow the identification of the mineral phases present. A Shimadzu XRD-6000 diffractometer was used,

equipped with CuK α radiation, operating at a voltage of 40 kV and a current of 30 mA, in fixed *time scan mode*, with a step of 0.02°, a counting time of 0.6 s, and a scanning range of 5° to 60° with a 2 θ angle. The trial was carried out at the LTM of UFCG.

3.2.4 Morphological and surface characterization

The morphological and surface analysis of the processed ash was performed by Scanning Electron Microscopy (SEM) at the Electron Microscopy Laboratory of the Center for Research in Plant Sciences of the Semi-arid Region (CPVSA) of UFERSA/Mossoró. The equipment used was TESCAN model VEGA 3, with an electron beam voltage of 30 kV, in different resolutions, expanding in 5kx, 10kx, 25kx, 40kx with a scale that varies according to the magnification (1 μ m; 2 μ m, 5 μ m and 10 μ m).

4 RESULTS AND DISCUSSIONS

4.1 CHEMICAL CHARACTERIZATION

Table 3 shows the chemical composition of the processed coal ash.

Table 3

Chemical composition of the processed coal ash. (Authors, 2025)

OXIDES	%
SiO ₂	53,04
Al ₂ O ₃	22,04
Fe ₂ O ₃	9,38
CaO	4,43
SO ₃	2,22
K ₂ O	2,03
Na ₂ O	1,95
MgO	1,50
TiO ₂	0,84
BaO	0,70
SrO	0,15
MnO	0,05
ZrO ₂	0,04
Rb ₂ O	0,01
Y ₂ O ₃	0,00
CO ₂	0,00
PF	1,64

*FP = Loss to Fire

Table 3 shows that the processed coal ash is mainly formed by silica (SiO_2) and alumina (Al_2O_3), and these substances are responsible for its pozzolanic reactivity when used as a partial substitute for *Portland cement* in concrete. It complies with NBR 12653 [12], regarding $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3 \geq 70$ (84.46%); $\text{SO}_3 \leq 5$ (2.22%) and $\text{PF} \leq 6$ (1.64%).

4.2 MINERALOGICAL CHARACTERIZATION

Figure 4 shows the diffractogram of heavy coal ash after processing.

Figure 4

Diffractogram of the processed heavy ash. (Authors, 2025)

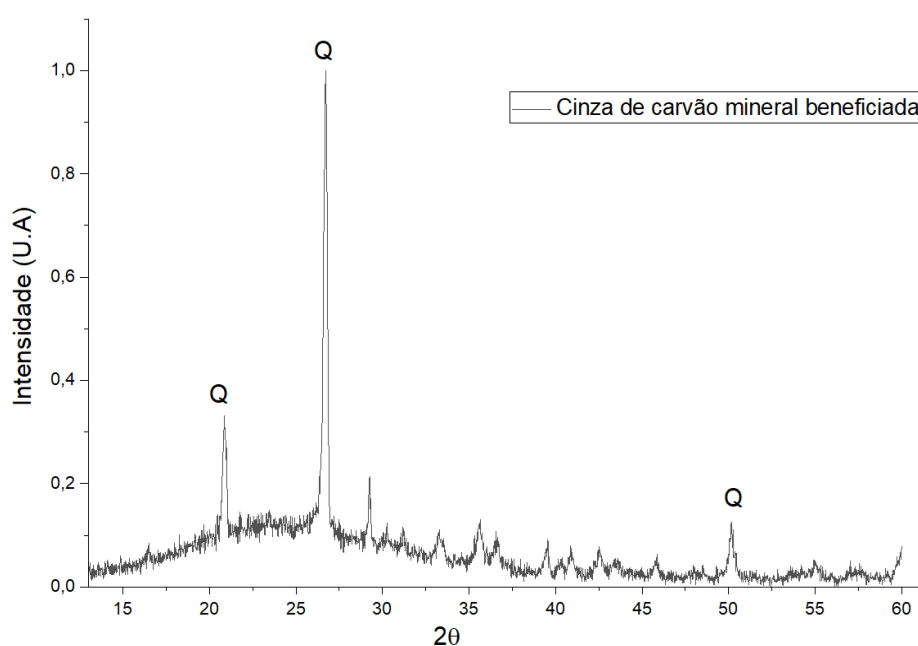


Figure 4 shows the formation of an amorphous halo between 15° and 40° , indicative of pozzolanic activity of the material, in addition to crystalline quartz peaks that are formed in the burning of coal at temperatures below 1000°C . The result obtained in the diffractogram is similar to that achieved by Cirino *et al.* [21] for light gray and not to those obtained by him for heavy gray (background gray). It is believed that this fact occurred because there was a reduction in the particle size of heavy ash in *the Los Angeles* abrasion and 200 mesh screening, making the material lighter.

4.3 MORPHOLOGICAL AND SURFACE ANALYSIS

Figure 5 presents the micrographs obtained for different magnifications, which allow a better morphological and surface visualization of the material studied.

Figure 5

a) Micrograph - Magnification of 4.99 kx b) Micrograph - Magnification 20.0 kx. (Authors, 2025)

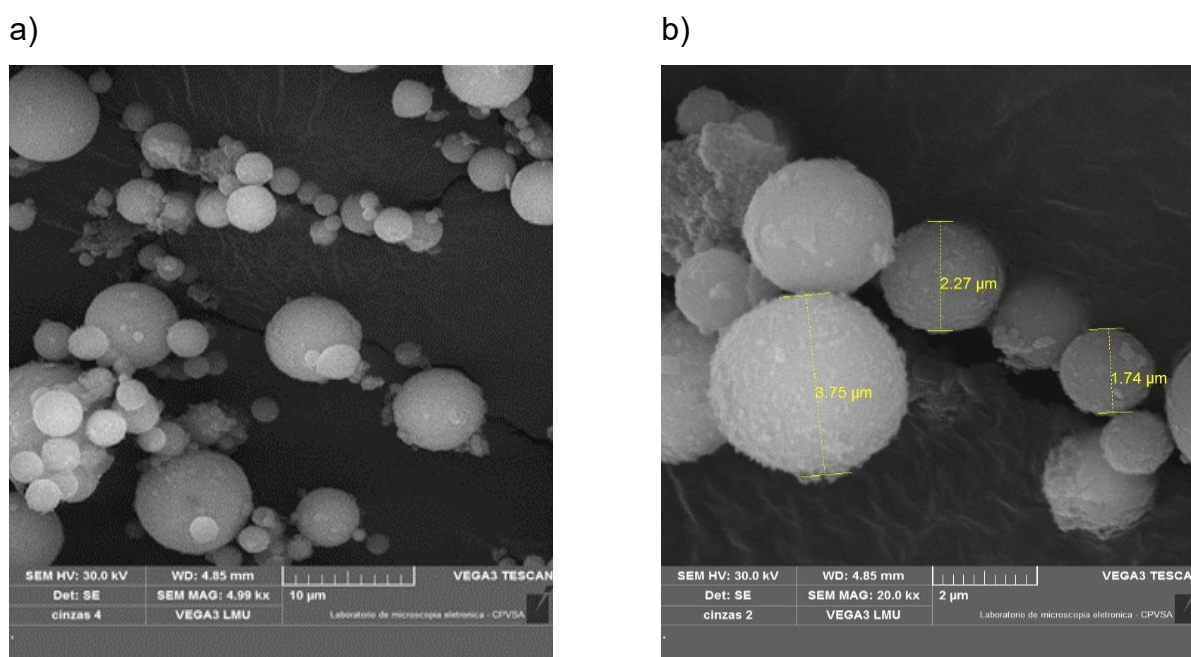


Figure 5a presents a low magnification, i.e., it shows the microstructure of the processed coal ash 4,990 times larger than its actual size. It shows its general morphology, which is made up of a diversity of spongy spherical particles.

While, Figure 5b shows the same material, but 20,000 times larger than the actual size. This makes it possible to verify the presence not only of spongy spherical particles but also of brittle and irregular particles formed from the aluminosilicate vitreous matrix. This fact indicates a mixture of crystalline and amorphous phases, corroborating the results obtained in the mineralogical characterization.

Figure 5b also shows the average sizes of the spherical particles that constitute the material studied, and that these are variable, with particles of diameter 1.74 μm , 2.27 μm and 3.75 μm . The morphology found is spherical with brittle particles. It is important to highlight that when there is the presence of spherical morphology, there is a tendency for grain sliding, a fact that can increase the workability and fluidity of cementitious compounds, according to

Cirino et al. [21].

5 FINAL CONSIDERATIONS

According to the research carried out, it is concluded that the heavy ash from the Pecém/CE Thermoelectric Plant, after undergoing processing, is classified as pozzolanic material belonging to class C according to NBR 12653. In addition, it has a spherical morphology with the presence of vitreous brittle particles, which gives it better reactivity when used in cementitious matrices, providing improvement in the properties of the construction materials made with it.

The formation of the amorphous halo in the diffractogram of the processed heavy ash corroborates the results obtained in the chemical characterization and the morphology presented, as it is indicative of pozzolanic activity of the material studied.

In view of the reactivity of the material, it is inferred that the processed heavy ash can be used in the manufacture of mortars, concretes and other cementitious matrices in partial replacement of *Portland* cement because it belongs to class C, which corresponds to materials with hydraulic/pozzolanic reactivity, thus contributing to promote the gain in strength and durability of the products made with it.

Finally, it is also concluded that this processed waste, in addition to promoting gains in the properties of mortars, concretes and other cementitious matrices, can have an adequate final destination when it is inserted in the production chain of cementitious matrices used in the construction processes of the Architecture, Engineering and Construction industry. In this way, contributing to the reduction of environmental impacts and to the fulfillment of the sustainable production and consumption goals set out in SDG 12.

ACKNOWLEDGMENT

Thanks to AAMEG UFERSA for the grant to the first author. To the coordinators of the Materials Technology Laboratory of the Academic Unit of Materials Engineering of the Center for Science and Technology of the Federal University of Campina Grande – PB for the partnership established that allowed the obtaining of important analyses to obtain the results of this research.

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**OPTIMIZING COMPUTATIONAL EFFICIENCY AND SECURITY-BY-DESIGN
CODE SECURITY IN LARGE LANGUAGE MODEL PIPELINES: COMPARATIVE
ANALYSIS OF INFERENCE COSTS**

**OTIMIZAÇÃO DA EFICIÊNCIA COMPUTACIONAL E SEGURANÇA DE CÓDIGO
POR PROJETO EM PIPELINES DE MODELOS DE LINGUAGEM DE GRANDE
PORTE: ANÁLISE COMPARATIVA DE CUSTOS DE INFERÊNCIA**

**OPTIMIZACIÓN DE LA EFICIENCIA COMPUTACIONAL Y SEGURIDAD DEL
CÓDIGO POR DISEÑO EN GRANDES CANALIZACIONES DE MODELOS DE
LENGUAJE: ANÁLISIS COMPARATIVO DE LOS COSTOS DE INFERENCIA**

 <https://doi.org/10.56238/sevened2025.036-117>

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José Baptista⁵**

ABSTRACT

Large Language Models (LLMs) have revolutionized software engineering by generating code rapidly and accurately across a wide range of programming tasks. However, the growing reliance on these models raises concerns regarding their energy consumption, runtime overhead, and the efficiency of achieving successful, security-by-design, and maintainable code. This article presents an analytical comparison of several leading LLMs—such as OpenAI’s GPT series, Anthropic’s Claude, Meta’s Llama, and Google’s Gemini—by evaluating their success rates in producing secure and optimized code, the number of prompts required for successful output, and the corresponding computational and energy costs. The findings emphasize strategies to balance accuracy, performance, and sustainability in LLM-assisted programming.

Keywords: LLMs. Energy Efficiency. Cybersecurity. Security-by-design. Optimization.

RESUMO

Os Grandes Modelos de Linguagem (LLMs) revolucionaram a engenharia de software ao gerar código de forma rápida e precisa em uma ampla gama de tarefas de programação. No

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entanto, a crescente dependência desses modelos levanta preocupações quanto ao seu consumo de energia, sobrecarga de tempo de execução e à eficiência na obtenção de um código bem-sucedido, seguro desde a concepção e de fácil manutenção. Este artigo apresenta uma comparação analítica de vários LLMs líderes — como a série GPT da OpenAI, Claude da Anthropic, Llama da Meta e Gemini do Google — avaliando as suas taxas de sucesso na produção de código seguro e otimizado, o número de prompts necessários para uma saída bem-sucedida e os custos computacionais e energéticos correspondentes. As conclusões enfatizam estratégias para equilibrar precisão, desempenho e sustentabilidade na programação assistida por LLM.

Palavras-chave: LLMs. Eficiência Energética. Cibersegurança. Segurança por Design. Otimização.

RESUMEN

Los Grandes Modelos de Lenguaje (LLM) han revolucionado la ingeniería de software al generar código de forma rápida y precisa en una amplia gama de tareas de programación. Sin embargo, la creciente dependencia de estos modelos genera inquietudes respecto de su consumo de energía, la sobrecarga en tiempo de ejecución y la eficiencia para lograr un código exitoso, seguro por diseño y mantenible. Este artículo presenta una comparación analítica de varios LLM líderes, como la serie GPT de OpenAI, Claude de Anthropic, Llama de Meta y Gemini de Google, evaluando sus tasas de éxito en la producción de código seguro y optimizado, el número de indicaciones necesarias para obtener un resultado satisfactorio y los correspondientes costes computacionales y energéticos. Los resultados ponen de relieve las estrategias para equilibrar la precisión, el rendimiento y la sostenibilidad en la programación asistida por LLM.

Palabras clave: LLMs. Eficiencia Energética. Ciberseguridad. Seguridad por Diseño. Optimización.

1 INTRODUCTION

The need to reduce costs and improve efficiency is a necessity of modern times. Code security and efficiency is critical for the best usage of required systems and functionalities that require less runtime and less energy expenditure. The focus of this analysis is conducted mainly on the parameters mentioned above, in order to determine if both of them can be lowered without sacrificing models resourcefulness and quality, therefore making sure that the desired output of a correct, error free code and the development of secure-by-design systems, can be achieved without having many losses in time, energy, code efficiency, and security. The effective need of having the safety and efficiency of the code generated by an LLM are the priority in this matter, however, the analysis of the cost-benefit ratio is also important for large scale programs that work with large data sets, making sure that no error occurs, and if it does, that the code refactoring is done appropriately and quickly, saving energy and time.

The motivation for the realization of this work is centered around the need for better management of good coding practices, as well as the need to analyze the resulting costs of the used energy and time spent working on providing possible code-refactoring solutions. This theme is relevant today as the demand for reliable, emission-free energy is increasingly urgent. Without one, the need to reduce costs and augment efficiency is critical for the well management of society nowadays. Therefore, the analysis of the objectives mentioned above, as well as the possible comparison between some LLMs, is highly needed to understand and make a full comprehensive use of the capabilities of the tools at hand in order to achieve the best possible result with low-cost performance (Bhatt, 2025).

2 METHOD

In this investigation, an initial analysis of recent and relevant literature was conducted, which sought both to identify the articles to be studied in technology and the usage of AI for the best possible code output with as few errors as possible, whilst maintaining energy efficiency and low runtime overhead. The process of evaluation and interpretation of the reflections placed on the selected bibliographic material was made over selected articles that made comparisons between different LLM models, as well as the study of spent energy resources when refactoring or generating specific code.

(I) Efficient, faster coding to increase success rates

The need to enhance and improve the coding methods and speed has always been a much regarded need in tech. Nowadays, LLMs combined with agentic AIs can reduce time strains and make apps, programs and websites in a matter of minutes, in comparison to a human developer. However, since the models are not perfect, the code can contain some noticeable errors that a good developer would not make, even if it takes them longer to develop the software in question. Another impactful parameter when generating good and efficient code is a well written prompt that the model will be able to process with a more degree of precision, without the need to deviate from the objective at hand. Different prompt strategies may be implemented when using LLMs to determine the success rate that one can output, as an example, the comparison of the success rates of six different prompt strategies was made on GPT-4, as well as other LLMs, showing the difference in the number of attempts, as well as the change in the degree of difficulty of the tasks themselves (Hou, 2024).

Another control parameter that should be considered is the self-planning code generation that we can implement using LLMs. The self-planning phase can be done by matching the intent with the plan therefore not only giving the initial prompt of what the user wants the LLM to do but also indicating step by step specifically what the LLM needs to do therefore the output should be a lot cleaner and a lot more accurate than if it was only with the initial prompt without any guidance (Jiang, 2023; Ye, 2025). Another technique involving a Large language model Aware selection approach for In-context-Learning based code generation named LAIL, is also to be considered for the remarkable improvements in generating desired programs, outperforming state-of-the-art baselines by considerable amount (Li, 2023). This new approach uses other LLMs To select a positive or negative example for requirement, this means that other LLMs are responsible for the ultimate outcome of LAIL.

(II) Measuring energy and emissions in ML

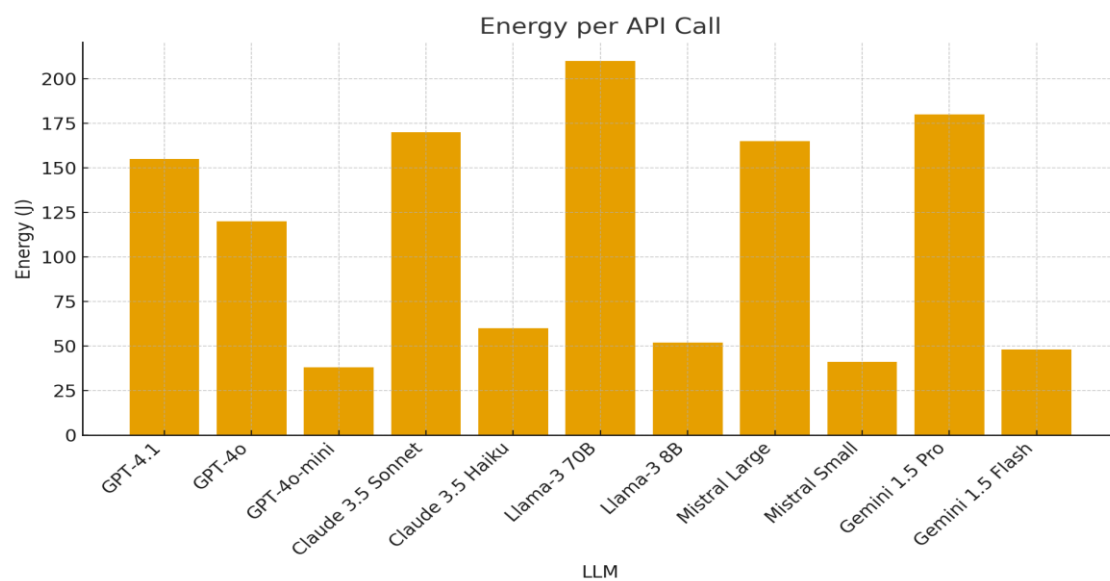
The environmental costs that training an LLM have are significant. Dozens of hundreds of tons of CO₂ are just a simple fact of the cost of training and LLM, not to mention the expenditure and energy. An example of that is the LLM Bloom which generated 24,7 and 50,5 tons of CO₂ (Luccioni, 2022; Jiang, 2024; Singh, 2024). The training costs of LLMs are indeed significant, however inference, the process of responding to user queries is where costs ultimately increase exponentially and the environment is more affected. One query on ChatGPT is estimated to cause an emission of 4 grams of CO₂ more than 20 times more

than one web search. The reduction of carbon footprint when training/using LLMs has been largely overlooked, therefore the need to make responsible advancements to reduce carbon emissions prioritizing the environment without decreasing efficiency when using LLMs is a needed directive for the future (Wu, 2025; Ding, 2024; Ozcan, 2025).

To show an initial example of a small sample of models, in terms of energy per API call that the models represented in Figure 1. This shows us that there is a certain amount of energy that is used whenever we prompt the model to obtain a relative output. We can also infer from this that the largest models use the most amount of energy, whereas the smaller models use the least amount.

Figure 1

Energy per API Call Model Comparison

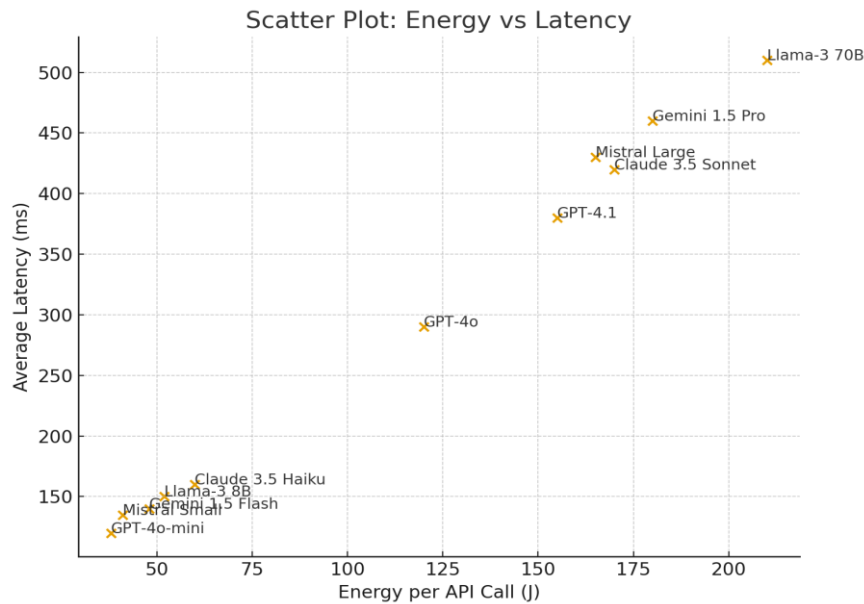


Source: Produced by the author, 2025.

As can be observed on Figure 2 again, the largest models consume the highest amount of energy per API call and have the largest response time, whereas the low parameter models are the opposite. If the objective is to be truthful to energy efficient models, then we cannot use LLMs. However compressed LLMs can provide results with near equal success rate in comparison to uncompressed LLMs while spending less energy per API call and taking less time.

Figure 2

Energy vs Latency Model Comparison

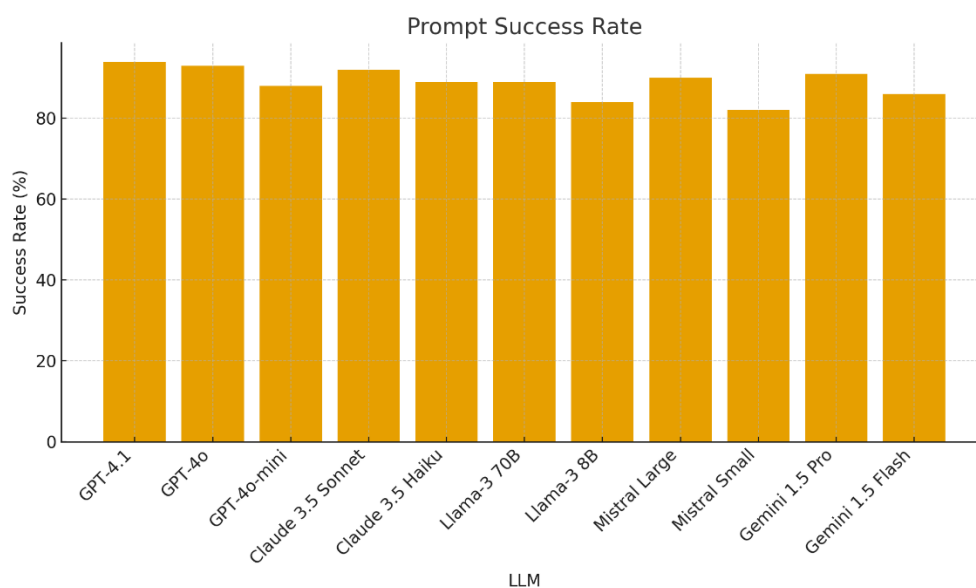


Source: Produced by the author, 2025.

As can be seen, Figure 3, the prompt success rate doesn't differ much from model to model, only on more complex prompts can relevantly differences from model to model.

Figure 3

Prompt Success Rate Model Comparison

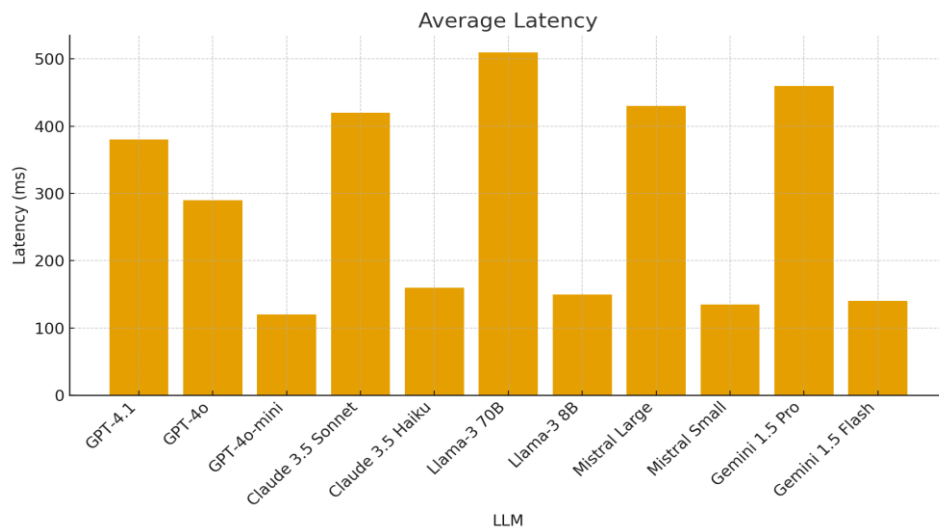


Source: Produced by the author, 2025.

Prompt success rate is considered the capability of an LLM to complete the task given by the used in a single prompt with no additional guidelines/instructions on any other prompts. However, in Figure 4 it can be observed, in a much more comprehensive manner, that latency differs from models with more parameters in comparison to models with less parameters.

Figure 4

Average Latency Model Comparison



Source: Produced by the author, 2025.

(III) Model selection & architecture choices

Model selection and Architectural choices are important for achieving a more accurate LLM. Studies indicate that 7B and 13B models can achieve high accuracy rates despite having lower parameters and in token usage. The more tokens are used in inference processes the more energy will be consumed for the expected output. Not only this but there's also a need to reduce the latency of said inference. The idea is that the usage of less tokens per second over a large share batch size as well as over time becomes less and less, therefore reducing the associated energy costs and carbon footprint (Bian, 2025; Yuan, 2025).

There's also the possibility to use a mixture of experts' architecture for better and faster reasoning from LLMs. This consists of a router that redirects tokens to the experts, specialized sub-networks, that handle different parts of the problem, weighing them to give a more accurate and precise output (Yuan, 2025). This approach is one of the most energy saving options that we must consider, since it disperses energy for more selected and unique parts of processing and comprehension whereas beforehand one would need to access an

entire LLM for just a simple query. With this method only parts of an LLM need to be accessed to generate a viable and accurate response. The more complex the mending process, more parts will need to be accessed in order to be accurate and therefore achieve a proper output.

The consideration of smaller language models to achieve low latency while maintaining the same level of accuracy as larger models is noticeable, inference and token utilization are also kept low therefore the need to use less memory is also noticeable. For problem specific questions/objectives the 7B parameters LLMs are an option to be considered, they can even be used to train larger LLMs with 70B or 150B parameters. This takes into consideration the rate of accuracy and success when responding to user inputs. However, the degree of accuracy and detail on a response needs to be followed with reduction and energy costs.

(IV) Runtime Optimizations

Runtime optimizations are important to consider reducing time spent and energy spent with reasoning. Quantization is an important technique to consider for improving model memory footprint and keeping model accuracy. Post training quantization reduces inference compute by up to 3x-4x, with no noticeable performance loss. The knowledge distillation technique relies on smaller models teaching larger ones, therefore reducing costs associated with processing information and reducing runtime overhead, as well as cutting costs by 70% (Xiao, 2023; Ganesh, 2024).

The early exit technique allows the reduction of execution time, therefore being an interesting aspect to consider when wanting to lower energy costs. The technique consists in reducing the time of reasoning by verifying the threshold of said reasoning and when the threshold achieves a desired percentage (40-70%), the reasoning will stop, and an answer will be given. This method benefits simpler, less complex input prompts from the user, reducing overall run time overhead and lowering energy costs by 23-50% but also lowering response time (Ilager, 2025).

(V) Hardware & Infrastructure Choices

Hardware selection is a fundamental prospect that needs to be considered when establishing new LLM training routines. GPUs are the standard for LLM inference, however special accelerators such as TPUs, AWS Inferentia, and other emerging AI specific Asics, can also achieve a high energy efficiency per token processed. The need to develop new customized accelerators has been a modern advancement made by companies like Google, to improve speed and energetic efficiency on LLMs (Li, 2024; Chowdhery, 2022). Tensor

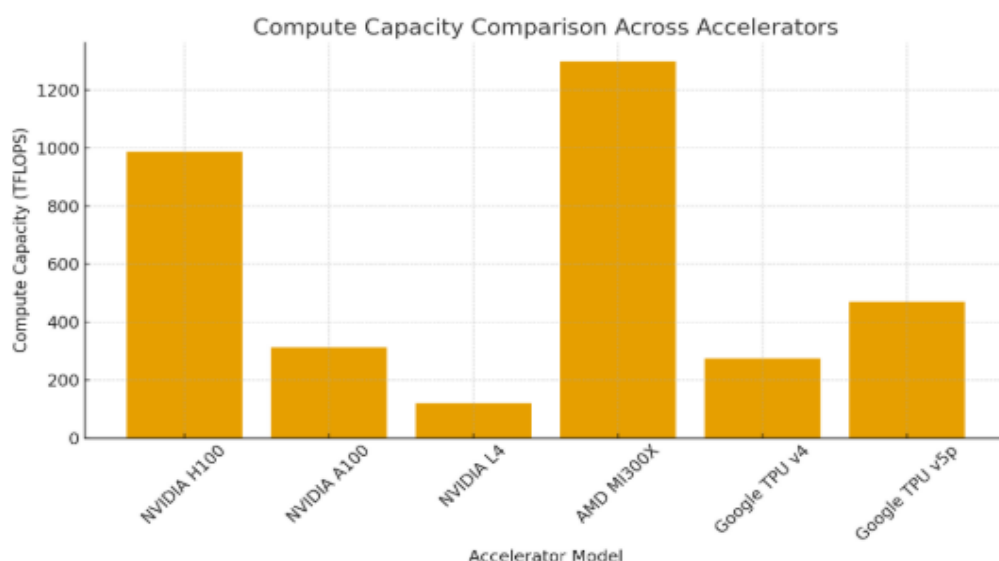
model parallelism is another method to improve overall processing on the LLM by creating different partitions of the weights and then concatenating them to achieve the desired output. This is done so that there is less strain on memory. The most commonly used format is the Megatron LM, which is used on LLM's with 50-70b parameters, however, the latency increases with this technique, however the precision and scalability increase as well. (Narayanan, 2021).

An important note to take into account is that energy efficiency per token is referring to long-term usage since we are discussing LLMs that is the main crucial point that we need to take into account when we speak about energy efficiency we need to consider a long-term options instead of short-term ones, reliability needs to be achieved, for that to consideration of accuracy and precision as the core and primary motivators for such research needs to be invoked. After that, the need for energy efficient solutions must be pursued. the next Figures will show the difference in energy as well as cost efficiency between certain GPUs and TPUs, as well as inference latency comparison, so that inadequate study of such values can be done.

In Figure 5 shows the difference from several GPUs and TPUs in compute capacity. This is meant to illuminate regarding the Tensor Processing Units which ultimately cost more energy to run, as well as working with a different architecture than a GPU. The biggest bars in this Figure are of the GPUs.

Figure 5

Compute Capacity Comparison Across Accelerators

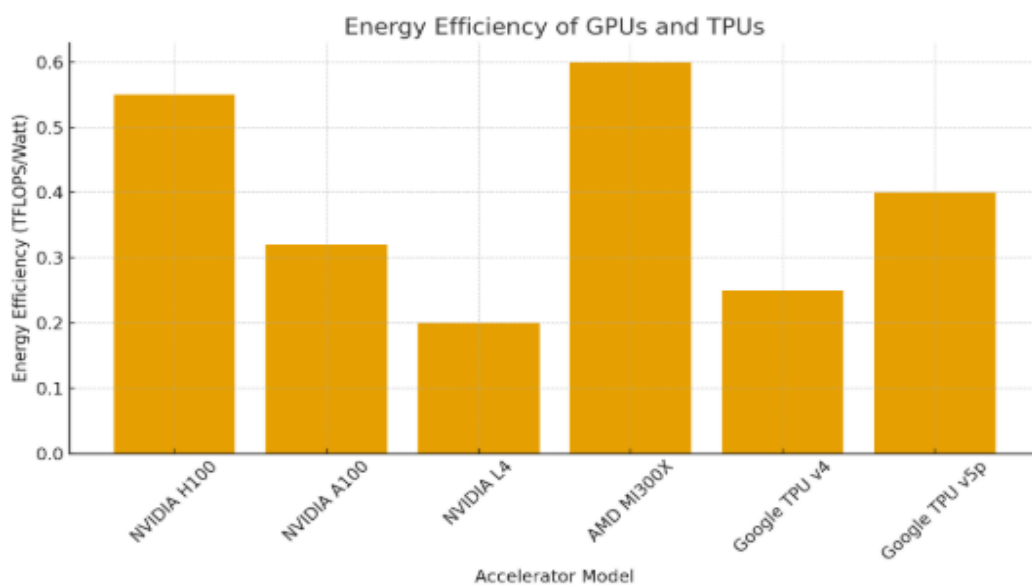


Source: Produced by the author, 2025.

The Figure 6 shows the difference between GPUs and TPUs regarding Energy Efficiency. Due to the specific design of a TPU, the usage of energy is more controlled since only some parts of the architecture are chosen to run the models themselves, this makes it a much more energetically efficient strategy to reduce the carbon footprint associated with LLMs

Figure 6

Energy Efficiency of GPUs and TPUs

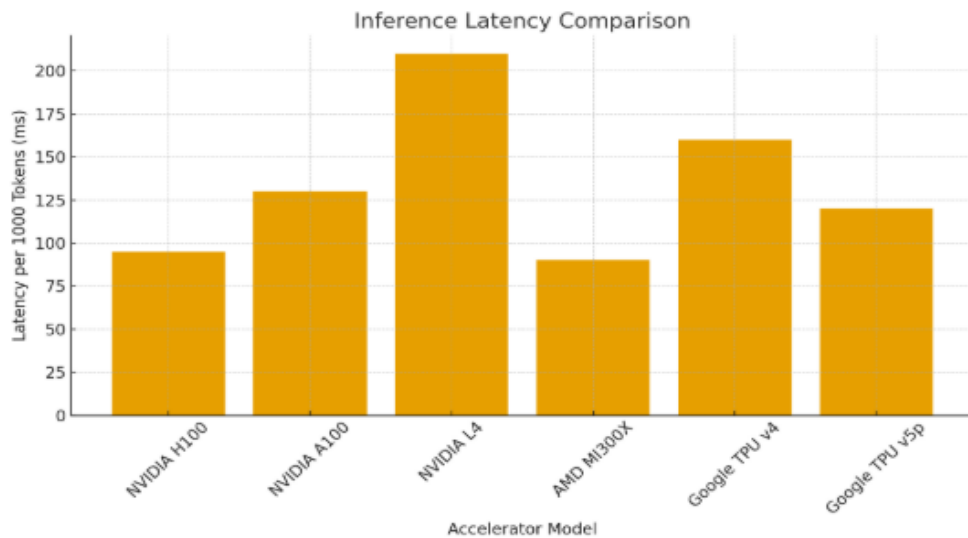


Source: Produced by the author, 2025.

In Figure 7 is meant to show the inference to latency comparison between GPUs and TPUs. It can be observed that since the customized architecture of a TPU is more energy friendly the latency will therefore increase. The division of weights for this architecture is the main concern when it comes to latency issues, for the concatenation of the weights needs to be done so that the overall output can be accurate and precise. On the other hand the GPUs have less latency and more power expenditure.

Figure 7

Inference Latency Comparison



Source: Produced by the author, 2025.

(VI) Secure and Clean Code Practices to Reduce Overhead

There's now more than ever an urgent need to write good, polished, clean and secure code, not only to avoid critical errors but also to maintain good security measures on websites, but also for the development of security-by-design systems, as well as to avoid possible bugs/errors in the future of a critical piece of software. Code reusability as well as revision and maintenance, are all important and for that, code needs to be written in a manner that generally can be well perceived by anyone that works with writing or reading code (Hunter-Zinck, 2021; Digkas, 2020).

Azure guidelines provide a set of best practices to build secure, scalable, clean and maintainable as well as cost-efficient applications. These guidelines are important because they are also applied in AI pipelines as well as LLMs. The figures below are meant to illustrate the difference between good and bad coding.

The Figure 8 shows code that loads and sends entire logs with a massive token usage, allowing for the user to input information that can be out of context or just not need it therefore making latency time higher as well as energy costs. Figure 9 shows a clean code that determines the length of the input therefore giving it a smaller token window lowering energy cost and allowing for a faster runtime.

Figure 8

Bad coding example #1

```
# Sends full logs, large unfiltered text, unnecessary context
prompt = f"""
User Input:
{user_input}

System Logs:
{open("server.log").read()} # HUGE FILE LOADED EVERY REQUEST

Debug Info:
{debug_info}

Please answer the question.
"""

response = call_llm(prompt)
```

Source: Produced by the author, 2025.

Figure 9

Good Coding Example #1

```
def sanitize(text: str) -> str:
    return text.strip()[:1000] # cap input to 1000 chars

prompt = (
    "Answer concisely. User message:\n"
    f"{sanitize(user_input)}"
)

response = call_llm(prompt)
```

Source: Produced by the author, 2025.

In Figure 10 shows code that just attaches the results meaning every single request made from a user into an LLM, whereas Figure 11 routes input query from the user adding a length to the input and then rerouting it to a small LLM if it meets that criteria or to a large LLM if it meets other criteria this allows for faster queries so lower latency reducing overhead runtime from 50 to 80%.

Figure 10*Bad Coding Example #2*

```
# Every request uses GPT-4-class model regardless of complexity
result = llm_large.generate(user_query)
```

Source: Produced by the author, 2025.

Figure 11*Good Coding Example #4*

```
def route_request(query):
    if len(query) < 80:
        return llm_small.generate(query)
    return llm_large.generate(query)

result = route_request(user_query)
```

Source: Produced by the author, 2025.

(VII) Case Studies & Worked Examples

Real world deployments of LLMs, like Llama-3 series models, provide estimates of inference energy per 1k tokens. Meta's Llama-3 Shows that a 70B-parameter model consumes several times more energy than a fine-tuned 8B model, while the smaller one still performs adequately for many domain-specific applications. Another example, is a noticeable energy reduction of almost 100 Joules per API call is OpenAI's GPT-4o Mini, compared with GPT-4o (OpenAI, 2024; Meta AI, 2024).

3 CONCLUSION

The initial analysis presented throughout this chapter demonstrates that reducing energy consumption and runtime overhead in LLM-assisted software development is both technically feasible and essential for sustainable computational practices. Modern Large Language Models, such as GPT-4o, Claude 3, Llama-3, and Gemini, offer extraordinary capabilities for generating secure, clean, and efficient code, yet their performance must be weighed against the significant environmental and computational costs associated with large-scale inference. As shown through recent scientific studies, smaller or optimized models (7B–13B parameters), quantized architectures, mixture-of-experts routing, early-exit reasoning,

and hardware-aware deployment strategies can collectively reduce energy consumption by 50–80% without compromising accuracy or security.

The review also reinforces that prompt engineering, self-planning strategies, and LLM-aware selection frameworks such as LAIL significantly increase code-generation success rates while minimizing the number of model calls required—directly reducing energy expenditure. Likewise, secure and clean code practices, backed by Azure’s engineering guidelines, show that well-structured, modular, and token-efficient code pipelines contribute meaningfully to reducing computational overhead. In parallel, empirical case studies confirm that the shift from monolithic 70B-parameter systems to distilled or specialized smaller models results in dramatic gains in efficiency, lower emissions, and improved maintainability, especially when caching, batching, and routing mechanisms are included.

Ultimately, this chapter highlights that the path toward sustainable AI-assisted programming relies on a holistic approach: combining model-level optimizations, careful choice of architecture, infrastructure-aware deployment, low-overhead prompt strategies, and strict adherence to secure coding principles, such as security-by-design software development. By integrating these practices, developers can aim to achieve high-quality, error-free code while simultaneously lowering carbon footprints, operational costs, development of security-by-design systems and avoiding runtime inefficiencies. As the technology continues to evolve, responsible model usage—focused on accuracy, energy efficiency, security and long-term sustainability—must become a central pillar of modern software engineering.

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**THE “PARAREALITY” OF A “PARALLEL BRAZIL”: COULD THIS
COMMUNICATION AGENCY BE A THINK TANK?**

**A “PARARREALIDADE” DE UM “BRASIL PARALELO”: SERIA ESTA AGÊNCIA
DE COMUNICAÇÃO UMA THINK TANK?**

**LA “PARARREALIDAD” DE UN “BRASIL PARALELO”: ¿PODRÍA ESTA
AGENCIA DE COMUNICACIÓN SER UN THINK TANK?**

 <https://doi.org/10.56238/sevened2025.036-118>

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ABSTRACT

This article analyzes the activities of the company Brasil Paralelo as an expression of Brazil's new digital far right, discussing its configuration as a hybrid think tank that combines strategies of communication, market logics, and ideology. Using an empirical-documentary approach, it examines documentaries, texts, and audiovisual materials produced between 2019 and 2024, focusing on their discursive strategies and presence on digital platforms. The study draws on theoretical frameworks concerning the attention economy, disinformation production, and circulation of conservative ideas, engaging both Brazilian and international scholarship. Findings indicate that Brasil Paralelo functions as a producer of political meaning by reframing historical and moral narratives through a cinematic aesthetic that legitimizes far-right ideology. The paper concludes that the company acts as a symbolic mediator between the digital market and the political sphere, transforming engagement into authority and audience into ideological capital. The case exemplifies the transition from traditional intellectual influence to audiovisual and market-oriented forms of truth production, characteristic of contemporary platform capitalism.

Keywords: Think Tank. Far Right. Brasil Paralelo. Historical Revisionism. Fake News.

RESUMO

O artigo analisa a atuação da empresa Brasil Paralelo como expressão da nova extrema direita digital no Brasil, discutindo sua configuração enquanto um think tank híbrido que combina estratégias de comunicação, mercado e ideologia. A partir de abordagem empírico-documental, foram examinados documentários, textos e conteúdos audiovisuais produzidos entre 2019 e 2024, com foco em suas estratégias discursivas e em sua inserção nas plataformas digitais. O estudo mobiliza referenciais sobre economia da atenção, produção de desinformação e circulação de ideias conservadoras, articulando autores nacionais e internacionais. Os resultados indicam que o Brasil Paralelo opera como produtora de sentido político, ao reconfigurar narrativas históricas e morais sob uma estética cinematográfica que

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legitima a ideologia da extrema direita. Conclui-se que a empresa atua como mediadora simbólica entre o mercado digital e a esfera política, transformando engajamento em autoridade e audiência em capital ideológico. O caso exemplifica a transição de modelos tradicionais de influência intelectual para formas audiovisuais e mercadológicas de produção de verdade, típicas do capitalismo de plataforma contemporâneo.

Palavras-chave: Think Tank. Extrema Direita. Brasil Paralelo. Revisionismo Histórico. Fake News.

RESUMEN

El artículo analiza la actuación de la empresa Brasil Paralelo como una manifestación de la nueva extrema derecha digital en Brasil, discutiendo su configuración como un think tank híbrido que combina estrategias de comunicación, mercado e ideología. A partir de un enfoque empírico-documental, se examinaron documentales, textos y contenidos audiovisuales producidos entre 2019 y 2024, con énfasis en sus estrategias discursivas y en su inserción en las plataformas digitales. El estudio se apoya en marcos teóricos sobre la economía de la atención, la producción de desinformación y la circulación de ideas conservadoras, articulando referencias nacionales e internacionales. Los resultados indican que Brasil Paralelo actúa como productor de sentido político, al reconfigurar narrativas históricas y morales bajo una estética cinematográfica que legitima la ideología de la extrema derecha. Se concluye que la empresa funciona como mediadora simbólica entre el mercado digital y la esfera política, transformando el compromiso del público en autoridad y la audiencia en capital ideológico. El caso ejemplifica la transición de los modelos tradicionales de influencia intelectual hacia formas audiovisuales y mercadológicas de producción de verdad, características del capitalismo de plataforma contemporáneo.

Palabras clave: Think Tank. Extrema Derecha. Brasil Paralelo. Revisionismo Histórico. Fake News.

1 INTRODUCTION

The recent rise of the far right in different democracies has reconfigured the communication ecosystem and repositioned the dispute for epistemic authority in the public space. In Brazil, this process has gained traction with the intensification of the use of digital platforms as arenas for affective mobilization and the circulation of political narratives, as well as changing patterns of trust and perception about institutions, science, and the media (Mudde, 2022; Lavareda, 2023). It is in this scenario that the company Brasil Paralelo, founded in 2016 and self-defined as an "independent producer of journalism, entertainment and education", has become a hub for the production of audiovisual content that combines strong aesthetic appeal, a promise to "retell" national history and a discursive repertoire in tune with moral-conservative agendas.

The performance of this company is an example of a communicational arrangement in which media consumption operates as a mechanism of political socialization. Instead of being limited to an informative function, its products, documentaries, series, courses and digital publications, articulate historical revisionism, denunciation of "cultural hegemonies" and defense of traditional values, offering the public a coherent cosmology about the country's past, present and future. This arrangement is reinforced by a narrative grammar that alternates denunciation and redemption: there is a "lost" Brazil, diverted by cultural and political elites; there is an internal/external enemy (communism, globalism, gender ideology); Finally, there is a promise of moral restoration through knowledge "free from ideology". The internal coherence of this cosmology sustains a credibility mechanism based less on verification procedures than on emotional adherence, a central feature of the contemporary digital ecosystem (Cesarino, 2023).

If, on the one hand, part of the literature defines think tanks as non-profit organizations dedicated to producing technical knowledge to influence public policies (Rich, 2004; Medvetz, 2012), on the other hand, recent studies have pointed to the need to extend this concept to hybrid forms of ideological production, in which applied research, activism, and the market interpenetrate (Hauck & Mendonça, 2022). Such expansion is pertinent in the Brazilian case: Brasil Paralelo adopts a business model supported by subscriptions and digital products, but acts as an entrepreneur of ideas capable of organizing cognitive and moral repertoires, offering diagnoses and guiding solutions. Communicational authority stems less from formal academic affiliation and more from the audiovisual performativity associated with brands,

influencers, and a community of members, reconfiguring what counts as "expertise" in the public debate.

The logic of platforms intensifies this process. By subjecting the circulation of messages to engagement metrics, the attention economy converts polarization and outrage into economic assets (Couldry & Mejias, 2019; Ribeiro, 2024). In this environment, the distinction between "informative content", "entertainment" and "normative proposition" loses clarity: videos and articles function simultaneously as cultural products and as devices of political persuasion. Audience success feeds back into perceived legitimacy ("if many watch, it must be true"), producing a confirmation cycle in which visibility becomes authority. This cycle, combined with a cinematic aesthetic and the selection of ideologically aligned "experts", sustains an ethos of apparent impartiality that masks editorial choices and interpretive biases (Salgado & Jorge, 2021).

It is also important to note that the insertion of right-wing parliamentarians, influencers, and intellectuals in the company's ecosystem strengthens the interface between content production and institutional political action. It is a network of symbolic capitals that recognize each other: the company legitimizes actors and agendas; these actors, in turn, legitimize the company as an "alternative" voice to the mainstream (Dieguez, 2022; Nobre, 2022). The result is the conformation of a parallel circuit of authority that disputes meanings, regulates belongings, and demarcates moral boundaries, operating as a digital think tank whose laboratory is the platform culture itself.

This article proposes to interpret Brasil Paralelo as an emerging form of hybrid think tank of the Brazilian far right. The central hypothesis is that the company not only disseminates content with a conservative bias, but organizes a regime of truth adjusted to algorithmic logic, in which high-quality audiovisual production, the community of members, and the rhetoric of "independence" make up a legitimation device that combines apparent technical credentials, moral emotion, and the market. In analytical terms, this device operates on three interdependent planes: (i) discursive, through revisionist and moralizing narratives; (ii) organizational, via a business model that converts audience into revenue and authority; and (iii) political-symbolic, through the mediation between leaders, influencers, and aligned audiences.

Methodologically, an empirical-documentary approach is adopted focused on the analysis of public materials of greater scope published between 2019 and 2024 (documentaries and digital articles), articulated with national and international bibliography

on the digital far right, think tanks, and the political economy of attention (Marres, 2017; Venturini, 2023). The excerpt seeks to apprehend how editorial choices, themes, framing, selection of voices, translate into routines of production of meaning and how these routines, in turn, produce effects of truth and belonging.

From a theoretical point of view, the contribution lies in bringing the classical discussion on think tanks (organized production of expertise and influence) closer to the contemporary analysis of algorithmic mediations. By characterizing Brasil Paralelo as a hybrid digital think tank, it is argued that the concept should incorporate performative and marketing dimensions that today sustain cognitive authority in the platform environment. Such an update has implications for the study of political communication and the quality of democracy: if a growing portion of public deliberation takes place mediated by devices whose vector is commercial engagement, understanding their mechanisms of legitimation becomes a necessary step to think about regulation, accountability, and media literacy.

In summary, this work is based on the diagnosis that the dispute over the meaning of Brazil has also been fought, and increasingly, as a dispute over models of production and certification of truth. Brasil Paralelo is taken here as a strategic case to observe this displacement. The article continues by presenting the theoretical contribution mobilized and the methodological design, and then analyzes the empirical material and discusses its findings in the light of recent literature, concluding with implications and research agendas.

2 WHAT IS "PARALLEL BRAZIL"?

Brasil Paralelo is a Brazilian audiovisual production company founded in Porto Alegre in 2016 by three young entrepreneurs — Henrique Viana, Lucas Ferrugem and Filipe Valerim, with the proposal of "rescuing values and ideas that formed Brazil". From the beginning, the project presented itself as a response to the supposed cultural hegemony of the left, adopting the narrative that the country would have been "contaminated" by decades of progressive intellectual dominance. This discourse, which reinterprets the Gramscian concept of hegemony, serves as an articulating axis for what the company calls "cultural reconstruction", in line with the ideas of the "cultural war" popularized by Olavo de Carvalho and incorporated into the political rhetoric of Bolsonaroism.

Over time, Brasil Paralelo has consolidated itself as an independent streaming platform, offering documentaries, series and courses under subscription, as well as free content on social networks. Its catalog includes productions such as 1964 – Brazil between

Arms and Books (2019), Cortina de Fumaça (2020), The First Art (2021) and The Inconfidência Mineira (2022), which recount historical episodes with a strong revisionist bias. The cinematic aesthetic, the epic narrative and the rhetoric of the discovery of "hidden truths" create a sensory experience of revelation and belonging, bringing the viewer closer to the logic of "initiation" typical of online ideological communities.

The business structure combines a digital business model with community loyalty strategies. According to data released by Exame (Amorim, 2023), the company has surpassed the mark of half a million subscribers and operates with recurring revenue from monthly fees, course sales, and commercial partnerships. Although he presents himself as "independent of governments and parties", his production strongly converges with the political and moral agenda of the new right, especially in the Bolsonaro cycle. In addition to public figures linked to this field, several parliamentarians and influencers participated in its productions, configuring a network of ideological affinities and symbolic exchanges between the political and media spheres.

This transversal insertion between market and ideology brings Brasil Paralelo closer to the concept of a "hybrid digital think tank", understood here as an organization that combines the business model of communication with the function of production and dissemination of political ideas (Rich, 2004; Medvetz, 2012). Unlike traditional think tanks, research institutes, or public policy foundations, the digital hybrid mobilizes audiences in real time, transforms engagement into financial capital, and converts entertainment into persuasion. Expertise does not derive from recognized specialists, but from audiovisual performance that confers authority on certain interpreters of national history and morals.

Another defining feature is the strategic use of social networks as instruments of political pedagogy. The company maintains an active presence on platforms such as YouTube, Instagram and X (formerly Twitter), adapting excerpts from its films into short formats, subtitled and optimized for algorithmic engagement. This fragmentation of the content expands the reach and reinforces the effect of ubiquity, allowing fragments of their narratives to be reproduced in different contexts, often detached from the original source. The result is a parareality, an appropriate term here to describe the way in which the company constructs a parallel interpretive universe, coherent in itself, but disconnected from external factual parameters.

Now, from the company's statements, it can be seen that, still on the discursive level, there is an argumentative need to demonstrate an alleged "independence" through an alleged

financial distance from "parties, politicians, social movements and even laws" (Paralelo, 2024c). In fact, they rejoice that, apparently, they have never benefited from money from the public sector, an idea that is premised on a pessimistic and negative view of the State and institutions. In another article published by the company itself, "Brasil Paralelo" brings, by name, the first collaborators of its first productions, among whom are politicians, businessmen, judges, journalists, advertisers, digital influencers, ministers of the Federal Supreme Court, and far-right thinkers (Paralelo, 2022d).

Among them, the presence of the late astrologer and self-taught Olavo de Carvalho, a kind of celebrity in the right-wing extremist environment, stands out. In turn, former President Jair Messias Bolsonaro himself and his son Eduardo Bolsonaro are expressly cited as the company's first "contributors" (Prado, 2023). It is important to note that Beatriz Kicis, Joice Hasselmann, Janaína Paschoal, Rodrigo Constantino and Luiz Felipe Pondé are public figures who are enthusiasts of the Bolsonarist movement and, nevertheless, the first three mentioned participated institutionally in Bolsonarism through legislative elective mandates at the federal and state levels, respectively.

The "parareality" of Brasil Paralelo is not, therefore, a simple distortion of facts; It is a self-sufficient system of meaning, which combines moral plots, affective images and totalizing explanations. Within this logic, each historical, political or social event is reread as a manifestation of a larger struggle between "Brazilian values" and "enemies of the nation". This dualistic structure confers emotional intelligibility to complex phenomena, simplifying the real and making it compatible with a conservative collective identity project. The force of conviction derives less from rational argument and more from narrative pleasure, the viewer is invited to participate in a moral epic, not to critically evaluate evidence.

The empirical analysis carried out in this study confirms that Brasil Paralelo operates simultaneously as a media company, a political actor and a producer of ideology. Its ability to articulate discourse, aesthetics, and business model makes it a privileged laboratory for understanding the new forms of political advertising in the age of platforms. More than a communication channel, it is an ecosystem for the production of meaning, in which truth, emotion and merchandise merge. This fusion is the core of its symbolic efficacy, and also the starting point for understanding how the Brazilian far right reconfigures the public sphere and the boundaries between information, belief, and belonging.

3 OF THE CONTENT MADE AVAILABLE ON SOCIAL PLATFORMS AND ITS FAR-RIGHT PROPAGANDA

The content produced and disseminated by Brasil Paralelo is an exemplary case of how the digital far right transforms communication platforms into instruments of ideological persuasion, disguised in the form of entertainment and "cultural formation". Instead of resorting to explicit political speeches, the company adopts a cinematic aesthetic and emotional narrative that replaces rational argumentation with sensory and moral immersion. This characteristic is consistent with what Cesarino (2023) calls the digital epistemology of Bolsonarism, marked by the fusion between affects, beliefs, and recommendation algorithms.

The discursive strategy of Brasil Paralelo is based on three complementary axes: the revisionist reinterpretation of national history, the construction of moral enemies, and the aestheticization of politics. In his documentaries, Brazil's recent history is reframed as a struggle between the "true nation" and a corrupt intellectual elite. The civil-military coup of 1964 is portrayed as a "preventive revolution" against communism; social movements are presented as products of ideological manipulation; inclusion policies, as threats to meritocracy. This narrative operation creates an inverted temporality, in which the authoritarian past is converted into a symbol of order and virtue, while the democratic present is read as moral decadence.

The second axis, of a moral and affective nature, is structured around the figure of the enemy – be it "globalism", "gender ideology" or "cultural Marxism". The function of this rhetoric is not to describe reality, but to organize collective affects and offer a simplified framing of the world. The systematic repetition of binary oppositions (good/evil, truth/lie, Christian/communist) produces a grammar of identity recognition that replaces political complexity with a morality of cultural war. In this grammar, the adhesion is not only intellectual, but emotional: the viewer is invited to feel indignation, repulsion and redemption — emotions that reinforce the bond with the brand's symbolic community.

The third axis is that of political aestheticization, which operates at the intersection between form and ideology. Brasil Paralelo invests in high-standard technical production, dramatic lighting, heroic soundtracks, reconstructed historical sets, to coat its narratives with an aura of authenticity. This investment is decisive for convincing: aesthetic quality is mobilized as proof of truth. The filmic form replaces the empirical evidence, and the viewer tends to associate visual verisimilitude with the legitimacy of the argument. Such use of audiovisual as a symbolic capital of credibility brings the company closer to the logic of "real

entrepreneurs" (Medvetz, 2012), who shape public perceptions through performance and aesthetic authority.

In the platform environment, this operation is amplified by the algorithmic architecture that favors highly engaging content. Brasil Paralelo fragments its documentaries into short videos, subtitles and *reels* of rapid circulation, optimized for the recommendation logics of YouTube, Instagram and X. The excerpts chosen condense emotionally intense passages, impactful speeches, crying scenes, accusations of corruption, which work as engagement triggers. At the same time, these decontextualized fragments maintain the affective coherence of the whole, allowing each clip to act as an autonomous unit of propaganda. The cumulative effect is that of ubiquity: the message infiltrates the digital daily lives of users, dissolving between humorous videos, music and news.

In addition, the company builds a system of community belonging around the identity of the "Brasil Paralelo member". The subscriber is invited to join a group of "awakened" people, bearers of a truth denied by the mainstream media. The rhetoric of persecution ("they want to shut us up") reinforces the emotional bond between brand and audience, transforming the act of consuming content into a gesture of political resistance. This symbiotic relationship between producer and consumer reproduces the logic of conspiratorial communities described by Venturini (2023): information circulates as proof of exclusivity and reinforcement of group cohesion.

From a communicational point of view, the company exemplifies what Ribeiro (2024) calls "monetization of polarization". Affective engagement (likes, comments, shares) converts into visibility, and visibility, into revenue from subscriptions and advertising. Polarization, far from being an unwanted byproduct, becomes the basis of the business model. Every heated public debate, every controversy over censorship or free speech, increases the brand's reach and legitimizes its narrative of dissent. Ideology feeds back on the algorithm.

These mechanisms demonstrate that the content made available on the platforms by Brasil Paralelo cannot be understood only as alternative media, but as an infrastructure of symbolic power. Its effectiveness does not derive from a supposed monopoly of information, but from the ability to structure perceptions and affections. The "parareality" constructed by its products is self-referential: the films, posts and speeches confirm each other, forming a circuit of self-evidence. Thus, the spectator who adheres to this worldview begins to inhabit his own interpretative reality, in which facts are filtered by ideological fidelity and emotional belonging.

In summary, the content produced and disseminated by Brasil Paralelo illustrates the consolidation of a far-right propaganda model anchored in digital platforms. It combines moralizing storytelling, authority aesthetics, and emotional engagement to transform the audiovisual experience into political pedagogy. This synthesis, at once commercial and ideological, makes the company a paradigmatic case of how platform capitalism reconfigures political communication and redefines the very concept of public truth in contemporary Brazil.

4 WOULD BRASIL PARALELO BE A *THINK TANK*?

The question of whether Brasil Paralelo could be considered a think tank, or if it just mimics the format, is central to understanding its unique position in the Brazilian communication ecosystem. The term think tank historically refers to independent institutions dedicated to the production of specialized knowledge with the intention of influencing public policies and strategic debates (Rich, 2004; Medvetz, 2012). These centers of reflection, which emerged in the post-war Anglo-Saxon context, operated as mediators between academia, the state, and the market, building a hybrid space of expertise and advocacy. In the Brazilian case, however, this category acquires its own contours: organizations proliferate that, although they claim the label of think tank, move between activism, communication, and ideological mobilization (Hauck & Mendonça, 2022).

Brasil Paralelo participates in this process of hybridization by adopting typical functions of a think tank, without sharing its classic institutional structure. Its declared mission, "to rescue forgotten values and ideas", fulfills a role equivalent to the formulation of an agenda of thought; its documentaries and courses operate as vehicles for the dissemination of doctrine; and its subscriber base functions as a community of financial and ideological support. The company, therefore, brings together three structuring dimensions: the intellectual (production of ideas), the communicational (symbolic mediation) and the economic (business model). The result is an organizational form that we could describe as an idea company, in which the commodification of content does not weaken, but reinforces the power of symbolic influence.

A decisive aspect to understand this transformation is the performativity of expertise. In Brasil Paralelo's productions, knowledge is staged through aesthetic and rhetorical devices: interviews in austere settings, use of technical language, citation of authors and international conservative institutions. This *mise-en-scène* of erudition replaces academic status with an aesthetic of authority. As Medvetz (2012) notes, the power of think tanks

derives less from their scientific rigor than from their ability to "appear competent". In the case under analysis, the opinion becomes the very substance of authority, that is, the performance replaces the title, and the audiovisual narrative becomes the main vehicle of cognitive legitimation.

Another relevant dimension is the insertion in transnational networks of ideas from the global right. Many of the concepts disseminated by Brasil Paralelo, such as "cultural Marxism", "gender ideology" and "globalism", circulate in North American, European and Latin American think tanks, being translated and adapted to the national context. This circulation suggests a form of ideological transposition, in which the company acts as a cultural intermediary between foreign discourses and the Brazilian public. Thus, at the same time that it projects an image of national authenticity, Brasil Paralelo is part of a global circuit of production with a conservative sense, reproducing discursive and strategic models already consolidated in experiences such as PragerU and The Daily Wire (Ward & Vreese, 2023).

The fundamental difference, however, lies in the digital and commercial nature of the operation. While traditional think tanks rely on philanthropic donations or state funding, Brasil Paralelo sustains itself by the direct sale of symbolic products — films, subscriptions, and courses. This format eliminates institutional intermediation and creates a direct relationship between producer and consumer, transforming political engagement in relation to the market. The act of "subscribing" to the service also becomes a gesture of ideological adherence. From this perspective, the company carries out what we could call the privatization of the public sphere of opinion: the debate is shifted to a space controlled by audience metrics and consumption models.

This reconfiguration of the role of a think tank is consistent with the communicational environment of platform capitalism. As Couldry and Mejias (2019) observe, data extraction and the conversion of attention into value are the principles that structure the digital economy. By operating under such logics, Brasil Paralelo transforms ideological production into a product and, simultaneously, into a commodity. Its success does not depend on persuading political or bureaucratic elites, but on capturing and retaining audiences on a large scale. Instead of white papers, reports, or opinions, his language of influence is the viral documentary; its arena of action is the social media feed; Its symbolic capital is measured in likes and subscriptions.

Thus, the question "would Brasil Paralelo be a think tank?" does not have a binary answer. The company does not fit the classic definitions, but neither can it be reduced to a

mere media producer. It embodies a new form of think tank: decentralized, entrepreneurial, and algorithmic. Authority does not emanate from academic institutions or state legitimacy, but from the ability to produce convincing and emotionally mobilizing meaning on a digital scale. It is a model of "cognitive market production", in which symbolic capital is accumulated not by the production of validated knowledge, but by the reiterated performance of certainty.

The case of Brasil Paralelo, therefore, signals a structural transformation in the relations between communication, politics and the production of truth. What was once the domain of specialized institutes has become a field of action for media entrepreneurs capable of translating doctrine into narrative. The company represents the tip of a broader process: the emergence of an ecosystem of audiovisual think tanks that operate at the intersection of the attention economy, political morality, and the cultural industry.

With this, the role of the public intellectual and the circulation of ideas in Brazilian society is redefined. If, as Bourdieu states, symbolic power consists in the ability to impose a legitimate vision of the world, Brasil Paralelo demonstrates that, in the digital age, this imposition can be exercised through images and algorithms, and not only through books and academic debates.

5 CONCLUSION

The analysis carried out throughout this study allows us to affirm that Brasil Paralelo constitutes a new form of political-communicational organization, whose singularity lies in articulating functions of media, enterprise and ideology under the same operational model. Although the company presents itself as an independent cultural producer, its practices and narratives show the typical structure of a hybrid think tank, oriented to the construction of moral consensus and the production of cognitive legitimacy within the Brazilian far right. Its differential is not only in the content it disseminates, but in the way it converts ideas into products and beliefs into audience, operating simultaneously on the symbolic and economic planes.

The investigation showed that Brasil Paralelo does not act as a simple disseminator of disinformation or a marginal agent, but as part of an ecosystem of meaning-making that redefines the mediation between politics and communication. By exploring the logic of digital platforms, the company shifts the notion of public debate to a space dominated by engagement metrics, in which truth is less a matter of evidence than of circulation and visibility. In this context, the audiovisual becomes the main grammar of legitimation: authority

derives from the performance of certainty, and not from verification. This aesthetics of conviction gives political discourse the form of a moral spectacle, converting cultural consumption into an act of civic faith.

Such dynamics challenge the traditional boundaries between media, ideology, and knowledge production. The case analyzed shows that the classic concept of think tank, centered on the rational and institutionalized production of ideas, needs to be updated to include commercial and media actors who organize and disseminate worldviews through entertainment formats. "Thinking", the etymological core of the term, moves from technical rationality to the ability to construct convincing narratives, supported by algorithms and affects. It is a transition from the think tank to the feeling tank: a center of emotional production of meaning, in which politics is converted into symbolic consumption.

The implications of this transformation are profound. First, they indicate that the dispute for cultural hegemony is no longer limited to the sphere of traditional institutions, but extends to the environment of platforms, where the power to guide and define the truth is mediated by invisible metrics and market dynamics. Secondly, they reveal that the attention economy has become a fertile ground for the consolidation of authoritarian ideologies, which find in speed, repetition and the aesthetics of certainty the instruments of their effectiveness. Finally, they point to the need to rethink the mechanisms of communicational responsibility and regulation of disinformation, not only from a legal perspective, but as a matter of democratic culture and media literacy.

It is concluded, therefore, that Parallel Brazil is less an anomaly and more a symptom of structural reconfiguration of the Brazilian public space. By fusing market and ideology, the company demonstrates that contemporary politics is also, and perhaps above all, made in the symbolic economy of platforms. Understanding this phenomenon requires broadening the view of the social sciences on the role of communication and recognizing that, in the digital age, the production of truth is inseparable from the production of the audience.

From this diagnosis, paths are opened for future research that compares the Brazilian case to international experiences, identifies transnational financing networks, and investigates the social consequences of the convergence between technology, economics, and politics. The parareality constructed by Brasil Paralelo, far from being just distortion or manipulation, constitutes a form of symbolic ordering of the world, and precisely for this reason, a decisive field for understanding the contemporary challenges of democracy.

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**REMOTE SENSING IN RESEARCH PROJECTS FROM SOUTHERN BRAZIL
AND URUGUAY**

**SENSORIAMENTO REMOTO EM PROJETOS DE PESQUISA DO SUL DO
BRASIL E DO URUGUAI**

**TELEDETECCIÓN EN PROYECTOS DE INVESTIGACIÓN DEL SUR DE BRASIL
Y URUGUAY**

 <https://doi.org/10.56238/sevened2025.036-119>

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ABSTRACT

Remote sensing is an innovative technique derived from technical and instrumental advances with support capacity for several activities, including scientific research. This article describes the use of orbital images related to environmental planning activities in Embrapa, a Brazilian research public firm. 161 publications related to the period 1998 – 2025, including applications as soil surveys, environmental monitoring and precision agriculture were discussed.

Keywords: Land Use. Classification. Images. Survey.

RESUMO

O sensoriamento remoto é uma técnica inovadora derivada de avanços técnicos e instrumentais, com capacidade de suporte para diversas atividades, incluindo a pesquisa científica. Este artigo descreve o uso de imagens orbitais relacionadas a atividades de planejamento ambiental na Embrapa, uma empresa pública de pesquisa brasileira. Foram discutidas 161 publicações relacionadas ao período de 1998 a 2025, abrangendo aplicações como levantamento de solos, monitoramento ambiental e agricultura de precisão.

Palavras-chave: Uso da Terra. Classificação. Imagens. Levantamento.

RESUMEN

La teledetección es una técnica innovadora derivada de avances técnicos e instrumentales, con capacidad de apoyo para diversas actividades, incluida la investigación científica. Este artículo describe el uso de imágenes orbitales relacionadas con actividades de planificación ambiental en Embrapa, una empresa pública de investigación brasileña. Se discutieron 161 publicaciones relacionadas con el período de 1998 a 2025, incluyendo aplicaciones como levantamientos de suelos, monitoreo ambiental y agricultura de precisión.

Palabras clave: Uso del Suelo. Clasificación. Imágenes. Levantamiento.

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1 INTRODUCTION

The National Institute of Spatial Research, INPE, created in 1961 and the RADAM project, effective during the period 1970 – 1985 (Wikipedia, 2025), were perhaps, the main Brazilian entities involved with remote sensing. INPE remains active nowadays, capturing and distributing orbital images, promoting related research, and organizing, at least partially, the Brazilian thematic symposium. Orbital imagery are useful by several perspectives, by instance, coverage capacity, temporal changes, historical record and comprehensive sight. The last Symposia (INPE, 2025) included forty themes, involving disciplines as Agriculture, Geology, Meteorology and Oceanography, technical aspects as hyper-spectral remote sensing, image processing and mapping, and specific affairs, that is, climate change, fires, wetlands and soils. Furthermore, several undergraduate and postgraduate courses in Brazilian universities have incorporated the discipline of "Remote Sensing" into their curricula, deriving in associated dissertations and thesis.

This article considered 161 references related to the author, including the topics agriculture, geosciences, and edaphology, focusing a discussion about the influence of remote sensing in that context and its innovations related to socioeconomic phenomena.

2 DESCRIPTION OF WORKS

The 161 works mentioned before cover the period 1998 – 2025, being 27 technical-scientific articles, 7 books, 20 chapters of books, 39 extended or resumed abstracts in events and 68 serial publications of Embrapa, that is, 17%, 4%, 12%, 24% and 42% of total publications respectively. Since a research point of view, serial publications of Embrapa include bulletins of research and development, a structure very similar to a technical-scientific article; technical circular, technical communication and "documents", focusing aspects related to producers or a less academic public. Table 1 shows the main themes considered here and the quantity of works for each case.

"Diversified" refers to methodological studies or innovation, by instance, spectroradiometry applied to agriculture (Filippini-Alba et al., 2007) or new agricultural products, as olives (Filippini-Alba et al., 2013) and pecan-nuggets (Filippini-Alba et al., 2020). Environmental aspects related to climate change, ecotoxicology, geosciences, sustainability and the Mirim lagoon, a big water body in the Brazil – Uruguay frontier, were also involved.

Table 1

Some characteristics of the research themes considered in this article

Theme	Quantity	%	Description
Diversified	21	13	Several themes (see text)
Geochemistry	6	4	Chemistry of rocks and minerals
GIS	35	22	Spatial analysis and modeling
PA	22	14	Specific agricultural managing
Soil mapping	32	20	Municipality or regional scale
Zoning	30	18	Agricultural zones discrimination
Remote sensing	15	9	Change detection mapping or monitoring

PA = Precision Agriculture; GIS = Geographic information system

Uruguay was the geographical site in 8 times, Rio Grande do Sul state 123 times, Santa Catarina state 11 times, Parana state 10 times, São Paulo state 3 times and 6 times was considered Brazil or the world as a whole.

3 THE REMOTE SENSING INFLUENCE

As the Brazilian Agricultural Research Corporation, Embrapa generally focuses on rural areas. However, studies related to mineral resources and urban expansion are considered due to technical aspects or based on the author's profile, sometimes geared towards Geosciences.

Some examples related to urban expansion, soil mapping, land use, mineral exploration and cartography positioning are presented as following.

3.1 URBAN EXPANSION

Filippini-Alba e Moreira (2009) analyzed the urban expansion of some cities located near the RS122, a road located north of Porto Alegre, in the state of Rio Grande do Sul, Brazil. The images showed different expansion patterns, mainly from the year 2000, when there was an acceleration of the process. São Leopoldo grow up 55 hectares/year during 1987 to 2000 and 270 hectars/year after 2000 (2000-2007), values were 10 and 112 hectars/year for Bom Princípio, 2 and 7 hectars/year for Garcés, 32 and 77 hectars/year for Portão and 23 and 146 hectars/year for São Sebastião do Caí. The acceleration process after 2000 showed different velocities according to place, a condition related to multiple factors. Gallo (2014) describes the growth of Pelotas, Rio Grande, and Capão do Leão, cities in Rio Grande do Sul state during the period from 1990 to 2010. Several original nucleus already existed for the three cities in 1990, including the Fragata and Laranjal neighborhoods in

Pelotas, as well as Cassino in Rio Grande. So, the cities advanced to new habitable spaces after 1990s, restricted by water bodies, swamps and dunes.

3.2 SOIL MAPPING

Conventional soil mapping is based on aerial photographs interpreting (Flores; Filippini-Alba, 2015). However, few developments considered remote sensing imagery for soil mapping recently, in spite of Ikonos was the first high resolution satellite, launched in 1999, with 80 cm pixel and four bands (Apollo Mapping, 2025).

A more recent technology, the “digital soil mapping” (DSM) uses digital layers for mapping, as the digital elevation model or remote sensing imagery, besides field information, the soil-scientist knowledge and data of the profiles. So, polygons are elaborated based on digital layers, then adjusted by means of field information and the profiles data. Nachtigall (2022) applied the DSM in Marau municipality, Rio Grande do Sul state, Brazil. Soil mapping requires knowledge of the successive layers down to the bedrock. Therefore, automated mapping using surface data has not been possible until now.

Bare or sandy soils and vegetation are prominent features in remote sensing imagery, highlighting areas of mineral exploration or other types of degradation. Filippini-Alba (2018) discussed three study cases in Rio Grande do Sul state using remote sensing imagery: (1) granite exploration in Capão do Leão municipality; (2) coal mining in Candiota municipality; and, (3) sandy areas in the west of the state. Topics (1) and (2) relate to mineral sector, however, topic (3) is a natural process due to the occurrence of sandstone as basal rock.

3.3 LAND USE

Filippini-Alba et al. (2015a) compared orbital images of medium resolution, Landsat (30m pixel) and Aster (15-30m pixel), in the region of the lagoons Mirim and Patos. The main geographical features evaluated were water bodies and dunes including 25 areas of 60 hectares to more than 70 thousand hectares. The medium error was 11% (corrected value) and individual errors were less than 5% for geographical bodies bigger than 1000 hectares. Schroder and Filippini-Alba (2010) and Filippini-Alba et al. (2015b) evaluated land use on specific municipalities discriminating agricultural, environmental and urban areas.

The rice-crop area varied from 13 to 22 thousand hectares during 37 years (1973 to 2009) in Caiubá lagoon region, Rio Grande do Sul state (Filippini-Alba et al., 2012), but

variation of “pastures” and “areas without vegetation cover” was significantly greater, from 5 to 30 thousand hectares, in the same period.

3.4 MINERAL EXPLORATION

The processing and overlay of three layers derived from remote sensing data with eleven geochemical layers, discriminated twelve classes (Filippini-Alba, 1998). The remote sensing layers were TM4 Landsat band, representing vegetation, and the factor-F and factor-H (Crósta and Moore, 1989). That is, a combination of TM bands associated to iron oxides (Factor-F) and clay-minerals (factor-H) respectively. Content of elements in stream sediments (Ba, Co, Cu, Mn, Ni, Pb, P, V, Y and Zn) and Gamma-radiometry were the geochemical layers. So, one class represented rivers and forests and two classes characterized the geochemical background, one of them with the minimal content of trace elements and the other one, slight enriched with Co, Cu, Ni, V and Zn. Both classes, covering 56% of the research area, 28% for each, presented an intermixed spatial pattern (Filippini-Alba, 1998). Two classes appeared associated with mineralization, coinciding with geochemical anomalies derived from statistical processing, spread throughout the territory, reinforcing the possibility of mineral deposits. Finally, seven classes related to lithology, forming a large patch in the northwestern part of the research area, in the Zapican geographic sheet.

3.5 CARTOGRAPHY POSITIONING

Remote sensing imagery can be used as cartographic base, as aerial photographs were used in previous times. Anyway, there are a variety of available scales in the commercial context today, deriving on high prices and different technical aspects.

4 CONCLUSION

Remote sensing is a broad discipline encompassing applied, exact and life sciences, however, with potential for commercial and management activities too. Land use excels as the main application of remote sensing, including urban expansion. Soil mapping, mineral exploration and cartography positioning are more specific applications and they utilize the location advantages of remote sensing, functioning as a supporting discipline and a source of complementary information. The spectral properties of remote sensing have been only

partially explored to date; perhaps further progress in this area can be expected in the coming years.

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**UNIFACVEST EDUCATIONAL TECHNOLOGY AND ACTIVE LEARNING: A
REPORT ON THE TRAINING PRACTICES OF THE COURSE FORMATIVE
ACTIVITY VII IN THE 2025.2 SEMESTER**

**TECNOLOGIA EDUCACIONAL UNIFACVEST E APRENDIZAGEM ATIVA:
RELATO DAS PRÁTICAS FORMATIVAS DA DISCIPLINA ATIVIDADE
FORMATIVA VII NO SEMESTRE 2025.2**

**TECNOLOGÍA EDUCATIVA UNIFACVEST Y APRENDIZAJE ACTIVO: RELATO
DE LAS PRÁCTICAS FORMATIVAS DE LA ASIGNATURA ACTIVIDAD
FORMATIVA VII EN EL SEMESTRE 2025.2**

 <https://doi.org/10.56238/sevened2025.036-120>

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ABSTRACT

This article presents a systematized report of the activities developed in the course Educational Technology – Formative Activity VII, from the Centro Universitário UNIFACVEST, during the 2025.2 academic semester. The actions involved planning, execution and analysis of pedagogical practices integrating digital technologies, maker culture, active methodologies, computational thinking and theoretical foundations from Developmental Psychology, especially Piaget and Vygotsky. Among the activities carried out, the following stand out: construction of sensory panels, development of digital and physical games using Scratch, Micro:bit, laser cutting and 3D printing, field visits, pedagogical workshops, application of projects in public schools, and production of lesson plans in ENADE format. The practices demonstrated the transformative potential of educational technology in promoting autonomy, creativity, scientific investigation and meaningful learning. The results indicate that the course successfully articulated theory and practice in a critical and innovative manner.

Keywords: Educational Technology. Maker Culture. Scratch. Active Learning. Piaget.

RESUMO

O presente artigo tem como objetivo apresentar um relato sistematizado das atividades desenvolvidas na disciplina Atividade Formativa VII do Curso de Tecnologia Educacional do Centro Universitário UNIFACVEST, no semestre 2025.2. As ações envolveram planejamento, execução e análise de práticas pedagógicas integrando tecnologias digitais, cultura maker, metodologias ativas, pensamento computacional e referenciais teóricos da Psicologia do Desenvolvimento, especialmente Piaget e Vygotsky. Entre as atividades realizadas destacam-se: construção de painel sensorial, elaboração de jogos digitais e físicos utilizando Scratch, Micro:bit, corte a laser e impressão 3D, saídas de campo, oficinas

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pedagógicas, aplicação de projetos em escolas municipais e estaduais, além da produção de planos de aula no formato ENADE. As práticas evidenciaram o potencial transformador da tecnologia no contexto educacional, promovendo autonomia, criatividade, investigação científica e aprendizagem significativa. A disciplina cumpriu seu papel formativo ao articular teoria e prática de modo crítico e inovador.

Palavras-chave: Tecnologia Educacional. Cultura Maker. Scratch. Aprendizagem Ativa. Piaget.

RESUMEN

El presente artículo tiene como objetivo presentar un relato sistematizado de las actividades desarrolladas en la asignatura Actividad Formativa VII del Curso de Tecnología Educativa del Centro Universitario UNIFACVEST, en el semestre 2025.2. Las acciones involucraron la planificación, ejecución y análisis de prácticas pedagógicas que integraron tecnologías digitales, cultura maker, metodologías activas, pensamiento computacional y referentes teóricos de la Psicología del Desarrollo, especialmente Piaget y Vygotsky. Entre las actividades realizadas se destacan: la construcción de un panel sensorial; la elaboración de juegos digitales y físicos utilizando Scratch, Micro:bit, corte láser e impresión 3D; salidas de campo; talleres pedagógicos; la aplicación de proyectos en escuelas municipales y estatales; además de la elaboración de planes de clase en formato ENADE. Las prácticas evidenciaron el potencial transformador de la tecnología en el contexto educativo, promoviendo la autonomía, la creatividad, la investigación científica y el aprendizaje significativo. La asignatura cumplió su papel formativo al articular teoría y práctica de manera crítica e innovadora.

Palabras clave: Tecnología Educativa. Cultura Maker. Scratch. Aprendizaje Activo. Piaget.

1 INTRODUCTION

Teacher training in the digital age requires the integration between pedagogical foundations and the critical and creative use of technologies. In the Educational Technology Course at the UNIFACVEST University Center, the discipline Formative Activity VII plays a central role in the development of practical, critical, reflective and investigative skills necessary for contemporary professional performance.

In Freire's perspective, educational practice requires a critical positioning of the educator in the face of the world and the instruments that constitute it, including technologies. As Freire (1996, p. 31) states:

[...]Teaching is not transferring knowledge, but creating the possibilities for its own production or construction. Therefore, teaching practice requires curiosity, criticality, methodical rigor and openness to the new knowledge that emerges in social, scientific and technological life". In this way, the critical and creative use of technologies cannot be dissociated from pedagogical reflection, because, as the author adds, "it is in the problematization of reality, in dialogicity and in transformative action that the educator affirms himself as a subject who learns by teaching and teaches by learning. (Freire, 1996, p. 43).

The 2025.2 semester was marked by a significant set of training experiences, which included maker culture, programming, robotics, field trips, construction of pedagogical materials, application of projects in schools, and preparation of lesson plans aligned with the BNCC. All these experiences were based on classical and contemporary theoretical references, such as Piaget, Libâneo, Vygotsky, Wallon, Freire, Resnick and authors of Environmental Education and Active Learning.

The article presents a detailed account of these practices, highlighting their pedagogical, methodological and technological contributions to the training of academics in the context of democracy, inclusion and social justice.

For Libâneo, teaching requires much more than technical mastery; It requires a critical understanding of the educational reality and the ability to articulate knowledge, methods and resources in an intentional and reflective way. As the author states:

[...]Teaching practice is an intentional and systematic activity, guided by educational objectives and supported by theoretical foundations that enable the teacher to analyze, interpret and intervene consciously in the school reality. Teaching implies selecting methods, using instruments and resources – including technological ones – in a

critical, ethical and appropriate way to the students' training needs. (Libâneo, 2013, p. 28).

From the perspective presented, it is understood that teacher training in contemporary times cannot dissociate the theoretical domain from the ability to use technologies in a critical and intentional way. By integrating pedagogical foundations with innovative practices, the discipline Formative Activity VII reaffirms the role of the teacher as a reflective agent, capable of transforming the educational reality through conscious methodological choices aligned with the current demands of learning.

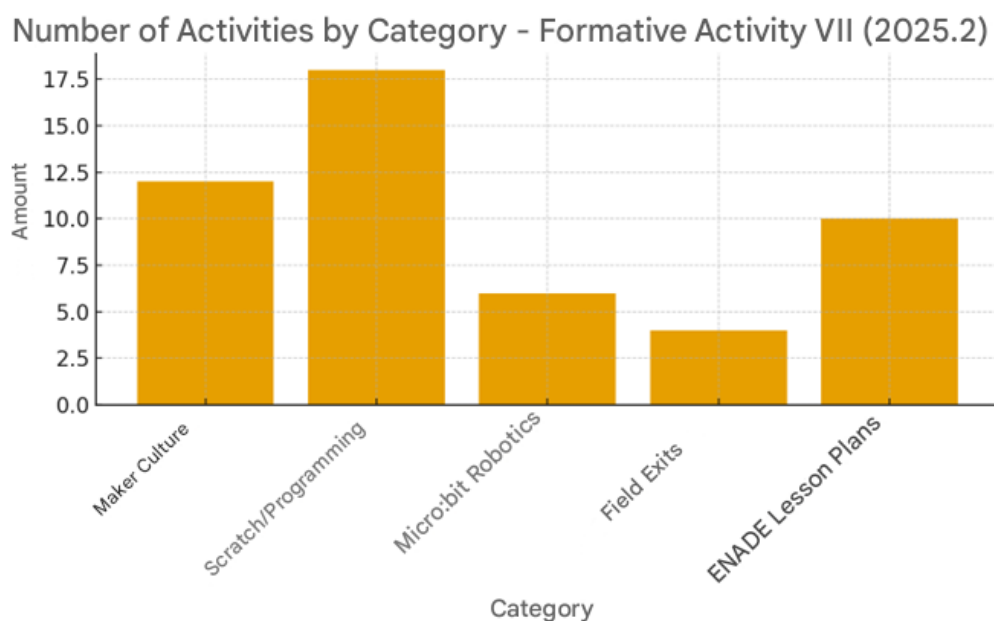
2 THEORETICAL FRAMEWORK AND REPORT OF ACTIVITIES

2.1 THEORETICAL FOUNDATIONS: PIAGET, CONSTRUCTIVISM AND MAKER CULTURE

The activities developed were guided by the constructivist theory of Jean Piaget, who understands learning as: "[...] active construction, occurring through assimilation, accommodation and balance". (Piaget, 1999; 2014). The proposals were structured respecting the cognitive stages: sensory-motor, preoperative, concrete operative and formal operative.

Figure 1

Number of activities by category - Training activities VII (2025.2)



Maker culture and computational thinking, according to Resnick (2017), were integrated as tools to favor project-based learning, autonomy, creativity, and problem-solving.

2.2 CONSTRUCTION OF SENSORY PANEL – SENSORIMOTOR STAGE

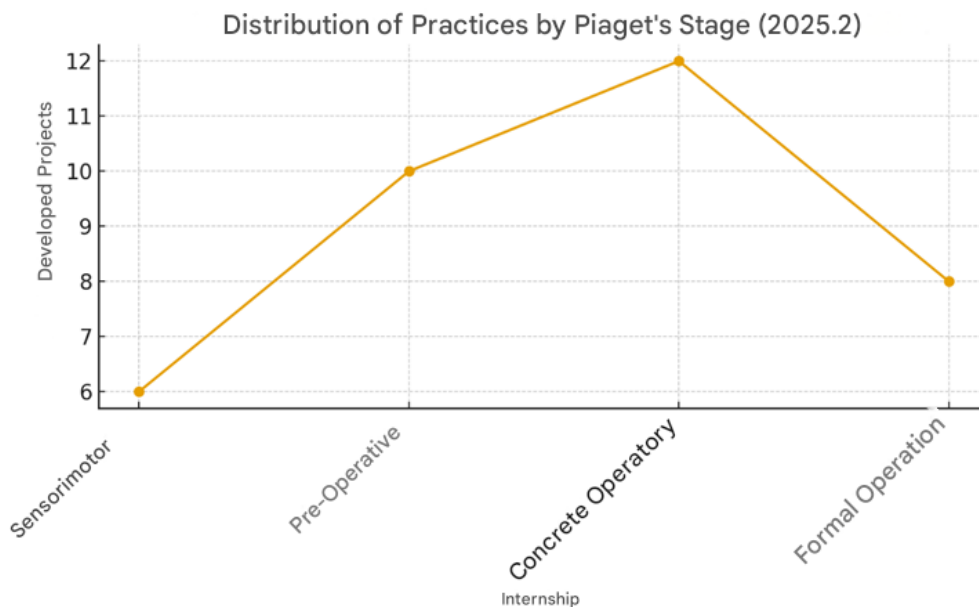
Based on the teaching plan provided, students built a sensory panel inspired by the sensorimotor stage (0–2 years). The activity involved:

- selection of objects with textures, sounds and colors;
- collaborative assembly with the support of the Maker Laboratory;
- understanding of cause and effect and motor coordination;
- theoretical foundation in Piaget's proposals and in the use of Scratch to stimulate sound and visual associations.

The panel demonstrated the relevance of sensory exploration for early cognitive development.

Figure 2

Distribution of practices by Piaget's stage (2025.2)



2.3 PROJECT "CONTATUDO 3000" – LOGICAL THINKING IN EARLY CHILDHOOD EDUCATION

The project applied with Maternal II used resources such as the Treasure Chest, flashlights with numerals and the Contatudo 3000 Machine. The children explored quantities,

colors and numerical relationships, experiencing playful, meaningful and investigative situations.

The activity dialogued directly with the preoperative stage, stimulating language, symbols and first logical-mathematical notions.

2.4 "RECICLAGAME" PROJECT – ENVIRONMENTAL EDUCATION, SUSTAINABILITY AND GAMES

Academics developed an ENADE lesson plan and a digital HTML game to teach recycling to Elementary School. The project involved:

- BNCC competencies such as EF03CI05 and General Competence 10;
- gamification, cooperation and decision-making;
- integration between Science, Technology, Languages and Mathematics;
- valuing environmental responsibility.

The practice exemplifies the use of technology as an interdisciplinary and engaging pedagogical resource.

2.5 MAKER CULTURE: LASER CUTTING, 3D PRINTING, AND PROTOTYPING

The Geometric Shapes Educational Game project involved:

- initial prototyping in MDF in Professor Alberto's laboratory;
- 3D modeling in Tinkercad and printing in the Maker Lab;
- digital version programming in OneCompiler;
- pedagogical application with 5th grade classes;
- observation of strategies, hypotheses, logical reasoning and cooperation.

It is a robust example of the integration between physical and digital materials, favoring computational thinking and socio-emotional skills.

2.6 EDUCATIONAL ROBOTICS WITH MICRO:BIT

Workshops held with guest professor Cristian allowed the students to understand the potential of robotics:

- hands-on experimentation with sensors and logic;
- intuitive programming for beginners;
- perception of the role of robotics in technological literacy.

2.7 PEDAGOGICAL VISITS AND OBSERVATION OF INNOVATIVE PRACTICES

The field trips to the institutions SESI, EEB Godolphin and EEB Vidal Ramos made it possible to:

- analysis of innovative educational environments;
- contact with active methodology practices;
- dialogue with former students who now work in the state network;
- articulation between academic theory and school practice.

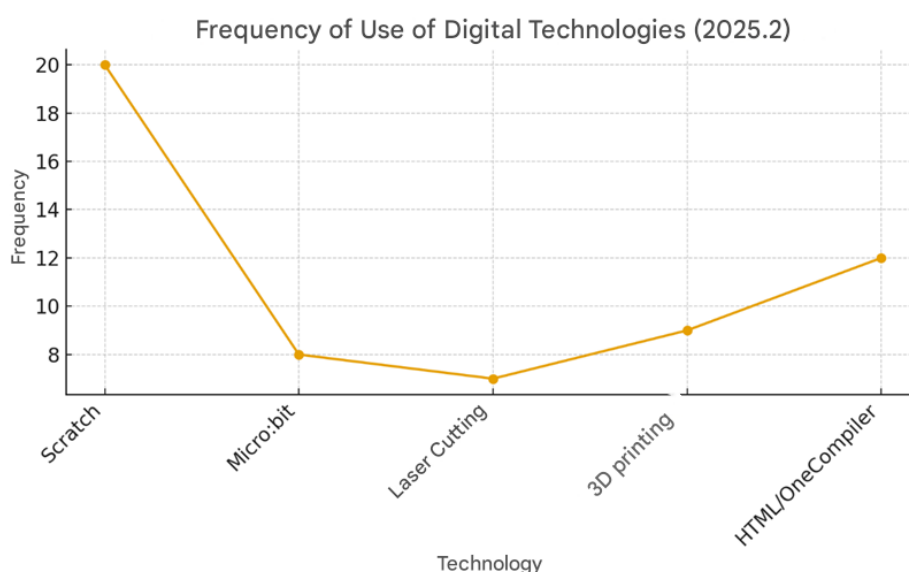
2.8 SCRATCH: PROGRAMMING, GAMIFICATION, AND DIGITAL STORYTELLING

The discipline produced projects in the different stages of Piaget:

- Sensorimotor: sound and visual responses in panels connected via Makey Makey;
- Preoperative: interactive stories, digital narratives and physical cards;
- Concrete operative: logical challenges, mazes and numerical sequences;
- Formal operative: games that require abstraction, hypotheses, and strategic reasoning.
- Scratch has proven to be an accessible and powerful tool, allowing creation, authorship and experimentation.

Figure 3

Frequency of use of digital technologies (2025.2)



3 SET OF ACTIVITIES

The set of activities described evidences a formative proposal based on Piagetian constructivism, in which learning is understood as an active process, resulting from the interactions between subject and environment. By respecting the stages of cognitive development — sensory-motor, preoperative, concrete operative and formal operative — pedagogical practices were organized to favor meaningful experiences, ensuring that each project was aligned with the capacities and ways of thinking characteristic of each age group. In this sense, the actions carried out in the discipline materialize concepts such as assimilation, accommodation and balance, promoting situations that challenge students and allow the construction of new mental schemes.

The integration between maker culture and computational thinking, inspired by authors such as Resnick, strengthened the perspective that learning involves creating, experimenting, testing hypotheses, and transforming ideas into concrete products. Projects such as the sensory panel, Contatudo 3000, ReciclaGame, and the game of geometric shapes illustrate this approach, as they articulate digital technologies, manipulable materials, and problem-solving in real contexts. Each activity was planned to stimulate autonomy, creativity and collaboration, core values of active methodologies.

The use of tools such as laser cutting, 3D printing, Micro:bit, and Scratch has broadened academics' understanding of the role of technology in contemporary education. Robotics and programming demonstrated their potential in technological literacy, while digital and hybrid projects enabled experiences that dialogue with the principles of the BNCC, especially with regard to digital skills, scientific thinking, and environmental responsibility.

The pedagogical visits reinforced the articulation between theory and practice, providing students with the observation of innovative environments and critical reflection on different teaching models. This movement between learning, observing, creating and applying reflects the essence of professional training in the area of educational technology: an education that integrates scientific knowledge, pedagogical sensitivity and technological mastery.

Freinet argues that learning is strengthened when it is born from concrete experience and reflective action on the school routine. According to the author:

[...]It is not possible to conceive of the education of the educator or the student apart from life. It is in direct observation, in contact with reality and in continuous experimentation that critical spirit, autonomy and the ability to create new solutions are developed. The school

must open itself to the environment, study it, transform it and allow itself to be transformed by it, because it is in the living relationship between practice and reflection that knowledge gains meaning and becomes truly formative. (Freinet, 1998, p. 42).

Field trips and interschool visits play an essential role in teacher training when seen from the perspective of Célestin Freinet. For the author, the school cannot remain isolated, because it is in the living relationship with the environment, with people and with social practices that knowledge gains meaning. By taking students to observe other educational environments, different methodologies and school realities, learning is promoted that is born from concrete experience — a fundamental principle of Freire's pedagogy. These moments allow the future educator to develop sensitivity, an investigative posture and the ability to critically analyze the daily school life, understanding that teaching is also studying the world, interacting with it and transforming it. Interschool visits broaden horizons, enrich pedagogical practice and strengthen the articulation between theory and life, as Freinet defended.

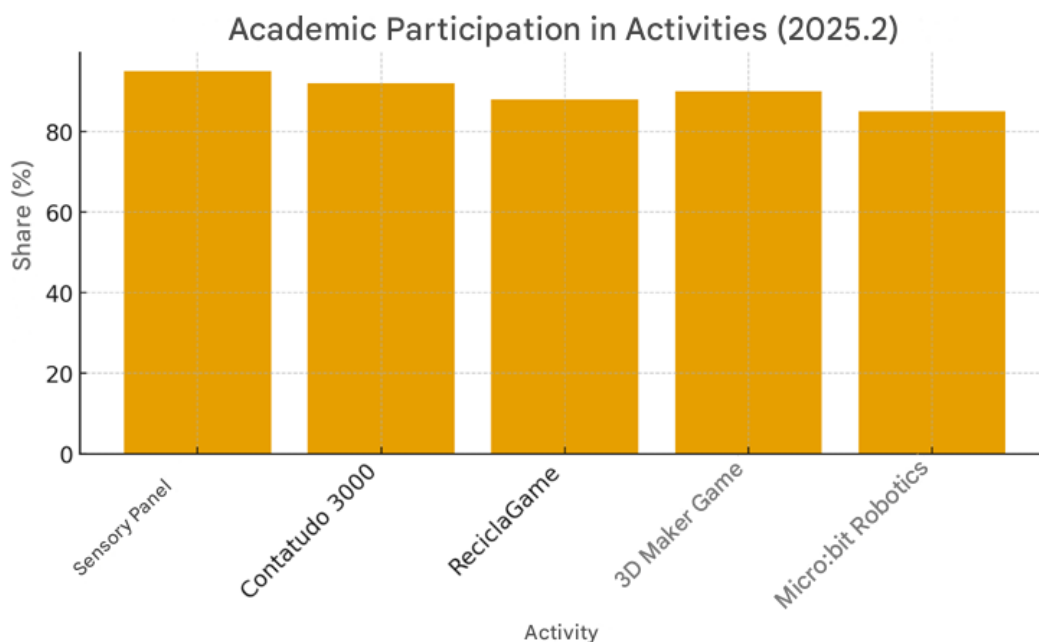
The set of activities shows a coherent curricular proposal, which understands learning as an active, interdisciplinary and creative process, while preparing future professionals to act with pedagogical intentionality and technical competence in different educational contexts.

4 FINAL CONSIDERATIONS

The 2025.2 semester of the Formative Activity VII discipline demonstrated the power of the integration between constructivist theory, digital technologies and maker culture in the training process of future educational technologists. The activities carried out enabled the students to experience active methodologies, develop creative, technological and socio-emotional skills, in addition to experiencing real pedagogical practices in different school contexts.

Figure 4

Academic participation in activities (2025.2)



The discipline fully fulfilled its objective of providing formative experiences that articulate innovation, criticality, authorship and social commitment, preparing professionals capable of transforming the contemporary educational scenario.

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**ACTIVE METHODOLOGIES IN VOCATIONAL AND TECHNOLOGICAL
EDUCATION - CONTRADICTIONS AND POSSIBILITIES**

METODOLOGIAS ATIVAS NA EPT - CONTRADIÇÕES E POSSIBILIDADES

**METODOLOGÍAS ACTIVAS EN LA ETP - CONTRADICCIONES Y
POSIBILIDADES**

 <https://doi.org/10.56238/sevened2025.036-121>

Adriana Pancotto¹, Luciana dos Santos Rosenau²

ABSTRACT

This study analyzes the contradictions and possibilities of active methodologies in light of critical pedagogies within Professional and Technological Education (EPT). The investigated problem refers to the tensions between the growing use of active methodologies and the theoretical-critical foundations that guide integrated education. The general objective was to examine the representations of pedagogical practices in the teaching plans of technical courses integrated into upper secondary education across three campuses of the Federal Institute of Paraná (IFPR) regarding the use of active methodologies, identifying the contradictions and possibilities that emerge in light of critical pedagogies. A total of 438 documents referring to 13 courses were analyzed. The qualitative research was conducted in two stages: a literature review, including authors from EPT, critical pedagogies, and active learning methodologies; and a documentary analysis of the Teaching and Faculty Work Plans (PTD) obtained from the Teaching and Work Plan Platform (PLANIF). The data were organized in an analytical matrix with categories defined a priori: Critical Pedagogies (CP), Non-Critical Pedagogies (NCP), and Active Methodologies (AM), and examined through Content Analysis (Bardin, 2016). The results indicate that although there is significant use of active methodologies, 77.6% of the plans align with non-critical approaches, revealing a certain contradiction between institutional discourse and declared practices. The findings reveal challenges related to teacher training and the persistence of an education oriented toward the market, while also indicating a movement toward breaking with the banking model of education.

Keywords: Active Methodologies. Critical Pedagogies. Non-Critical Pedagogies. Professional and Technological Education.

RESUMO

Este estudo analisa as contradições e possibilidades das metodologias ativas à luz das pedagogias críticas na Educação Profissional e Tecnológica (EPT). O problema investigado refere-se às tensões entre a crescente utilização das metodologias ativas e os fundamentos teórico-críticos que orientam o ensino integrado. O objetivo geral foi analisar as representações das práticas pedagógicas nos planos de ensino dos cursos técnicos

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integrados ao ensino médio de três campi do Instituto Federal do Paraná (IFPR) quanto ao uso das metodologias ativas, identificando as contradições e possibilidades que emergem à luz das pedagogias críticas. Foram analisados 438 documentos referentes a 13 cursos. A pesquisa, qualitativa, desenvolveu-se em duas etapas: revisão bibliográfica, contemplando autores da EPT, pedagogias críticas e das metodologias ativas; e análise documental dos Planos de Ensino e Trabalho Docente (PTD) obtidos na plataforma de Planos de Ensino e Trabalho (PLANIF). Os dados foram organizados em matriz analítica com categorias definidas a priori: Pedagogias Críticas (PC), Pedagogias Não Críticas (PNC) e Metodologias Ativas (MA), e examinados por meio da Análise de Conteúdo (Bardin, 2016). Os resultados indicam que, embora haja uso significativo de metodologias ativas, 77,6% dos planos alinham-se a abordagens não críticas, evidenciando certa contradição entre o discurso institucional e as práticas declaradas. Os achados revelam desafios relacionados à formação docente e à persistência de uma educação orientada pelo mercado, ao mesmo tempo em que apontam um movimento de ruptura com a educação bancária.

Palavras-chave: Metodologias Ativas. Pedagogias Críticas. Pedagogias Não Críticas. Educação Profissional e Tecnológica.

RESUMEN

Este estudio analiza las contradicciones y posibilidades de las metodologías activas a la luz de las pedagogías críticas en la Educación Profesional y Tecnológica (EPT). El problema investigado se refiere a las tensiones entre el creciente uso de las metodologías activas y los fundamentos teórico-críticos que orientan la educación integrada. El objetivo general fue analizar las representaciones de las prácticas pedagógicas en los planes de enseñanza de los cursos técnicos integrados a la educación secundaria de tres campus del Instituto Federal de Paraná (IFPR) en relación con el uso de metodologías activas, identificando las contradicciones y posibilidades que emergen a la luz de las pedagogías críticas. Se analizaron 438 documentos referentes a 13 cursos. La investigación, de enfoque cualitativo, se desarrolló en dos etapas: revisión bibliográfica, contemplando autores de la EPT, pedagogías críticas y metodologías activas; y análisis documental de los Planes de Enseñanza y Trabajo Docente (PTD) obtenidos en la plataforma de Planes de Enseñanza y Trabajo (PLANIF). Los datos fueron organizados en una matriz analítica con categorías definidas a priori: Pedagogías Críticas (PC), Pedagogías No Críticas (PNC) y Metodologías Activas (MA), y examinados por medio del Análisis de Contenido (Bardin, 2016). Los resultados indican que, aunque existe un uso significativo de metodologías activas, el 77,6% de los planes se alinean con enfoques no críticos, evidenciando cierta contradicción entre el discurso institucional y las prácticas declaradas. Los hallazgos revelan desafíos relacionados con la formación docente y la persistencia de una educación orientada al mercado, al mismo tiempo que señalan un movimiento de ruptura con la educación bancaria.

Palabras clave: Metodologías Activas. Pedagogías Críticas. Pedagogías No Críticas. Educación Profesional y Tecnológica.

1 INTRODUCTION

Contemporary technological and social transformations have directly impacted the educational field, requiring new forms of teaching organization and reconfigurations in pedagogical practices. In Professional and Technological Education (EFA), this scenario becomes even more challenging, since integrated training requires articulating scientific, technical, and sociopolitical knowledge to changes in the world of work and society.

In the context of Paraná, the Federal Institute of Paraná (IFPR) stands out as a public institution of reference, created by Law No. 11,892/2008 and currently present in 33 municipalities. Offering integrated technical courses, subsequent, undergraduate and graduate programs, its institutional mission is to articulate work, science and technology, aiming at the formation of critical, autonomous citizens able to work in different areas of the economy (Brasil, 2008).

The research focused on three *campuses*: Curitiba, Palmas and Umuarama, selected for presenting different socioeconomic realities, enabling the understanding of how pedagogical practices are configured in different contexts. This choice dialogues with the Institutional Development Plan (PDI 2024–2028), which guides the IFPR to strengthen the relationship between training and territorial development (Brasil, 2024).

Active methodologies have gained prominence as pedagogical alternatives that seek to expand student protagonism. However, as Rosenau, Strapasson, and Canziani (2023) point out, it is a polysemic concept, whose application can occur both through instrumental and technicist perspectives and through approaches aligned with ethical-political projects of integral education. Thus, the objective of this study was to analyze to what extent such methodologies, when present in teaching plans, are close to or distant from critical pedagogies.

Authors such as Saviani (2021), Frigotto (2015) and Libâneo (2022) emphasize that EFA must overcome the historical duality between manual and intellectual work, ensuring access to systematized knowledge and promoting the omnilateral training of students. Although active practices can contribute to more dynamic and interactive pedagogical relationships, their isolated use does not ensure an emancipatory perspective, especially in the face of the neoliberal trend of emptying the critical sense of autonomy and learning by competences.

In this sense, the analysis of the teaching plans of the integrated technical courses proved to be strategic to understand how teachers have incorporated diversified

methodologies and which pedagogical conceptions guide such practices. It was assumed that the simple adoption of active methodologies does not guarantee critical intentionality or overcoming passive practices, and it is essential to identify contradictions and possibilities of their use in the context of EFA.

In view of this, the central question that guided this study was: What representations of pedagogical practices are evidenced in the teaching plans of technical courses integrated with high school at IFPR regarding the use of active methodologies, considering the contradictions and possibilities that emerge in the light of critical pedagogies?

The research, of exploratory nature and qualitative approach, aimed to analyze the representations of pedagogical practices in the teaching plans of technical courses integrated to high school in three IFPR campuses regarding the use of active methodologies, identifying the contradictions and possibilities that emerge in the light of critical pedagogies. The methodological path included a bibliographic review on EFA, critical pedagogies and active methodologies, and documentary analysis of the available teaching plans.

The relevance of this research consists in evidencing how an institution guided by critical premises and comprehensiveness has materialized such principles in its planning and teaching practices. By analyzing the coherence between the educational project and what is carried out in the pedagogical routine, especially in the context of EFA, historically crossed by tensions, it is intended to foster reflection and broaden the debate on the use of diversified methodologies that are intentionally anchored in a critical perspective.

2 THEORETICAL FRAMEWORK

The theoretical framework of this study was organized around three fundamental axes: Professional and Technological Education (EPT), critical pedagogies and active methodologies. The first discusses the relationship between education and work, highlighting its historical challenges and the main concepts that underlie EFA. The second addresses critical pedagogies and their central characteristics, including the implications for teacher performance and training, as well as for teaching methodologies. Finally, the third axis deals with active methodologies, presenting their concept and their adoption in the context of EFA.

2.1 PROFESSIONAL AND TECHNOLOGICAL EDUCATION

The relationship between work and education is a central element in the understanding of human formation, being historically and socially inseparable (Saviani, 2007). In primitive

societies, learning took place through productive practice, so that work was a condition for existence and acquisition of knowledge. The separation between education and work, resulting from private property, marked a process of fragmentation that is perpetuated over time. In this context, the Professional and Technological Education (EPT) and the Integrated High School (EMI) offered by the Federal Institutes, seek to resume the unity between work, science, culture and technology, promoting the integral and critical formation of the subjects (Brasil, 2024).

In the Brazilian scenario, EFA has two main strands: the immediate one, aimed at insertion in the labor market, and the polytechnic one, aimed at the integral formation of the individual, integrating scientific, technological and cultural knowledge (Ciavatta, 2012). The Federal Institute of Paraná (IFPR), through its Institutional Development Plan (PDI 2024-2028), adopts the polytechnic perspective, emphasizing integrality, emancipation, and the omnilateral training of students (Brasil, 2024).

Historically, Professional and Technological Education in Brazil has undergone significant transformations. Its path begins with the Apprentice and Artificer Schools, marked by a welfare character and aimed at the popular classes. In the following decades, especially during the dictatorship, professionalization took on a compulsory and instrumental bias, reinforcing the duality between intellectual training and preparation for work. In the 1990s and early 2000s, educational reforms increased the fragmentation between general and technical education, making it difficult to integrate proposals (Frigotto, 2018).

This scenario began to change with Decree No. 5,154/2004, which rescued the possibility of integrated curricular organization, articulating theory and practice in the same formative trajectory. Subsequently, Law No. 11,892/2008 consolidated this movement by creating the Federal Institutes, triggering an educational project committed to omnilateral and socially referenced education. Thus, the historical evolution of EFA expresses the search for overcoming the structural duality that has historically marked Brazilian education, towards a critical and integrated education (Frigotto, 2018).

The concept of omnilaterality, central to the perspective of the IFPR, is based on the integral formation of the subject, capable of understanding reality in a broad and critical way, articulating theory and practice, science, culture, manual and intellectual work (Saviani, 2007; Neves, 2009 apud Brasil, 2024). The Integrated High School (EMI) in the IFs is premised on the consolidation of a unitary, polytechnic and omnilateral education, articulating high school and technical professional education in an integrated curriculum. Such a configuration seeks

to overcome historical fragmentation and favor the articulation between science, culture and work, promoting integral human development and the critical consciousness of students (Frigotto; Ciavatta; Ramos, 2012).

2.2 CRITICAL PEDAGOGIES

Critical pedagogies are based on the understanding that education is a historically situated social practice, capable of favoring the critical reading of reality and the transformative action of the subjects. For Freire (1987), teaching is a political act that awakens awareness and enables educators and students to perceive themselves as historical agents. Saviani (2021) reinforces this perspective by stating that critical pedagogy is guided by a counter-hegemonic project, which links educational work to social transformation.

In this sense, critical pedagogies propose a formative process committed to human emancipation, articulating theoretical rigor, mastery of knowledge and reflection on social conditions. The school is understood as a space for the appropriation of systematized knowledge and for questioning the current order, contributing to the formation of subjects capable of intervening in reality (Suhr, 2012). Thus, knowledge assumes centrality as a cultural and political instrument, and not as mere content to be memorized (Libâneo, 1999).

In the context of critical pedagogies, the teaching work acquires an eminently social, political and ethical character. Libâneo (2013) highlights that pedagogy, when investigating educational practice in its links with society, dialogues with different fields: Philosophy, History, Sociology, Psychology and Economics, evidencing the complexity imbricated in the teaching practice, "being a human activity necessary for the existence and functioning of all societies" (Libâneo, 2013, p. 17).

Freire (1996) emphasizes the ethical-political commitment of the teacher, pointing out that the act of teaching requires awareness of the ideological dimensions of education. Saviani (2021), in turn, highlights that it is up to the school to transmit historically accumulated knowledge intentionally, ensuring that new generations are able to understand and transform reality.

Thus, the teaching work, in this approach, requires theoretical mastery, social awareness and clarity of formative purpose. It is a practice that articulates knowledge, historicity, and educational project, breaking with technicist or adaptive views of the teaching function (Saviani, 2021).

The political, economic and social contexts directly reflect on the training and performance of teachers." The school is in close relationship with society, that is, each society creates the school it needs. Therefore, the school can be a factor of exclusion or social inclusion" (Suhr, 2012, p. 112). The non-critical pedagogies: traditional, escolanovista, and technicist, present different understandings of education, but share the central characteristic of the tendency to reproduce the dominant social order (Saviani, 2021).

Traditional pedagogy, consolidated in the nineteenth century, focuses the process on the teacher and content, conceiving the school as an instrument of social integration and discipline (Saviani, 2021). The New School, in reaction to this model, shifts the focus to the student, prioritizing methods, experiences and individual interests, a movement that, despite the democratic discourse, has little changed the structural inequalities of the system (Suhr, 2012). On the other hand, technicism, strengthened during the military dictatorship, reduces teaching to technical execution, in line with productivist demands and bureaucratic rationality (Libâneo, 1999).

Such approaches generated a historical split in teacher training, which is still present today: while graduates bring some pedagogical basis, teachers from technical areas often have gaps in pedagogical training, a fragility that especially affects EFA. Added to this are structural problems such as: precarious working conditions, discontinuity of policies and insufficient infrastructure, directly impacting teaching practice (Saviani, 2011).

Critical pedagogies, on the other hand, understand teacher training as a process that articulates theory and practice, scientific knowledge, political awareness and methodological domain. Education is conceived as a social practice that can both reproduce inequalities and contribute to overcoming them (Freire, 1996). Thus, the teacher needs to understand reality in its multiple dimensions and organize teaching in such a way that the knowledge produced historically is critically appropriated by the students (Saviani, 2021).

The discussion about teaching methodologies is intrinsically linked to pedagogical conceptions. In non-critical theories, education tends to be understood as a neutral instrument, capable of promoting the equalization of inequalities (Saviani, 2021).

In traditional pedagogy, the teacher is the center of the process and the student assumes a passive role, focused on memorization. The New School, by emphasizing student protagonism, shifts the focus from content to methods, proposing the idea of "learning by doing" (Suhr, 2012). Technicism, in turn, is aligned with an instrumental model, in which both

the teacher and the student become cogs in a system oriented by efficiency and productivity (Frigotto; Ciavatta, 2022).

Critical pedagogies, on the other hand, understand methodologies as political-pedagogical mediations. The method is not neutral, but expresses a project of education and society. Thus, teaching methodologies should favor the critical appropriation of knowledge, the problematization of reality, and the development of social awareness, in line with an emancipatory educational project (Saviani, 2021).

2.3 ACTIVE METHODOLOGIES

Active methodologies have been widely debated in the educational field and, more recently, stand out as an alternative to reorganize pedagogical practices in both face-to-face teaching and Distance Education. The conception adopted in this research is in line with the reflections of Pereira (2021), who proposes to understand them beyond the simple updating of traditional didactics. For the author, it is not just about putting the student in a more active position in the learning process; by suggesting the spelling "[...]active strategies", it expands the understanding of these strategies, highlighting dimensions such as collaboration, creativity, integration, participation and construction of meaning, essential to an education committed to criticality and social transformation.

This means that, before resorting to a repertoire of techniques or a pedagogical prescription, the teacher needs to understand what is the intentionality behind the chosen methodology and what its training objectives are. This requires a critical and contextualized analysis of each content in order to select the most appropriate approach. The active methodology must be applied coherently, ensuring that the interaction promoted between the subjects of the teaching-learning process is effectively significant (Rosenau; Strapasson; Canziani, 2023).

The discussion about active methodologies requires, therefore, attention to the disputes in the contemporary educational field. As Rosenau, Strapasson, and Canziani (2023) warn, liberal proposals have appropriated terms linked to critical pedagogies, producing confusion that can lead teachers to identify as "advanced" practices that, in reality, reinforce individualistic or technicist conceptions. When active methodologies are incorporated uncritically, especially under the influences of escolanovismo, there is a risk of minimizing the role of teachers and compromising the appropriation of historically

systematized knowledge. Thus, its adoption must be anchored in a dialectical relationship between theory and practice, where teacher and student are protagonists (Pereira, 2021).

From a conceptual point of view, active methodologies can be understood as teaching strategies designed to promote dynamic and collaborative practices, stimulating autonomy, creativity, and reflection (Bacich; Moran, 2018). They involve active participation in cognitively challenging activities, situated in real or simulated contexts, mobilizing processes such as interpretation, analysis, evaluation, and application of knowledge (Pereira, 2021).

From a critical perspective, as Libâneo (2022) and Pereira (2021) argue, the adoption of active methodologies can transform the classroom into a dynamic space in which the student is no longer passive and the teacher no longer acts as a mere transmitter of knowledge, assuming the roles of mediator, advisor and director, since he holds essential knowledge for the learning processes of the students. The following table presents the active methodologies and strategies identified in the plans investigated.

Table 1

Active methodologies present in the analyzed teaching plans

Active Methodology	Description
Debates and discussions	Activities in which students exchange opinions, defend divergent positions and build knowledge in a cooperative way. It requires prior preparation, definition of roles and clear rules, stimulating critical thinking and active participation (Libâneo, 2013; Bacich; Moran, 2018).
Seminars, Exhibition, Exhibition, Presentation	Activity in which students prepare and present content, promoting research, organization and debate. The public also participates with questions and observations, favoring collaborative learning, development of autonomy, and collective construction of knowledge (Scorsolini-Comin, 2023).
Practical (e.g. practical class)	Activities in which students carry out experiments, applications or experiences of the contents, actively participating in the learning process, building knowledge in a reflective way (Bacich; Moran, 2018).
Group work, teamwork	Activity in which students collaborate in solving problems and projects, sharing responsibilities and building knowledge collectively. It favors dialogue and cooperation (Bacich; Moran, 2018).
Research	Activity in which students investigate problems or questions and raise hypotheses. It promotes curiosity, reflection and dialogue with reality (Demo, 2003; Bacich; Moran, 2018).

Active Methodology	Description
Problem-solving / Problem-based learning	A strategy in which students investigate real or simulated problems, developing hypotheses, researching solutions, and discussing results in groups. It promotes autonomy, critical thinking, collaborative learning and practical application of content (Bacich; Moran, 2018).
Projects / Project-based learning	A strategy in which students develop projects or solve real problems, making individual and group decisions. It promotes interdisciplinary learning, critical and creative thinking, collaboration, production of products or solutions, and continuous reflection on the process (Bacich; Moran, 2018).
Case Studies	Approach that starts from the analysis of real or simulated situations or problems in a realistic way, so that students develop skills of investigation, reflection and problem solving (Bacich; Moran, 2018).
Flipped classroom	A strategy in which students study content in advance, accessing digital or face-to-face materials, and use class time for debates, problem solving, and practical activities. It promotes autonomy, collaboration and socialization with the teacher, acting as an advisor and organizer of the experiences (Bacich; Moran, 2018; Pereira, 2021).
Gamification	Strategy that uses game elements such as: points, avatars and narratives, in educational contexts, without the need to create a complete game. It allows students to be engaged, stimulates participation, motivation and interaction, applying playful principles to favor learning (Pereira, 2021 apud Fardo, 2013)
Round table	A strategy in which students discuss a previously defined theme, with the active participation of all, allowing different perspectives. It favors argumentation, critical listening and the development of communicative and reflective skills (Bacich; Moran, 2018).
Moot Jury	Students take on typical trial roles, analyzing real or fictitious cases, debating evidence, and presenting reasoned decisions. It promotes critical thinking, argumentation, and collaboration.
Workshop (miscellaneous)	Students participate in practical and guided activities, aimed at the development of specific skills, such as reading, writing or artistic production. It stimulates active learning, creativity and practical application of knowledge (Bacich; Moran, 2018).
Exploratory teaching	Approach that encourages students to investigate, experiment, and discover concepts through observation and practice. Develops curiosity, autonomy, critical thinking and scientific investigation skills (Bacich; Moran, 2018),

Source: Prepared by the authors (2025).

Therefore, active methodologies are flexible pedagogical support resources, which can vary according to the intentions of the teachers and the educational context. In the plans analyzed, it was identified that teachers use them as a strategy to organize teaching sequences that encourage student involvement, combining diversified approaches ranging from practical and cooperative activities to the use of motivational tools, such as music, videos and games. This can materialize in learning products, reflecting, creativity, innovation, retention and understanding of content, such as literary pieces, models, videos, presentations, concept maps, among others (Pereira, 2025).

Figure 1

Motivational Tools



Source: Pereira (2025).

Finally, it should be emphasized that there are no ready-made models for its application. The use of active methodologies implies careful planning, constant adjustments and commitment to teacher training. In EFA, it is in the daily work, permeated by contradictions, technical demands and socio-political dimensions, that the teacher must seek strategies capable of integrating theory and practice and promoting the critical and active participation of students (Rosenau; Strapasson; Canziani, 2023).

3 METHODOLOGY

This research was exploratory in nature, which according to Gil (2017) is adequate to deepen the understanding of phenomena that are still little studied, such as the representations of pedagogical practices present in the investigated teaching plans. The

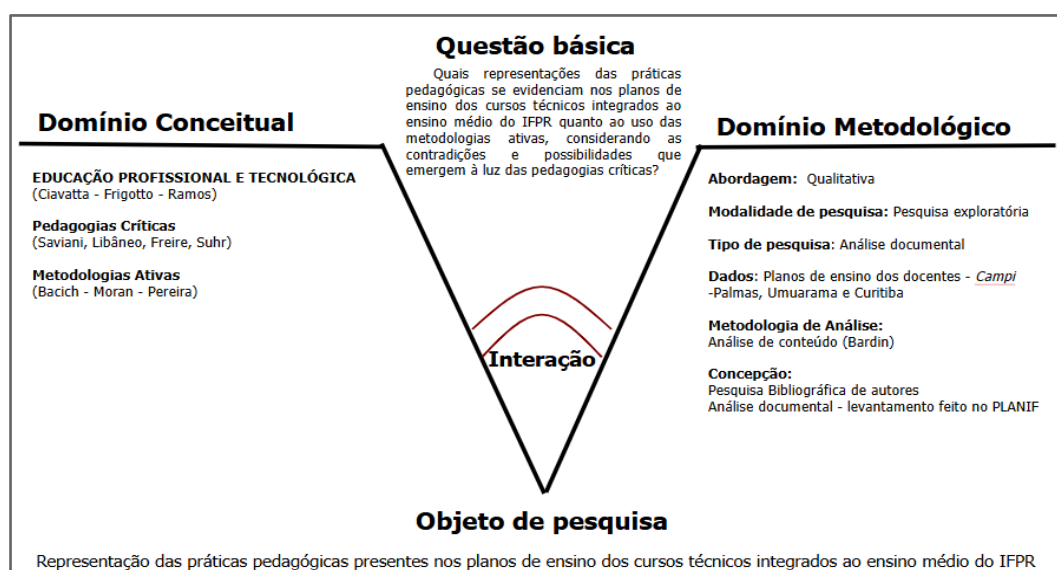
qualitative approach was adopted because it values the perspectives of the subjects of practice, in this case, the teachers, allowing us to understand their conceptions and the meanings attributed to the methodologies used. Thus, the qualitative analysis favored the identification of the meanings constructed in practice, as expressed in the teaching plans.

The methodological path was organized in two main stages: literature review and document analysis. The literature review enabled the construction of the conceptual tripod composed of: (a) Professional and Technological Education (EPT), supported by the references of Gaudêncio Frigotto, Maria Ciavatta and Marise Ramos; (b) Critical Pedagogies, based especially on Dermeval Saviani, José Carlos Libâneo, Paulo Freire and Inge Renate Froese Suhr; and (c) Active Methodologies, supported by the theoretical contributions of José Moran, Lilian Bacich and Máriam Trierveiler Pereira.

The survey was carried out on platforms such as SciELO and CAPES Journal Portal, as well as books, dissertations and digital materials, ensuring a solid theoretical foundation for the analysis. To support the organization of the methodological path, the Gowin diagram ("Gowin's V") was used, which articulates theoretical foundations, procedures and research objectives. This instrument allowed an integrated view of the stages of the investigation, as shown in Figure 2.

Figure 2

Planning of the Research.



Source: The authors (2025, adapted from Rosenau, 2017 from Novak and Gowin, 1983)

Gowin's "See" of knowledge is a heuristic instrument developed to assist in

understanding the structure of knowledge and the process of scientific construction (Novak and Gowin 1983). Rosenau (2017, adapted from Catapan, 2001), used this heuristic for research planning purposes, allowing us to visualize the articulation between theoretical foundations, methodological procedures and analytical processes.

The documentary research had as its main source the Teaching and Work Plans registered on the PLANIF Platform, referring to the technical courses integrated to high school at the Umuarama, Curitiba and Palmas campuses of the IFPR. Access to the system considered filters such as campus, course and year, adjusted according to the availability of documents.

Table 2

Plans collected from the PLANIF system

CAMPUS	YEAR	QUANTITY
Palmas	2023	46
Umuarama	2023	82
Curitiba	2024	310

Source: Prepared by the authors (2025).

In the selection of documents, it was decided to use the most recent plans available. However, the *Campuses* Palmas and Umuarama did not have published records for 2024, so the documents for 2023 were analyzed. To avoid redundancies, when the same professor taught more than one component using identical or very similar methodologies, his name was counted only once within each course. Specialized educational service plans were also excluded, in order to ensure greater precision in the representativeness of the pedagogical practices investigated. All selected documents were organized in an analytical matrix built in an electronic spreadsheet, prepared specifically for this purpose.

The data were analyzed through the Content Analysis proposed by Bardin (2016). The pre-analysis involved the floating reading of the planes organized in the analytical matrix, allowing the delimitation of the *corpus*. Then, the material was explored, deepening the concepts of critical and non-critical pedagogies and active methodologies. Subsequently, the data extracted from PLANIF were coded and categorized. The categories were defined *a priori*: Non-Critical Pedagogy (PNC), Critical Pedagogy (PC) and Active Methodologies (MA), with PNC and CP broken down into the subcategories Traditional, New School, Technician, Liberating and Historical-Critical.

4 RESULTS AND DISCUSSIONS

The result of the data analysis is presented below, based on the conceptual categories defined in the methodology: Non-Critical Pedagogy (PNC), Critical Pedagogy (CP) and Active Methodologies (AM). The initial analysis focused on the first two categories, PNC and CP, which were broken down into the following subcategories:

Non-Critical Pedagogies: Traditional, New School and Technician

Critical Pedagogies: Liberating and Historical-Critical

In the group of Non-Critical Pedagogies, the following indicators were identified:

- Traditional: emphasis on content transmission and memorization
- Technical: impersonality, search for efficiency and control, with a focus on operational objectives and reinforcements
- New School: valorization of "learning by doing" and the methods used.

In the Critical Pedagogies group, the following stood out:

- Liberating: selection of generating themes, problematization of reality and establishment of a dialogical relationship between teacher and student
- Historical-Critical: critical reading of reality, articulation between prior knowledge and elaborated knowledge, and historical-political understanding of the contents

The active methodologies and motivational tools present in the plans were initially generically grouped in a single column, and were later separated for a more detailed analysis. The interpretation of the data demanded constant returns to the *corpus*. First, the non-critical pedagogies of New School, Traditional and Technician were analyzed; then, the critical pedagogies: liberating and historical-critical. The results revealed differences in the application of the methodologies: in the plans aligned with critical pedagogies, the strategies adopted favored dialogue, reflection and problematization of reality; In the non-critical planes, its use was often restricted to decontextualized dynamics, without explicit pedagogical objectives

In traditional practices, expository methodologies predominated, with active strategies employed only in a complementary way. In the escolanovista proposals, the focus on "learning by doing" was highlighted, in practical and collaborative activities. In technical practices, the emphasis was on efficiency, targeted execution and the development of specific skills. In turn, the liberating and historical-critical pedagogies presented practices based on

dialogue, problematization, collective work and critical reading of reality, mobilizing active methodologies as a means of promoting engagement and critical awareness among learners.

Table 3

Documentary analysis of the teaching plans of the integrated technical courses

Campus	Integrated Technical Course in:	PNC	PC
Palmas	Food	16	07
Palmas	Legal Services	14	09
Umuarama	Buildings	29	05
Umuarama	Informatics	20	04
Umuarama	Chemistry	18	06
Curitiba	Administration	30	09
Curitiba	Accounting	37	07
Curitiba	Electronics	32	08
Curitiba	Mechanics	32	13
Curitiba	Oil & Gas	32	10
Curitiba	Informatics	32	08
Curitiba	Photographic Processes	23	08
Curitiba	Digital Game Programming	25	04
Total		340	98

Source: Prepared by the authors (2025).

Of the thirteen courses analyzed, 438 teaching plans were considered, of which 340, corresponding to 77.6%, were classified as belonging to non-critical pedagogies, and 98 or 22.4%, as linked to critical pedagogies. With regard to the use of active methodologies, 86.07% of the plans associated with non-critical pedagogies and 100% of those linked to critical pedagogies incorporate active practices in their planning.

Figure 3

General results - Analysis Matrix

PNC	TOTAL	MA	FM	SEM MA/FM
TRADICIONAL	51	33	11	16
ESCOLANOVISTA	236	229	164	2
TECNICISTA	53	38	28	9
TOTAL GERAL	340	300	203	27

PC	TOTAL	MA	FM	SEM MA/FM
LIBERTADORA	35	34	31	0
HISTÓRICO-CRÍTICA	63	62	55	0
	98	96	86	0

Source: Prepared by the authors (2025).

The values presented in the MA and FM columns should not be interpreted as sums, since in several cases the same teaching plan simultaneously contained active methodologies and motivational tools. This overlap reveals the diversity of the pedagogical practices adopted. Within this panorama, it is observed that the plans classified as New School represent 53.9% of the total number of documents analyzed, surpassing the sum of the liberating critical and historical-critical subcategories.

In this sense, some considerations pertinent to the results should be highlighted, since the dichotomy of teaching techniques does not depend on the classification into New School, Traditional or Technicist currents; The real challenge is to reframe its application. "Any technique, therefore, understood as mediation, must be recognized within its limits and without the certainty that it is a guarantee of success in teaching and learning in the formation of broad human capacities" (Araújo; Frigotto, 2015, p. 72).

It can be said that the scope of active methodologies in the promotion of cooperation, autonomy and emancipation constitutes a set of complementary effects, whose effectiveness depends directly on the intentionality that guides the pedagogical process. Thus, such methodologies, often associated with a neoliberal logic, do not have an intrinsic or determined meaning, and can be appropriated by different political and pedagogical projects (Rosenau; Strapasson; Canziani, 2023).

Thus, it is important to remember that integrated education "[...] it requires criticism of reductionist perspectives of teaching, which are committed to developing some human activities to the detriment of others [...]" (Araújo; Frigotto, 2015, p. 63). In this sense, active methodologies can be resignified in order to promote learning in a critical scope and aligned

with the educational project proposed by the IFPR, which values the integral formation and emancipation of the subjects.

That said, in view of such findings raised in the analyzed plans, it is worth reflecting on important points that emerged as a result of the data analysis:

1. There is a movement against banking education in the IFPR courses analyzed.
2. Most teachers adopt diversified active strategies, materialized in active methodologies or motivational tools, or both.
3. It is noted that critical pedagogical practices are a reality among some teachers according to the numbers presented, however they are a minority as the numbers revealed.
4. The need to broaden the debate and reflection on the alignment with the critical assumptions of the institution and its materiality.
5. New studies that contemplate the investigation on the influence of the training of teachers who work in EFA and the impact on their educational guidelines.
6. The understanding that strategies such as active methodologies are complementary and not the core of the process.
7. The relevance of bringing provocative and controversial studies within the area of education, such as active methodologies in a critical context.

It is noteworthy that the classifications adopted have an analytical character, based on the predominant characteristics of each plane, without implying rigidity or exclusivity, since "they are not always mutually exclusive, nor are they able to capture all the richness of concrete practice" (Libâneo, 1999, p. 21). Thus, the predominant core of the methodologies described in each plan was considered for classification purposes.

5 CONCLUSION

The results indicate that 86.07% of the plans of the IFPR integrated technical courses analyzed incorporate diversified methodologies, including active methodologies and motivational tools. In qualitative terms, it is observed that most professors seek strategies that go beyond the mere transmission of content, favoring greater student participation. However, such strategies are not always aligned with the foundations of critical pedagogies, which can limit their formative potential. When applied intentionally and critically, active methodologies favor protagonism, cooperation, engagement, and meaningful learning, converging with the principles of Professional and Technological Education.

This finding shows that the technique, although necessary, has less relevance in the face of the pedagogical conception that guides the educational process, which is the determining factor for a practice capable of methodologically situating the critical formative project. This research, as a result, establishes a direct relationship with the finding of Araújo and Frigotto (2015, p.76) when they state that it is necessary to "consider different methodological possibilities for the experimentation of the integrated teaching project and we maintain that there is no single technique more appropriate for the implementation of integrated teaching, because to consider this possibility would be to succumb to a methodological determinism". This understanding reinforces that the focus of pedagogical work should not reside in the adoption of a specific technique, but in the coherence between the formative principles and the practices developed.

The findings reaffirm that the use of active methodologies, by itself, does not guarantee a critical and integral education, since no teaching technique automatically ensures the development of human capacities. As Araújo and Frigotto (2015) argue, techniques constitute mediations between teacher and student and remain subordinated to the ethical-political purposes that guide the educational work. Thus, the same strategy, whether directed study, lecture, debate, or any active or non-active procedure, can serve both hegemonic reproduction and human emancipation, depending on the formative project that guides it (Libâneo, 2022).

It is emphasized that the challenge that is imposed on EFA is not the adoption of an "ideal method", but the construction of practices that are aware of their limits and potentialities, capable of integrating different teaching procedures without succumbing to methodological determinism (Araújo; Frigotto, 2015). The results show that, although there is a consistent movement of overcoming banking education in the courses analyzed, this transformation occurs in a partial and asymmetrical way, marked by the predominance of non-critical practices. The methodological diversification identified in the plans demonstrates that most teachers seek to expand student engagement through active methodologies and motivational tools, even though such resources are not always linked to the critical formative purposes that underlie the IFPR's educational project.

It is verified that critical pedagogical practices are a reality among some teachers, but remain in the minority, which reinforces the need to deepen the institutional debate on the alignment between conceptions and practices. The findings also point to the urgency of studies that investigate the role of teacher training in EFA and its impact on methodological

choices, recognizing that strategies such as active methodologies are complementary and do not constitute the core of the educational process. In this sense, bringing to light provocative discussions and theoretical controversies, especially about the place of active methodologies in critical perspectives, becomes fundamental to sustain an integrated, intentional education committed to human emancipation.

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**LAND REGULARIZATION, SOCIAL FUNCTION OF PROPERTY, AND
METHODOLOGICAL APPROACHES FOR THE ANALYSIS OF SPECIAL RURAL
ADVERSE POSSESSION IN THE DISTRICT OF MONTES CLAROS/MG**

**REGULARIZAÇÃO FUNDIÁRIA, FUNÇÃO SOCIAL DA PROPRIEDADE E
CAMINHOS METODOLÓGICOS PARA A ANÁLISE DA USUCAPIÃO ESPECIAL
RURAL NA COMARCA DE MONTES CLAROS/MG**

**REGULARIZACIÓN FUNDIARIA, FUNCIÓN SOCIAL DE LA PROPIEDAD Y
ENFOQUES METODOLÓGICOS PARA EL ANÁLISIS DE LA ADQUISICIÓN
POR PRESCRIPCIÓN EXTRAORDINARIA RURAL EN LA COMARCA DE
MONTES CLAROS/MG**

 <https://doi.org/10.56238/sevened2025.036-122>

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ABSTRACT

This article examines the theoretical foundations and methodological procedures adopted in the analysis of special rural adverse possession in the District of Montes Claros/MG, with an emphasis on verifying its effectiveness as an instrument for realizing the social function of land. Based on a historical understanding of Brazilian land formation and the constitutional framework that governs the productive and responsible use of land, the study points to a methodology that includes legal references, documentary analysis, and geoprocessing techniques to identify, systematize, and evaluate the effectiveness of the social function of rural properties susceptible to special rural adverse possession, notably in the district of Montes Claros/MG. The methodology developed involves three main stages: bibliographic and regulatory review; collection and examination of registry and judicial documents produced by the district's registry offices; and spatial analysis of the selected areas using MapBiomass geographic databases integrated with QGIS software. This interdisciplinary approach allows not only for an understanding of the legal history of the institution, but also for the mapping, description, and interpretation of the territorial dynamics linked to possessions qualified by residence and family productivity. By proposing a replicable methodological model, the article contributes to the improvement of academic research on land regularization, land use, and rural development, providing support for the empirical evaluation of the social function of property in specific regional contexts.

Keywords: Special Rural Adverse Possession. Social Function of Land. Land Regularization. Legal Methodology. Geoprocessing. Mapbiomas. Montes Claros/MG. Rural Possession. Territorial Development. Agrarian Property.

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RESUMO

O presente artigo examina os fundamentos teóricos e os procedimentos metodológicos adotados na análise da usucapião especial rural na Comarca de Montes Claros/MG, com ênfase na verificação de sua efetividade como instrumento de concretização da função social da terra. Partindo da compreensão histórica da formação fundiária brasileira e do arcabouço constitucional que rege o uso produtivo e responsável da terra, o estudo aponta metodologia que compreende referenciais jurídicos, análises documentais e técnicas de geoprocessamento para identificar, sistematizar e avaliar a efetividade da função social dos imóveis rurais suscetíveis à usucapião especial rural, notadamente, na comarca de Montes Claros/MG. A metodologia desenvolvida envolve três etapas principais: revisão bibliográfica e normativa; coleta e exame de documentos registrares e judiciais produzidos pelos cartórios da comarca; e análise espacial das áreas selecionadas mediante o uso de bases geográficas do MapBiomias integradas ao software QGIS. Essa abordagem interdisciplinar permite não apenas compreender o percurso jurídico que do instituto, mas também mapear, descrever e interpretar as dinâmicas territoriais vinculadas às posses qualificadas por residência e produtividade familiar. Ao propor um modelo metodológico replicável, o artigo contribui para o aprimoramento das investigações acadêmicas sobre regularização fundiária, uso da terra e desenvolvimento rural, oferecendo subsídios para a avaliação empírica da função social da propriedade em contextos regionais específicos.

Palavras-chave: Usucapião Especial Rural. Função Social da Terra. Regularização Fundiária. Metodologia Jurídica. Geoprocessamento. Mapbiomas. Montes Claros/MG. Posse Rural. Desenvolvimento Territorial. Propriedade Agrária.

RESUMEN

El presente artículo examina los fundamentos teóricos y los procedimientos metodológicos adoptados en el análisis de la prescripción especial rural en la comarca de Montes Claros/MG, con énfasis en la verificación de su eficacia como instrumento para concretar la función social de la tierra. Partiendo de la comprensión histórica de la formación fundiaria brasileña y del marco constitucional que rige el uso productivo y responsable de la tierra, el estudio propone una metodología que comprende referencias jurídicas, análisis documentales y técnicas de geoprocetamiento para identificar, sistematizar y evaluar la eficacia de la función social de los inmuebles rurales susceptibles de prescripción especial rural, en particular en la comarca de Montes Claros/MG. La metodología desarrollada comprende tres etapas principales: revisión bibliográfica y normativa; recopilación y examen de documentos registrares y judiciales producidos por las oficinas notariales de la comarca; y análisis espacial de las áreas seleccionadas mediante el uso de bases geográficas de MapBiomias integradas al software QGIS. Este enfoque interdisciplinario permite no solo comprender la trayectoria jurídica de la institución, sino también mapear, describir e interpretar las dinámicas territoriales vinculadas a las posesiones calificadas por residencia y productividad familiar. Al proponer un modelo metodológico replicable, el artículo contribuye al perfeccionamiento de las investigaciones académicas sobre regularización fundiaria, uso de la tierra y desarrollo rural, ofreciendo subsidios para la evaluación empírica de la función social de la propiedad en contextos regionales específicos.

Palabras clave: Usucapión Especial Rural. Función Social de la Tierra. Regularización Fundiaria. Metodología Jurídica. Geoprocetamiento. Mapbiomas. Montes Claros/MG. Posesión Rural. Desarrollo Territorial. Propiedad Agraria.

1 INTRODUCTION

Understanding the institute of special rural adverse possession and its legal, social and spatial developments requires a methodological approach capable of articulating historical, normative and empirical dimensions. In Brazil, the land structure was constituted under a deep concentration of land, from the colonial sesmarias to the Land Law of 1850, through processes of private appropriation that transformed land into an object of economic and political exclusion. As Marés (2003, p. 12) observes, "the practice of concentrating production in a space of land, and even more recent, transforming this concentration to the benefit of a single person and calling it a right of property", showing that the relationship between land and society was historically constructed in such a way as to privilege private accumulation to the detriment of collective destination.

In this scenario, the Federal Constitution of 1988 introduced criteria for legitimizing property based on its social function, linking it to the fulfillment of economic, environmental and social requirements, as established in article 186. Special rural adverse possession is based on this paradigm, operating as a mechanism for historical correction and land regularization by legally recognizing the prolonged, productive and responsible possession of small farmers. However, despite its normative relevance, there are still few empirical analyses that examine the effectiveness of this institute and, above all, the appropriate methods to study it in the Brazilian territorial context.

Notwithstanding the normative advance introduced by the 1988 Constitution and the importance of special rural adverse possession as an instrument for democratizing access to land, it remains poorly understood, especially at the local level, whether this institute has been able to produce concrete effects related to the fulfillment of the social function of property. In the District of Montes Claros/MG, despite the significant presence of family farming and the recurrence of consolidated possessory situations, no empirical studies were identified that allow verifying, based on documentary and spatial evidence, whether the properties regularized by special rural adverse possession have been used in a rational, productive and environmentally appropriate manner. Thus, the research problem that guides this study is: has the special rural adverse possession, as applied in the District of Montes Claros/MG, effectively promoted the fulfillment of the constitutional criteria of the social function of property? The answer to this question requires the adoption of methodological procedures capable of articulating legal analysis, systematic document collection and spatial

evaluation of land use and land cover, since only the convergence of these dimensions allows the socio-legal effects of land regularization to be consistently assessed.

The methodology adopted in the research from which this article derives was structured to, as a general objective, evaluate, in an interdisciplinary way, whether the properties regularized by rural adverse possession in the District of Montes Claros/MG meet the criteria of social function. For this, in addition to the deep understanding of the underlying legal concepts; it was necessary to rigorously identify the available registration and judicial data; and the application of geoprocessing instruments capable of representing land use dynamics over time.

Thus, this article presents an expanded detail of the methodological choices that guided the investigation, articulating basic theoretical foundations to the technical and analytical strategies employed. It is, therefore, a work that seeks to demonstrate a methodological procedure that, because it is adequate to scientific requirements, is capable of subsidizing future research on land regularization, rural development and legal geography of land.

2 METHODOLOGICAL FOUNDATION

The investigation is guided by references that understand research as a process articulated between different analytical stages. Minayo (2009, p. 23) teaches that the method constitutes "a path of thought and practice exercised in the approach to reality", being inseparable from the object researched and the objectives that one wishes to achieve. Thus, the methodology was not conceived as a mere instrumental step, but as a structure that allowed the recognition of the complexity of the phenomenon studied, integrating legal, historical and spatial dimensions.

Gil (2017; 2019) points out that exploratory research is especially indicated when the object lacks previous studies or when it is intended to deepen understanding of little-known phenomena in certain territorial areas, exactly the case of special rural adverse possession in the District of Montes Claros. Adopting the premises of this author, it seeks to combine data collection with analysis of its descriptive elements to characterize, in a systematized way, the properties, their records, the dynamics of land use and the adherence to the constitutional criteria of the social function.

Still seeking to meet the exploratory character of the research, indicated by the author, it is possible to see that the methodology of the present analysis is proposed from three main

foundations. First, the preservation of interdisciplinarity, necessary to articulate law, geography and rural development. In addition, the maintenance of documentary rigor, required in legal studies and, finally, spatial analysis, indispensable when examining land use and territorial transformations.

3 STEP 1 – BIBLIOGRAPHIC AND DOCUMENTARY REVIEW

The first stage consists of the construction of the theoretical framework necessary for the interpretation of the legal institutes involved and the Brazilian agrarian context. The review follows the procedure recommended by Gil (2019), which establishes the need to delimit central topics, select reference materials, and proceed with analytical reading capable of guiding the formulation of the analysis categories. In this context, the consultation of books, scientific articles, theses, dissertations and normative documents that deal with the historical formation of property, possession, adverse possession and, above all, the social function of rural property is inserted.

As the author of a necessary review in research on the social function of the ownership of rural properties subject to adverse possession, Carlos Frederico Marés stands out, with his work *The Social Function of Land*. The work of Marés (2003) is fundamental to understand the historical characteristics of land concentration and the social nature of property rights. In a relevant passage, the author states that "land cannot be reduced to a commodity without losing its dimension as an indispensable good for life" (Marés, 2003, p. 21). By glimpsing this excerpt, it is reinforced how much the analysis methodology cannot ignore the social dimension implicit in the institute of special rural adverse possession.

Maria Helena Diniz, in her *Course on Brazilian Civil Law* (2022), and Sílvio de Salvo Venosa, in the work *Civil Law: Real Rights* (2021), play a fundamental role in the conceptual structuring that supports the legal analysis undertaken in this study. Both authors offer classic and widely referenced systematizations in Brazilian law on the institutes of possession and property, so that their contributions not only define dogmatic categories, but also provide the interpretative parameters indispensable to understand adverse possession as an original form of property acquisition. In the methodological sphere, the reading of these works is essential because it establishes the theoretical basis necessary to distinguish possession *ad usucapionem* from other possessory modalities, to identify the constituent elements of *animus domini* and to recognize the objective conditions that characterize the prolonged, continuous and public exercise of possession, without opposition from the registered holder.

In addition, Diniz (2022) and Venosa (2021) offer conceptual frameworks that allow us to accurately differentiate qualified possession relevant to special rural adverse possession from mere irregular detention, a distinction that is central when examining lawsuits and real estate records. By systematizing the legal requirements of the various modalities of adverse possession, especially with regard to the time, area and socioeconomic purpose of the occupation, these authors enable the construction of a methodological filter through which it becomes possible to select, in a rigorous manner, the cases effectively compatible with the special rural adverse possession provided for in article 1,239 of the Civil Code. From this systematization, it becomes feasible to recognize, in the documents collected, situations in which possession is exercised as a true exteriorization of dominion, configuring itself as "possession-work" or "possession-productive" — categories that dialogue directly with the constitutional paradigm of the social function of property.

In view of the above, the review of these authors provides the theoretical and legal basis that guides the entire stage of documentary analysis and allows the proper interpretation of the registration descriptions, court sentences and factual elements mentioned in the registrations. Without this conceptual basis, the understanding of the legal meaning of the possessory situations under analysis and the verification of whether the possessions meet the normative requirements that legitimize the original acquisition of the property by special rural adverse possession are compromised.

In turn, the studies of Oswaldo Opitz & Silvia C.B. Opitz in the *Complete Course of Agrarian Law* (2017) and Louise Gabler, in the article *Sesmarias*, published in MAPA – Memory of Brazilian Public Administration (2015) are essential to reconstruct the historical and normative formation of the Brazilian rural territory, offering the necessary depth to understand land inequalities and how these structures impact effectiveness of the special rural adverse possession. These authors demonstrate that the constitution of the national agrarian space takes place through processes that, since the colonial period, institute forms of concentrated appropriation of the soil, either by the sesmarias distributed over large areas, or by the subsequent norms that transform land into merchandise and restrict its access to the economically privileged strata. By showing that the Brazilian territorial organization is based on exclusion, Opitz & Opitz (2017) and Gabler (2015) offer elements that allow us to interpret adverse possession not only as a legal institute, but as a state response to a long-term structural problem.

These studies, then, are able to reveal that the institute of special rural adverse possession does not arise in isolation, on the contrary, it is inserted in a scenario marked by historical disputes over access to land, by the late positivity of the social function of property and by the permanence of consolidated possessory situations on the margins of the registry system. By resuming the trajectory of the Land Law of 1850, for example, these authors explain how the requirement of purchase for the acquisition of vacant land instituted a privatist and exclusionary model, the effects of which are felt to this day in regions such as the North of Minas. Thus, the review of these authors allows us to understand that the prolonged and productive possession examined in the cases studied is not an isolated phenomenon, but a direct consequence of a territorial arrangement that, for decades, restricted formal access to property, strengthening the explanatory capacity of the research.

Through the bibliographic review, mainly of these authors, the theoretical exposition is not limited only to the presentation of concepts, but constitutes the basis for the subsequent methodological choices, which guides the collection of documents before the Notary Services and the spatial analysis of the areas studied.

4 STEP 2 – DOCUMENT COLLECTION AND IDENTIFICATION OF ENROLLMENTS

Having understood the institutes that make up the special rural adverse possession in Brazil, as well as their articulations with the distribution of land, land regularization and the social function of property — an understanding built from the specialized literature —, the second cycle of the research consists of the collection of documents that allow the delineation of the spatial fragmentation of the Comarca of Montes Claros and, particularly, to identify their rural areas. Once these zones have been delimited, data are obtained from the Real Estate Registry Offices of the district, consisting of the records of declaratory judgments of special rural adverse possession. At this time, with the support of a quantitative approach, it seeks to identify which areas and in which periods this type of adverse possession is registered, based on the sentences handed down between the years 2013 and 2023.

The choice of this time frame is justified by two central factors. First, the implementation of the Electronic Judicial Process (PJe) in the District of Montes Claros, in 2015, significantly expands access to digitized documents, as recorded by Minas Gerais (2015). The digitalization of the civil courts, where rural adverse possession actions are processed, allows the processes to be fully produced, managed and consulted electronically, giving greater precision and transparency to the research. Second, as Salomão and Madeira

(2023) consider, the Sars-Covid 19 pandemic intensifies the need to adopt technological tools for the provision of extrajudicial services, generating regulations that accelerate the transition from public records to the digital environment. This movement culminates in Law No. 14,382/2022, which establishes the Electronic System of Public Records (Serp), aimed at the national integration of registration services.

Although the Serp is more recent, the system observes the Principle of Registry Conservation, which, according to Venosa (2021), ensures that the real estate registration contains the permanent and continuous file of the property's history. In this way, even documents scanned later preserve the collection necessary to identify sentences recorded in previous periods. This methodological condition makes it possible to map adverse possession actions based on the registrations themselves, which is an indispensable stage of the research.

However, although the investigation seeks to determine which areas have records of special rural adverse possession and in which years such records occur, the consultations carried out on the data of the 1st and 2nd Real Estate Registry Offices of the District of Montes Claros reveal that there are no records of judgments classified as special rural adverse possession in the selected period. This finding is not an empirical result per se, but an element of the methodological path, which requires the adoption of complementary strategies for identifying cases that, although registered as ordinary or extraordinary, factually correspond to the requirements of special rural adverse possession.

4.1 SURVEY OF REGISTRATIONS IN THE REAL ESTATE REGISTRY OFFICES

The initial stage of document collection consists of requesting certificates from the 1st and 2nd Real Estate Registry Offices of the District, requesting the list of all rural properties with an area of less than 50 hectares and that present a record of adverse possession judgment from 2013 onwards. This methodological choice stems from the limitations of the notary systems themselves, which do not allow a specific search for the "special rural" modality. Thus, the area criterion — an objective requirement provided for in article 1,239 of the Civil Code — is used as a viable initial filter.

The 1st Official Letter indicates 19 enrollments that meet the established criteria, while the 2nd Official Letter presents 13. With these reports, each registration is individually analyzed through the SAEC platform (currently called RI Digital), seeking to identify: the ownership, the number of the judicial process that supports the registration and any

references to the owner's residence in the usucapido property. This check is essential for subsequent filters.

4.2 SELECTION OF ADVERSE POSSESSION LAWSUITS

After surveying the enrollments, the research stage of the respective legal proceedings begins on the portal of the Court of Justice of Minas Gerais, with the objective of verifying which type of adverse possession was proposed by the plaintiff. In physical processes, the consultation is restricted to the information made available by the system; In electronic proceedings, it is possible to fully examine the procedural documents, from the initial petition to the judgment.

It is observed, in this methodological phase, that most of the processes are registered as ordinary or extraordinary adverse possession. The methodology thus foresees the need to identify, among these actions, those that meet the requirements of special rural adverse possession. Such a procedure is justified because this modality presents additional subjective requirements — such as the inexistence of another property owned by the possessor and productivity through the family's work for at least five years (Brasil, 1988, art. 191) — which often lead the plaintiffs to opt for modalities with less evidential rigor. On the other hand, ordinary and extraordinary adverse possession (Brasil, 2002, arts. 1.238 and 1.240) do not have such limitations, which explains their greater recurrence.

Thus, in order to meet the objective of the research — which consists of analyzing the fulfillment of the social function in small rural properties whose owners reside and produce on the site — a methodological filter is carried out that selects, among the records of ordinary and extraordinary adverse possession, those that materially fit the constitutional requirements of special rural adverse possession.

4.3 RESIDENCE FILTERS AND PRODUCTIVE ACTIVITY

Based on the registrations provided by the registry offices, the filter related to the rural location and the size of the property (less than 50 ha) is applied, considering the entire territorial extension of the District of Montes Claros as defined by the Law of Judicial Organization of Minas Gerais (2001), which includes the municipalities of Montes Claros, Claro dos Poções, Glaucilândia, Itacambira and Juramento. Then, it is verified, through the registration certificates and the initial documents of the processes, if the possessors reside in the property.

Once this second filter is consolidated, only the registrations that indicate habitual residence are selected, as this requirement is an essential element of special rural adverse possession. The verification of the productive activity complements the filtering: only the registrations whose owners demonstrate, in the documents analyzed, that they exercise productive exploitation of the property by their own or family work, in accordance with article 191 of the Federal Constitution, remain in the sample.

These filters allow the identification of the areas that make up the universe of the research and constitute the basis for the subsequent stages of spatial analysis and legal interpretation.

4.4 SPATIAL ANALYSIS AND LAND USE

Once the areas that meet the methodological filters have been identified, the spatial analysis begins to examine their territorial conformation in the selected period. To this end, the MapBiomass platform is used, a collaborative network that has produced annual mapping of land cover and use in Brazil since 1985, and whose bases allow observing environmental changes in a standardized and comparable way. The selection of the period is based, on the one hand, on the digitization of enrollments by notary offices and, on the other hand, on the availability of MapBiomass Collection 9, in September 2024, which covers data up to 2023.

Spatial analysis is performed using QGIS software, an open-source tool widely used in geographic surveys. Initially, the geographic coordinates of the enrollments are structured in a compatible spreadsheet (CSV), converting data from degrees, minutes and seconds to decimal degrees when necessary. These coordinates are then imported as a vector layer, using SRC EPSG:4326 (WGS 84). To spatially represent the areas, the points are converted into polygons, observing the correct order of the vertices.

After the delimitation of the areas, the *raster* data from MapBiomass are integrated into the project, and the layer is cut out based on the defined polygons. Then, the classes of land use and land cover are identified and quantified using tools such as *r.report*, which allows the generation of analytical tables and comparative tables that support subsequent interpretations. This methodological stage is not intended to present results, but to demonstrate the technical procedure that allows, in later stages, to examine the dynamics of land use in the period from 2013 to 2023.

Once the preparation, treatment and organization of the registration, judicial and spatial data is concluded, the third cycle of the research begins, dedicated to the integrated

analysis of these materials. The objective is to evaluate, in a methodologically grounded manner, whether the selected areas — characterized by prolonged possession, residence and productive activity — present conditions that allow, at a later stage, to examine their fit in the constitutional criteria of the social function of rural property. It is, therefore, the consolidation of a methodological path that articulates geotechnologies, documentary analysis and normative interpretation, constituting a solid basis for the development of the following stages of the study.

5 FINAL CONSIDERATIONS

The methodological trajectory outlined throughout this study shows that the analysis of special rural adverse possession, especially when inserted in contexts marked by historical inequalities in access to land, demands an approach that transits between disciplinary fields and integrates different scales of reading the territory. The combination of legal foundations, historical reconstruction, detailed documentary analysis and geoprocessing techniques allowed us to achieve a model capable of apprehending the phenomenon in its complexity, offering solid parameters to assess the conformity of the properties studied with the constitutional criteria of the social function of property.

The application of this methodological path demonstrated that the understanding of special rural adverse possession is not limited to the fulfillment of legal requirements, as it necessarily involves the empirical verification of how prolonged possession materializes in space and how productive occupation contributes to the transformation of local agrarian dynamics. By integrating registry data, judicial information and spatial evidence on land use, the methodology adopted demonstrated the ability to produce diagnoses on the land reality of the Montes Claros County, expanding the interpretative scope of the institute and allowing a more concrete approximation of its socio-legal effects.

The procedures employed, while allowing a detailed characterization of the selected properties, also showed that the study of special rural adverse possession can play a relevant role in the construction of public policies aimed at land regularization, the strengthening of family farming and territorial planning. The ability to identify patterns of productive use, family permanence and environmental management shows that legal instruments, when properly used, can function as effective mechanisms to lead to the fulfillment of the social function of property and to promote sustainable rural development.

Although this paper does not aim to present material conclusions about each case analyzed, the consolidation of a rigorous methodological model provides a basis for future research interested in evaluating the effectiveness of special rural adverse possession in different regions. By structuring a replicable path, this study contributes to the advancement of the dialogue between law and territorial sciences, reinforcing that land regularization should be understood as a process that involves legal, geographic and historical dimensions. In this sense, the methodology presented, by structuring safe means of interpretation and analysis, contributes not only to the academic literature, but also to the formulation of state interventions necessary to confront the historical inequalities that still mark the Brazilian rural space.

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**SOCIOLOGICAL ANALYSIS OF THE ENROLLMENT OF STUDENTS WITH
DISABILITIES IN HIGHER EDUCATION BY GENDER AND RACE**

**ANÁLISE SOCIOLÓGICA DAS MATRÍCULAS DE ESTUDANTES COM
DEFICIÊNCIAS NO ENSINO SUPERIOR POR GÊNERO E RAÇA**

**ANÁLISIS SOCIOLÓGICO DE LAS MATRÍCULAS DE ESTUDIANTES CON
DISCAPACIDADES EN LA EDUCACIÓN SUPERIOR POR GÉNERO Y RAZA**

 <https://doi.org/10.56238/sevened2025.036-123>

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ABSTRACT

This article presents data regarding the enrollment of students with disabilities in Brazilian higher education with a focus on data from Paraná state universities (IEES-PR) and the characterization of these students by race/gender. The data were extracted from INEP (2011-2019), exported using SPSS (Statistical Package for the Social Sciences), and analyzed in light of Sociology. The main objectives were to identify the characterization of these students and to map what the scenario found reveals to us, making it possible to clarify who these subjects are. In general terms, the data reveal many challenges for the access of the black and brown population with disabilities to higher education. In relation to sex, we observe that the national sociological characterization points out that one of the effects of state policy, which does not align the State of Paraná with the national trend, is the greater access of male persons with disabilities than female persons with disabilities. Regarding the type of disability, we observed a higher incidence of physical disability in the national data and in the State of Paraná, followed by low vision. In the state universities of Paraná, we highlight low vision, which makes up 68% of the total enrollments of people with disabilities throughout the entire period. Such data evidence, for example, the need for public policies that contemplate the incentive for a transformation of the scenario of this social reality found, that is, of the social markers that often configure themselves as markers of inequalities and differences.

Keywords: Higher Education. Disability. Race. Gender. Social Indicators.

RESUMO

Este artigo, apresenta dados referente a matrículas de estudantes com deficiências no ensino superior brasileiro com foco nos dados das universidades estaduais do Paraná IEES-PR e à caracterização das mesmas por raça /gênero. Os dados foram extraídos do INEP(2011-2019), exportados através do SPSS (Statistics (Statistical Package for the Social Science), e analisados à luz da Sociologia. Os principais objetivos esteve em identificar a caracterização desses estudantes e mapear o que o cenário encontrado nos revelam, viabilizado esclarecer quem são esses sujeitos. Em linhas gerais, os dados revelam muitos

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desafios do acesso da população preta e parda com deficiência ao ensino superior. Em relação ao sexo, observamos que a caracterização sociológica nacional aponta que um dos efeitos da política estadual é que não coloca o Estado do Paraná alinhado à tendência nacional é em relação ao maior acesso de pessoas com deficiência do sexo masculino, do que de pessoas com deficiência do sexo feminino. Sobre o tipo de deficiência, observamos maior incidência de deficiência física nos dados nacionais e no Estado do Paraná, seguida pela baixa visão. Já nas universidades estaduais do Paraná, destacamos a baixa visão, a qual compõe 68% do total de matrículas de pessoas com deficiência ao longo do período todo. Tais dados evidenciam, por exemplo, a necessidade de políticas públicas que contemplem o incentivo a uma transformação do cenário dessa realidade social encontrada, ou seja dos marcadores sociais que se configuram, muitas vezes, como marcadores das desigualdades e das diferenças.

Palavras-chave: Ensino Superior. Deficiência. Raça. Gênero. Indicadores Sociais.

RESUMEN

Este artículo presenta datos referentes a la matrícula de estudiantes con discapacidad en la educación superior brasileña con foco en los datos de las universidades estatales de Paraná (IEES-PR) y a la caracterización de las mismas por raza/género. Los datos fueron extraídos del INEP (2011-2019), exportados a través del SPSS (Statistical Package for the Social Sciences), y analizados a la luz de la Sociología. Los principales objetivos fueron identificar la caracterización de esos estudiantes y mapear lo que el escenario encontrado nos revela, posibilitando esclarecer quiénes son esos sujetos. En líneas generales, los datos revelan muchos desafíos del acceso de la población negra y parda con discapacidad a la educación superior. En relación al sexo, observamos que la caracterización sociológica nacional apunta que uno de los efectos de la política estadual y que no coloca al Estado de Paraná alineado a la tendencia nacional es en relación al mayor acceso de personas con discapacidad del sexo masculino, que de personas con discapacidad del sexo femenino. Sobre el tipo de discapacidad, observamos mayor incidencia de discapacidad física en los datos nacionales y en el Estado de Paraná, seguida por la baja visión. Ya en las universidades estatales de Paraná, destacamos la baja visión, la cual compone el 68% del total de matrículas de personas con discapacidad a lo largo de todo el período. Tales datos evidencian, por ejemplo, la necesidad de políticas públicas que contemplem el incentivo a una transformación del escenario de esa realidad social encontrada, o sea, de los marcadores sociales que se configuran, muchas veces, como marcadores de las desigualdades y de las diferencias.

Palabras clave: Educación Superior. Discapacidad. Raza. Género. Indicadores Sociales.

1 INTRODUCTION

In this, we present the enrollment data of students with disabilities in Brazil, in Paraná (all HEIs) with a focus on the state universities of Paraná⁵, between the years 2012 and 2019, based on the intersectionality of the data with the race/gender categories allowed us to draw a parameter on the characterization of the enrollment of these students in higher education. From a dialectical and critical perspective, we will make considerations of what we have found.

Table 1 presents data on the race category among people with disabilities enrolled in Brazilian higher education, at the State of Paraná level (including public and private) and the quantitative focused on the State Universities of Paraná. Table 2 shows the data distributed in the same sequence for the gender category. Below, we find table 3 in these same distributions, referring to the category "types of disabilities" addressed in this article, namely: hearing, physical, intellectual, multiple disabilities, deafness, deaf-blindness, low vision and blindness.

It is important to analyze these specificities as an axis of discussion, because according to data from the "2010 Census Booklet - People with Disabilities", organized by Luiza Maria Borges Oliveira (2012), among 45,606,048 Brazilians, 23.9% of this total population have some type of disability – visual, hearing, motor and mental or intellectual.

Therefore, the main objective is to map and characterize who are the subjects with disabilities who occupy the benches of universities and from this to carry out a sociological analysis of what these data reveal to us in the face of a given social reality.

2 THEORETICAL FRAMEWORK

We started with the category of race among people with disabilities, because it is not only a marker of difference and belonging, but also a marker of inequality in the country, which justifies the relevance of public educational policies that expand the access and permanence of black populations and people with disabilities in universities. After all, as Quijano (2005) reports, "race has become the first fundamental criterion for the distribution of the world population in the levels, places and roles in the power structure of the new society. In other words, in the basic mode of universal social classification of the world

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population (QUIJANO, 2005, p.118). It should be noted how the category of race carries a Eurocentric ideology of whitening, which synthesizes the conceptions of colonialism to justify exploitation, discrimination, inequalities in power relations against historically marginalized populations. Thus, for the same author, the category of race consists;

[...] with total certainty, the most effective instrument of social domination invented in the last 500 years. Produced at the mere beginning of the formation of America and capitalism, in the transition from the fifteenth to the sixteenth century, in the centuries that followed it was Ethnic-racial Characteristics of the Population: Classifications and Identities imposed on the entire population of the planet as part of the colonial domination of Europe (QUIJANO, 2000, n.p.).

Another marker of difference and belonging, but also of social inequality in Brazil, is configured in the gender category, hence the importance of analyzing such data when reflecting on the characterization of people with disabilities in Brazil, in Paraná and in the IEES/PR. In this research, as well as in Gomes (2018, p.01), "gender is taken as a question, as a category that allows us to question subjects – as subjects of culture, as social subjects, as historical subjects, as political subjects and as subjects of rights".

Based on data from the "2010 Census Booklet - People with Disabilities", prepared by Luiza Maria Borges Oliveira (2012), of the 45,606,048 Brazilians, 25,800,681 (26.5%) are women and 19,805,367 (21.2%) are men. From this general demographic data (45,606,048 Brazilians), 38,473,702 people live in urban areas and 7,132,347 Brazilians live in rural areas.

From a sociological perspective, we can say that gender;

[...] as an ontological category, it considers the differences and inequalities attributed to men and women, which gain meaning through cultural symbolic systems that designate masculinity and femininity as a set of opposite and hierarchical qualities within the framework of androcentrism (the view of men as the center and the norm for human beings) and patriarchy (institutionalized systemic sexism, which implies subordination and oppression of women) (CARVALHO; ANDRADE; MENEZES, 2010; HOOKS, 2000). Feminist studies problematize the notion of the naturalness of sex, based on the biological view, and seek to understand the power relations that are imbricated in gender roles, identities and stereotypes. (Apud DANTAS, SILVA, CARVALHO, 2014, n.p.).

These data show the importance of public policies that consider the intersectionality between disability and gender, a connection that still appears undervalued in national surveys. As a cause or as a consequence of this, there is a "common view about people with

disabilities generally related to the disabling label of disability, leading to the invisibility of sexuality and the non-recognition of being a man/woman with a disability" (DANTAS, SILVA, CARVALHO, 2014, n.p.).

3 METHOD

Of a predominantly quantitative nature, we will resort to educational indicators, obtained through the National Institute of Educational Studies and Research Anísio Teixeira (INEP), extracted and exported through the SPSS (*Statistics (Statistical Package for the Social Science)*). Interpreted via "Read-Me" corresponding to each year and subsequently analyzed. Social indicators via microdata refer to quantitative data that reveal different variables about a social reality. It is possible, through this methodological resource, to identify, demonstrate and prove social changes during its process. (JANNUZZI, 2002, p. 2)

We can characterize the reading of the results based on the knowledge of the Social Sciences "[...] by a multiplicity of approaches, with different assumptions, methodologies and styles" (ALVES-MAZOTTI; GEWANDSZNAJDER, 2000, p. 128). In the case of this qualitative-quantitative research, we defend the analytical, critical and dialectical approach in the understanding of social phenomena.

4 RESULTS AND DISCUSSION

Table 1, 2 and 3 present the results obtained, as well as their analysis according to their categories.

Table 1

Number of enrollments of people with disabilities by race in higher education in Brazil, Paraná and with a cut in the state schools of Paraná

National					Paraná			State (PR)		
Color/Race	Year	No. Total	%	% among declared	Núm. Total	%	% among declared	N. Total	%	% among declared
White	2012	9110	26,3 %	58,5%	950	32,6 %	62,2%	285	59,0 %	70,7%
	2013	9800	25,9 %	57,2%	680	27,2 %	66,3%	244	57,7 %	70,1%
	2014	14161	31,4 %	49,2%	1471	40,8 %	65,4%	327	62,0 %	72,2%

	2015	19825	38,4%	50,1%	2051	39,7%	62,8%	378	65,6%	73,1%
	2016	20706	41,6%	52,5%	2552	40,9%	65,1%	423	68,1%	72,2%
	2017	22323	42,5%	51,4%	2670	41,1%	61,7%	453	69,4%	70,8%
	2018	25723	43,2%	49,1%	3981	53,4%	58,3%	493	70,0%	70,9%
	2019	28879	43,3%	47,7%	4631	55,2%	59,2%	517	67,8%	68,5%
Black	2012	1113	3,2%	7,2%	53	1,8%	3,5%	10	2,1%	2,5%
	2013	1258	3,3%	7,3%	63	2,5%	6,1%	8	1,9%	2,3%
	2014	2452	5,4%	8,5%	143	4,0%	6,4%	14	2,7%	3,1%
	2015	5361	10,4%	13,5%	187	3,6%	5,7%	21	3,6%	4,1%
	2016	3881	7,8%	9,8%	201	3,2%	5,1%	31	5,0%	5,3%
	2017	4564	8,7%	10,5%	262	4,0%	6,1%	37	5,7%	5,8%
	2018	5506	9,3%	10,5%	483	6,5%	7,1%	38	5,4%	5,5%
	2019	5948	8,9%	9,8%	518	6,2%	6,6%	46	6,0%	6,1%
	2012	4068	11,7%	26,1%	174	6,0%	11,4%	74	15,3%	18,4%
Brown	2013	5121	13,5%	29,9%	220	8,8%	21,4%	67	15,8%	19,3%
	2014	10808	24,0%	37,5%	519	14,4%	23,1%	82	15,6%	18,1%
	2015	13030	25,2%	32,9%	788	15,3%	24,1%	91	15,8%	17,6%
	2016	13471	27,0%	34,2%	907	14,5%	23,1%	99	15,9%	16,9%
	2017	15157	28,8%	34,9%	1136	17,5%	26,3%	116	17,8%	18,1%
	2018	19524	32,8%	37,3%	2020	27,1%	29,6%	124	17,6%	17,8%
	2019	23959	35,9%	39,6%	2371	28,3%	30,3%	145	19,0%	19,2%
Yellow	201	1178	3,4%	7,6%	345	11,8	22,6%	32	6,6%	7,9%

	2	%								
	201 3	870	2,3%	5,1%	56	2,2%	5,5%	28	6,6%	8,0%
	201 4	1248	2,8%	4,3%	104	2,9%	4,6%	26	4,9%	5,7%
	201 5	999	1,9%	2,5%	223	4,3%	6,8%	22	3,8%	4,3%
	201 6	1047	2,1%	2,7%	229	3,7%	5,8%	30	4,8%	5,1%
	201 7	1098	2,1%	2,5%	235	3,6%	5,4%	31	4,7%	4,8%
	201 8	1227	2,1%	2,3%	295	4,0%	4,3%	37	5,3%	5,3%
	201 9	1279	1,9%	2,1%	248	3,0%	3,2%	41	5,4%	5,4%
Indigenous	201 2	95	0,3%	0,6%	5	0,2%	0,3%	2	0,4%	0,5%
	201 3	98	0,3%	0,6%	7	0,3%	0,7%	1	0,2%	0,3%
	201 4	141	0,3%	0,5%	13	0,4%	0,6%	4	0,8%	0,9%
	201 5	357	0,7%	0,9%	18	0,3%	0,6%	5	0,9%	1,0%
	201 6	320	0,6%	0,8%	29	0,5%	0,7%	3	0,5%	0,5%
	201 7	327	0,6%	0,8%	23	0,4%	0,5%	3	0,5%	0,5%
	201 8	411	0,7%	0,8%	53	0,7%	0,8%	3	0,4%	0,4%
	201 9	431	0,6%	0,7%	60	0,7%	0,8%	6	0,8%	0,8%

Source: INEP-Census Data (2020)

Whites represent the largest proportion of students with disabilities at all levels (national, state and state levels of PR). People of brown color showed significant growth in the period, both in Brazil and in Paraná. The increase in the number of browns enrolled reflects greater access to higher education for historically underrepresented groups. In relation to black people, a percentage still lower than the other groups, but on the rise, especially from 2016 onwards.

In this context, we identified, in table 01, through national data, from Paraná and from the state universities of Paraná, the prevalence of white people with disabilities in relation to

people with black and brown disabilities, classified by the IBGE as the black population. Thus, among people with disabilities inserted in higher education institutions there should also be this same proportion, that is, greater in numbers of blacks and browns.

What the data reveal is that the access of the black and brown population with disabilities to higher education does not follow the same demographic proportion of this population, whether in the state of Paraná, in the state of Paraná or at the national level. For example, in the State of Paraná, we have a percentage of black and brown people that is around 34%, according to the latest demographic surveys (BRASIL, IBGE-2010).

With regard to data on the population with disabilities in Paraná, among the people who most access higher education, the white population prevails. This information follows the trend of having a majority of people without disabilities white in the State of Paraná, as well as in the seven IEES/PR, but with a rate much lower than that related to people with disabilities when we make the demographic comparison of the general population.

Table 2

Number of enrollments of people with disabilities by gender in higher education in Brazil, in the State of Paraná and with a focus on the State Schools of Paraná

Gender	Year	National		Paraná		State (PR)	
		In a . Total	%	Num. Total	%	No. Total	%
Male	2012	17035	49,2%	1522	52,2%	260	53,8%
	2013	18586	49,2%	1427	57,1%	227	53,7%
	2014	22079	49,0%	2000	55,5%	275	52,2%
	2015	25477	49,3%	2997	58,1%	297	51,6%
	2016	24070	48,3%	3467	55,5%	328	52,8%
	2017	25270	48,1%	3596	55,3%	351	53,8%
	2018	28227	47,4%	3815	51,2%	393	55,8%
	2019	31744	47,6%	4215	50,3%	412	54,0%
Women	2012	17621	50,8%	1396	47,8%	223	46,2%
	2013	19210	50,8%	1074	42,9%	196	46,3%
	2014	23009	51,0%	1606	44,5%	252	47,8%
	2015	26208	50,7%	2163	41,9%	279	48,4%
	2016	25743	51,7%	2776	44,5%	293	47,2%
	2017	27272	51,9%	2907	44,7%	302	46,2%

2018	31269	52,6%	3639	48,8%	311	44,2%
2019	35006	52,4%	4168	49,7%	351	46,0%

Source: Prepared by the authors based on microdata from the Higher Education Census (MEC/INEP, 2012-2019)

In relation to gender, we observed that the national sociological characterization points to a higher incidence of women with disabilities in universities and this national trend is not maintained in Paraná or in the state universities of Paraná. In the same way that there is no higher incidence of some type of disability in white people, we also do not have a higher incidence of disability in males. So, what we are going to observe is that one of the effects of the state policy that does not put the State of Paraná in line with the national trend is in relation to greater access for male people with disabilities than for female people with disabilities.

This higher incidence of males with disabilities is also observed in Basic Education and in even higher proportions than those found in this population's access to universities.

Table 3

Number of enrollments of people with disabilities by category of disabilities in higher education in Brazil, in the State of Paraná and with a cut in the State Schools of Paraná

Type of Disability	Year	National		Paraná		State (PR)	
		Num. Total	%	Num. Total	%	Num. Total	%
Hearing Impairment	2012	7464	21,0%	1117	38,0%	36	7,3%
	2013	8559	22,1%	189	7,2%	40	9,3%
	2014	7667	16,6%	475	12,9%	48	9,0%
	2015	7550	14,3%	539	10,2%	45	7,7%
	2016	7124	14,0%	702	11,0%	39	6,2%
	2017	7572	13,8%	617	9,3%	48	7,2%
	2018	8204	13,1%	895	10,8%	59	8,1%
	2019	9144	13,1%	1117	12,7%	70	8,6%
Physical Disability	2012	9007	25,3%	524	17,8%	56	11,3%
	2013	10354	26,7%	825	31,6%	42	9,8%
	2014	14216	30,8%	1020	27,8%	60	11,2%
	2015	18210	34,4%	1917	36,3%	72	12,4%
	2016	18319	36,0%	2527	39,8%	78	12,4%
	2017	20146	36,8%	2777	41,8%	95	14,2%

	2018	21762	34,7%	2760	33,2%	110	15,2%
	2019	23089	33,0%	2641	30,0%	131	16,0%
Intellectual Disability	2012	744	2,1%	37	1,3%	2	0,4%
	2013	746	1,9%	52	2,0%	1	0,2%
	2014	1346	2,9%	148	4,0%	4	0,7%
	2015	2280	4,3%	187	3,5%	3	0,5%
	2016	1895	3,7%	293	4,6%	4	0,6%
	2017	2724	5,0%	356	5,4%	4	0,6%
	2018	3662	5,8%	503	6,0%	12	1,7%
	2019	5605	8,0%	558	6,3%	11	1,3%
Multiple Disability	2012	666	1,9%	19	0,6%	0	0,0%
	2013	524	1,4%	17	0,7%	2	0,5%
	2014	781	1,7%	56	1,5%	2	0,4%
	2015	844	1,6%	77	1,5%	4	0,7%
	2016	1079	2,1%	104	1,6%	5	0,8%
	2017	961	1,8%	105	1,6%	5	0,7%
	2018	1336	2,1%	155	1,9%	5	0,7%
	2019	1201	1,7%	146	1,7%	5	0,6%
Deafness	2012	2197	6,2%	220	7,5%	5	1,0%
	2013	2061	5,3%	265	10,2%	3	0,7%
	2014	2361	5,1%	299	8,1%	3	0,6%
	2015	2464	4,7%	276	5,2%	3	0,5%
	2016	2520	4,9%	345	5,4%	8	1,3%
	2017	2857	5,2%	316	4,8%	19	2,8%
	2018	3053	4,9%	344	4,1%	18	2,5%
	2019	3459	4,9%	345	3,9%	37	4,5%
Deafblindness	2012	171	0,5%	6	0,2%	0	0,0%
	2013	208	0,5%	9	0,3%	0	0,0%
	2014	152	0,3%	13	0,4%	0	0,0%
	2015	156	0,3%	12	0,2%	1	0,2%
	2016	139	0,3%	16	0,3%	2	0,3%
	2017	210	0,4%	21	0,3%	0	0,0%
	2018	203	0,3%	27	0,3%	0	0,0%
	2019	229	0,3%	20	0,2%	0	0,0%

Low vision	2012	8399	23,6%	748	25,5%	388	78,5%
	2013	8830	22,8%	1049	40,2%	334	78,0%
	2014	10351	22,4%	1196	32,6%	403	75,5%
	2015	12297	23,2%	1291	24,4%	435	74,9%
	2016	14675	28,8%	1597	25,1%	469	74,3%
	2017	14326	26,2%	1560	23,5%	459	68,7%
	2018	17041	27,2%	2348	28,2%	463	63,8%
	2019	18951	27,1%	2523	28,6%	472	57,7%
Blindness	2012	5186	14,6%	100	3,4%	7	1,4%
	2013	5773	14,9%	56	2,1%	5	1,2%
	2014	2442	5,3%	222	6,0%	11	2,1%
	2015	2582	4,9%	388	7,3%	13	2,2%
	2016	2858	5,6%	439	6,9%	18	2,9%
	2017	2909	5,3%	405	6,1%	23	3,4%
	2018	3398	5,4%	566	6,8%	28	3,9%
	2019	3461	4,9%	685	7,8%	23	2,8%

Source: Prepared by the authors based on microdata from the Higher Education Census (MEC/INEP, 2012-2019)

If we take as a reference the total population residing in the country, according to the 2010 Census, that is, 45,606,048 Brazilians, we have that:

[...] 23.9% had at least one of the disabilities investigated: visual, auditory, motor, and mental or intellectual. The prevalence of disability varied according to their nature. Visual impairment had the highest occurrence, affecting 18.6% of the Brazilian population. In second place is motor disability, occurring in 7% of the population, followed by hearing impairment, in 5.10% and mental or intellectual disability, in 1.40%. (BRASIL, 2012, p. 07).

Regarding the type of disability, when we cut the data for the period from 2012 to 2019, we observed that the types with the highest incidence in the national data are physical disability and low vision, an incidence that is repeated in the state of Paraná.

What this data shows us, unlike all the data from Basic Education, in which the highest incidence is of intellectual disability, reaching almost 70% of the cases in some states, in higher education we have an alignment of the trend of incidence of the type of disability with the demographic data.

So, in higher education, we observed a higher incidence of physical disability in national data and in the State of Paraná (all HEIs), followed by low vision, in the same way that there is this incidence of both conditions in the population in general. In the state universities of Paraná, we highlight low vision, which makes up 68% of the total enrollment of people with disabilities throughout the period, with a drop in the incidence of low vision from 2017 onwards, corresponding to about 60% of cases.

Another highlight is the low incidence of people with hearing impairment or deafness in state universities. In the national data, we observed the numbers of hearing impairment oscillating from 2012 with 20% of cases to reaching 2019, between 12% and 13%. While, in the state universities of Paraná, throughout the period, cases of hearing impairment do not exceed 10% and in Paraná as a whole, it is noteworthy that in 2012 hearing impairment made up almost 40% of cases, but reaching 12% in 2019, fluctuating very little over the period.

Therefore, we conclude that, in relation to these data, we have a greater guarantee of access to higher education for people with these two types of disabilities, both physical and low vision. Such information shows that there must be an increase in these public policies so that there is greater acceptance of people with other types of disabilities in universities.

5 INTERSECTIONALITY BETWEEN RACE, GENDER, AND DISABILITY

The relationship of coloniality takes us back to past times and presupposes that a group of people overlaps with others, that is, the persistence in the relations of power and domination between dominant and dominated. However, not living in colonial times is not the same as breaking with the characterization of this context, because from a social logic, those so-called dominated subjects of colonial times would occupy which places within a social reality throughout history?

In this context of inequalities and colonialism, Quijano (2005) explains that colonialism is established in a global structure, because its main articulator is power. Those who hold power are the dominant ones, while the others, their dominated. From this perspective, colonialism or these unequal power relations allow us to think about the persistence of oppression in relations of gender, sex, schooling, and also for people with disabilities.

The coloniality of power is a concept originally developed by Aníbal Quijano in 1989 and widely used by the group. It expresses a simple observation, that is, that the relations of coloniality in the economic and political spheres did not end with the destruction of colonialism. The concept has a double pretension. On the one hand, it

denounces "the continuity of colonial forms of domination after the end of colonial administrations, produced by colonial cultures and by the structures of the modern/colonial capitalist world-system" (Grosfoguel, 2008, p.126). On the other hand, it has an explanatory capacity that updates and temporizes processes that supposedly have been erased, assimilated or overcome by modernity. This understanding is well explained by Grosfoguel. (Apud BALLESTRIN, 2013, p.99-100).

Organization and labor relations are forms of domination, especially when we think from the perspective of the capitalist system and its forms of control through the division of labor. In addition, it is worth thinking about the intersectionality of gender, race, class, and also of people with disabilities. Thus, when Quijano (2005) proposes that one of the forms of domination occurs through the organization of work and its products (the wealth it generates), it can be thought that the division of labor itself, when understood based on the criterion of racialization, consolidated colonial power and reaffirmed new forms of control, especially from the development of the capitalist system.

Coloniality of power consists **of the identification of peoples according to certain phenotypes established and imposed by Western thought**. It can be seen that race has become the most effective and durable instrument of domination, also influencing other aspects that were used for the propagation of Modernity and Eurocentric thought, such as gender, sexuality, knowledge, political, environmental and economic relations (QUIJANO, 2005, p.118).

In these assumptions, we are faced with countless possibilities of social inequalities and exclusionary scenarios, education being one of them. Therefore, how the schooling process of people who experience or carry some social mark of inequality takes place is a pertinent problematization.

One of the ways to combat the contexts of exclusion, to which different social groups are exposed, is through public policies that operate in different ways. In this sense, it is relevant to understand what inclusion policies and programs say and, above all, their effects on a certain social reality, in this case, on the enrollment of students with disabilities in IEES-PR.

When we talk about race, specifically, we think of the power relations established throughout history between the white man and his superiorities over the black man. When we look at history, we realize the authority of whites over public control, identifying themselves as different and superior.

In this sense, the operationalization of the so-called democracy is put at risk, since it is required that everyone sees themselves and exercises their rights as equals, compromising the position of the so-called whites, because for this, it would be necessary to break with the relations of dominator-dominated-exploiter and exploited, that is, it would be necessary to give up their privileges maintained by this unequal relationship.

The "abolition" constitutes a milestone in this process, which placed the black man in the position of adapting to the new system of work, that is, of inferior and disadvantageous conditions that little by little, in the need for cheap labor, were introduced into the economic development of society. The relationships in which they experienced in the historical context of enslavement, for many generations, are characterized, to this day, as a result of the delay in access to various areas of life and education, and one of them.

To combat this backwardness, which still persists, even within public policies in Brazil, it is necessary to consider the distinction between "black theme" and "black life", brought by the black Brazilian sociologist Guerreiro Ramos, because one conception of public policy is that aimed at black populations with disabilities and another conception of public policies is that not only aimed at these populations, but built by these people and gestated by them, valuing their knowledge, their voices, their demands and their spaces of speech.

There is the theme of the black and there is the life of the black. As a theme, blacks have been, among us, the object of scalping perpetrated by literati and by the so-called "anthropologists" and "sociologists". As life or effective reality, blacks have been assuming their destiny, they have been making themselves, according to the particular conditions of Brazilian society. But one thing is the black theme; the other, the black-life. The black-theme is something examined, looked at, seen, sometimes as a mummified being, sometimes as a curious being, or in any case as a risk, a trait of the national reality that draws attention. The black-life is, however, something that does not allow itself to be immobilized; it is misleading, prophetic, multiform, of which, in fact, one cannot give a definitive version, because it is today what it was not yesterday and tomorrow it will be tomorrow what it is not today (GUERREIRO RAMOS, 1955, p. 215).

Therefore, we can infer that the trajectory and historical marks of black people in life in society reflect to this day in different contexts, especially regarding schooling. When we refer to black people with disabilities, we can say that it is a great advance to have this reality present in higher education institutions.

But, if we consider that more than half of the Brazilian population, according to data from the 2010 IBGE Census, are brown and black, identified by the agency as black, and that

we are far from having the same proportion in public universities in Paraná, this denotes that existing public policies have not yet been sufficient to increase this number.

When we look at the gender category, from this same perspective, we identify relations of oppression on women's rights in society. It is not difficult to remember the predominantly caretaker role of the home and children. However, the very constitution of the capitalist market requires the help of women's labor force in the family income, from the perspective of the productive work performed by women, corresponding to a cheaper labor force that at the same time generates profit, in addition to the fact that such activities already add to so many others already performed by them.

There is no doubt that the introduction of women into the educational system and, above all, into the qualified labor market is much more costly and disturbing. In this scenario, of women in the labor market, we have another front of analysis, that is, the participation of black women in society, who were exposed not to a labor relationship, but to an exclusively commodity relationship, which unfortunately was not overcome, even with the "abolition" of the slave system.

In other words, in this connection already mentioned in the history of blacks, we have an aggravating factor when we talk about the history of black women in society. In this sense, the understanding of the phenomenon of the number of enrollments in higher education of people with disabilities must consider the intersectionality of intrinsically interconnected elements when one wishes to have a parameter of a given social reality. In this case, when we talk about people with disabilities, we also talk, for example, about other social markers of inequalities, such as black people and different gender identities.

When we turn our gaze specifically to people with disabilities, the social markers lead us to the same categories in which black people and also women were constituted, that is, indicators of segregation, exclusion and inequality in different contexts. With regard to education, the reality was no different.

In the capitalist context in which society develops, the human being has his value for his potential to produce and contribute to this system, so people with disabilities were very late being introduced into civic life, in education, for example, the "special" model began only at the end of the twentieth century.

When we talk specifically about higher education, the advances are more recent and still incipient, as the data show. In this context, although we have noticed a slight increase in the number of enrollments of students with disabilities in higher education in Paraná, for

example, it is still a much lower amount than the number of people with disabilities in Brazil (23.9% of the Brazilian population in general).

Here again the importance of public policies and Affirmative Actions to expand access and permanence to actually provide the process of democratization in public higher education, even if it is still an inexpressive measure in the face of social inequalities that affect all institutions, not only educational ones.

In addition, it is stated that gender and race are the main factors between people with and without disabilities, due to the trajectory and historical marks of both the slavery and patriarchal issues. However, there is still a lack of more studies in the areas of Social Sciences and Education that articulate the connection of these categories in terms of their effective participation in different social areas, especially in school institutions.

6 FINAL CONSIDERATIONS

We understand that in addition to access, public educational policies that deal with the permanence of people with disabilities in Higher Education must strive to combat all types of violence and injustice, which expand the confrontation of the violence of ableism. This means that such public policies need to excel in the dimension of intersectionality of positive markers of belonging, differences, identities and diversities, vehemently combating the markers of racial, sexual, gender, generational, economic, regional, territorial, ethnic, racial, cultural, and political inequalities, historically crystallized in this country and in the State of Paraná. In this path, we also emphasize the methodological importance used, which provides us and reveals the statistical sources via microdata about this social and educational reality, where we highlight as main results found the characterization of the enrollment of students with disabilities in Higher Education, revealing their race/color, their sex/gender, their types of disabilities, among other relevant variables. The data show us many challenges. The access of the black and brown population with disabilities to higher education does not follow the same demographic proportion of this population, whether in the state of Paraná, in the state of Paraná or at the national level. With regard to data on the population with disabilities in Paraná, among the people who most access higher education, the white population prevails. As we have shown, this information follows the trend of having a majority of people without white disabilities in the State of Paraná, as well as in the seven IEES/PR, but with a rate much lower than that of people with disabilities when we make the demographic comparison of the general population. In other words, there is no statistically speaking, the

representativeness, according to statistics between demographic data and INEP, of the number of enrollments of black and brown people in IEES-PR.

In relation to gender, we observed that the national sociological characterization points out that one of the effects of the state policy and that does not place the State of Paraná in line with the national trend is in relation to greater access for male people with disabilities than for female people with disabilities. Regarding the type of disability, when we cut the data for the period from 2012 to 2019, we observed a higher incidence of physical disability in the national data and in the State of Paraná, followed by low vision, in the same way that there is this incidence of both conditions in the population in general. In the state universities of Paraná, we highlight low vision, which makes up 68% of the total enrollment of people with disabilities throughout the period, with a drop in the incidence of low vision from 2017 onwards, corresponding to about 60% of cases.

Therefore, we conclude that, in relation to these data, we have a greater guarantee of access to higher education for people with these two types of disabilities, both physical and low vision. Such information shows that there must be an increase in these public policies so that there is greater acceptance of people with other types of disabilities in universities.

We can affirm, from the set of data presented, that specific public policies for the state universities of Paraná benefit the access of people with disabilities to higher education institutions, but they are still incipient and very timid, with regard to ensuring effective conditions for the permanence of these people. It is still necessary to conceive what conception of permanence we are defending. It is a conception of permanence with dignity, with accessibility in all senses, with inclusive actions of pedagogical monitoring and with the right to access services that confront all types of discrimination and violations of the rights of this population.

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**RELATIONSHIP BETWEEN MANDIBULAR AMPLITUDE AND KINESIOPHOBIA
IN PATIENTS WITH MAXILLOFACIAL FRACTURE: CASE REPORT**

**RELAÇÃO ENTRE AMPLITUDE MANDIBULAR E KINESIOFOBIA EM
PACIENTES COM FRATURA BUCOMAXILOFACIAL: RELATO DE CASO**

**RELACIÓN ENTRE LA AMPLITUD MANDIBULAR Y LA KINESIOPHOBIA EN
PACIENTES CON FRACTURA MAXILOFACIAL: REPORTE DE CASO**

 <https://doi.org/10.56238/sevened2025.036-124>

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ABSTRACT

Objective: To investigate the relationship between mandibular range of motion (ROM) and kinesiophobia in patients with maxillofacial fractures.

Methodology: Descriptive, observational study in the form of a case series report, conducted at the Núcleo de Atenção Médica Integrada from September to October 2022, approved by ethics committee protocol 5.641.381. The assessment included a form with sociodemographic data, fracture characteristics, and main complaints, followed by a physical examination in which pain was quantified using the VAS, sensitivity using microfilaments, and mandibular ROM—measured in mouth opening, protrusion, and right and left lateral deviation using a caliper. Kinesiophobia was assessed using the Tampa Scale for Kinesiophobia for TMD, and functional limitation using the Mandibular Function Impairment Questionnaire.

Results: Only one patient presented a mandibular fracture, while the others underwent orthognathic surgery. In the assessment, Case 1 showed: mouth opening 11 mm, RLD 1 mm, LLD 3 mm, protrusion 0 mm; Case 2: mouth opening 4 mm, RLD 0 mm, LLD 1 mm, protrusion 0 mm; Case 3: mouth opening 18 mm, RLD 4 mm, LLD 5 mm, protrusion 2 mm. All patients reported moderate pain, with the most frequent complaints being movement limitation, hypoesthesia, and edema. Cases 1 and 2 showed severe kinesiophobia, and Case 3 presented moderate kinesiophobia.

Conclusion: Patients with reduced mandibular movements exhibit increased kinesiophobia, along with edema and pain.

Keywords: Face. Fracture Healing. Mandibular Fractures. Kinesiophobia. Range of Motion.

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RESUMO

Objetivo: Relacionar ADM mandibular e cinesiofobia em pacientes com fratura bucomaxilofacial.

Metodologia: Estudo descritivo, observacional do tipo relato de caso em série, no Núcleo de Atenção Médica Integrada, de setembro a outubro de 2022, parecer ético 5.641.381. Avaliação contou com ficha contendo dados sociodemográficos, características da fratura e principais queixas, seguida da avaliação física, onde a dor foi quantificada segundo a EVA, sensibilidade pelos microfilamentos e ADM mandibular nos movimentos de abertura, protrusão, desvio lateral esquerdo e direito utilizando o paquímetro. A cinesiofobia foi avaliada pela Escala Tampa de Cinesiofobia para DTM e limitação funcional pelo Mandibular Function Impairment Questionnaire.

Resultados: Apenas um dos pacientes apresentou fratura mandibular, enquanto os outros realizaram uma cirurgia ortognática. Na avaliação, o Caso 1 apresentou abertura: 11mm, DLD: 1mm, DLE: 3mm, protrusão: 0mm; Caso 2 abertura: 4mm, DLD: 0mm, DLE: 1mm, protrusão: 0mm; Caso 3, abertura: 18mm, DLD: 4mm, DLE: 5mm, protrusão: 2mm. A dor apresentou-se moderada em todos e as queixas mais frequentes foram limitação de movimento, hipoestesia e edema. Os casos 1 e 2 apresentaram grau grave de cinesiofobia e o caso 3 moderado.

Conclusão: Pacientes com redução dos movimentos mandibulares apresentam aumento da cinesiofobia, presença de edema e dor.

Palavras-chave: Face. Cicatrização de Fraturas. Fraturas de Mandíbula. Cinesiofobia. Amplitude de Movimento.

RESUMEN

Objetivo: Relacionar la amplitud de movimiento mandibular (ADM) y la kinesiofobia en pacientes con fractura bucomaxilofacial.

Metodología: Estudio descriptivo y observacional, tipo serie de casos, realizado en el Núcleo de Atención Médica Integrada, entre septiembre y octubre de 2022, con aprobación ética n.º 5.641.381. La evaluación incluyó un formulario con datos sociodemográficos, características de la fractura y principales quejas, seguido de la evaluación física, en la cual el dolor se cuantificó mediante la EVA, la sensibilidad con microfilamentos y la ADM mandibular en los movimientos de apertura, protrusión y desviación lateral derecha e izquierda, utilizando un calibrador. La kinesiofobia se evaluó mediante la Escala de Tampa de Kinesiofobia para DTM y la limitación funcional a través del Mandibular Function Impairment Questionnaire.

Resultados: Solo uno de los pacientes presentó fractura mandibular, mientras que los demás fueron sometidos a cirugía ortognática. En la evaluación, el Caso 1 presentó: apertura 11 mm, DLD 1 mm, DLI 3 mm, protrusión 0 mm; Caso 2: apertura 4 mm, DLD 0 mm, DLI 1 mm, protrusión 0 mm; Caso 3: apertura 18 mm, DLD 4 mm, DLI 5 mm, protrusión 2 mm. El dolor fue moderado en todos los casos, y las quejas más frecuentes fueron limitación del movimiento, hipoestesia y edema. Los Casos 1 y 2 presentaron un grado severo de kinesiofobia y el Caso 3 un grado moderado.

Conclusión: Los pacientes con reducción de los movimientos mandibulares presentan mayor kinesiofobia, además de edema y dolor.

Palabras clave: Cara. Consolidación de Fracturas. Fracturas de Mandíbula. Cinesiofobia. Amplitud de Movimiento.

1 INTRODUCTION

Maxillofacial fractures are a significant public health problem due to their high frequency in trauma centers, being one of the leading causes of morbidity and mortality worldwide. Studies indicate that young adult males, aged between 21 and 30 years, have the highest incidence of maxillofacial trauma, with traffic accidents and physical assaults being the most evident causal factors. According to the same study, the most affected area is the mandible due to its prominence, followed by the nasal bones (1,2).

Fractures of the middle facial region are commonly classified according to René Le Fort, who observed recurring fracture patterns and categorized them into Le Fort I, II, and III (3). Mandibular fractures are classified according to their location and can occur in the symphysis, horizontal ramus, angle, ramus, condyle, and coronoid process. One of the main consequences of these fractures can be malocclusion, leading to functional changes (4). This factor is classified according to Angle, who divides occlusions into three classes: Class I, normal occlusion; Class II, the lower molar is distal to the upper first molar; and Class III, the lower molar is mesial to the upper first molar (5).

Orthognathic surgery is a therapeutic option for correcting these malocclusion patterns, allowing the restoration of the patient's functionality (6,7). The craniofacial skeleton plays key roles such as speech, chewing, vision, smell, and breathing. The masticatory muscles are directly related to factors such as mandibular range of motion, dental occlusion, and bite force. Any alteration in these structures can lead to functional changes in the patient, as the skeletal muscles of the face can modify their morphology to meet specific demands (6,7,8).

Additionally, temporomandibular joint (TMJ) dysfunctions, osteoarthritis, tumor resections, and facial trauma also directly influence mandibular movement, load, and muscle activity modification, making the analysis of range of motion clinically relevant for the success of rehabilitation (9,10). Another important aspect is kinesiophobia, or the fear of movement, which is defined as an excessive, irrational, and debilitating fear of performing a movement in which the patient feels vulnerable to injury or relapse.

Developed from direct experience, such as trauma, or through observations and instructions, kinesiophobia can be linked to functional disability and quality of life, as it has the potential to alter how a person moves to avoid pain, which can affect their performance in actions related to pain control and identification (11). In a study conducted in 2020 by Brown et al., it was observed that kinesiophobia negatively impacts the patient's performance in

achieving active range of motion. The same study demonstrated that for the patient to achieve good results, both physiotherapeutic and psychological interventions are necessary (12,13).

The observation of the increasing number of facial trauma cases and the importance of understanding the care of these patients motivated this study. This research is relevant as it will help us better understand the functional implications of facial trauma and the importance of quantifying kinesiophobia for better therapeutic outcomes. The aim of this study is to relate mandibular range of motion and kinesiophobia in patients who have suffered maxillofacial fractures, by quantifying mandibular range of motion and its impacts on patients' functionality.

2 METHODOLOGY

A descriptive, observational study in the form of a case series report was conducted at the *Núcleo de Atenção Médica Integrada* (NAMI) between September and October 2022. The research project was approved by the Ethics Committee of the University of Fortaleza and by *Plataforma Brasil*, resulting in ethical approval number 5.641.381. Participants aged between 18 and 60 years, of both sexes, who underwent surgery for the correction of maxillofacial fractures were included. Exclusion criteria were patients with more than 15 days postoperatively, those who presented any central or peripheral neurological disorder, or those who had used analgesic medication within 24 hours prior to the assessment.

Data collection from the participants occurred immediately after reading and signing the Informed Consent Form. Subsequently, the assessment was initiated, consisting of a form containing sociodemographic data, physical evaluation, application of the kinesiophobia scale, and the mandibular functionality questionnaire, with an average duration of 45 minutes. Initially, the participants completed a form developed by the researchers, which included socio demographic data, fracture characteristics, and the main complaints. Subsequently, the physical evaluation was performed, with pain quantified using the Visual Analog Scale (VAS), sensitivity assessed using monofilaments, and analysis of mandibular range of motion using a caliper, considering the movements of active mouth opening, protrusion, and right and left lateral deviations.

After that, the participants were administered the Tampa Scale for Kinesiophobia for Temporomandibular Disorders (TSK/TMD), an adapted version of the Tampa Scale for Kinesiophobia (TSK), a questionnaire developed to assess kinesiophobia in patients with musculoskeletal pain. In the TSK/TMD, some terms were adapted, providing specificity to the questionnaire. It consists of 18 items with four response options, with scores ranging from 1

to 4. To obtain the final score, the item scores are summed, resulting in a total score ranging from 18 to 72, in which higher scores indicate a greater degree of kinesiophobia (12).

Additionally, the Mandibular Function Impairment Questionnaire (MFIQ) was applied, which assesses mandibular functional limitation, classifying it as mild, moderate, or severe. The questionnaire consists of 17 questions with five response options, scored from 0 to 4. The result is obtained through an equation that generates a coefficient, which is compared with predefined intervals to determine the degree of the patient's functional limitation—where lower results indicate less functional limitation, and higher results indicate more severe limitation.

3 CASE SERIES OF CLINICAL REPORTS

Case 1

A 28-year-old female patient, a street vendor, sought physiotherapeutic care after suffering an accident in which she slipped and fell from a height of 10 meters while attempting to take a photograph from the top of a waterfall. During the fall, the patient sustained multiple injuries, including an open tibial fracture, acromioclavicular joint dislocation, and a comminuted fracture in the mandibular symphysis region with avulsion of tooth 31. Three days after undergoing surgery for correction of the mandibular fracture, the patient began the assessments.

During the physical evaluation, the patient presented active mouth opening of 11 mm, right lateral deviation (RLD) of 1 mm, left lateral deviation (LLD) of 3 mm, and 0 mm of protrusion (Table 1), with moderate pain (VAS score of 5). The main complaints reported were hypoesthesia and the presence of edema. The TSK/TMD score was 52, indicating severe kinesiophobia, and the MFIQ indicated a severe degree of functional impairment.

Case 2

A 32-year-old female patient, a security guard, with a history of bruxism, sought physiotherapeutic care after temporomandibular joint locking that led to reduced mandibular range of motion, and for preoperative management prior to orthognathic surgery aimed at functional improvement; the patient was classified as Class II. During surgery, maxillary, mandibular, and mentonian osteotomies were performed. In addition to orthognathic surgery, bichectomy and cervicofacial liposuction were also performed.

After the surgical interventions, the patient began the assessments. During the physical evaluation, the patient presented active mouth opening of 4 mm, RLD of 0 mm, LLD

of 1 mm, and 0 mm of protrusion (Table 1), with moderate pain (VAS score of 4). The main complaints reported were hypoesthesia and limitation of movement. The TSK/TMD score was 51, indicating severe kinesiophobia, and the MFIQ indicated a severe degree of functional impairment.

Case 3

A 23-year-old male patient, a student, sought physiotherapeutic care after undergoing orthognathic surgery due to respiratory and aesthetic complaints; the patient was classified as Class II. During surgery, maxillary and mandibular osteotomies and a mentonian osteotomy were performed. In addition to orthognathic surgery, bichectomy and cervicofacial liposuction were also performed.

During the physical evaluation, the patient presented active mouth opening of 18 mm, RLD of 4 mm, LLD of 5 mm, and 2 mm of protrusion (Table 1), with moderate pain (VAS score of 6). The main complaints reported were pain, limitation of movement, edema, and paresthesia. The TSK/TMD score was 44, indicating moderate kinesiophobia, and the MFIQ indicated a severe degree of functional impairment.

Table 1

Mandibular Range of Motion

Cases	Active Mouth Opening (mm)	RLD (mm)	LLD (mm)	Protrusion (mm)
Case 1	11	1	3	0
Case 2	4	0	1	0
Case 3	18	4	5	2

Source: Research data. Note: mm= millimeters.

4 DISCUSSION

This study demonstrated that the main motivation for undergoing fracture correction surgery was functional and aesthetic improvement. During the physical assessment, all patients presented limitations in range of motion, reporting moderate pain, edema, and altered sensitivity. Regarding kinesiophobia, participants presented moderate to severe levels, possibly indicating a relationship between limited range of motion and fear of mandibular movements. Concerning the motivations for undergoing orthognathic surgery,

functional and aesthetic-functional complaints were reported, corroborating the study by Ambrizzi et al., which indicated that the primary motivation for undergoing orthognathic surgery is aesthetic concerns, followed by aesthetic-functional complaints and, lastly, purely functional complaints, including difficulties in mastication, breathing, pain, and speech alterations.

Factors such as bite force and muscle activity tend to improve after surgery; however, all malocclusion groups tend to present some degree of temporomandibular joint (TMJ) hypomobility in the postoperative period (16). The reduction in mandibular range of motion may result from the type of fixation used during the surgical procedure, combined with postoperative edema and pain, which is consistent with the findings of this study (17). Although all patients presented moderate VAS scores, the patient in Case 3 reported a VAS score of 6, the highest value observed, reporting edema as a complaint while presenting the greatest range of motion among the described cases. Conversely, the patient in Case 2 reported a VAS score of 4, the lowest among the cases, did not report edema, and presented extremely reduced range of motion.

However, pain is a complex and subjective process, which may impact the accuracy of the findings (18). Regarding the consequences of maxillofacial fracture correction surgeries, studies indicate that sensory alteration is a common complication in these patients, which is consistent with the findings of this research, as all patients reported some type of sensory alteration. These injuries generally affect the area of the inferior alveolar nerve, including the chin, lower lip, and gingival mucosa, leading to slow recovery of up to one year and potentially resulting in complete and permanent paresthesia (19). As presented in the case reports, both patients who underwent orthognathic surgery were classified as Class II and underwent the same procedures. However, the observed ranges of motion were markedly divergent, particularly in active mouth opening, in which Case 2 presented 4 mm and Case 3 presented 18 mm.

This result may be explained by the patients' clinical history, different motivations for surgery, and different degrees of kinesiophobia—being severe in Case 2 and moderate in Case 3, according to the TSK/TMD scale. In this context, it is known that a previous injury, as observed in Cases 1 and 2, may significantly impact the patient's psychological state. Patients may perceive pain as non-threatening and perform their activities normally, or they may catastrophize pain, developing kinesiophobia and movement hypervigilance, which tends to increase rehabilitation time (21,22).

Mandibular fractures are more likely to reduce mandibular range of motion, with fractures in the posterior region having a greater impact than anterior fractures (23). According to the same study, and considering Case 1, in which the fracture occurred in the mandibular symphysis region, the patient tends to present a more functional range of motion in the postoperative period and not maintain a malocclusion pattern during this time. With regard to mandibular functionality, the severity observed may be justified by the postoperative phase in which the patients were, characterized by significant edema and pain.

Another important aspect is masticatory function, which tends to be altered after maxillofacial fracture correction surgeries, varying according to the phase and type of postoperative treatment (24,25). Finally, some limitations of this study should be acknowledged. The first is the small number of participants, which limits the generalizability of the results. In addition, the absence of data such as a history of psychological treatment and variables related to psychosocial aspects may have influenced questionnaire scores. These findings suggest the need for a biopsychosocial approach for the appropriate rehabilitation of these patients.

5 CONCLUSION

Postoperative patients with maxillofacial trauma who present reduced mandibular range of motion tend to exhibit higher levels of kinesiophobia, in addition to the presence of edema and moderate pain. These findings reinforce the importance of an integrated assessment of functional and psychosocial aspects during the rehabilitation process.

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A STUDY OF THE RELATIONSHIP BETWEEN CARBOHYDRATE RESTRICTION AND THE TREATMENT OF GLIOBLASTOMA: A LITERATURE REVIEW

ESTUDO DA RELAÇÃO ENTRE RESTRIÇÃO DE CARBOIDRATOS E O TRATAMENTO DE GLIOBLASTOMA: UMA REVISÃO BIBLIOGRÁFICA

ESTUDIO DE LA RELACIÓN ENTRE LA RESTRICCIÓN DE CARBOHIDRATOS Y EL TRATAMIENTO DEL GLIOBLASTOMA: UNA REVISIÓN DE LA LITERATURA

 <https://doi.org/10.56238/sevened2025.036-125>

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ABSTRACT

5 years of 5%. Because it is a difficult diagnosis to treat, it motivates several lines of research to optimize the currently proposed standard treatment, which consists of chemoradiation and surgical resection, when possible. The reduced use of the citric acid cycle and mitochondrial oxidative phosphorylation for energy production in cancer cells that primarily use anaerobic glycolysis, even in the presence of oxygen, characterizes the Warburg effect, which justifies the use of diets with restricted carbohydrate intake that generate ketosis to reduce energy intake and consequently delay tumor progression, since healthy cells are able to receive energy more efficiently from fatty acids. The conclusions of 21 articles selected from databases (PubMed and LILACS) related to diets with reduced carbohydrate intake and the treatment of glioblastoma were correlated, as well as seeking to analyze the secondary variables present in clinical studies. Thus, the complexity of conducting research on this topic becomes clear, and the need for more robust studies, especially clinical ones, is proposed to allow for a meta-analysis of the subject in order to define therapeutic approaches that may include or rule out the implementation of carbohydrate-restricted diets in the treatment of glioblastoma.

Keywords: Glioblastoma. Ketogenic Diet. Atkins Diet. Warburg Effect. Carbohydrate Restriction.

RESUMO

5 anos de 5%. Por ser um diagnóstico de difícil tratamento, motiva diversas linhas de pesquisa para otimizar o tratamento padrão atualmente proposto que consiste em quimiorradiação e ressecção cirúrgica, quando há esta possibilidade. A redução da utilização do ciclo do ácido cítrico e da fosforilação oxidativa mitocondrial para a produção de energia em células cancerosas que utilizam prioritariamente a glicólise anaeróbica, mesmo na presença de oxigênio, caracteriza o efeito Warburg, que fundamenta a utilização de dietas com restrição na ingestão de carboidratos geradoras de cetose para diminuir o aporte energético e consequentemente retardar a progressão tumoral, uma vez que as células

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sadias são capazes de receber aporte energético com maior eficiência de ácidos graxos. Relacionaram-se as conclusões de 21 artigos selecionados em bases de dados (PubMed e LILACS) relacionados a dietas com diminuição da ingestão de carboidratos e o tratamento de glioblastoma, assim como busca analisar as variáveis secundárias presentes nos estudos clínicos. Dessa maneira, compreende-se a complexidade de execução das pesquisas acerca do tema exposto e propõe-se a necessidade de estudos, sobretudo clínicos, mais robustos que permitam uma meta-análise do tema para definir condutas terapêuticas que possam incluir ou descartar a implementação de dietas com restrição de carboidratos no tratamento de glioblastoma.

Palavras-chave: Glioblastoma. Dieta Cetogênica. Dieta Atkins. Efeito Warburg. Restrição de Carboidratos.

RESUMEN

5 años de 5%. Debido a su difícil tratamiento, se motivan diversas líneas de investigación para optimizar el tratamiento estándar propuesto, que consiste en quimiorradiación y resección quirúrgica, cuando sea posible. La reducción del uso del ciclo del ácido cítrico y la fosforilación oxidativa mitocondrial para la producción de energía en células cancerosas que utilizan principalmente la glucólisis anaeróbica, incluso en presencia de oxígeno, caracteriza el efecto Warburg, lo que justifica el uso de dietas con ingesta restringida de carbohidratos que generan cetosis para reducir la ingesta energética y, en consecuencia, retrasar la progresión tumoral, ya que las células sanas pueden recibir energía de los ácidos grasos de forma más eficiente. Se correlacionaron las conclusiones de 21 artículos seleccionados de bases de datos (PubMed y LILACS) relacionados con dietas con ingesta reducida de carbohidratos y el tratamiento del glioblastoma, y se buscó analizar las variables secundarias presentes en estudios clínicos. Por lo tanto, se hace evidente la complejidad de la investigación sobre este tema, y se propone la necesidad de estudios más sólidos, especialmente clínicos, que permitan un metaanálisis del tema y definan enfoques terapéuticos que puedan incluir o descartar la implementación de dietas con restricción de carbohidratos en el tratamiento del glioblastoma.

Palabras clave: Glioblastoma. Dieta Cetogénica. Dieta Atkins. Efecto Warburg. Restricción de Carbohidratos.

1 INTRODUCTION

1.1 GLYOMAS

Gliomas are classified into different types of tumors according to their glial lineages, including astrocytomas, oligodendrogliomas, mixed oligoastrocytomas, ependymomas, and several less common types of glioneuronal tumors¹. Astrocytic brain tumors are primary CNS tumors derived from astrocytes. Astrocytes provide structural and metabolic support to neurons, regulate ion concentrations in the extracellular space, modulate synaptic transmissions, release neurotransmitters, compose the blood-brain barrier, among other functions².

The WHO classifies astrocytic tumors into 4 classes, according to the degree of aggressiveness (Table 1), and low-grade astrocytomas (I and II) tend to be present in younger patients and have a better prognosis. High-grade astrocytomas (III and IV) typically present in older patients and the prognosis is worse². Glioblastoma multiforme (GBM) is considered grade IV, since it is highly aggressive, with a mean survival rate of 15 months³ and a 5-year survival rate of 5%⁴.

Table 1

Classification of glioma subtypes according to their histological characteristics by the World Health Organization

Degree	Tumor histology	Subtype according to Histology
I	Benign, well set	Pilocytic Astrocytoma
II	Diffuse infiltration and high proliferation	Diffuse Astrocytoma, Oligodendroglioma, Oligoastrocytoma
III	Very infiltrative and with a lot of proliferation	Anaplastic Astrocytoma, Anaplastic Oligoastrocytoma, Oligodendroglioma Anaplastic
IV	Very infiltrative, high cell and vascular proliferation, necrosis, hemorrhage	Glioblastoma multiforme

Source: adapted from JONES & HOLLAND, 2011.

Macroscopically, GBM denotes a poorly delimited expansive mass in the white matter of a cerebral hemisphere with central necrosis, which may affect most of the tumor. Cysts and hemorrhages may be present, as well as peritumoral edema and midline deviation, with hernias. In some cases, the tumor infiltrates the corpus callosum, passing into the contralateral hemisphere forming a pattern called "butterfly wing tumor." Histopathologically, GBM presents cellular atypia exhibiting cells of different sizes and degrees of variation. Some cells have 2 bipolar extensions, resembling glioblasts - embryonic cells of the neural tube that give the tumor its name. Grade IV astrocytomas also present vascular proliferation, with an increase in the number of capillaries, both in the tumor and in the adjacent nervous tissue. These capillaries resemble the renal glomeruli, which is why they are called pseudoglomeruli. The endothelial cells of the pseudoglomeruli are numerous and have swollen nuclei, which usually leads to thrombosis and consequent coagulative necrosis. There is also a high mitotic activity and infiltrative capacity of tumor cells that generates the poorly defined characteristic of GBM⁵.

The pathophysiology of GBMs, as well as other brain tumors, is related to a metabolic disorder of tumor cells, so that cancer cells, in order to maintain a high mitotic rhythm, reduce the use of the citric acid cycle and mitochondrial oxidative phosphorylation for energy production and, instead, use anaerobic glycolysis as a priority. even in the presence of oxygen. This change in the pattern of obtaining cellular energy increases the glucose consumption of tumor cells and is called the "Warburg Effect", described in 1927 by the German scientist Otto Warburg⁶.

In view of the Warburg effect and the pathophysiological characteristics of GBM, many researchers question alternatives that can help in the treatment of GBM, since current therapeutic measures do not provide a cure or considerable survival in the vast majority of cases. One of the current pathways is based on the fact that GBMs use glucose at a much higher intensity than the normal cortex and in states of prolonged glucose deprivation, normal brain cells metabolize ketone bodies derived from fatty acids to obtain energy instead of glucose, while tumor cells are barely able to do so. making them depend on glucose and glycolysis to survive. The energy delivery route of gliomas has a much lower yield than that of eutrophic cells, leading to a much higher need for glucose⁷. This makes tumor cells vulnerable to glucose-restriction therapies⁸.

1.2 CARBOHYDRATE RESTRICTION AND KETOSIS

When carbohydrates are eliminated from the diet, either in fasting or low carbohydrate intake, energy can be obtained from the oxidation of fatty acids that occurs within the liver. This process generates ketone bodies (acetoacetate, hydroxybutyrate, and acetone) that are transported to the tissues where they are converted into acetyl-coenzyme A, which serves as a substrate in the citric acid cycle⁹. The state of use of this alternative pathway of obtaining cellular energy is called ketosis or ketone state, so that ketone bodies are an alternative energy source for the cells of the cortex, while tumor cells, due to dysfunctions resulting from their mutations, have mitochondria that are incapable of this process and generate many reactive species during the process, leading to apoptosis¹⁰.

2 OBJECTIVES

2.1 GENERAL OBJECTIVE

To relate different conclusions about diets with reduced carbohydrate intake, in addition to CD proposed as classic, as alternatives to complementary treatment of patients with diagnosed GBM, as well as to perceive the conclusions about the applicability of CD and its variations with effectiveness in the state of ketosis, with variables such as palatability, tolerance and maintenance of diets.

2.2 SPECIFIC OBJECTIVES

- Analyze the main difficulties in carrying out the clinical studies carried out so far (August/2022);
- To consolidate the existing conclusions and compare these conclusions with what there is research on the subject in other educational institutions after the publication of the article by the Laboratory of Cell Biology of Gliomas of the Department of Cell Biology, Embryology and Genetics, with a view to valuing local science;
- Use medical-scientific knowledge platforms to signal conclusions of topics studied in different scenarios of pre-clinical, clinical and review studies.

3 WORK METHODOLOGY

A search of 21 articles selected from the related search of the terms "Diet, Ketogenic" and its variations suggested by the Medical Subject Headings (MeSH) was conducted; as well as the keywords "Glioblastomas", "Astrocytoma, Grade IV", "Glioblastoma Multiforme",

"Giant Cell Glioblastomas" and their variations; in addition to the terms "Diet, High Protein Low Carbohydrate", "Low-Carbohydrate", "Atkins Diet", "High-Protein Carbohydrate - Restricted Diets" and their variations in the PubMed and LILACS databases.

The inclusion criteria were the year of publication after 2014, written language, English, and Portuguese. The exclusion criteria were: unavailability of the full article on online platforms for the online availability of scientific knowledge and single case report studies due to its low impact on the scale of evidence and conclusions redundant to systematic review studies and laboratory tests.

After searching on knowledge platforms and reading the abstracts of the papers initially listed, the research proceeded with the full reading of each selected article and correlation of its results.

4 RESULTS AND DISCUSSION

4.1 PRECLINICAL STUDIES

Preclinical studies trace a path for the use of carbohydrate-restricted diets, both the ketogenic diet with different proportions ^{11,12,13,14} and the supplemented high-fat low-carbohydrate (sHFLC)¹⁵ diet, in the adjunct treatment to the measures already implemented (radiochemotherapy). Although studies sometimes evaluate the same diet, as in the case of the ketogenic diet, they conclude different variables, since one study pointed to immune-enhancing effects, especially of Th1 and NK¹¹ cells, on tumor control while another study pointed to synergy with chemotherapy drugs in interrupting tumor migration¹². There was also a histoanatomical correlation of the effect of CD, so that astrocytes were pointed out as the main cellular target of CD with greater synaptic participation in the region of the striatum¹³. The interaction of CD with Bevacizumab has also been shown to be beneficial for prolonging survival¹⁴. Thus, classic CD was promising in 4 preclinical studies, each of which listed a particularly beneficial characteristic of the association with standard care.

Other diets are being studied to serve as an adjuvant treatment to the one already applied clinically, such as sHLFC. Basically, the theory of this diet is also based on Warburg's effect and the state of ketosis, but his suggestion is due to the fact that this diet is more nutritionally complete, more flexible and palatable, due to the implementation of proteins and supplementation with medium-chain triglycerides¹⁵. Following the hypoglycemic logic, the study also compares the effects of metformin - a drug that acts to reduce hepatic glucose production by inhibiting gluconeogenesis and glycogenolysis, increasing tissue sensitivity to

insulin and delaying intestinal glucose absorption¹⁶, when associated or not with CD and SHLFC, so that there was no synergistic effect between the measures¹⁵.

However, there is no consensus among preclinical studies about the synergy of carbohydrate-restricted diets, since 2 studies found adaptive mechanisms of GBM to decrease glucose availability^{17,18}. One of them evaluated the use of fatty acids as an energy substrate in 9L and RG2 tumor models and found values close to those of the human brain of oxidative metabolism made by tumors in vivo, demonstrating that tumors have a certain tumor flexibility capable of maintaining their mitotic rhythm. The authors comment on the difference in the time of insertion of tumor lines in mice, a factor that brings this study closer to reality, since patients do not start carbohydrate restriction immediately after the appearance of GBM, but after diagnosis, with a variable time that can take weeks to months¹⁷. The other study that points to the inefficacy of CD as an adjuvant therapy to the treatment of GBM denotes a decrease in tumor survival (of the U87 lineage, different from the tumor lines of the previous study) under the effect of a fatty acid oxidation inhibitor, with negative results in the survival rate of mice submitted to unrestricted CD, indicating the use of fatty acids for energy by GBM¹⁸.

4.2 CLINICAL STUDIES

Clinical studies do not seem as promising as preclinical studies in their main objective of prolonging patient survival, as well as revealing important limitations related to patient adherence to studies until their conclusion. Studies that use CD have high rates of patient dropout. A study involving 15 patients undergoing a 3:1 CO with 10 patients completing the study generated secondary conclusions to those initially proposed, since the survival rate was the same as that found in patients who did not undergo any intervention¹⁹. Similarly, another study involving the implementation of CD, initially liquid and after two weeks solid with medium-chain triglyceride emulsions, obtained a survival rate compatible with the expectations of patients who do not undergo any specific diet²⁰. In addition, another study with the implementation of the more classic CD following the 4:1 ratio, reached a mean survival rate of 12.8 months, with no increase in survival expectancy²¹.

In all the clinical studies cited, the number of patients who finish the research is very small, especially in a study in which only 3 patients completed the study²². In this case, the conclusions point to the perceptions related to patient dropouts, as all 4 articles^{19,20,21,22} qualify quality of life as a fundamental factor for patients and their families. As highlighted by

the clinical trials, GBM is considered an end-of-life certificate and most patients are not willing to spend their last days following an extremely restrictive diet that isolates them in their daily lives, making it impossible to socialize around a meal. In addition, the need for caregivers, partners or companions is a limiting factor for certain people who are unable to have a companion for all the necessary moments in their food preparation. Therefore, the applicability of CD is determined by the condition of the study or the patient in having aid for the preparation and maintenance of CD, as well as by the palatability offered by the diet. In addition, many patients reported intestinal discomfort, constipation, feeling hungry, nausea, vomiting and dizziness, although these symptoms may be caused by chemoradiation and by the pathological condition itself, and it is not possible to say with absolute certainty whether or not they are due to CD.

Another diet demonstrated greater adherence (96.6%) until the conclusion of the study in 29 patients. The Atkins diet involves a greater participation of proteins as an energy substrate and has greater palatability reported by patients, with the potential to generate ketosis, as well as CD. In this way, the study tries to correlate the survival of patients with a survival predictor: O⁶ methylguanine-DNA methyltransferase (MGMT), but the number of patients with survival analysis is small and makes percentage analysis difficult. Therefore, this diet is pointed out as promising for studies with a larger number of participants²³.

4.3 PUBLISHED REVIEWS

The reviews follow the trend of clinical studies to adjust the expectation about CD at a lower level in relation to the results of preclinical studies, as well as signal more flexible and applicable paths for implementing a diet that brings the patient's blood glucose to lower levels.

New variables were added in relation to *in vivo* studies, both the psychosocial factors related to patients following CD in a strict way, which directly impacts the motivation, discipline and need for strict guidance from a nutritionist, and the interaction with corticosteroids used in the treatment to reduce cerebral edema and reduce the symptoms of patients with consequent increase in blood glucose and decreased efficacy of CD in generating ketosis^{24 25}.

Although some associations are positive in *in vivo* studies, their reproduction is not recommended clinically in humans, as is the case with calorie restriction associated with CD in order to enhance ketosis. Since the review of preclinical studies and case reports²⁵

suggests this as a possibility to circumvent the effect of corticosteroids that, if withdrawn, impact a significant decrease in the quality of life of patients. However, another review, from 2018, states that body weight should be maintained, as weight loss and malnutrition in GBM patients are associated with a worse response to therapies, more adverse effects, complications, short mean survival, and poor quality of life. This suggests a concept of balance between the efficacy in generating ketosis and the feasibility of implementing dietary characteristics²⁶.

A review involving preclinical and clinical studies from 2020 traces the same trend already explained, because even though the survival rate was perceived in 17 of the 24 preclinical studies reviewed, the 4 clinical studies have great possibilities of bias. Thus, it is necessary to analyze the low number of patients followed, which makes it difficult to draw a percentage with a concrete reflection on reality. Also, the search of patients for various substances and alternative treatments in order to find a cure, which creates variables not analyzed in the studies. As well as the influence of corticosteroid therapy, implemented in standard treatment, which can decrease the effectiveness of CD in generating ketosis. Furthermore, the onset of CD is usually days or weeks after the diagnosis of GBM in real patients, unlike what is usually analyzed in preclinical studies that start CD at a time very close to tumor insertion. In addition, the guarantee of full follow-up of patients with CD is an important limiting factor, since many patients relate the diet to the side effects experienced during the treatment process and withdraw from the study²⁷.

Two reviews^{28, 29} are dedicated to clarifying the influence of hyperglycemia as an independent factor of poor prognosis for the survival rate in patients with GBM, even reducing by half the mean survival in patients from a cohort of 367 patients³⁰. Thus, not only CD but habits and diets with the potential to lower blood glucose could be suggested as protective factors for patients during treatment, and it is important to reduce carbohydrate intake, since the use of corticosteroids usually raises blood glucose, a fact that in patients who continue to eat high levels of carbohydrates can lead to recurrent hyperglycemia (determined as a risk factor for lower survival)^{28, 29}.

In general, preclinical studies determine more restrictive and rigid measures. On the other hand, clinical studies demonstrate the inapplicability of these measures due to a sum of factors added to the complexity of establishing in humans the same effects generated *in vivo* and *in vitro*, such as, for example, the need for a strong bond between researchers and patients to maximize patient motivation and the domestic support of a family member or friend

to help the patient overcome physical difficulties. cognitive and psychosocial aspects of the WBG. In this sense, a review tried to relate several dietary interventions already studied with the aim of generating ketosis with the use of the Warburg effect. Thus, unlike what some preclinical studies pointed to a classic, rigid CD with exact measurements of long-chain fatty acids and even a calorie deficit, clinical studies have seen more advantages in alternative diets such as diets with medium-chain triglyceride oil that provide more ketones per kilocalorie and enter the circulation more readily and the Atkins diet that is considered more flexible, applicable, palatable, and tolerable by patients with CD-like efficacy in generating ketosis. Thus, the concept cited by all reviews of balance between efficacy and viability is better contemplated by diets that are not necessarily CO³¹.

The search for a cure for GBM instigates patients to undergo several processes with or without scientific recognition and this is pointed out as a probable generator of bias in the reviews^{27,32}, but it also drives the research of several substances that could complement the standard treatment, such as penicillamine, vitamin A, vitamin C, selenium, boswellic acid oil and curcumin, which have studies on their therapeutic use in cases of GBM. However, until the publication of the present study, there were no studies that support the clinical use of these substances, so that there are ongoing studies to understand their mechanisms³¹.

4.4 STUDENT LEARNING

It is worth emphasizing, in addition to the better understanding related to the revised theme for the preparation of the study, the importance of the scientific initiation project for the critical sense and familiarity with scientific journals of the beneficiary, since it becomes increasingly necessary to critically read studies in the midst of so much circulating misinformation masked as science, especially in the field of medicine, who suffers daily attacks from those who do not understand the process of evidence-based analysis and continues to perpetuate bad practices, with consequent harm to their patients.

5 CONCLUSIONS

Most studies point to a positive interaction between the restriction of carbohydrate consumption and the standard treatment established for GBM, so that other diets, in addition to CD, have been gaining greater attention and have a promising future when it comes to applicability and efficacy in generating ketosis to induce the Warburg effect.

Preclinical studies, although without consensus^{17,18}, point to promising paths of CD

and alternatives, such as sHFLC¹⁵, as synergists to chemoradiation in the treatment of GBM. However, preclinical studies do not find support in clinical studies carried out so far for the increase in the survival rate^{19,20,21,222}, the main objective of dietary measurement, as well as variables increased in human studies not perceptible in *in vitro* and *in vivo studies*, as the psychosocial factors linked to the maintenance of patients in the studies, had a decisive weight in the high dropout rate of the studies that did not allow an absolute analysis of the results. In addition, review studies reject the idea of calorie restriction proposed by some preclinical studies in patients with a consumptive syndrome, since weight loss is related to worse prognosis and higher chances of complications in patients with GBM^{32,33}.

In this scenario, one of the most cited variables in the review studies, as it was present in all the clinical studies analyzed, is quality of life. It was noticed that the efficiency of the diets should be linked to their potential for application, so that more restrictive diets with recipes that are difficult to prepare had a higher number of dropouts in their studies, while the Atkins diet (considered a more flexible and palatable diet) obtained good numbers regarding the number of patients who finished the study and state of ketosis during the process. The presence of a friend, family member or partner was decisive for the completion of the diets and maintenance of the patients' motivation, being a characteristic listed with a decisive role in the quality of life of the patients^{20,22}.

That said, the mechanisms established as beneficial need further studies for complete elucidation, since not only the state of ketosis proved to be adjuvant to the standard treatment, but also the maintenance of euglycemia in patients implies a higher survival rate when compared to patients with recurrent hyperglycemia. Thus, a diet that contributes less to the increase in blood glucose (already caused by the effect of corticosteroid therapy implicit in the treatment and responsible for improving the quality of life of patients during the process) is necessary as a prophylactic measure for the recurrent increase in blood glucose in these patients^{28, 29}.

Nevertheless, this is a literature review with its limitations, which implies the need for larger studies, with more refined methodologies in order to determine with certainty and/or recommend carbohydrate-restricted diets for the adjunct treatment of GBM.

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**CHEST WALL RECONSTRUCTION FOR STERNUM COMPLICATIONS IN
CARDIOVASCULAR SURGERY: A SYSTEMATIC REVIEW**

**RECONSTRUÇÃO DA PAREDE TORÁCICA POR COMPLICAÇÕES DO
ESTERNO EM CIRURGIA CARDIOVASCULAR: REVISÃO SISTEMÁTICA**

**RECONSTRUCCIÓN DE LA PARED TORÁCICA PARA COMPLICACIONES DEL
ESTERNÓN EN CIRUGÍA CARDIOVASCULAR: UNA REVISIÓN SISTEMÁTICA**

 <https://doi.org/10.56238/sevened2025.036-126>

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ABSTRACT

Introduction: Sternal suture dehiscence represents a serious complication after cardiac surgery, with an incidence ranging from 0.5% to 5% of median sternotomy procedures. This condition is associated with high morbidity and mortality rates, often requiring reconstructive surgical intervention. Muscle flaps, particularly the pectoralis major and rectus abdominis, constitute fundamental therapeutic options for the definitive treatment of this complication.

Objective: To conduct a systematic review of the literature on the use of muscle flaps in the reconstruction of mediastinal suture dehiscence after cardiac surgery, with emphasis on pectoralis major and rectus abdominis flaps, analyzing indications, surgical techniques, outcomes, and complications.

Methodology: Systematic literature review in PubMed, MEDLINE, Scopus, Web of Science, and LILACS databases, including articles published between 2010 and 2024. Studies addressing sternal dehiscence reconstruction with muscle flaps were selected, focusing on pectoralis major and rectus abdominis. The analysis included data on epidemiology, risk factors, surgical techniques, success rates, and complications.

Results: The literature demonstrates that pectoralis major flaps present success rates between 85-95%, being the first choice for anterior and lateral mediastinal defects. The rectus abdominis flap, with success rates of 80-92%, is indicated for extensive defects of the lower third of the sternum. Significant risk factors include diabetes mellitus, obesity, bilateral use of internal mammary artery, COPD, and deep infection. Mortality associated with mediastinitis ranges from 10% to 47% in recent literature.

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Conclusion: Pectoralis major and rectus abdominis flaps represent effective and safe reconstructive options for treating sternal suture dehiscence. Flap selection should consider the location and extent of the defect, patient clinical conditions, and surgical team experience. Multidisciplinary approach and early treatment are fundamental for reducing morbidity and mortality. A systematized safety algorithm is proposed to optimize the management of this complication.

Keywords: Mediastinitis. Sternal Osteomyelitis. Sternal Dehiscence. Surgical Flaps. Pectoralis Major Muscle. Rectus Abdominis Muscle. Cardiac Surgery. Median Sternotomy.

RESUMO

Introdução: A deiscência de sutura esternal representa uma complicação grave após cirurgia cardíaca, com incidência variando entre 0,5% a 5% dos procedimentos que envolvem esternotomia mediana. Esta condição está associada a elevadas taxas de morbidade e mortalidade, exigindo frequentemente intervenção cirúrgica reconstrutiva. Os retalhos musculares, particularmente usando peitoral maior e reto abdominal, constituem opções terapêuticas fundamentais para o tratamento definitivo desta complicação.

Objetivo: Realizar uma revisão sistemática da literatura sobre o uso de retalhos musculares na reconstrução de deiscência de sutura mediastinal pós-cirurgia cardíaca, com ênfase nos retalhos de peitoral maior e reto abdominal, analisando indicações, técnicas cirúrgicas, resultados e complicações.

Metodologia: Revisão sistemática da literatura nas bases de dados PubMed, MEDLINE, Scopus, Web of Science e LILACS, com base em artigos publicados entre os anos de 2010 e 2024. Foram selecionados estudos que abordam reconstrução de deiscência esternal com retalhos musculares, com foco em peitoral maior e reto abdominal. A análise incluiu dados sobre epidemiologia, fatores de risco, técnicas cirúrgicas, taxas de sucesso e complicações.

Resultados: A literatura demonstra que os retalhos de peitoral maior apresentam taxas de sucesso entre 85-95%, sendo a primeira escolha para defeitos anteriores e laterais do mediastino. O retalho de reto abdominal, com taxas de sucesso de 80-92%, é indicado para defeitos extensos do terço inferior do esterno. Fatores de risco significativos incluem diabetes mellitus, obesidade, uso bilateral de artéria mamária interna, DPOC e infecção profunda. A mortalidade associada à mediastinite varia de 10% a 47% na literatura recente.

Conclusão: Os retalhos de peitoral maior e reto abdominal são opções reconstrutivas eficazes e seguras para tratamento de deiscência de sutura esternal. A escolha do retalho deve considerar a localização e extensão do defeito, condições clínicas do paciente e experiência da equipe cirúrgica. A abordagem multidisciplinar e o tratamento precoce são fundamentais para redução da morbimortalidade. Um algoritmo de segurança sistematizado é proposto para otimizar o manejo desta complicação.

Palavras-chave: Mediastinite. Osteomielite do Esterno. Deiscência de Sutura Esternal. Retalhos Cirúrgicos. Músculo Peitoral Maior. Músculo Reto Abdominal. Cirurgia Cardíaca. Esternotomia Mediana.

RESUMEN

Introducción: La dehiscencia de la sutura esternal representa una complicación grave después de la cirugía cardíaca, con una incidencia que varía del 0,5% al 5% de los

procedimientos que involucran esternotomía media. Esta condición se asocia con altas tasas de morbilidad y mortalidad, requiriendo con frecuencia intervención quirúrgica reconstructiva. Los colgajos musculares, particularmente utilizando el pectoral mayor y el recto abdominal, son opciones terapéuticas fundamentales para el tratamiento definitivo de esta complicación.

Objetivo: Realizar una revisión sistemática de la literatura sobre el uso de colgajos musculares en la reconstrucción de la dehiscencia de la sutura mediastínica después de la cirugía cardíaca, con énfasis en los colgajos de pectoral mayor y recto abdominal, analizando las indicaciones, las técnicas quirúrgicas, los resultados y las complicaciones.

Metodología: Revisión sistemática de la literatura en las bases de datos PubMed, MEDLINE, Scopus, Web of Science y LILACS, basada en artículos publicados entre 2010 y 2024. Se seleccionaron estudios que abordaron la reconstrucción de la dehiscencia esternal con colgajos musculares, centrándose en el pectoral mayor y el recto abdominal. El análisis incluyó datos sobre epidemiología, factores de riesgo, técnicas quirúrgicas, tasas de éxito y complicaciones.

Resultados: La literatura demuestra que los colgajos de pectoral mayor tienen tasas de éxito entre 85-95%, siendo la primera opción para defectos mediastínicos anteriores y laterales. El colgajo de recto abdominal, con tasas de éxito de 80-92%, está indicado para defectos extensos del tercio inferior del esternón. Los factores de riesgo significativos incluyen diabetes mellitus, obesidad, uso bilateral de la arteria mamaria interna, EPOC e infección profunda. La mortalidad asociada con mediastinitis varía de 10% a 47% en la literatura reciente.

Conclusión: Los colgajos de pectoral mayor y recto abdominal son opciones reconstructivas efectivas y seguras para el tratamiento de la dehiscencia de la sutura esternal. La elección del colgajo debe considerar la ubicación y extensión del defecto, la condición clínica del paciente y la experiencia del equipo quirúrgico. Un enfoque multidisciplinario y el tratamiento temprano son fundamentales para reducir la morbilidad y la mortalidad. Se propone un algoritmo de seguridad sistematizado para optimizar el manejo de esta complicación.

Palabras clave: Mediastinitis. Osteomielitis del Esternón. Dehiscencia de la Sutura Esternal. Colgajos Quirúrgicos. Músculo Pectoral Mayor. Músculo Recto Abdominal. Cirugía Cardíaca. Esternotomía Media.

1 INTRODUCTION

The median sternotomy is the most used access route in cardiac surgery, providing excellent exposure of the mediastinal structures and allowing the performance of various cardiovascular procedures. Despite advances in surgical, anesthetic, and perioperative care techniques, sternal suture dehiscence and mediastinitis remain serious and potentially fatal complications in the postoperative period of cardiac surgeries. [1,2,3]

The incidence of sternal dehiscence varies between 0.5% and 5% of procedures involving median sternotomy, and may reach higher rates in high-risk populations. [4,5,6] When associated with deep infection (mediastinitis), mortality can reach 10% to 47%, depending on the severity of the condition, patient comorbidities, and time until definitive treatment. [7,8,9] In addition to the impact on mortality, these complications result in a significant increase in morbidity, prolongation of hospital stay, increased treatment costs, and impairment of patients' quality of life. [10,11]

The pathophysiology of sternal dehiscence is multifactorial, involving factors related to the patient (diabetes mellitus, obesity, chronic obstructive pulmonary disease, smoking, use of corticosteroids), surgical technique (bilateral use of the internal mammary artery, inadequate sternal closure technique, prolonged surgical time), and postoperative period (infection, hemodynamic instability, need for reoperation, prolonged mechanical ventilation, cough, among others). [12,13,14]

The treatment of mediastinal suture dehiscence has evolved significantly in recent decades. Initially, management consisted of debridement, irrigation, and primary closure, with often unsatisfactory results and high recurrence rates. [15] From the 1960s onwards, with the pioneering work of Jurkiewicz et al., the use of vascularized muscle flaps revolutionized the treatment of this condition, providing adequate coverage of the mediastinum, obliteration of the dead space, improvement of local blood supply, and significant reduction in recurrence and mortality rates. [1,13,15]

Among the muscle flap options available, techniques involving the pectoralis major and rectus abdominis stand out as the most frequent choices, due to their reliability, versatility, favorable vascular anatomy, and proximity to the area to be reconstructed. [16,17,21] The pectoralis major flap, first described by Jurkiewicz in 1963, has become the gold standard for reconstruction of upper and middle sternal defects, while the rectus abdominis flap, popularized by Nahai et al. in 1982, is particularly useful for extensive and lower third sternal defects. [22,25,26]

The choice of the appropriate flap should consider multiple factors, including the location and extent of the defect, the presence of active infection, the patient's nutritional and clinical status, previous surgeries in the thoracic or abdominal region, and the experience of the surgical team. [23,27] The multidisciplinary approach, involving cardiac surgeons, plastic surgeons, infectious disease specialists, and intensive care staff, is critical to successful treatment. [9,28]

Despite the vast literature on the subject, there are still controversies regarding the ideal time of intervention, the choice of the most appropriate flap for each clinical situation, the role of negative pressure therapy as an adjuvant or bridge to definitive reconstruction, and antibiotic therapy protocols. [12,29,30] In addition, the heterogeneity of published studies, with different definitions of mediastinitis, varied inclusion criteria, and inconsistent follow-up, makes it difficult to compare results and develop robust evidence-based guidelines.

In this context, the present systematic review aims to critically analyze the scientific literature on the use of muscle flaps, with emphasis on pectoralis major and rectus abdominis flaps, in the reconstruction of sternal suture dehiscence after cardiac surgery. It seeks to consolidate the available evidence on indications, surgical techniques, outcomes, complications, and prognostic factors, providing subsidies for clinical decision-making and identifying gaps in knowledge that can guide future research.

2 METHODOLOGY

2.1 SEARCH STRATEGY

This systematic review was conducted following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The bibliographic search was carried out in the following electronic databases: PubMed/MEDLINE, Scopus, Web of Science, Cochrane Library and LILACS (Latin American and Caribbean Literature on Health Sciences).

The search period included articles published between January 2010 and October 2024, with the aim of capturing the most recent and relevant literature on the topic. The search strategy was developed using MeSH terms and related keywords, combined with Boolean operators.

The search terms used included: "mediastinitis" OR "sternal dehiscence" OR "sternal wound infection" OR "deep sternal wound infection" AND "surgical flaps" OR "muscle flaps"

OR "pectoralis major" OR "rectus abdominis" OR "reconstruction" AND "cardiac surgery" OR "sternotomy" OR "coronary artery bypass".

2.2 ELIGIBILITY CRITERIA

2.2.1 Inclusion Criteria:

- Original studies (case series, cohort studies, case-control studies, clinical trials)
- Systematic review articles and meta-analyses
- Publications in English, Portuguese or Spanish
- Studies involving adult patients (≥ 18 years)
- Approach to reconstruction of sternal dehiscence or mediastinitis with muscle flaps
- Description of surgical technique, results or complications
- Focus on pectoralis major and/or rectus abdominis flaps

2.2.2 Exclusion Criteria:

- Isolated case reports (less than 3 cases)
- Studies in the paediatric population exclusively
- Articles without original data (editorials, letters to the editor, comments)
- Studies with incomplete data or inadequate methodology
- Duplicate posts
- Studies focused exclusively on other reconstructive options (omentum, latissimus dorsi) without mentioning pectoralis major or rectus abdominis

2.3 SELECTION OF STUDIES

Study selection was carried out in two stages by two independent reviewers. Initially, we were screened by titles and abstracts, excluding articles clearly unrelated to the theme. In the second stage, potentially eligible articles were read in full for evaluation of the inclusion and exclusion criteria. Disagreements among the reviewers were resolved by consensus or by consulting a third reviewer.

2.4 DATA EXTRACTION

Data were extracted in a standardized way using a specific form, including the following information: study characteristics (author, year, country, study design, sample size), patient characteristics (age, gender, comorbidities, type of cardiac surgery), definition of

mediastinitis or sternal dehiscence used, risk factors identified, type of flap used (pectoralis major, rectus abdominis, bilateral, unilateral), surgical technique described, time between cardiac surgery and reconstruction, use of adjuvant therapy (negative pressure, antibiotic therapy), results (success rate, length of hospital stay, mortality), complications (recurrence, flap necrosis, infection, seroma, hematoma), and follow-up time.

2.5 EVALUATION OF THE QUALITY OF STUDIES

The methodological quality of the included studies was assessed using appropriate tools for each type of study design: Newcastle-Ottawa Scale for observational studies, Cochrane Risk of Bias Tool for randomised controlled trials, and AMSTAR-2 for systematic reviews.

2.6 SUMMARY OF THE DATA

Due to the heterogeneity of the included studies (different definitions, populations, surgical techniques, and outcomes), we chose to perform a narrative synthesis of the data, with a descriptive presentation of the main findings. When possible, aggregate success, complication, and mortality rates were calculated.

2.7 MICROBIOLOGY AND DIAGNOSIS

The microbiology of post-sternotomy mediastinitis is predominantly bacterial, with *Staphylococcus aureus* (including methicillin-resistant strains - MRSA) being the most frequently isolated pathogen, accounting for 30-50% of cases. [8,9] Coagulase-negative *Staphylococcus* accounts for 15-30% of cases, followed by gram-negative bacilli (*Escherichia coli*, *Klebsiella*, *Pseudomonas*) in 15-25% and polymicrobial infections in 10-20% of cases.

The diagnosis of mediastinitis is based on clinical, laboratory, and imaging criteria. [3,8,9] The most commonly used diagnostic criteria include sternal instability on palpation, purulent drainage through the sternal wound, persistent fever ($>38^{\circ}\text{C}$) after the 5th postoperative day, persistent or recurrent leukocytosis, disproportionate sternal pain, and signs of local inflammation (erythema, edema, heat).

Among the laboratory criteria, persistent elevation of inflammatory markers (CRP, ESR, procalcitonin), positive culture of sternal or mediastinal secretion, and positive blood culture with a compatible pathogen stand out. [9,12] Imaging criteria include CT scan showing

mediastinal fluid collection, gas in the mediastinum after 2 weeks postoperatively, soft tissue enhancement, and sternal osteomyelitis. [3,8]

The temporal classification of mediastinitis is clinically relevant: early (up to 2 weeks after surgery, usually related to intraoperative contamination) and late (after 2 weeks, usually related to bacteremia or secondary contamination). [3,27]

2.8 PRINCIPLES OF PROCESSING

The treatment of mediastinal suture dehiscence and mediastinitis requires a multidisciplinary and aggressive approach. [9,13,15] The fundamental principles include:

- **Surgical Debridement:** Complete removal of all necrotic, devitalized, or infected tissue, including compromised sternal bone, necrotic costal cartilages, and devitalized soft tissues.[13,15,26] Debridement should be radical and repeated as many times as necessary until viable and well-vascularized tissue is obtained.
- **Infection Control:** Broad-spectrum antibiotic therapy initially, adjusted according to culture and antibiogram results.[5,9] The duration of antibiotic treatment varies from 4 to 6 weeks, depending on the severity of the infection and clinical response.
- **Sternal Stabilization:** When possible, maintenance or restoration of sternal stability through rigid fixation with plates and screws, especially in cases of dehiscence without significant infection.[16:18]
- **Dead Space Obliteration:** Filling of the mediastinal defect with vascularized tissue (muscle flaps) to obliterate the dead space, improve local blood supply, and facilitate healing.[1,13,15,21]

The timing of the definitive reconstruction is controversial in the literature. Traditionally, late reconstruction after complete control of the infection was advocated. However, more recent studies have shown that early reconstruction (within 7-14 days of diagnosis) is associated with better outcomes, shorter hospital stays, and reduced mortality. [13,15,27,28]

Vacuum-Assisted Closure (VAC) therapy has been used as an adjunct to treatment, either as a bridge to definitive reconstruction or as primary therapy in selected cases. [12,29,30] Studies have shown that VAC promotes edema reduction, exudate removal, stimulation of granulation tissue formation, and reduction of bacterial load. However, its use alone without definitive reconstruction is associated with higher recurrence rates.

2.9 PECTORALIS MAJOR FLAP

The pectoralis major flap represents the most widely used reconstructive option for the treatment of sternal dehiscence and mediastinitis, and is considered the gold standard for defects of the upper and middle third of the sternum. [1,13,17,21]

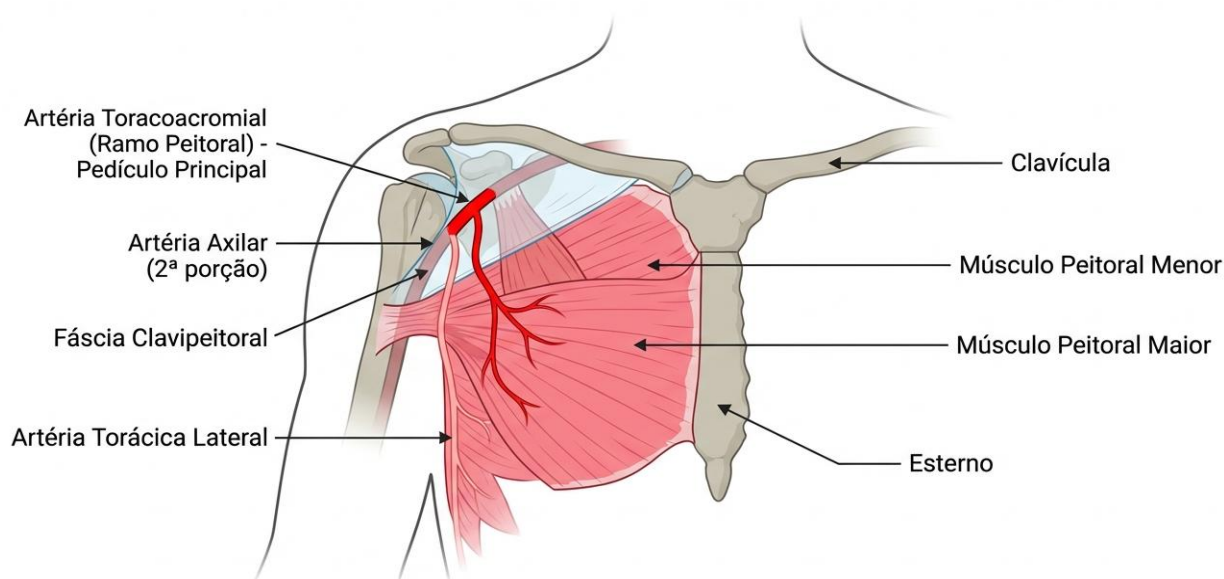
2.9.1 Anatomy and Vascularization

The pectoralis major muscle is a broad, flat muscle that forms the anterior wall of the armpit and most of the anterior contour of the chest. [21,24] It originates from the clavicle (clavicular portion), the sternum and costal cartilages (esternocostal portion) and the aponeurosis of the external oblique muscle (abdominal portion), inserting into the lateral lip of the intertubercular groove of the humerus.

The vascularization of the pectoralis major muscle is twofold, originating from the thoracoacromial artery (dominant pedicle, branch of the axillary artery, penetrates the muscle in its superior portion), lateral thoracic artery (branch of the axillary artery, provides additional supply to the lateral portion) and perforating the internal mammary artery (provides supply to the medial portion, often compromised in cardiac surgery). [20,21,24]

Figure 1

Vascular Anatomy of the Thoracoacromial Artery



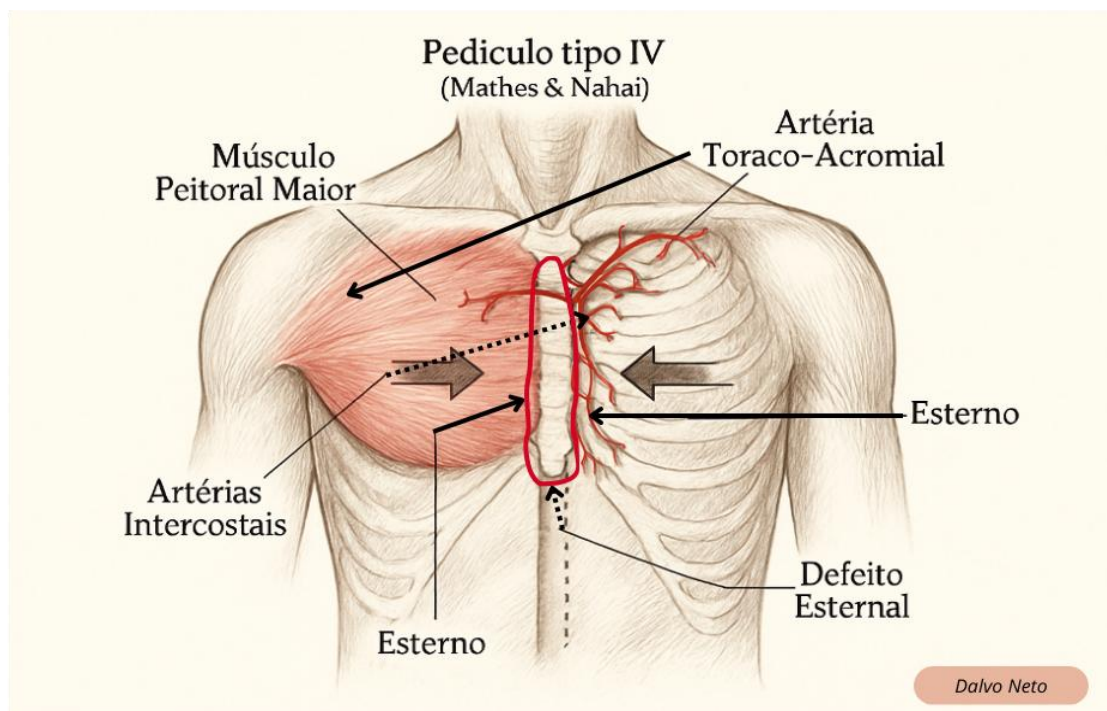
Source: José Dalvo Maia Neto Created BioRender

2.9.2 Surgical Technique

The pectoralis major flap can be performed unilaterally or bilaterally, depending on the extent of the defect. [17,21,22] The standard technique includes: (1) Incision with extension of the median incision or creation of lateral incisions for adequate exposure; (2) Dissection identifying the limits of the muscle, initiated laterally in the deltopectoral sulcus, preserving the cephalic vein, with detachment of its sternal and costal origin, preserving the superior thoracoacromial pedicle; (3) Medial transposition over the sternal defect, with midline suture in bilateral cases; (4) Fixation to the remaining sternum, costal cartilages, or adjacent tissues with absorbable sutures; (5) Closure with proper drainage and tension-free skin closure. [17,21,22]

Figure 2

Schematic drawing of the Pectoral flap



Source: José Dalvo Maia Neto created BioRender

2.9.3 Indications

Upper and middle sternal defects, mediastinitis after median sternotomy, sternal dehiscence without significant infection, sternal osteomyelitis, and exposure of cardiovascular structures. [13,17,21,23]

2.9.4 Results

The literature shows success rates for the pectoralis major flap ranging from 85% to 95%. [13,15,17,21] Primary success rate of 85-95%, mortality of 5-15%, infection recurrence of 5-10%, and need for reintervention of 10-20%.

2.9.5 Complications

Partial flap necrosis (3-8%), seroma (10-15%), hematoma (5-10%), recurrent infection (5-10%), functional deficit of the upper limb (rare, usually minimal), and variable aesthetic deformity, usually well tolerated. [17,21,23]

2.10 RECTUS ABDOMINIS FLAP

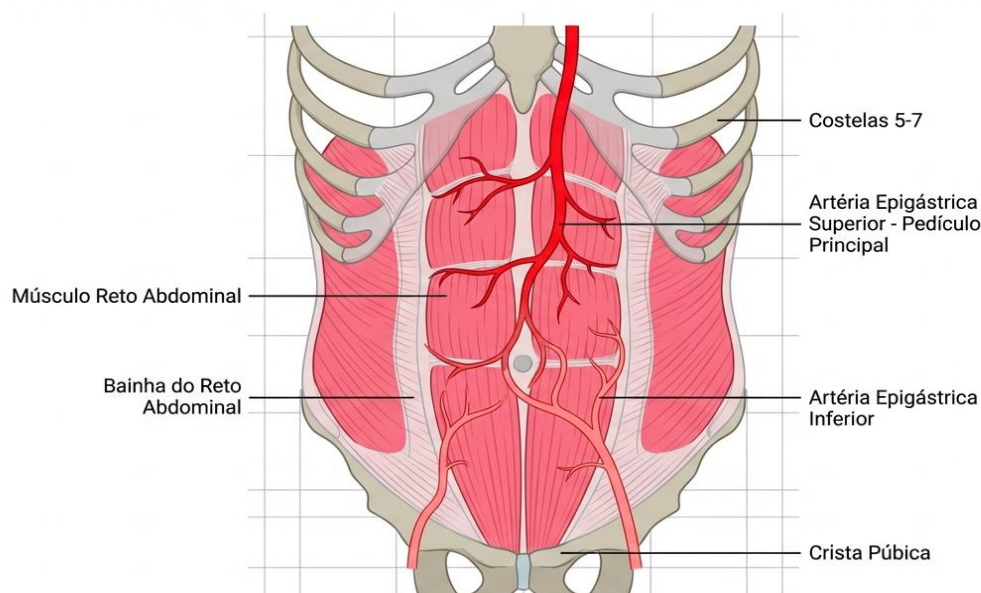
The rectus abdominis flap represents an excellent reconstructive option for extensive sternal defects, particularly of the lower third, and in situations where the pectoralis major flap is not available or insufficient. [22,23,25,26]

2.10.1 Anatomy and Vascularization

The rectus abdominis muscle is a long, flat muscle that extends from the xiphoid process and costal cartilages 5-7 to the pubic symphysis. [24,25] It is surrounded by the rectus abdominis sheath and has tendon intersections that divide it into segments. Vascularization originates from the superior epigastric artery (branch of the internal thoracic artery, vascular pedicle for the superior pedicled flap), inferior epigastric artery (branch of the external iliac artery), and intercostal and lumbar arteries (provide additional supply through perforators). [24,25]

Figure 3

Vascular Anatomy of the Superior Epigastric Artery



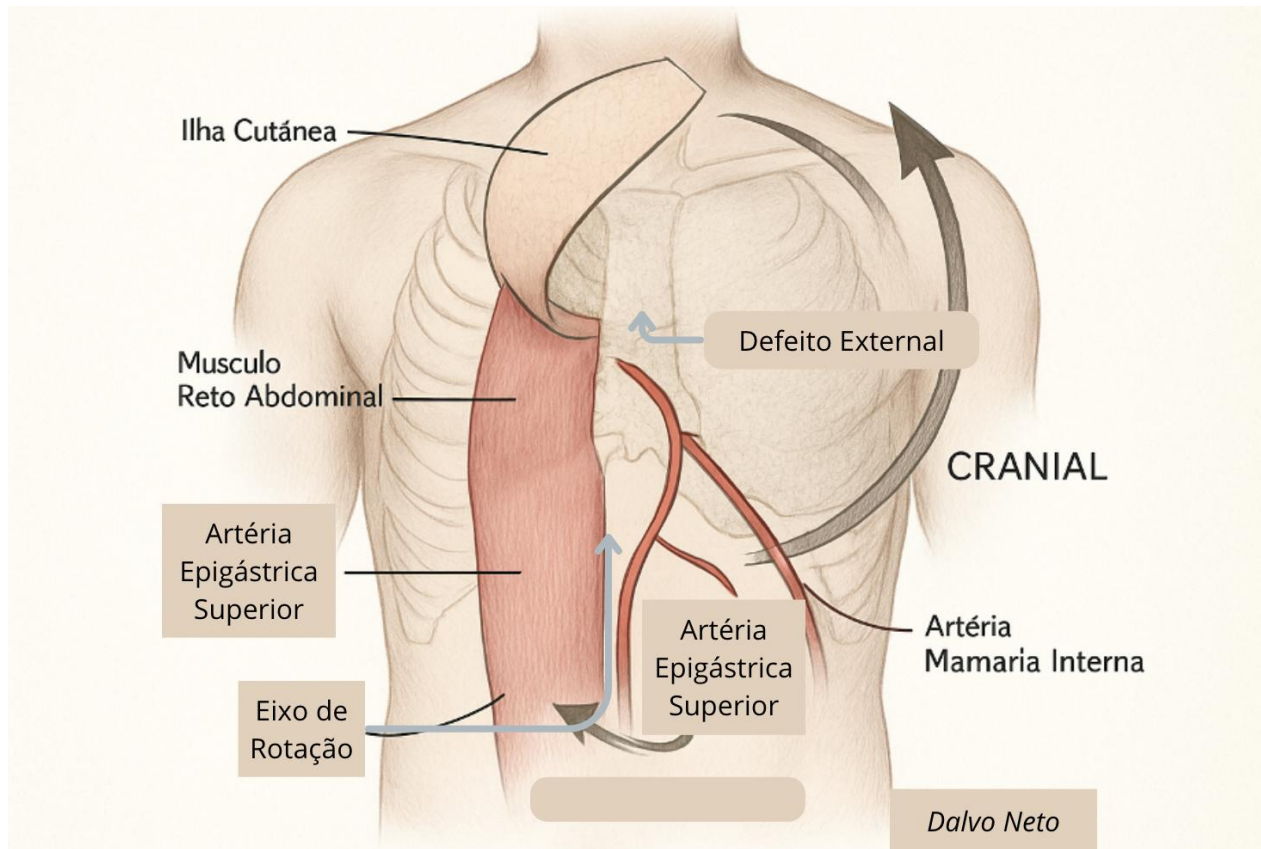
Source: José Dalvo Maia Neto created BioRender

2.10.2 Surgical Technique

The rectus abdominis flap for sternal reconstruction is typically performed as a superior pedicled flap, based on the superior epigastric artery. [22,25,26] The technique includes: (1) Vertical or paramedian incision over the muscle, from the costal margin to the infraumbilical region; (2) Dissection with opening of the anterior sheath and dissection of the muscle of its posterior sheath or peritoneum, from inferior to superior, connecting the inferior epigastric pedicle; (3) Complete mobilization preserving the superior epigastric pedicle, which may include adjacent costal cartilage; (4) Superior transposition through the subcutaneous tunnel to the sternal defect; (5) Attachment to the sternum, cartilage or adjacent tissues; (6) Abdominal closure of the anterior sheath with nonabsorbable sutures, with the possible use of prosthetic mesh in significant defects; (7) Proper drainage and skin closure without tension. [22,25,26]

Figure 4

Schematic drawing of the V.R.A.M. Retail



Source: created by José Dalvo Maia Neto with BioRender

2.10.3 Indications

Extensive defects of the sternum (particularly lower third), failure or unavailability of the pectoralis major flap, defects extending to the xiphoid process or epigastric region, need for large tissue volume, and reconstruction after extensive tumor resection. [23,25,26]

2.10.4 Results

The literature shows success rates for the rectus abdominis flap ranging from 80% to 92%: primary success rate of 80-92%, mortality of 8-18%, recurrence of infection of 8-15%, and need for reintervention of 15-25%. [25,26,27]

2.10.5 Complications

Partial necrosis of the flap (5-12%), seroma (15-25%), hematoma (8-15%), recurrent infection (8-15%), abdominal hernia (5-15%, specific complication of the donor site), abdominal wall weakness (20-30%), and variable abdominal aesthetic deformity. [23,25,26]

2.11 COMPARISON BETWEEN FLAPS

The choice between pectoralis major flap and rectus abdominis must consider multiple factors. [23] For the localization of the defect, the pectoralis major is preferable for the upper and middle third of the sternum, while the rectus abdominis is more suitable for the lower third and xiphoid region. [21,25] For small to moderate defects, unilateral pectoralis major is usually sufficient, while extensive defects require bilateral pectoralis major or rectus abdominis. [17,23]

Bilateral use of the internal mammary artery may compromise both flaps, but generally the pectoralis major remains viable. [19,20] Regarding the morbidity of the donor site, the pectoralis major has lower morbidity and minimal functional deficit, while the rectus abdominis has higher morbidity with risk of hernia and abdominal weakness. [23,25] The success rate of pectoralis major is slightly higher (85–95% vs 80–92%). [13,15,17,21,25,26] Technically, the pectoralis major is simpler with less surgical time, while the rectus abdominis is more complex and requires careful abdominal closure. [23]

Table 1

Results of Surgical Interventions with Muscle Flaps

Retail Type	No of Cases	Success Rate (%)	Complications (%)	Mortality (%)	Hospitalization time (days)
Unilateral Greater Pectoralis	145-320	85-95	10-15	5-10	18-25
Bilateral Pectoralis Major	80-180	88-96	12-18	8-12	20-28
Unilateral Rectus Abdominis	65-150	80-90	15-25	10-15	22-30
Bilateral Rectus Abdominis	25-60	82-92	18-28	12-18	25-35
Patchwork Combination	15-45	78-88	20-32	15-20	28-40

Source: Compilation of data from the reviewed literature (2010-2024).

Table 2

Comparison between Pectoralis Major and Rectus Abdominis Flaps

Feature	Pectoralis Major	Rectus Abdominis
Main Indication	Upper and middle third defects	Lower third and extensive defects
Success Rate	85-95%	80-92%
Technical Complexity	Low to moderate	Moderate to high
Surgical Time	120-180 minutes	180-240 minutes

Morbidity Donor Site	Low (5-10%)	Moderate to high (15-25%)
Functional Deficit	Minimum (<5%)	Moderate (20-30%)
Risk of Hernia	Not applicable	Yes (5-15%)
Tissue Volume	Moderate	Large
Arc of Rotation	Excellent	Good
Impact on Prior Surgery	Moderate (bilateral AML)	Alto (abdominal surgery)
Aesthetic Deformity	Mild to moderate	Moderate to severe
Preference for Bilateral	First choice	Second choice

Source: Comparative analysis based on a systematic review of the literature.

3 DISCUSSION

Sternal suture dehiscence and post-sternotomy mediastinitis continue to pose significant challenges in contemporary cardiac surgery, despite advances in surgical techniques, perioperative care, and antibiotic therapy. [1,9] This systematic review consolidates the current evidence on the use of muscle flaps, particularly pectoralis major and rectus abdominis, demonstrating that these reconstructive options constitute the gold standard for the definitive treatment of this serious complication.

The analysis of the literature reveals that, although the incidence of sternal dehiscence has remained relatively stable in recent decades (0.5-5%), the associated mortality has shown a significant reduction, from approximately 50% in the 1970s-1980s to 10-20% in the most recent studies. [6,7,8,11,27] This improvement in outcomes can be attributed to multiple factors: early recognition of the complication, multidisciplinary approach, more aggressive debridement, early reconstruction with vascularized muscle flaps, targeted antibiotic therapy, and better intensive care. [9,13,15,28]

The pectoralis major flap emerged as the most used and studied reconstructive option, with consistently high success rates (85-95%) in multiple series. [13,15,17,21] Its advantages include reliable vascular anatomy, proximity to the defect, relative technical ease, low morbidity of the donor site, and the possibility of bilateral performance for extensive defects. Preservation of the thoracoacromial pedicle is critical to flap viability, and the surgical technique should emphasize careful dissection and vascular preservation. [21,24]

A relevant issue in the literature is the impact of bilateral use of the internal mammary artery on the viability of the pectoralis major flap. Traditionally, it was considered that bilateral use would significantly compromise the vascularization of the muscle, making it unsuitable for reconstruction. [19] However, more recent anatomical and clinical studies have shown that, although there is a reduction in medial blood supply, the dominant thoracoacromial pedicle generally maintains adequate vascularization for most of the muscle. [20,21]

The rectus abdominis flap, although less widely used than the pectoralis major, represents a valuable option, particularly for defects of the lower third of the sternum, extensive defects, or when the pectoralis major is not available. [23,25,26] Reported success rates (80-92%) are slightly lower than those of pectoralis major, possibly due to greater technical complexity, greater dissection extension, and selection of more complex cases.

The timing of the definitive reconstruction is a controversial aspect in the literature. Historically, late reconstruction was advocated after complete control of the infection. [15] However, more recent studies have shown that early reconstruction (within 7-14 days of diagnosis) is associated with better outcomes, shorter hospital stays, and reduced mortality. [13,27,28]

Negative pressure therapy (VAC) has been increasingly used in the management of sternal dehiscence and mediastinitis. [12,29,30] Its role can be as a primary therapy, as a bridge to definitive reconstruction, or as a post-reconstruction adjuvant. The literature shows that VAC promotes edema reduction, exudate removal, stimulation of granulation tissue formation, and reduction of bacterial load. However, studies indicate that isolated use without definitive reconstruction is associated with higher recurrence rates. [29,30]

The identification of risk factors and the implementation of preventive strategies are essential to reduce the incidence of this complication. [5,9,10,11] Evidence-based prevention protocols include: strict perioperative blood glucose control, judicious use of bilateral internal mammary artery with preference for skeletonization techniques, adequate sternal closure technique, adequate skin preparation, appropriate antibiotic prophylaxis, and optimized management of comorbidities.

The multidisciplinary approach is essential for successful treatment. The collaboration between cardiac surgeons, plastic surgeons, infectious disease specialists, intensivists, nutritionists and physiotherapists allows for integrated and optimized management. [9,13,27,28]

4 CONCLUSION

Sternal suture dehiscence and post-sternotomy mediastinitis represent serious complications that require early recognition and aggressive multidisciplinary treatment. The present systematic review of the literature demonstrates that pectoralis major and rectus abdominis muscle flaps are effective, safe, and reliable reconstructive options, with success rates between 80-95% and reduced mortality when compared to historical approaches.

4.1 SUMMARY OF THE EVIDENCE

The contemporary scientific literature extensively deals with post-dehiscence reconstructions of sternal sutures, consolidating robust evidence on various aspects of this complication. Studies consistently demonstrate that the pectoralis major flap remains the first choice for defects of the upper and middle third of the sternum, presenting significant advantages in terms of technical simplicity, shorter surgical time, reliable vascular anatomy, and reduced morbidity of the donor site. The rectus abdominis flap, in turn, is reserved for specific situations such as extensive defects of the lower third, unavailability of the pectoralis major, or the need for greater tissue volume.

The temporal evolution of the treatment of this complication reflects significant advances in pathophysiological and technical knowledge. The transition from conservative approaches with debridement and primary closure to early reconstructions with vascularized flaps has resulted in a dramatic reduction in mortality, from approximately 50% to 10-20% in recent decades. This progress highlights the importance of early definitive treatment, adequate obliteration of dead space, and restoration of local blood supply through vascularized tissue.

The identification and stratification of risk factors remain fundamental for prevention and proper management. Diabetes mellitus, obesity, bilateral internal mammary artery use, COPD, smoking, and reoperation due to bleeding consistently emerge as independent predictive factors of sternal complications. Perioperative optimization of these modifiable factors, particularly strict glycemic control, represents an essential preventive strategy.

4.2 POST-STERNAL DEHISCENCE SAFETY AND RESCUE ALGORITHM

Based on the critical analysis of the literature and the best available evidence, a systematized safety algorithm is proposed for the management of patients with sternal suture dehiscence after cardiac surgery. This protocol aims to standardize the approach, minimize delays in definitive treatment, and optimize clinical outcomes:

4.2.1 Phase 1: Early Recognition and Diagnosis (0-24 Hours)

- Active surveillance for warning signs: sternal instability on palpation, purulent drainage, persistent fever ($>38^{\circ}\text{C}$ after day 5), recurrent leukocytosis, disproportionate sternal pain
- Daily physical examination with systematic sternal palpation

- Monitoring of inflammatory markers (CRP, leukocytes, procalcitonin)
- Collection of cultures (sternal discharge, blood culture) at the slightest sign of infection
- Contrast-enhanced chest CT scan in suspected cases (assess collection, mediastinal gas, osteomyelitis)

4.2.2 Phase 2: Multidisciplinary Stratification and Activation (24-48 Hours)

- Once the diagnosis is confirmed, IMMEDIATELY call a multidisciplinary team: cardiac surgeon, plastic surgeon, infectious disease specialist, intensivist
- Stratify severity: Type I (superficial dehiscence without deep infection), Type II (dehiscence with instability but no overt infection), Type III (mediastinitis with instability and active infection)
- Initiate empiric broad-spectrum antibiotic therapy: vancomycin + piperacillin-tazobactam (adjust after cultures)
- Clinical optimization: tight glycemic control (blood glucose 120-180 mg/dL), nutritional support, correction of anemia and fluid and electrolyte disturbances
- Joint surgical planning between cardiac and plastic surgery: define timing, flap type, need for transient VAC

4.2.3 Phase 3: Aggressive surgical debridement (48-72 hours)

- Early surgical approach (ideally within 48-72h of definitive diagnosis)
- Radical debridement: remove ALL necrotic, devitalized, or frankly infected tissue
- Resection of compromised sternal bone, necrotic costal cartilages, and devitalized soft tissues
- Removal of steel wires if there is deep infection or osteomyelitis
- Copious irrigation with saline solution (minimum 6-9 liters)
- Collection of multiple cultures (bone, deep tissue, secretion)
- Intraoperative evaluation of defect extent and reconstruction planning
- Options: (a) Immediate reconstruction if the bed is clean and the patient is stable; (b) Temporary VAC if significant contamination, wait 48-72h for second time

4.2.4 Phase 4: Definitive Reconstruction with Muscle Flap (3-14 Days)

- Ideal timing: early reconstruction (7-14 days) associated with better outcomes

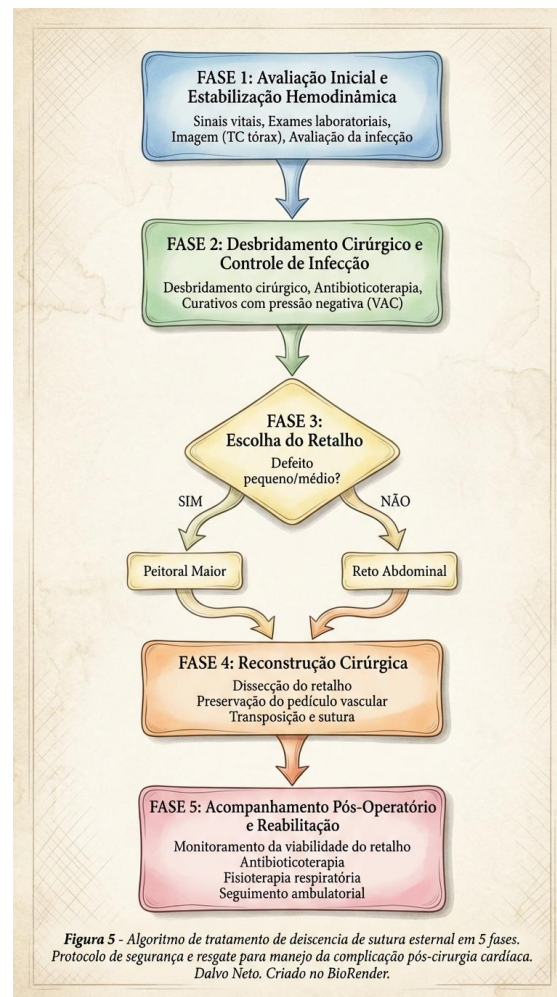
- Retail selection based on decision-making algorithm:
- → Upper/middle third defect + stable patient = Unilateral Pectoralis Major
- → Extensive Upper Thirds/Middle Defect = Bilateral Pectoralis Major
- → Lower third/xiphoid defect = unilateral rectus abdominis
- → Extensive Defect Entire Sternum = Combination or Bilateral
- → Pectoralis Major or Unavailable Failure = Rectus Abdominis
- Rigorous surgical technique: preservation of the dominant vascular pedicle, tension-free transposition, complete dead space obliteration
- Proper attachment of the muscle to adjacent tissues
- Efficient drainage (suction drains)
- Tension-free skin closure

4.2.5 Phase 5: Post-reconstruction management and follow-up

- Prolonged antibiotic therapy: minimum 4-6 weeks (adjusted for cultures and clinical course)
- Close monitoring for signs of residual or recurrent infection
- Drain management: maintain up to <30 mL/24h
- Surgical wound care: occlusive dressing, avoid excessive manipulation
- Relative chest immobilization: avoid sudden upper extremity movements in the first 2 weeks
- Optimized nutritional support: albumin >3.0 g/dL, positive nitrogen balance
- Gradual respiratory physiotherapy, avoiding high-impact maneuvers initially
- Tight glycemic control maintained
- Outpatient follow-up: 7 days, 14 days, 30 days, 90 days, and 6 months
- Flap viability assessment, infection recurrence, affected limb function, quality of life

Figure 5

5-phase external dehiscence treatment algorithm, safety and rescue protocol for post-cardiac surgery management



Source: José Dalvo Maia Neto created at BioRender

5 FINAL CONSIDERATIONS

The implementation of this security algorithm requires adequate infrastructure, trained staff, and efficient communication between the specialties involved. Centers that perform highly complex cardiac surgery must establish clear institutional protocols, with care flowcharts, criteria for activating the multidisciplinary team, and measurable quality indicators.

The continuing education of care teams, including nursing and physiotherapy, is essential for the early recognition of warning signs and timely implementation of rescue measures. Audit programs and systematic feedback of institutional results allow the identification of opportunities for improvement and continuous refinement of protocols.

In summary, sternal suture dehiscence and post-sternotomy mediastinitis, although potentially devastating complications, can be successfully managed when approached in a

systematized, early and multidisciplinary manner. The pectoralis major and rectus abdominis muscle flaps represent consolidated and effective reconstructive tools. The proposed safety algorithm provides a structured roadmap for optimizing care, with the potential to significantly reduce the morbidity and mortality associated with this severe complication of cardiovascular surgery.

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**USE OF GEOPROCESSING AND HISTORICAL PHOTOGRAPHS TO ASSESS
THE SUPPRESSION OF VEGETATED AREAS AND SUBSEQUENT
INTERPRETATION USING ARTIFICIAL INTELLIGENCE**

**USO DO GEOPROCESSAMENTO E FOTOS HISTÓRICAS PARA AVALIAÇÃO
DA SUPRESSÃO DE ÁREAS VEGETAIS E POSTERIOR INTERPRETAÇÃO
COM USO DE INTELIGÊNCIA ARTIFICIAL**

**USO DEL GEOPROCESAMIENTO Y FOTOGRAFÍAS HISTÓRICAS PARA LA
EVALUACIÓN DE LA SUPRESIÓN DE ÁREAS VEGETADAS Y SU POSTERIOR
INTERPRETACIÓN MEDIANTE EL USO DE INTELIGENCIA ARTIFICIAL**

 <https://doi.org/10.56238/sevened2025.036-127>

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ABSTRACT

The present study employs geoprocessing techniques, automated interpretation using Artificial Intelligence (AI), and historical aerial images to assess urban expansion and the suppression of vegetated areas in the municipality of Assis (São Paulo State, Brazil) between 1960 and 2025. The images were georeferenced and digitized, generating tables that quantify changes in land use over time. AI was applied to the interpretative analysis of these data, enabling the identification of patterns of urban growth, vegetation fragmentation, and environmental changes across decades. An increase in built-up areas and a progressive reduction in vegetation cover were observed, highlighting anthropogenic pressure on local ecosystems. This approach stands out for its low operational cost, since, after obtaining aerial images—often freely available in public databases—the processing and analysis stages are carried out quickly and efficiently. This characteristic assigns geoprocessing a strategic role in territorial management and sustainable urban planning, allowing public managers to understand urban growth dynamics with precision and agility, supporting environmental and land-use policies. The integration of geoprocessing and Artificial Intelligence proved to be an indispensable tool for monitoring spatial transformations, providing real-time environmental diagnostics, and guiding evidence-based decision-making.

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Keywords: Geoprocessing. Artificial Intelligence. Vegetation Suppression. Urban Expansion. Temporal Analysis.

RESUMO

O presente estudo utiliza técnicas de geoprocessamento, interpretação automatizada por Inteligência Artificial (IA) e imagens aéreas históricas para avaliar a expansão urbana e a supressão de áreas vegetais no município de Assis (SP) entre os anos de 1960 e 2025. As imagens foram georreferenciadas e digitalizadas, gerando tabelas que quantificam a evolução da ocupação do solo. A IA foi empregada na análise interpretativa desses dados, permitindo identificar padrões do crescimento urbano, fragmentação da vegetação e alterações ambientais ao longo das décadas. Observou-se um aumento das áreas construídas e uma redução progressiva da cobertura vegetal, evidenciando a pressão antrópica sobre ecossistemas locais. Este tipo de abordagem destaca-se por apresentar baixo custo operacional, uma vez que, após a obtenção das imagens aéreas que, em muitas vezes, se encontram disponíveis gratuitamente em bases públicas, as etapas de processamento e análise são realizadas de forma rápida e eficiente. Tal característica confere ao geoprocessamento um papel estratégico na gestão territorial e no planejamento urbano sustentável, permitindo que gestores públicos compreendam a dinâmica de crescimento das cidades com precisão e agilidade, subsidiando políticas ambientais e de uso do solo. A integração entre geoprocessamento e Inteligência Artificial mostrou-se uma ferramenta indispensável para monitorar transformações espaciais, fornecer diagnósticos ambientais em tempo real e orientar tomadas de decisão fundamentadas em evidências.

Palavras-chave: Geoprocessamento. Inteligência Artificial. Supressão Vegetal. Expansão Urbana. Análise Temporal.

RESUMEN

O presente estudo utiliza técnicas de geoprocessamento, interpretação automatizada por Inteligência Artificial (IA) e imagens aéreas históricas para avaliar a expansão urbana e a supressão de áreas vegetais no município de Assis (SP) entre os anos de 1960 e 2025. As imagens foram georreferenciadas e digitalizadas, gerando tabelas que quantificam a evolução da ocupação do solo. A IA foi empregada na análise interpretativa desses dados, permitindo identificar padrões do crescimento urbano, fragmentação da vegetação e alterações ambientais ao longo das décadas. Observou-se um aumento das áreas construídas e uma redução progressiva da cobertura vegetal, evidenciando a pressão antrópica sobre ecossistemas locais. Este tipo de abordagem destaca-se por apresentar baixo custo operacional, uma vez que, após a obtenção das imagens aéreas que, em muitas vezes, se encontram disponíveis gratuitamente em bases públicas, as etapas de processamento e análise são realizadas de forma rápida e eficiente. Tal característica confere ao geoprocessamento um papel estratégico na gestão territorial e no planejamento urbano sustentável, permitindo que gestores públicos compreendam a dinâmica de crescimento das cidades com precisão e agilidade, subsidiando políticas ambientais e de uso do solo. A integração entre geoprocessamento e Inteligência Artificial mostrou-se uma ferramenta indispensável para monitorar transformações espaciais, fornecer diagnósticos ambientais em tempo real e orientar tomadas de decisão fundamentadas em evidências.

Palabras clave: Geoprocementamiento. Inteligencia Artificial. Supresión Vegetal. Expansión Urbana. Análisis Temporal.

1 INTRODUCTION

The advancement of geoprocessing technologies has revolutionized the ways of analyzing the territory, making it possible to understand the spatio-temporal dynamics of natural and anthropic environments with high precision. According to Florenzano (2011), geoprocessing is a set of techniques that integrates spatial data and descriptive attributes, allowing the mapping and modeling of geographic phenomena. These technologies, associated with satellite images and aerial photographs, provide essential data to assess urban growth, habitat fragmentation, and the suppression of vegetation areas, phenomena intensified in recent decades by the rapid process of urbanization in Brazil (IBGE, 2020).

The use of historical aerial images is a valuable tool for understanding the evolution of land occupation. According to Novak (1996), aerial photogrammetry allows the generation of cartographic products from photographs obtained by aircraft, providing metric and interpretative data that make it possible to reconstruct past landscapes. These images, when georeferenced, offer time series that show gradual changes in the territory, such as the urban advance over permanent preservation areas and riparian zones. According to Jensen (2006), multitemporal analysis is fundamental for environmental planning, as it allows the identification of patterns of vegetation suppression, expansion of the urban fabric and degradation of ecosystems over time.

In addition to aerial photographs, the use of satellite images has gained prominence for its ability to monitor continuously on a large scale. Richards and Jia (2012) state that orbital remote sensing has become one of the main tools for detecting environmental changes, allowing the estimation of deforested areas, land use dynamics, and the expansion of cities with high accuracy.

In this scenario, the integration between geoprocessing, historical images and new computational technologies has become an emerging trend in the scientific field. Artificial Intelligence (AI), according to Russell and Norvig (2020), represents one of the greatest innovations today due to its ability to interpret large volumes of data, recognize patterns, and provide predictive analysis. The use of AI applied to geospatial imagery has stood out in the automatic classification of land use and land cover, detection of deforestation and identification of irregular occupations, this work proposes an innovative approach by using AI not only as a classification tool, but as an interpretative instrument of geospatial data obtained through digitized historical aerial images.

The use of aerial photographs obtained in 1960, 1970, 2003 and 2025 allowed us to analyze the evolution of the urban landscape of the city of Assis (SP), a representative region of medium-sized cities in the interior of São Paulo. These cities, as observed by Santos and Silveira (2001), have played a strategic role in the process of industrial deconcentration and expansion of the national urban fabric, often associated with accelerated and poorly planned urbanization processes. The interpretation of the images revealed clear trends of advance of the urban fabric over natural areas, especially in the region of Ribeirão da Fortuna, evidencing the suppression of native vegetation and the intensification of soil impermeabilization.

Aerial photogrammetry, when integrated with digital image processing and Geographic Information Systems (GIS) tools, allows the precise delimitation of vegetation areas and buildings, enabling the quantification of vegetation suppression over time (Burrough & McDonnell, 2015). In this sense, multitemporal analysis becomes fundamental to evaluate the environmental impacts resulting from urban growth and to provide subsidies for public policies aimed at territorial planning and the conservation of natural resources.

The differential of this study lies in the application of Artificial Intelligence for automatic interpretation of data organized in tables, generated from the digitization of georeferenced aerial images. While previous studies are limited to human analysis of data, this work proposes an innovative approach, using AI as a spatial diagnostic tool, capable of analyzing patterns of urban expansion and vegetation suppression based on historical series. According to Goodfellow, Bengio and Courville (2016), AI models have a high capacity for generalization and learning, making them able to detect subtle changes in images over time, contributing to the understanding of territorial behavior and future land use projections.

Thus, this study seeks to answer the following central question: how can the temporal analysis of historical images associated with automated interpretation by artificial intelligence contribute to the understanding of the processes of vegetation suppression and urban expansion? The research presents itself as a significant contribution to the field of geoprocessing applied to territorial planning and environmental management, especially in a context of growing demand for digital technologies that assist in evidence-based decision-making.

In addition to technical accuracy, it is noteworthy that the use of georeferenced historical images and geoprocessing tools is highly cost-effective, because, after the initial data is obtained, the processing, digitization and analysis steps can be carried out quickly, with accessible or free software, which makes this type of study feasible for municipalities,

researchers and public institutions. The agility in spatial interpretation allows the evaluation of the development of cities in short intervals of time, contributing to sustainable urban planning and efficient environmental management (IBGE, 2020).

In this context, the objective of this work is to develop a study of the evolution of land occupation in a specific region of the municipality of Assis (SP), using geoprocessing and historical aerial images as tools to analyze urban expansion and the suppression of vegetation areas, also considering the advantages of low cost, high processing agility and practical applicability of these technologies in territorial planning and city management.

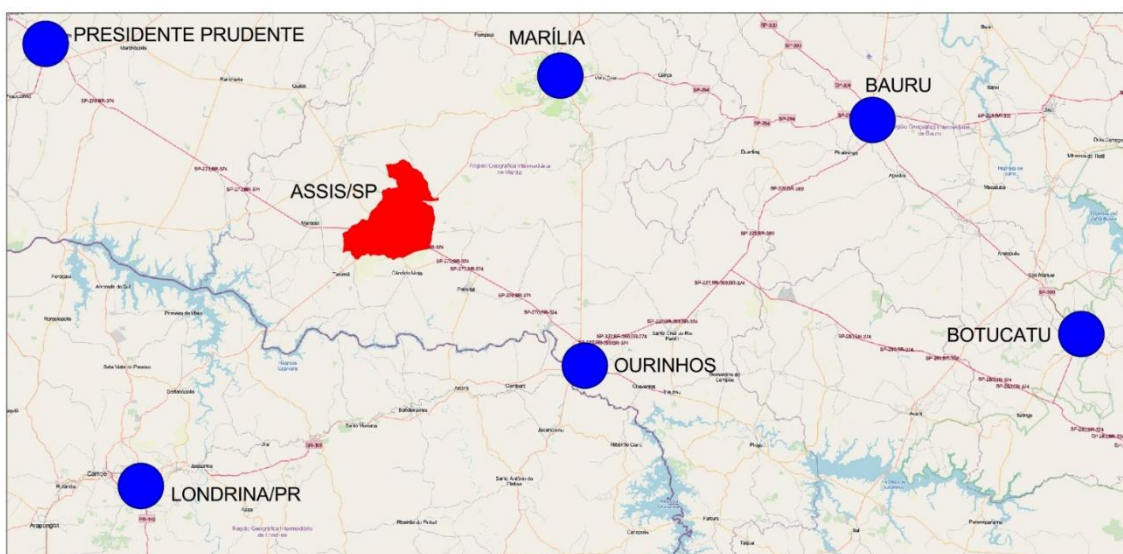
2 MATERIALS AND METHODS

2.1 FIELD OF STUDY

The study was carried out in a region located in the municipality of Assis, State of São Paulo, covering urban and permanent preservation areas located in the surroundings of Ribeirão da Fortuna. The area was selected because it has a history of urban expansion and vegetation suppression, being representative of the process of territorial transformation that has occurred over the last decades in medium-sized municipalities in the interior of São Paulo.

Figure 1

Location of the city of Assis in relation to the main cities in the region



To carry out this work, historical aerial photographs from the 1960s and 1970s were used, obtained through public collections of aerial photogrammetry, high-resolution aerial

image from the years 2003 and 2025, made available by digital geoprocessing platforms, as well as for the georeferencing and vector digitization of the images, the AutoCad 2025 software was used.

ChatGPT Artificial Intelligence (OpenAI – GPT-5): applied for automated interpretation and analysis of quantified data, identification of patterns of vegetation suppression and urban expansion.

Electronic spreadsheet (Excel): used for data organization and calculation of percentages and generation of tables.

The historical aerial images were imported into the AutoCAD 2025 software, where they were georeferenced from spatial reference points, ensuring the correct overlap between the different years analyzed. The UTM coordinate system, spindle 22S, Datum SIRGAS 2000, was adopted, in accordance with the Brazilian cartographic guidelines.

After georeferencing, the features were manually vectorized, classifying them into two categories: urban area: represented by houses, buildings, paved roads and allotments and vegetated area: encompassing native forests, permanent preservation areas (APP), pastures and forests.

Each class was delimited by vector polygons, allowing the quantification of the areas in hectares. With the polygons scanned, AutoCAD automatically generated the area values (in m²), which were converted into hectares (1 ha = 10,000 m²). The data were organized in an electronic spreadsheet to compose the table and calculate the percentage of urban occupation and vegetation suppression in each period analyzed.

Data analysis was carried out based on the comparison of the four historical periods: 1960, 1970, 2003 and 2025. For each year, the following were calculated:

- Total area analyzed
- Urban area
- Vegetated area
- Percentage of urban sprawl
- Percentage of suppression of vegetation cover

This comparison allowed us to identify the pace of urban growth and the reduction of vegetation over time.

The quantified data were entered into an Artificial Intelligence environment (ChatGPT – OpenAI), in which AI was used to automatically interpret land occupation trends, identify spatial patterns of vegetation suppression, point out potential environmental impacts resulting

from urban growth, generate projections and qualitative inferences about the observed results. This stage represents the technological innovation of this study, demonstrating the potential of AI as a tool for environmental interpretation and support for sustainable urban planning.

3 RESULTS AND DISCUSSION

The work began with the insertion of the image (Figure 2) in the ChatGPT Artificial Intelligence, requesting that the tool perform a visual interpretation of the studied area. The following are the main information automatically identified by the AI.

"This image is an aerial (satellite) view of an urban and peri-urban area of the city of Assis/SP, clearly showing natural and urban elements in interaction processes".

Here are the main visible elements: As natural elements, it indicated the following information based on Figure 2.

There is in figure 2 the Ribeirão da Fortuna that is identified with the name in the image and is an important watercourse that crosses the area. A stretch of riparian forest and dense vegetation can also be seen: located mainly around the stream, indicating a remnant of preserved vegetation or a permanent protection area.

Rural areas and pastures on the left of the image, with a typical pattern of agricultural lots or pasture areas, some urban elements visible especially in the central and right part of the image, with a high density of housing, there is also a recent housing complex in the upper left part, with organized blocks and straight streets, indicating planned and more recent occupation. Consolidated urban fabric on the right, with smaller blocks, paved streets and high density.

Also analyzing the image, ChatGPT identified important public equipment such as the "Tonicão" Antônio Viana da Silva Stadium: a large sports structure.

The Buracão Park is a green area for leisure and public recreation in the northeastern portion of the city.

The Fortuna stream acts as an ecological corridor and natural divider between the urban and rural sectors, there are also indications of urban expansion towards areas of vegetation and proximity to water bodies, which can be analyzed from the point of view of environmental impact or urban planning.

Figure 2

Aerial image of the study site in 2003



Then, Figure 3 was inserted into ChatGPT, corresponding to the 2025 aerial image, asking the AI for a direct comparison with the previous image to identify the changes that occurred over time.

Figure 3

Aerial image of the study site in the year 2025



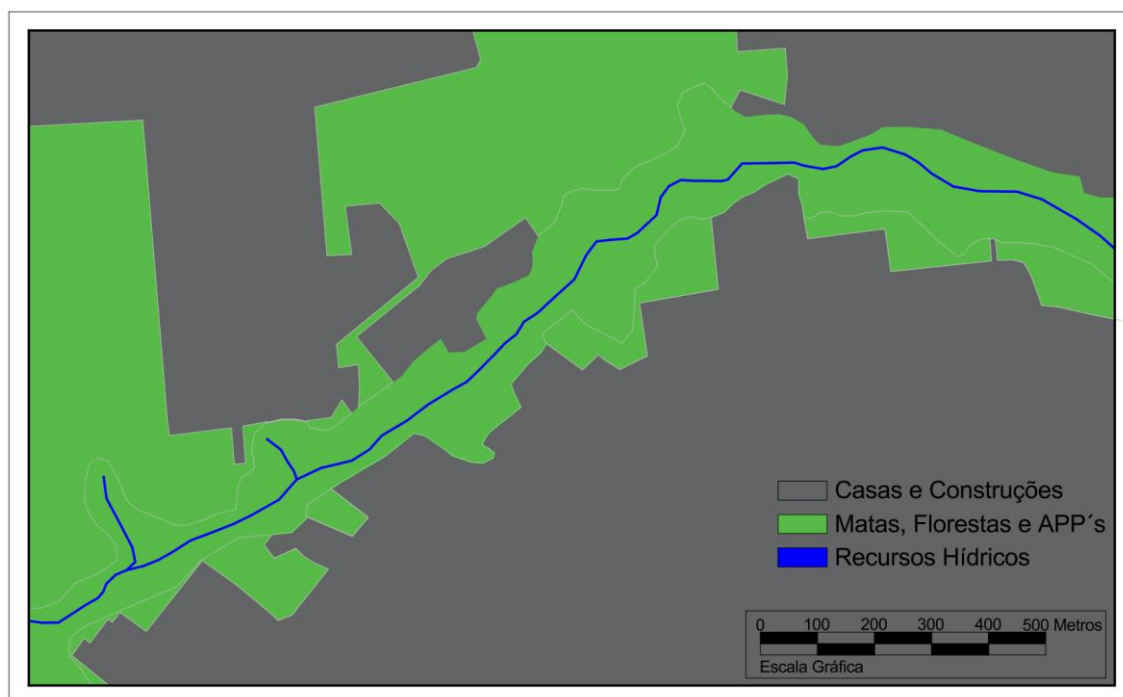
Comparing aerial images from the years 2003 and 2025, Artificial Intelligence identified significant changes in the urban landscape of the area studied. A significant increase in urban occupation was observed, especially in the vicinity of Ribeirão da Fortuna, where there was a densification of housing and expansion of the built network towards the west and south.

At the same time, there was a reduction in green areas and natural vegetation, with a decrease in riparian forest and replacement of old vegetated spaces by streets and buildings. Urban infrastructure has become more consolidated, with new allotments and paved roads, resulting in greater integration between neighborhoods and a less clear transition between the urban and rural perimeter.

These transformations indicate a continuous process of urban expansion and increased pressure on environmentally sensitive areas, typical characteristics of the accelerated growth of medium-sized cities in the interior of São Paulo.

Figure 4

Digitization of the areas under the 2025 aerial image



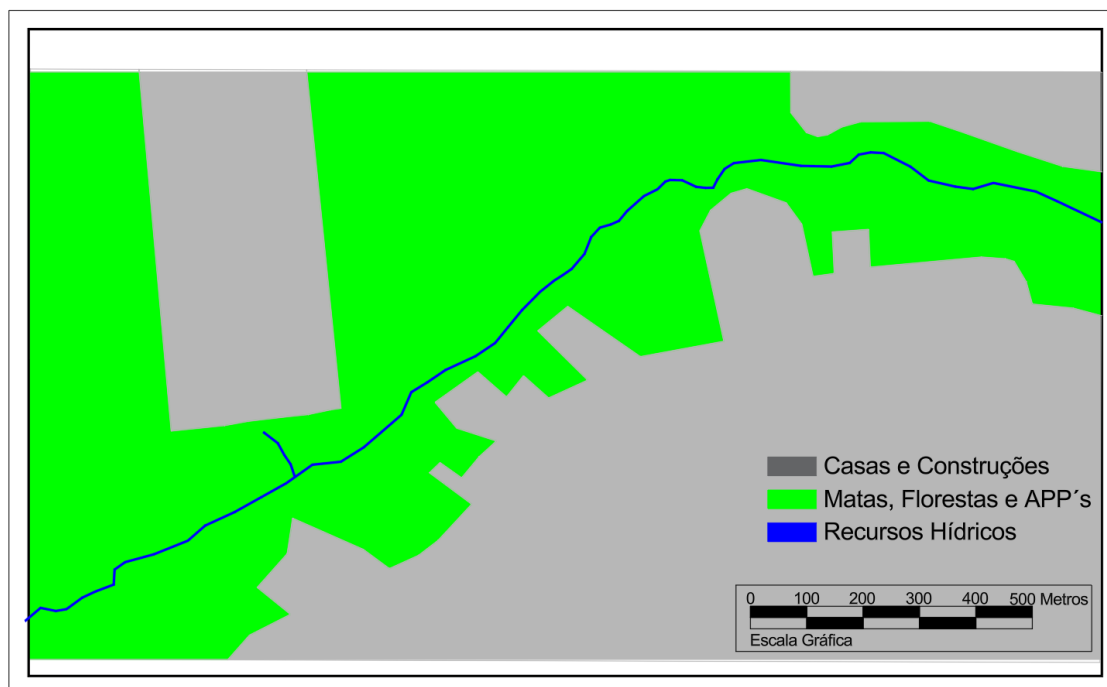
Based on the data presented, the aerial images referring to the years 1960, 1970, 2003 and 2025 were submitted to vector digitization. From this procedure, quantitative information was obtained that supports the analysis of the spatial evolution of the study area and supports the results presented below.

The vector digitization of the image for the year 2025 (Figure 4), carried out in the AutoCAD 2025 software, resulted in the quantification of 140.41 hectares occupied by urbanized areas (houses and buildings) and 78.18 hectares corresponding to vegetated areas, totaling the analyzed area.

Similarly, the digitization of the 2003 aerial image (Figure 2) allowed the distinction between vegetation areas (pastures, forests, forests and PPAs) and built-up areas, enabling the temporal comparison of land occupation and the identification of trends in urban expansion and vegetation suppression.

Figure 5

Digitization of the 2003 aerial image



The digitization of the aerial image for the year 2003 resulted in the quantification of a total of 199.14 hectares, of which 92.61 hectares corresponded to urbanized areas (houses and buildings) and 106.53 hectares were occupied by vegetation, including forests, forests and Permanent Preservation Areas (APPs).

Figure 6

Aerial photo of the city of Assisi in 1960

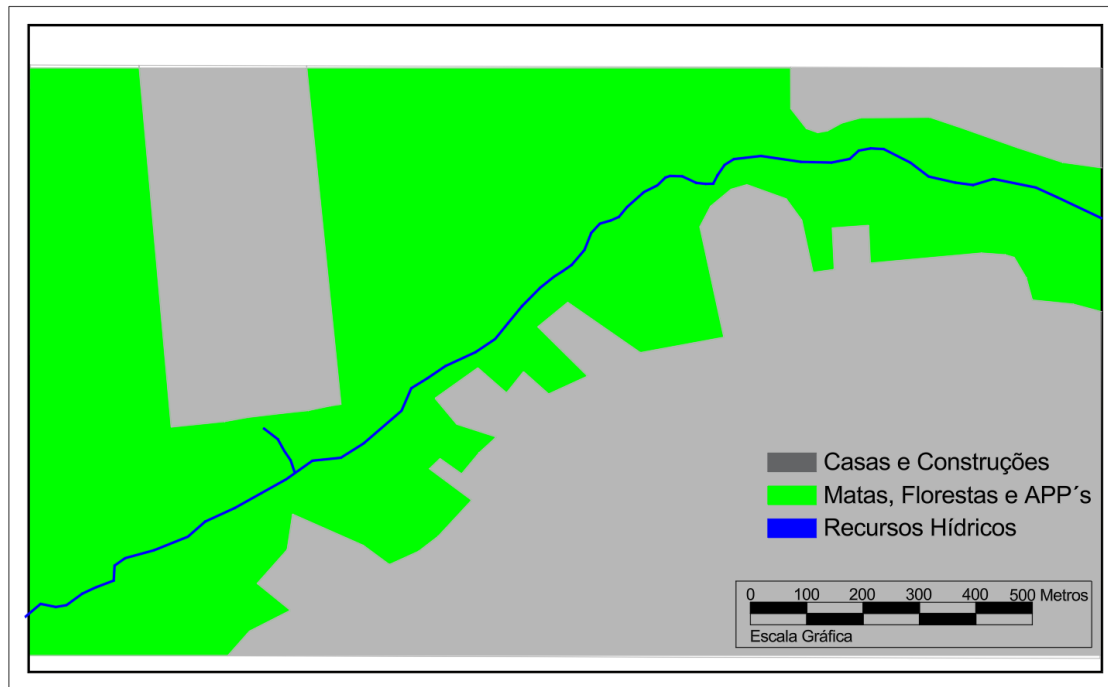
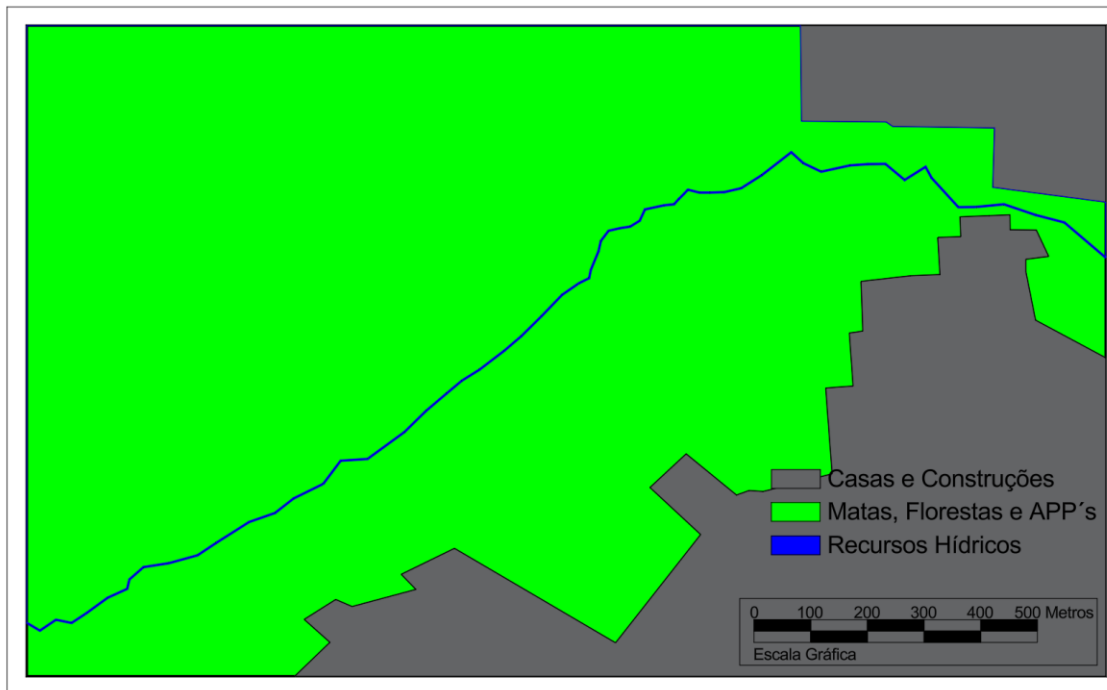


Figure 6 shows the aerial photograph of the city of Assis for the year 1960, obtained by means of aerial survey with aerial photogrammetry techniques. After georeferencing, the image was positioned in its original location in the coordinate system, allowing the delimitation and calculation of urbanized areas and areas of vegetation existing in that period. It is a valuable historical record, with more than six decades, which demonstrates the importance of the integration between historical images and geoprocessing for understanding the evolution of land occupation.

Figure 7

Digitization of the Aerial Image of the year 1960



The vector digitization of the aerial image from 1960 (Figure 7) resulted in the quantification of 154.52 hectares of vegetation cover, encompassing forests, forests and Permanent Preservation Areas (PPAs), and 64.08 hectares occupied by urban constructions, totaling 218.60 hectares analyzed in that period.

Figure 8 shows the aerial image for the year 1970, corresponding to the same study area. This image was submitted to the digitization process to obtain land cover data and compare the spatial evolution between the different periods analyzed.

Figure 8

Aerial photo of the city of Assisi in 1970

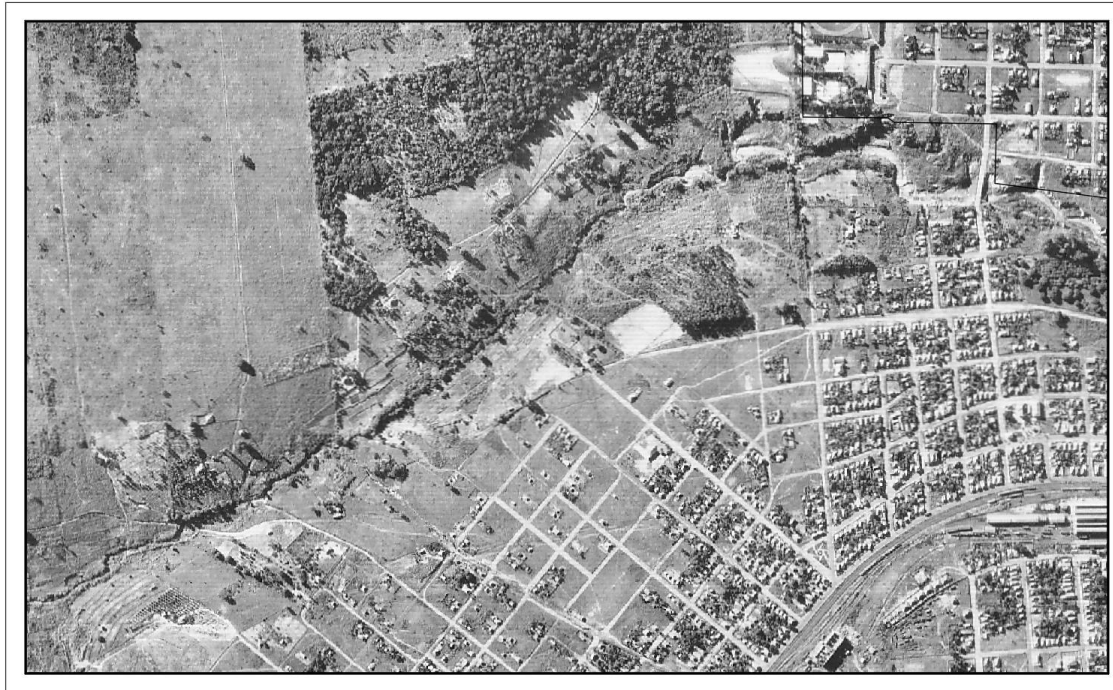
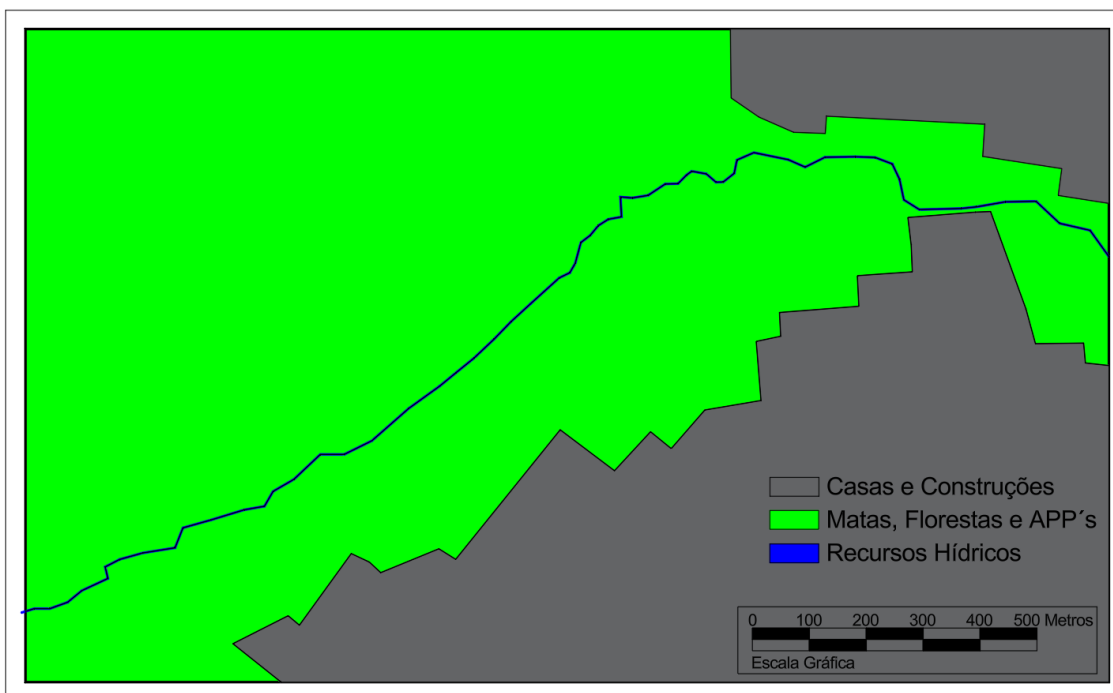


Figure 9

Digitized photo from the year 1970



The digitization of the aerial image from 1970 allowed the delimitation of the areas of urban occupation and vegetation cover. 83.06 hectares of built areas (houses and buildings) and 135.54 hectares of vegetation were identified, including pastures, forests, forests and Permanent Preservation Areas (PPAs), totaling 218.60 hectares analyzed.

From the data obtained for the four historical periods (1960, 1970, 2003 and 2025), it was possible to quantify the evolution of urban expansion and the suppression of vegetation in the study area. This multitemporal analysis evidenced the changes in land use and land cover over the decades, allowing the construction of the following table, which summarizes the results obtained.

Table 1

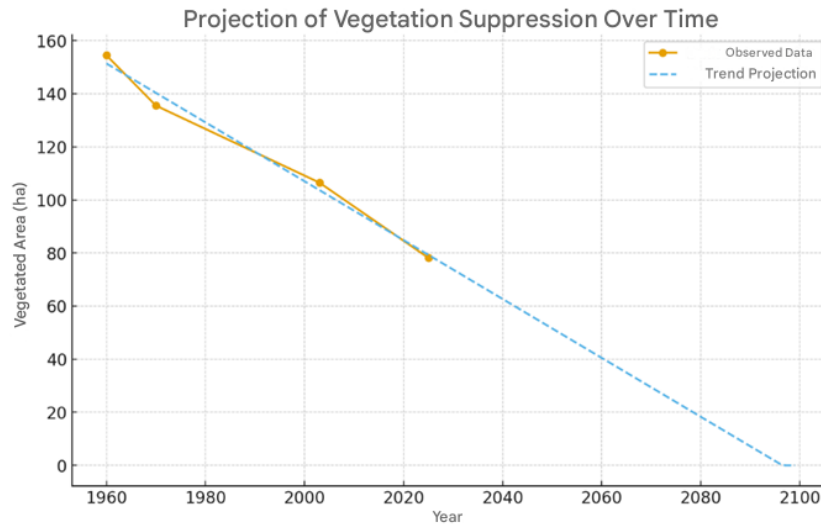
Evolution of land occupation in the municipality of Assis (SP) based on historical aerial images

Year of the image	Total area analysed (ha)	Urban area (houses/buildings)	Vegetated area (forests, pastures, APPs)	Urban percentage (%)	Percentage vegetated (%)
1960	218,6	64,08	154,52	29,30%	70,70%
1970	218,6	83,06	135,54	38,00%	62,00%
2003	199,14	92,61	106,53	46,50%	53,50%
2025	140,41*	62,23*	78,18*	44,30%	55,70%

With reference to the data above, Artificial Intelligence through ChatGPT made its quantitative analysis below:

Figure 10

Projection of Vegetation Suppression Over Time

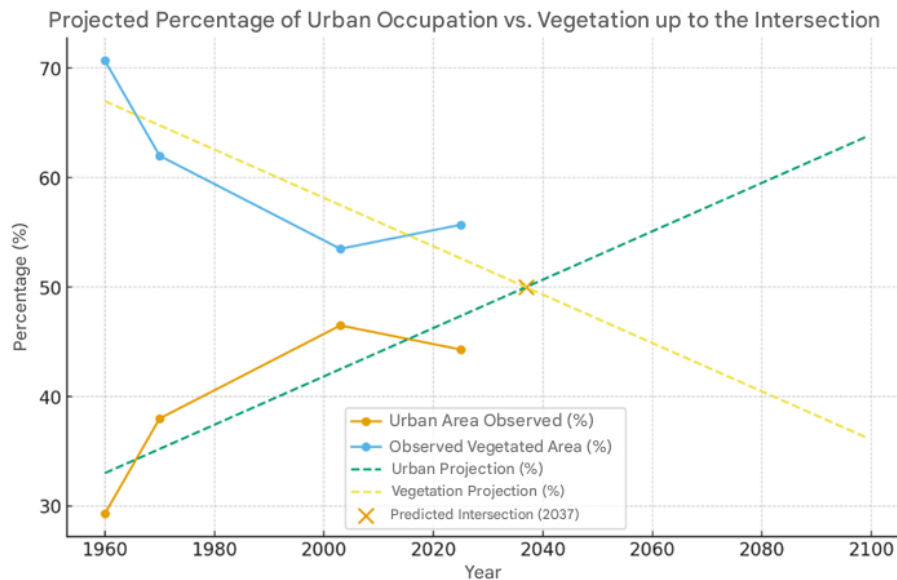


The generated graph represents the projection of vegetation suppression over time, based on real data from the years 1960, 1970, 2003 and 2025. The linear trend analysis indicates that the vegetation cover of the studied area shows a continuous pattern of reduction over the last decades. If the observed dynamics remain unchanged and no environmental restoration or preservation measures are implemented, it is estimated that the vegetation area may reach values close to zero between the years 2090 and 2100, implying the almost total disappearance of the remaining green areas. This result shows a critical scenario of environmental collapse, especially in areas close to rivers and springs, such as Ribeirão da Fortuna, highlighting the urgency of public policies for conservation and territorial planning.

Another relevant figure created by Artificial Intelligence was graph 2, which simulates the crossing of data, that is, when the percentage of buildings and houses becomes equal to or greater than the percentage value of vegetation areas in this same place.

Figure 11

Percentage Projection of Urban Occupation x Vegetation until the crossing of percentage values



The percentage analysis demonstrates a linear trend of convergence between the land use classes. Based on historical data and statistical projection, it is observed that urban occupation should reach 50% of the total area in approximately 2037, when it will equal the vegetation cover. From this point on, if environmental preservation and recovery policies are not implemented, the built areas will predominate over the vegetation, indicating a warning scenario for the environmental and urban sustainability of the region studied.

4 CONCLUSION

The temporal analysis of aerial images from the years 1960, 1970, 2003 and 2025 showed a significant advance in urban occupation over natural areas in the municipality of Assis (SP), resulting in significant vegetation suppression over the last decades. The integration between geoprocessing and Artificial Intelligence allowed us to interpret this dynamic, identifying urban growth trends that point to the intersection of the percentages of built and vegetated area around 2037, suggesting possible urban predominance in the near future.

One of the main differentials of this work was the use of low-cost technologies and high operational efficiency. After obtaining the aerial images, many of them available for free in public databases, the entire process of georeferencing, digitization, quantification and

automated interpretation occurred quickly and with minimal financial investment. The application of AI has accelerated the analytical steps, allowing the immediate generation of environmental diagnoses and future projections with scientific reliability.

Thus, it is concluded that the methodology adopted proves the impact of urban expansion on the reduction of vegetated areas, in addition to demonstrating the potential of digital tools as strategic allies in sustainable territorial planning. The study shows that it is possible to produce high-quality technical knowledge at low cost, speed of processing and practical applicability, making this approach extremely viable for public managers, researchers and institutions looking for efficient solutions for environmental and urban monitoring.

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**EVALUATION OF THE THEORETICAL DESIGN AND MATHEMATICAL
MODELING FOR DETERMINATION OF THERMAL AND VISCOUS
IRREVERSIBILITIES IN AXIALLY FINNED TWO-PHASE CLOSED
THERMOSYPHON HEAT EXCHANGER**

**AValiação DO PROJETO TEÓRICO E DA MODELAGEM MATEMÁTICA PARA
A DETERMINAÇÃO DAS IRREVERSIBILIDADES TÉRMICAS E VISCOSAS EM
UM TROCADOR DE CALOR DO TIPO TERMOSSIFÃO FECHADO DE DUAS
FASES COM ALETAS AXIAIS**

**EVALUACIÓN DEL DISEÑO TEÓRICO Y DEL MODELADO MATEMÁTICO
PARA LA DETERMINACIÓN DE LAS IRREVERSIBILIDADES TÉRMICAS Y
VISCOSAS EN UN INTERCAMBIADOR DE CALOR DE TERMOSIFÓN
CERRADO DE DOS FASES CON ALETAS AXIALES**

 <https://doi.org/10.56238/sevened2025.036-128>

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Tavares⁴**

ABSTRACT

Heat exchangers using thermosyphons have been used for decades in various applications in the aeronautical, military, nuclear, and electronics industries. One application that has gained recent interest, despite having been proposed around 1992, is thermal comfort in air conditioning systems. In this paper, we present a heat exchanger design that uses axially finned thermosyphons - AFTHE. The current design uses a radially finned heat pipe heat exchanger as a reference, whose theoretical and experimental analysis is already well established. Mathematical modeling applies to the thermal efficiency method to determine quantities of thermal interest, and the second law of thermodynamics, with an emphasis on the Bejan number, to determine thermal and viscous irreversibilities. Numerical and graphical results are determined and presented for the following physical quantities: velocities, Reynolds numbers, Nusselt numbers, convection heat transfer coefficients, number of thermal units, heat transfer rates, friction factors, pressure drops, and Bejan number. The results are used for theoretical analyses of the heat exchanger's evaporator and condenser, demonstrating the expected physical consistencies for all analyzed quantities. To consolidate the heat exchanger theoretical design and the applied theoretical model, a comparison is presented for the air outlet temperatures and effectiveness, using theoretical-experimental results obtained for the radial-fin heat exchanger, in the evaporator, and the condenser. The comparisons made demonstrate that the axially finned tube design presents better thermal performance with a lower heat exchange area than the radially finned heat pipe design, for the same inlet conditions. The current design presents promising results and should be used in the experimental implementation of an air conditioning system for surgical rooms.

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Keywords: Heat Exchangers. Axially Finned Heat Pipes. Thermal Efficiency Method. Thermal and Viscous Irreversibilities. Bejan Number.

RESUMO

Trocadores de calor que utilizam termossifões têm sido empregados há décadas em diversas aplicações nas indústrias aeronáutica, militar, nuclear e eletrônica. Uma aplicação que tem despertado interesse recente, apesar de ter sido proposta por volta de 1992, é o conforto térmico em sistemas de ar-condicionado. Neste artigo, apresenta-se um projeto de trocador de calor que utiliza termossifões com aletas axiais (AFTHE). O projeto atual utiliza como referência um trocador de calor com tubos de calor aletados radialmente, cuja análise teórica e experimental já se encontra bem estabelecida. A modelagem matemática aplica o método da eficiência térmica para a determinação de grandezas térmicas de interesse e a segunda lei da termodinâmica, com ênfase no número de Bejan, para a determinação das irreversibilidades térmicas e viscosas. Resultados numéricos e gráficos são obtidos e apresentados para as seguintes grandezas físicas: velocidades, números de Reynolds, números de Nusselt, coeficientes de transferência de calor por convecção, número de unidades de transferência de calor, taxas de transferência de calor, fatores de atrito, quedas de pressão e número de Bejan. Os resultados são utilizados para análises teóricas do evaporador e do condensador do trocador de calor, demonstrando as consistências físicas esperadas para todas as grandezas analisadas. Para consolidar o projeto teórico do trocador de calor e o modelo teórico aplicado, apresenta-se uma comparação das temperaturas de saída do ar e da efetividade, utilizando resultados teórico-experimentais obtidos para o trocador de calor com aletas radiais, no evaporador e no condensador. As comparações realizadas demonstram que o projeto com tubos aletados axialmente apresenta melhor desempenho térmico com menor área de troca de calor do que o projeto com tubos de calor aletados radialmente, para as mesmas condições de entrada. O projeto proposto apresenta resultados promissores e deve ser utilizado na implementação experimental de um sistema de ar-condicionado para salas cirúrgicas.

Palavras-chave: Trocadores de Calor. Tubos de Calor com Aletas Axiais. Método da Eficiência Térmica. Irreversibilidades Térmicas e Viscosas. Número de Bejan.

RESUMEN

Los intercambiadores de calor que utilizan termosifones se han empleado durante décadas en diversas aplicaciones en las industrias aeronáutica, militar, nuclear y electrónica. Una aplicación que ha despertado un interés reciente, a pesar de haber sido propuesta alrededor de 1992, es el confort térmico en sistemas de aire acondicionado. En este artículo se presenta un diseño de intercambiador de calor que utiliza termosifones con aletas axiales (AFTHE). El diseño actual utiliza como referencia un intercambiador de calor con tubos de calor aletados radialmente, cuyo análisis teórico y experimental ya se encuentra bien establecido. La modelización matemática aplica el método de la eficiencia térmica para determinar magnitudes térmicas de interés y la segunda ley de la termodinámica, con énfasis en el número de Bejan, para determinar las irreversibilidades térmicas y viscosas. Se obtienen y presentan resultados numéricos y gráficos para las siguientes magnitudes físicas: velocidades, números de Reynolds, números de Nusselt, coeficientes de transferencia de calor por convección, número de unidades de transferencia de calor, tasas de transferencia de calor, factores de fricción, caídas de presión y número de Bejan. Los resultados se utilizan para análisis teóricos del evaporador y del condensador del intercambiador de calor, demostrando las consistencias físicas esperadas para todas las magnitudes analizadas. Para consolidar el diseño teórico del intercambiador de calor y el modelo teórico aplicado, se presenta una comparación de las temperaturas de salida del aire y de la efectividad, utilizando resultados teórico-experimentales obtenidos para el intercambiador de calor con aletas radiales, en el evaporador y en el condensador. Las comparaciones realizadas

demuestran que el diseño con tubos aletados axialmente presenta un mejor desempeño térmico con una menor área de intercambio de calor que el diseño con tubos de calor aletados radialmente, para las mismas condiciones de entrada. El diseño propuesto presenta resultados prometedores y debería utilizarse en la implementación experimental de un sistema de aire acondicionado para salas quirúrgicas.

Palabras clave: Intercambiadores de Calor. Tubos de Calor con Aletas Axiales. Método de la Eficiencia Térmica. Irreversibilidades Térmicas y Viscosas. Número de Bejan.

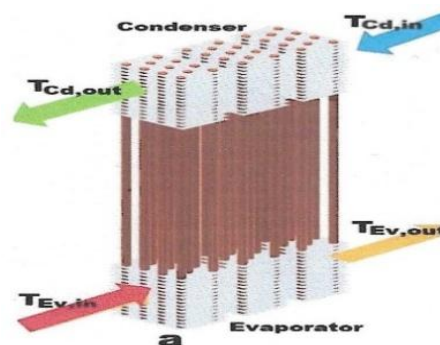
1 INTRODUCTION

Finned heat pipe heat exchangers (FHPHE) have been the subject of study and analysis, both theoretical and experimental, by several international research groups. These heat exchangers have a wide range of applications, notably in air conditioning systems for surgical rooms, which require strict specifications for temperature, air flow, relative humidity, and number of air changes per hour.

Ragil Sukarno and colleagues [1] developed an experimental HVAC system for surgical rooms using finned crossflow heat pipe heat exchangers. They achieved a maximum efficiency of 62.7% for the nine-row, 36-finned-tube heat exchanger shown in Figure 1 below, for an inlet temperature of 45°C.

Figure 1

Ragil Sukarno et al. [1]



H. Jouhara and collaborators [2] conducted a theoretical experimental study to analyze the thermal performance of a multipass heat pipe heat exchanger using theoretical models such as Logarithmic Mean Temperature Difference (LMTD) and the Effectiveness Method (ϵ -NTU). They highlighted the importance of heat exchangers in waste energy recovery.

Grzegorz Górecki and collaborators [3] presented a theoretical-experimental study of a finned heat pipe heat exchanger for small air conditioning systems, showing that finned heat pipes are a viable alternative to conventional exchangers.

Anwar Barrak [4] discussed the rising energy consumption in tropical countries and the importance of energy recovery to improve thermal performance. He highlighted that heat pipes are an excellent alternative for energy recovery and can improve fresh air quality.

Nandy Putra and colleagues [5] investigated the performance of finned heat pipes for heat recovery from exhaust air in an ambient room, showing that system efficiency increases with inlet air temperature.

Imansyah Ibnu Hakim and colleagues [6] analyzed HVAC systems using U-shaped finned heat exchangers, concluding that the two-tube row configuration significantly affects the pre-cooling and reheating processes.

Xuan Yin et al. [7] use experimental data as a numerical simulation to calculate the operating states of a two-phase thermosyphon evaporator. The numerical model comprised a vertically arranged steel tube with an inner diameter of 17 mm and a length of 800 mm, and water as the working fluid. Seven heat exchange tubes in the evaporator are distributed in a uniform vapor environment. The numerical results reveal the heat transfer and flow characteristics in the tube at different filling rates, with the evaporator exhibiting different flow and heat transfer characteristics under filling rates ranging from 40% to 65%. At a tube height of 0.7 m, the distributions of time-averaged vapor velocity and void fraction are similar for filling rates ranging from 55% to 65%, indicating a similar flow regime. The applicability of the numerical model is validated by the experimental results.

H. Eshwar, U.C. Arunachala, and K. Varun [8] state that passive heat transport has gained immense popularity. They cite heat pipes (HP) and two-phase closed thermosyphons (TPCT). They evaluated the effectiveness of closed two-phase thermosyphons through experimental investigation. Three thermosyphons (with the same geometry) were analyzed. They imposed isothermal (40°C–90°C) and isoflux (50–900 W) heating conditions. They concluded that in isothermal mode, the HP transports heat with a minimal temperature gradient and that, ultimately, the HP is the preferred option in terms of performance. Due to its superior operation, the HP can be used in isothermal applications where cost is not a significant concern.

Élcio Nogueira [9] analyzed energy efficiency in air conditioning systems by applying the "Thermal Efficiency Method" to evaluate the thermal performance of finned heat pipe heat exchangers. The parameters analyzed included the number of fins per tube, number of tubes, inlet temperatures, and fluid flow rates. The theoretical results were compared with experimental data, showing excellent agreement.

Another study, Nogueira [10] reviewed concepts of thermal and viscous irreversibilities, using the second law of thermodynamics and the Bejan number to analyze the thermal and viscous performance of heat exchangers. The "Thermal Efficiency Method"

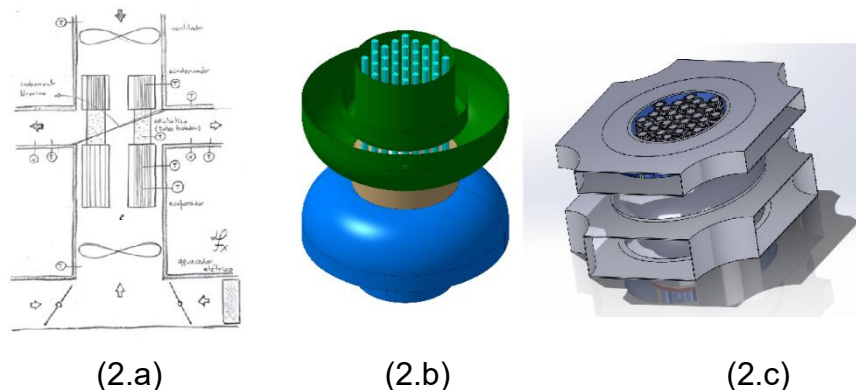
was applied to obtain quantities such as thermal effectiveness and thermal and viscous irreversibilities.

Nogueira [11] also developed an innovative theory for analyzing heat exchangers, applying dimensionless analytical modeling to various types of exchangers, regardless of their specific characteristics. The methodology is based on the concepts of thermodynamics, with an emphasis on the second law of thermodynamics.

2 BASIC CONCEPTS OF AXIALLY FINNED TWO-PHASE CLOSED THERMOSYPHON HEAT EXCHANGER - AFTHE

Some initial concepts of the axially finned tube heat exchanger with parallel flow in the evaporator and counterflow in the condenser are represented in Figures (2.a), (2.b) and (2.c).

Figure 2



Diniz Felix dos Santos Filho presents the initial design for the AFTHE [Figure 2.a], highlighting the fin designs and an initial proposal for air outlets in the evaporator and condenser. Eliseu Luan de O. Tavares [Figure 2.b], under the guidance of Élcio Nogueira, develops a new design for the heat exchanger, without fins, highlighting the vertical, diametrically symmetrical air outlets in the evaporator and condenser. Continuing the AFTHE concepts [Figure 2.c], Ryan Felix expands the heat exchanger design with radial air outlets for the evaporator and condenser.

An analysis of the above designs for the AFTHE will be presented in the section below, considering theoretical aspects that will be discussed in the following sections.

2.1 MATHEMATICAL MODEL DESCRIPTION OF THE AFTHE

In this section we present the mathematical formulation for solving the performance of the heat exchanger under analysis, through the Thermal Efficiency Method, which uses the concept called “Fin Analogy” by Ahamad Fakheri [12].

The saturation temperature of the working fluid (H₂O) is defined using equation (01).

$$T_{sat} = 27^{\circ}C \quad (01)$$

$$T_{sat}=27^{\circ}C \quad (01)$$

The air inlet temperature at the evaporator varies between 30°C and 45°C, according to equation (02).

$$30^{\circ}C \leq T_{airin} \leq 45^{\circ}C \quad (02)$$

The air inlet temperature at the condenser varies between 18°C and 26°C, according to equation (03).

$$18^{\circ}C \leq T_{airin} \leq 26^{\circ}C \quad (03)$$

The air mass flow rate varies between 0.02 kg/s and 0.15 kg/sec, according to equation (04).

$$0.02 \frac{kg}{s} \leq \dot{m}_{air} \leq 0.15 \frac{kg}{s} \quad (04)$$

Table 1 shows the properties of the working fluid as a function of the saturation temperature equal to 27°C.

Tabel 1

Working Fluid Properties (H₂O)

T_{sat} °C	P_{sat} Pa	ρ_l kg/m ³	ρ_v kg/m ³	h_l J/kg	h_v J/kg	h_{lv} J/kg
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27.0	91.535 10 ³	819.38	0.075	111.55	2563.19	2451.64
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Geometric and physical quantities for the heat exchanger are explained through equations (05) and (24).

$$D_{int} = (2.0 * 25.40) \text{ mm} \quad (05)$$

The internal diameter of the heat pipe is represented by equation (05).

$$D_{ext} = (2.0 * 25.40 + 0.893) \text{ mm} \quad (06)$$

The external diameter of the heat pipe is represented by equation (06).

$$P_{HP} = \pi * D_{ext} \quad (07)$$

The perimeter of the heat pipe is represented by equation (07).

$$Esp_{Fin} = \frac{P_{HP} - N_{Fin} * T_{Fin}}{N_{Fin} + 1.0} \quad (08)$$

The space between fins is represented by equation (08). The number of fins is represented by N_{Fin} and T_{Fin} represents the fin thickness.

$$N_{Fin} = 25 \quad (09)$$

$$T_{Fin} = 4.0 \text{ mm} \quad (10)$$

The basic reference number of heat pipes is represented by equation (11). The reference number has an exact quadratic root and, in this work, is equal to 9 for 29 heat pipes and 16 for 47 heat pipes.

$$N_{HPb} = 9 \text{ by default}; \quad 1 \leq N_{HPb} \leq 16 \quad (11)$$

The number of tubes in the main diagonal of the heat exchanger is represented by equation (12) [see Figure 2].

$$N_{HPR} = N_R + (N_R + 1.0) \quad (12)$$

Where:

$$N_R = \sqrt{N_{HPb}} \quad (13)$$

The number of heat pipes is represented by equation (14).

$$N_{HP} = N_{HPR} * (N_R + 1.0) + (N_R - 2.0) \quad (14)$$

The total number of fins in the heat exchanger is represented by equation (15).

$$N_{TotFin} = N_{HP} * N_{Fin} \quad (15)$$

The fin height is represented by equation (16).

$$H_{Fin} = 18.0 \text{ mm} \quad (16)$$

The diameter of the heat exchanger shell is represented by equation (17).

$$D_{Shell} = N_{HPR} * (D_{ext} + 2.0 * H_{Fin}) \quad (17)$$

The lengths of the regions in the heat pipe, evaporator, adiabatic region and condenser are represented by equation (18).

$$L_{Ev} = 220.0 \text{ mm}; L_{Ad} = 120.0 \text{ mm}; L_{Cd} = 120.0 \text{ mm} \quad (18)$$

It is assumed that the heat pipes and fins are made of copper, with thermal conductivity shown below [Equation (19)].

$$k_W = 380.0 \frac{W}{m \cdot K}; k_{Fin} = 380.0 \frac{W}{m \cdot K} \quad (19)$$

Equation 20, represented by σ_{Water} and reported by Górecki, G. et al. [3], is the surface tension for water:

$$\sigma_{Water} = 0.07275 * (1.0 - 0.002 * (K - 291)) \quad (20)$$

Where:

K is saturation temperature in Kelvin.

The air passage area at the heat exchanger inlet is represented by equation (21).

$$AEnt_{HE} = \pi * \frac{D_{Shell}^2}{4.0} \quad m^2 \quad (21)$$

The height of the heat pipes is represented by equation (22).

$$H_{HP} = L_{Ev} + L_{Ad} + L_{Cd} \quad (22)$$

The volume occupied by the heat pipes is represented by equation (23).

$$Vol_{HE} = H_{HP} * AEnt_{HE} \quad (23)$$

The value 0.006 [Equation 24], constant for the surface-fluid combination, was originally presented by Rhosenow [13], valid for the copper-water pair, and reported by H. Jouhara et al. [14].

$$C_{sf} = 0.006 \quad (24)$$

2.2 EVAPORATOR

Table 2 shows the air properties as a function of the air inlet temperature at the evaporator.

Table 2

Air properties as a function of evaporator air inlet temperature

T_{airin} °C	ρ_{air} Kg/m ³	k_{air} W/(m K)	Cp_{air} J/(kg K)	Pr_{air}	μ_{air} Pa.s	ϑ_{air} m ² /s	α_{air} m ² /s
30.0	1.219	2.67 10 ⁻²	1005.77	7.47 10 ⁻¹	1.98 10 ⁻⁵	1.63 10 ⁻⁵	2.18 10 ⁻⁵
35.0	1.219	2.70 10 ⁻²	1006.12	7.41 10 ⁻¹	1.99 10 ⁻⁵	1.63 10 ⁻⁵	2.20 10 ⁻⁵
40.0	1.219	2.74 10 ⁻²	1006.48	7.35 10 ⁻¹	2.00 10 ⁻⁵	1.64 10 ⁻⁵	2.23 10 ⁻⁵
45.0	1.218	2.77 10 ⁻²	1006.84	7.30 10 ⁻¹	2.01 10 ⁻⁵	1.65 10 ⁻⁵	2.26 10 ⁻⁵

The air passage area inside the heat exchanger is represented by equation (25).

$$A_{sec_{NHp}} = A_{Ent_{HE}} - \left(N_{HP} * \pi * \frac{D_{ext}^2}{4.0} - N_{TotFin} * H_{Fin} * T_{Fin} \right) \quad (25)$$

The hydraulic perimeter of the heat exchanger is represented by equation (26).

$$P_{hHP} = N_{HP} * P_{HP} + N_{TotFin} * (2.0 * H_{Fin} + T_{Fin}) - N_{TotFin} * H_{Fin} \quad (26)$$

The hydraulic diameter of the heat exchanger is represented by equation (27).

$$D_{hHP} = \frac{4.0 * A_{sec_{NHp}}}{P_{hHP}} \quad (27)$$

The heat exchange area associated with the fins is represented by equation (28).

$$A_{trFin} = N_{Fin} * N_{HP} * L_{EV} * (2.0 * H_{Fin} + T_{Fin}) \quad (28)$$

The heat exchange area associated with the heat pipe assembly is represented by equation (29).

$$A_{trEv} = L_{EV} * N_{HP} * (P_{HP} - N_{Fin} * T_{Fin}) \quad (29)$$

The total heat exchange area in the evaporator is represented by equation (30).

$$A_{totEv} = A_{trFin} + A_{trEv} \quad (30)$$

The Reynolds number associated with the air flow inside the evaporator is represented by equation (31).

$$Re_{AirEv} = \frac{4.0 * \dot{m}_{air}}{\pi * D_{hHP} * \mu_{air}} \quad (31)$$

The air velocity inside the evaporator is represented by equation (32).

$$V_{AirEv} = \frac{Re_{AirEv} * \mu_{air}}{D_{hHP}} \quad (32)$$

The Reynolds number associated with the air flow at the evaporator inlet is represented by equation (33).

$$Re_{AirEnt} = \frac{4.0 * \dot{m}_{air}}{\pi * D_{Shell} * \mu_{air}} \quad (33)$$

The air velocity at the evaporator inlet is represented by equation (34).

$$V_{AirEnt} = \frac{Re_{AirEnt} * \mu_{air}}{D_{Shell}} \quad (34)$$

The saturation temperature difference across the evaporator is represented by equation (35).

$$\Delta T_{Evsat} = T_{airin} - T_{sat} \quad (35)$$

The estimated heat transfer coefficient for the boiling process, h_{boil} , equation (36), was represented by Gupta and Varshney correlation [15], depend on the $Heat_{Flux}$, described by Piro correlation [16], equation (37).

$$h_{boil} = \left(\frac{k_{Water}}{l_*} \right) * 1.39 * [Heat_{Flux} * \rho_{Water} * Cp_{Water} * \frac{l_*}{\rho_l * h_{lv} * k_{Water}}] ** 0.7 * (\rho_l / \rho_v) ** 0.21 * \left(\mu_{Water} * \frac{Cp_{Water}}{k_{Water}} \right) ** (-0.21) \quad (36)$$

$$Heat_{Flux} = \mu_{Water} * h_{lv} * l_* * \left[\left(\frac{1.0}{C_{sf}} \right) ** 0.33 * Pr_{Water} ** \left(\frac{1.0}{0.33} \right) * \left(Cp_{Water} * \frac{\Delta T_{Evsat}}{h_{lv}} \right) ** \left(\frac{1.0}{0.33} \right) \right] \quad (37)$$

Where:

$$l_* = \left[\frac{\sigma_{Water}}{g * (\rho_l - \rho_v)} \right] ** \left(\frac{1.0}{2.0} \right) \quad (38)$$

The Nusselt number associated with air is represented by equation (39).

$$Nu_{airEv} = 0.696 * Re_{AirEv} ** 0.5 * Pr_{air} ** 0.36 * \left(\frac{Pr_{air}}{5.0 * Pr_{air}} \right) ** 0.25 \quad (39)$$

The heat transfer coefficient by air convection in the evaporator is obtained by:

$$h_{Ev} = Nu_{air} * \frac{k_{air}}{D_{ext}} \quad (40)$$

The application of the concept of “Aleta Analogy”, conceived by Fakheri [12] leads us to define the following parameters:

$$mL_{EvFin} = \sqrt{\frac{2h_{Ev}}{k_{Fin}t_{Fin}}} P_{hEv} \quad (41)$$

$$\eta_{EvFin} = \frac{\text{Tanh}(mL_{EvFin})}{mL_{EvFin}} \quad (42)$$

The fin efficiency for the evaporator section is defined through Equation (42) by η_{EvFin} [6].

$$\beta_{Ev} = \frac{A_{trFin}}{A_{totEv}} \quad (43)$$

$$\eta'_{EvFin} = \beta_{Ev} \eta_{EvFin} + (1 - \beta_{Ev}) \quad (44)$$

The efficiency associated with the set of fins in the evaporator, weighted by the area of change of the fins η'_{EvFin} , is represented through Equation (45).

$$Uo_{Ev} = \frac{1}{\frac{1}{h_{boil}} + \frac{D_{ext} - D_{int}}{kW} + \frac{1}{\eta'_{EvFin} h_{Evair}}} \quad (45)$$

The global heat transfer coefficient associated with air in the evaporator, Uo_{Ev} , is given by Equation 45.

$$C_{Air} = \dot{m}_{air} C_{p_{air}} \quad (46)$$

The heat capacity of the air in the evaporator, C_{Air} , is given by Equation (46).

$$C_{Ev} = C_{air} \quad (47)$$

$$NTU_{Ev} = \frac{Uo_{Ev} * A_{totEv}}{C_{Ev}} \quad (48)$$

The number of thermal units associated with air in the evaporator, NTU_{Ev} , is given by Equation (48).

$$Fa_{Ev} = \frac{NTU_{Ev}}{2.0} \text{ for parallel flow} \quad (49)$$

The dimensionless number, called "fin analogy," Fa_{Ev} is represented by Equation (49) as defined by Ahamad Fakheri [12] and reported by Nogueira, É. [9; 10; 11].

$$\eta_{TEv} = \frac{\tanh(Fa_{Ev})}{Fa_{Ev}} \quad (50)$$

The thermal efficiency associated with the evaporator is η_{TEv} [9; 10; 11].

$$\varepsilon_{TEv} = \frac{1}{\frac{1}{\eta_{TEv} NTU_{Ev}} + \frac{1}{2}} \quad (51)$$

The thermal effectiveness associated with the heat evaporator is ε_{TEv} .

$$\dot{Q}_{Ev} = \frac{C_{Ev} \Delta T_{Ev sat}}{\frac{1}{\eta_{TEv} NTU_{Ev}} + \frac{1}{2}} \quad (52)$$

The heat transfer rate between the air and the heat pipe in the evaporating region $\dot{Q}_{Ev}$ is given by the Equation (52).

$$T_{airout} = T_{airin} - \frac{\dot{Q}_{Ev}}{C_{Ev}} \quad (53)$$

After passing through the evaporator (precooling), the outlet air temperature is represented through Equation (53).

Thermal irreversibility in the evaporator is obtained using equation (54), below.

$$Irrev_{TEv} = \log \left(\frac{T_{airin}}{T_{airout}} \right) \quad (54)$$

The rate of thermal entropy generation is represented by equation (55).

$$\dot{S}_{gen_{TEv}} = Irrev_{TEv} * C_{Ev} \quad (55)$$

$$Fric_{Ev} = \frac{0.31}{Re_{AirHP} ** 0.25} \quad (56)$$

The friction factor in the evaporator is represented by equation (56).

$$\Delta p_{Ev} = Fric_{Ev} * \left(\frac{L_{Ev}}{D_{hEv}} \right) * \left(\frac{\rho_{Air} * V_{AirEv} ** 2.0}{2} \right) \quad (57)$$

The pressure drops across the evaporator is represented by equation (57).

The pressure at the evaporator inlet is represented by equation (58).

$$P_{1Ev} = P_{2Ev} + \Delta p_{Ev} \quad (58)$$

Where:

$$P_{2Ev} = P_{atm} \quad (59)$$

Viscous irreversibility in the evaporator is obtained using equation (60) below.

$$Irrev_{VEv} = \log \left(\frac{P_{2Ev}}{P_{1Ev}} \right) \quad (60)$$

The rate of viscous entropy generation is represented by equation (61).

$$\dot{S}_{gen_{VEv}} = Irrev_{VEv} * \dot{C}_{Ev} \quad (61)$$

The Bejan number in the evaporator is represented by equation (62).

$$Be_{Ev} = \frac{\dot{S}_{gen_{TEv}}}{\dot{S}_{gen_{TEv}} + \dot{S}_{gen_{VEv}}} \quad (62)$$

2.3 CONDENSER

Table 3 shows the air properties as a function of the air inlet temperature at the condenser.

Table 3

Air properties as a function of condenser air inlet temperature

T_{airin} °C	ρ_{air} Kg/m ³	k_{air} W/(m K)	Cp_{air} J/(kg K)	Pr	μ_{air} Pa.s	ν_{air} m ² /s	α_{air} m ² /s
18.0	1.219	2.59 10 ⁻²	1004.94	7.64 10 ⁻¹	1.97 10 ⁻⁵	1.61 10 ⁻⁵	2.11 10 ⁻⁵
20.0	1.219	2.60 10 ⁻²	1005.08	7.61 10 ⁻¹	1.9710 ⁻⁵	1.61 10 ⁻⁵	2.12 10 ⁻⁵
22.0	1.219	2.61 10 ⁻²	1005.22	7.58 10 ⁻¹	1.97 10 ⁻⁵	1.62 10 ⁻⁵	2.13 10 ⁻⁵
24.0	1.219	2.63 10 ⁻²	1005.36	7.55 10 ⁻¹	1.97 10 ⁻⁵	1.62 10 ⁻⁵	2.14 10 ⁻⁵
26.0	1.219	2.64 10 ⁻²	1005.49	7.52 10 ⁻¹	1.98 10 ⁻⁵	1.62 10 ⁻⁵	2.16 10 ⁻⁵

The heat exchange area of the heat pipes in the condenser is represented by equation (63).

$$A_{trCd} = L_{Cond} * N_{HP} * (P_{HP} - N_{Fin} * T_{Fin}) \quad (63)$$

The heat exchange area in the condenser is represented by equation (64).

$$A_{totCd} = A_{trFin} + A_{trCd} \quad (64)$$

The Reynolds number associated with the air flow inside the condenser is represented by equation (65).

$$Re_{AirCd} = \frac{4.0 * \dot{m}_{air}}{\pi * D_{hHP} * \mu_{air}} \quad (65)$$

The air velocity inside the condenser is represented by equation (66).

$$V_{AirCd} = \frac{Re_{AirCd} * \mu_{air}}{D_{hHP}} \quad (66)$$

The saturation temperature difference across the condenser is represented by equation (67).

$$\Delta T_{Cdsat} = T_{sat} - T_{airin} \quad (67)$$

The condensation coefficient in the condenser is represented by equation (68).

$$h_{Cond} = 0.943 * \left(\frac{\rho_l * (\rho_l - \rho_v) * h_{lv} * g * k_{water} ** 3}{\mu_{awter} * L_{Cd} * \Delta T_{Cdsat}} \right) ** \left(\frac{1}{4} \right) \quad (68)$$

The Nusselt number associated with the air in the condenser is represented by equation (69).

$$Nu_{airCd} = 0.696 * Re_{AirCd} ** 0.5 * Pr_{air} ** 0.36 * \left(\frac{Pr_{air}}{5.0 * Pr_{air}} \right) ** 0.25 \quad (69)$$

The Nusselt number associated with the air in the condenser is represented by equation (69).

$$h_{cd} = Nu_{airCd} * \frac{k_{air}}{D_{ext}} \quad (70)$$

The application of the concept of “Aleta Analogy”, conceived by Fakheri [12] leads us to define the following parameters:

$$mL_{CdFin} = \sqrt{\frac{2h_{Ev}}{k_{Fin}t_{Fin}}} P_{hCd} \quad (71)$$

$$\eta_{CdFin} = \frac{\text{Tanh}(mL_{CdFin})}{mL_{CdFin}} \quad (72)$$

The fin efficiency for the condenser section is defined through Equation (72) by η_{CdFin} .

$$\beta_{Cd} = \frac{A_{trFin}}{A_{totCd}} \quad (73)$$

$$\eta'_{CdFin} = \beta_{Cd}\eta_{CdFin} + (1 - \beta_{Cd}) \quad (74)$$

The efficiency associated with the set of fins in the condenser, weighted by the area of change of the fins η'_{EvFin} , is represented through Equation (75).

$$Uo_{Cd} = \frac{1}{\frac{1}{h_{cond}} + \frac{D_{ext}-D_{int}}{kW} + \frac{1}{\eta'_{CdFin}h_{Cd}}} \quad (75)$$

The global heat transfer coefficient associated with air in the condenser, Uo_{Cd} , is given by Equation (75).

$$C_{Air} = \dot{m}_{air}Cp_{air} \quad (76)$$

The heat capacity of the air in the condenser, C_{Air} , is given by Equation (76).

$$C_{Cd} = C_{air} \quad (77)$$

$$NTU_{Cd} = \frac{Uo_{Cd}A_{totCd}}{C_{Cd}} \quad (78)$$

The number of thermal units associated with air in the condenser, NTU_{Cd} , is given by Equation (78).

$$Fa_{Cd} = \frac{NTU_{Cd}}{2.0} \text{ for counterflow} \quad (79)$$

The dimensionless number, called "fin analogy," Fa_{Cd} is represented by Equation (79) as defined by Ahamad Fakheri [12] and reported by Nogueira, É. [9;10; 11].

$$\eta_{TCd} = \frac{\tanh(Fa_{Cd})}{Fa_{Cd}} \quad (80)$$

The thermal efficiency associated with the condenser is η_{TCd} .

$$\varepsilon_{TCd} = \frac{1}{\frac{1}{\eta_{TCd}NTU_{Cd}} + \frac{1}{2}} \quad (81)$$

The thermal effectiveness associated with the condenser is ε_{TCd} .

$$\dot{Q}_{Cd} = \frac{C_{Cd}\Delta T_{Evsat}}{\frac{1}{\eta_{TCd}NTU_{Cd}} + \frac{1}{2}} \quad (82)$$

The heat transfer rate between the air and the heat pipe in the condenser region $\dot{Q}_{Cd}$ is given by the Equation (82).

$$T_{airout} = \frac{\dot{Q}_{Cd}}{C_{Cd}} + T_{airin} \quad (83)$$

After passing through the condenser (heat recover), the outlet air temperature is represented through Equation (83).

Thermal irreversibility in the condenser is obtained using equation (84) below.

$$Irrev_{TCd} = \log\left(\frac{T_{airin}}{T_{airout}}\right) \quad (84)$$

The rate of thermal entropy generation in the condenser is represented by equation (85).

$$\dot{S}_{gen_{Tcd}} = Irrev_{Tcd} * C_{cd} \quad (85)$$

$$Fric_{cd} = \frac{0.31}{Re_{AirCd} ** 0.25} \quad (86)$$

The friction factor in the condenser is represented by equation (86).

$$\Delta p_{cd} = Fric_{cd} * \left(\frac{L_{cd}}{D_{hcd}} \right) * \left(\frac{\rho_{Air} * V_{AirCd} ** 2.0}{2} \right) \quad (87)$$

The pressure drops across the condenser is represented by equation (87).

The pressure at the evaporator inlet is represented by equation (88).

$$P_{1cd} = P_{2cd} + \Delta p_{cd} \quad (88)$$

By definition:

$$P_{2cd} = P_{atm} \quad (89)$$

Viscous irreversibility in the condenser is obtained using equation (90) below.

$$Irrev_{vcd} = \log \left(\frac{P_{2cd}}{P_{1cd}} \right) \quad (90)$$

The rate of viscous entropy generation in the condenser is represented by equation (91).

$$\dot{S}_{gen_{vcd}} = Irrev_{vcd} * C_{cd} \quad (91)$$

The Bejan number in the capacitor is represented by equation (92).

$$Be_{cd} = \frac{\dot{S}_{gen_{Tcd}}}{\dot{S}_{gen_{Tcd}} + \dot{S}_{gen_{cd}}} \quad (92)$$

3 RESULTS AND DISCUSSION

3.1 EVAPORATOR

This section presents results for thermal and viscous performances related to the evaporator of the axially finned heat pipe heat exchanger, for configurations with 29 and 47 heat pipes.

Figure 3 presents the average air velocities for the two configurations considered in this work, with shell diameters equal to 614 mm (29 heat pipes) and 789 mm (47 heat pipes). As expected, the inlet velocity of the heat exchanger with the larger diameter has a lower velocity.

Figura 3

Air velocity at the evaporator inlet versus mass flow rate

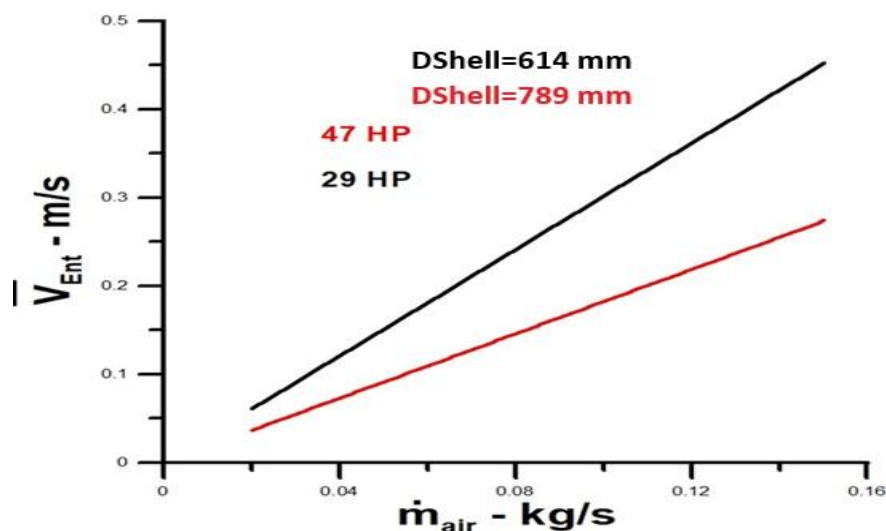


Figure 2 shows the average velocity inside the heat exchangers considered in the evaporator analysis. As expected, due to its larger equivalent diameter, the heat exchanger with 47 heat pipes has a lower internal velocity, despite the larger area occupied by the heat pipes and fins. Figure 4 shows a cross-sectional representation of the finned heat pipes arranged symmetrically inside the shell for the 29-heat pipe configuration. The radial configuration is designed to achieve homogeneous air distribution inside the heat exchanger.

Figure 4

Average air velocity inside the evaporator versus air mass flow rate

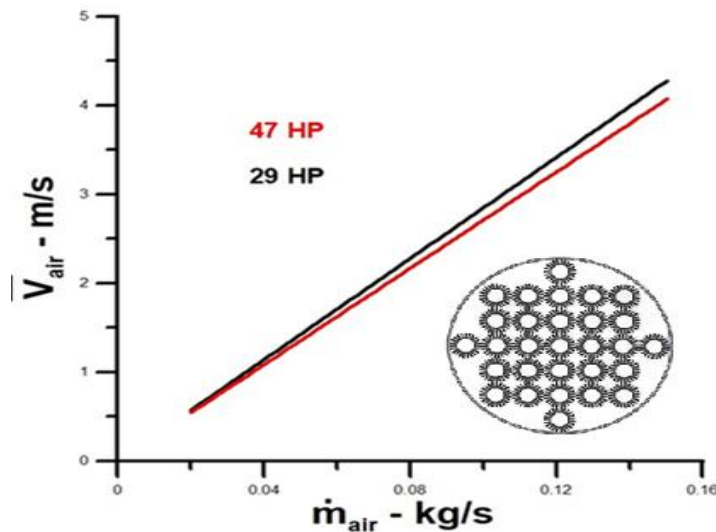
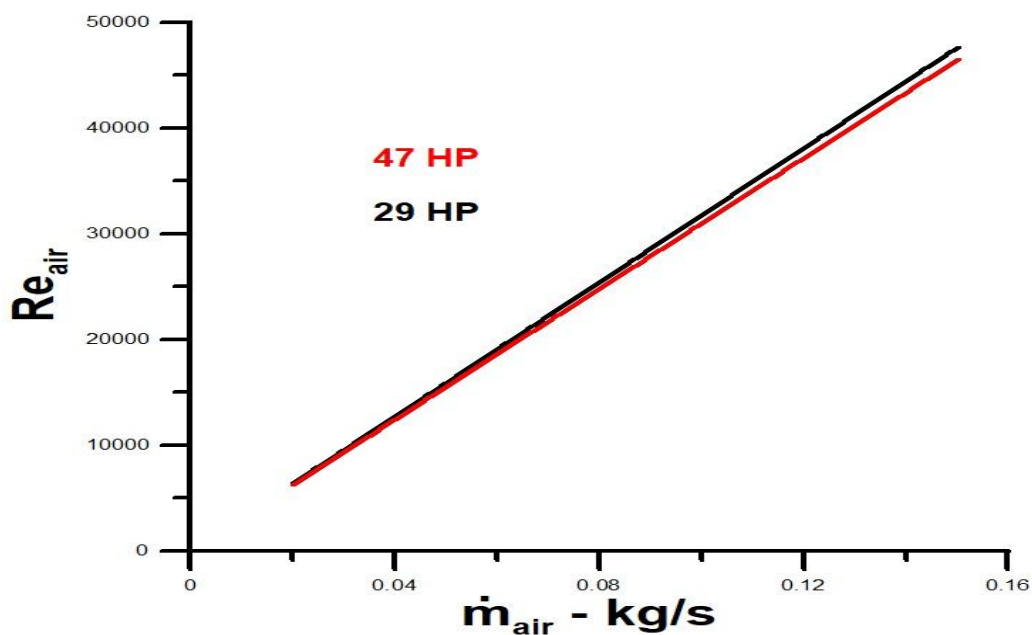


Figure 5

Evaporator Reynolds number versus air mass flow rate



As expected, the Reynolds number in the evaporator, represented in Figure 3, demonstrates a similar trend to the internal velocity in the evaporator, with the heat exchanger with 47 heat pipes presenting slightly lower values for higher air flows.

The Nusselt number, Figure 4, presents results like those obtained and represented in Figure 5, as it is strongly dependent on the Reynolds number.

Figure 6

Evaporator Nusselt number versus air mass flow rate

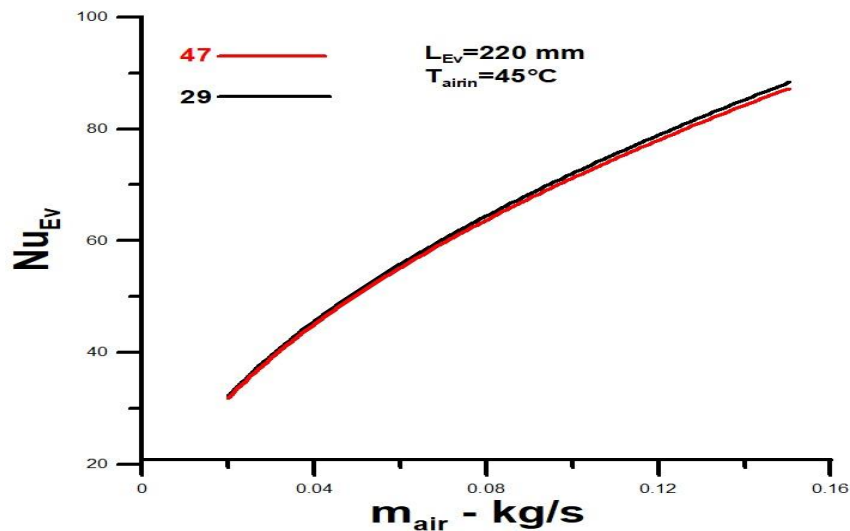


Figure 5 presents values for the boiling heat transfer coefficient. The boiling coefficient presents significantly higher values with increasing air temperature, since it depends on the temperature difference between the air inlet temperature and the saturation temperature of the working fluid.

The number of thermal units in the evaporator is represented in Figure 6, as a function of the air inlet flow rate and for the maximum temperature, equal to 45°C. The working fluid filling ratio in the heat pipes, in purely theoretical terms, varies from 50% to 100%. The number of thermal units increases with the filling rate, and the number of heat pipes and decreases with an increasing flow rate. The increase in the number of heat pipes can be explained by the increase in the heat exchange area, and the increase in the filling rate is explained by the higher value of the overall heat exchange coefficient, which is strongly dependent on the boiling coefficient.

Figure 6 presents result for evaporator thermal effectiveness, for an air inlet temperature of 45°C and a working fluid fill ratio ranging from 50% to 100%. As expected, thermal effectiveness presents results like those of the number of thermal units, since it is strongly dependent on this parameter. What stands out in the results obtained are the high thermal effectiveness values across the entire flow rate range under analysis. The extremely high effectiveness values, even for a working fluid fill ratio of 50%, demonstrate that the 47-finned heat pipe configuration has great potential for use in air conditioning systems for

thermal comfort. Even for the 29-tube configuration, the results presented, for a fill ratio of 60%, are extremely promising.

Figure 7

Boiling heat transfer coefficient versus air inlet temperature

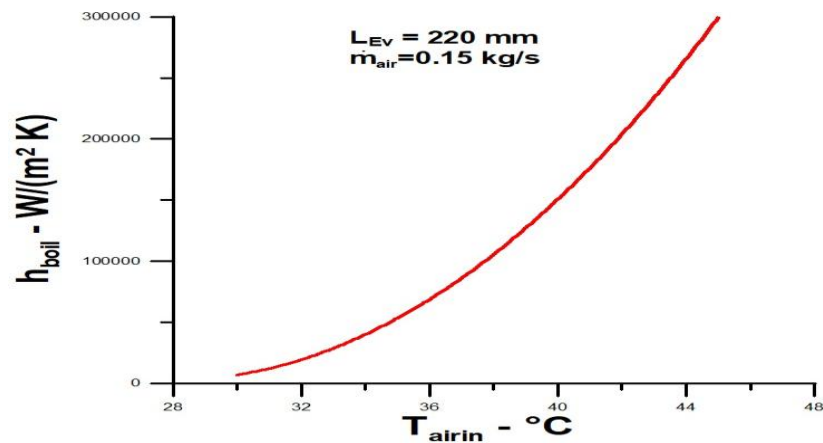
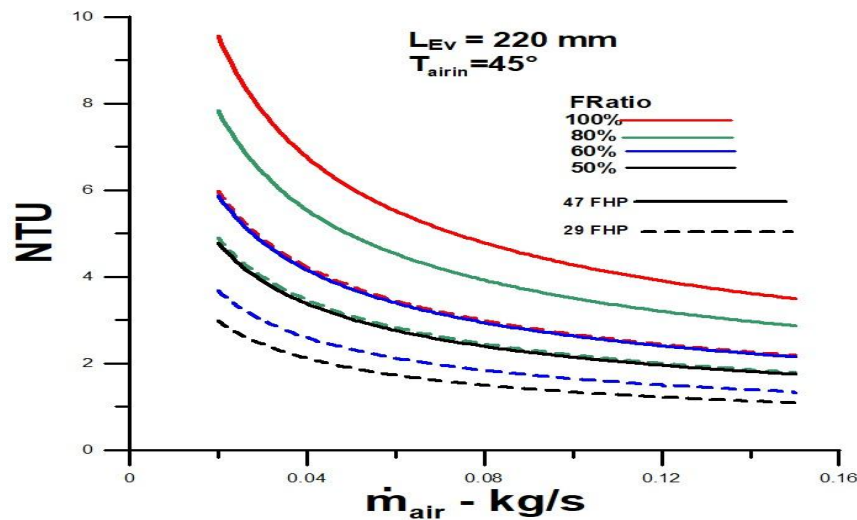


Figure 8

Number of thermal units versus air mass flow rate



The heat transfer rate in the evaporator, for an air inlet temperature of 45°C , is represented in Figure 8. The results obtained reflect what was observed for thermal effectiveness, with higher values for a greater number of heat pipes and higher working fluid filling rates. It should be noted that the analysis is restricted to the final position of the evaporator contained by the working fluid, since this is the most relevant region in terms of heat exchange.

The air outlet temperature is represented in Figure 9. The results obtained for the 47-finned heat pipe configuration, as expected, are extremely promising, since the temperature, for a 60% fill ratio, presents outlet temperatures between 27°C and 28°C, for almost the entire flow rate range under analysis. Even for the 29-tube configuration, the results obtained for a fill fraction of 80%, below 30°C and an air inlet temperature of 45°C, demonstrate exceptional thermal performance for the theoretical design of the heat exchanger under analysis.

Figure 9

Thermal effectiveness versus air mass flow rate and with filling fraction as a parameter

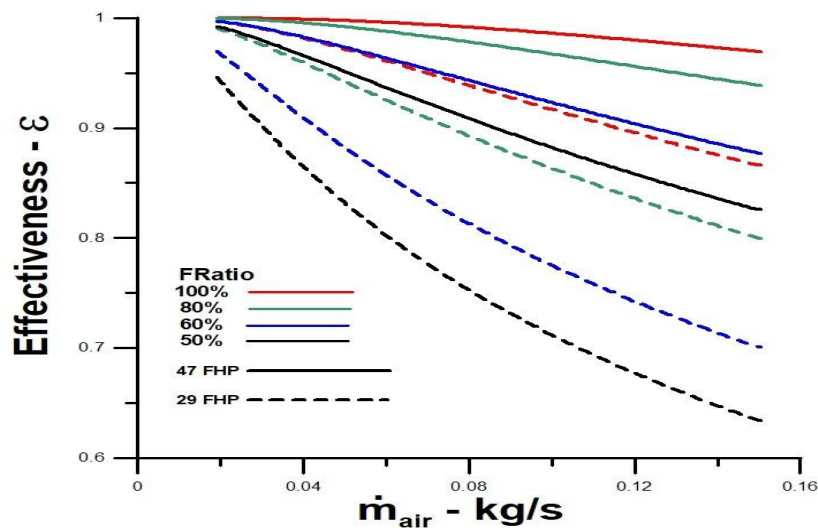


Figure 10

Heat transfer rate versus air mass flow rate and with filling ratio as a parameter

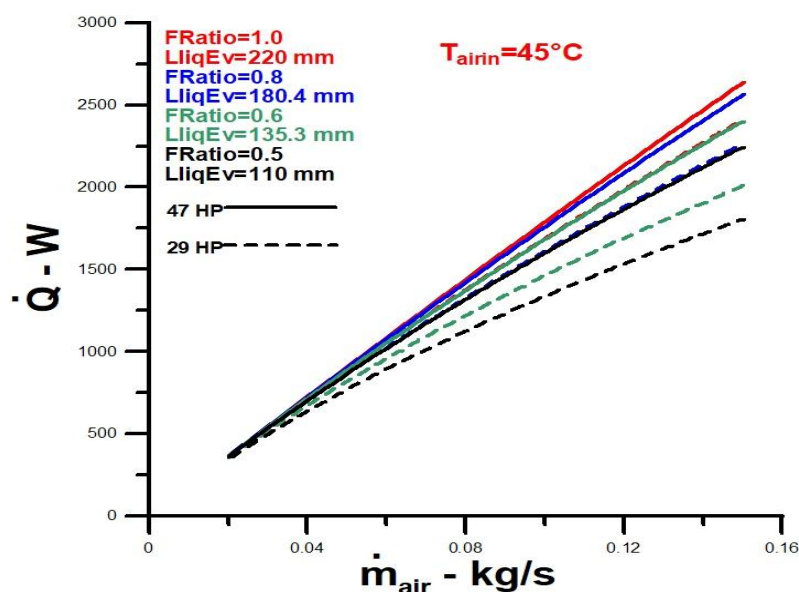
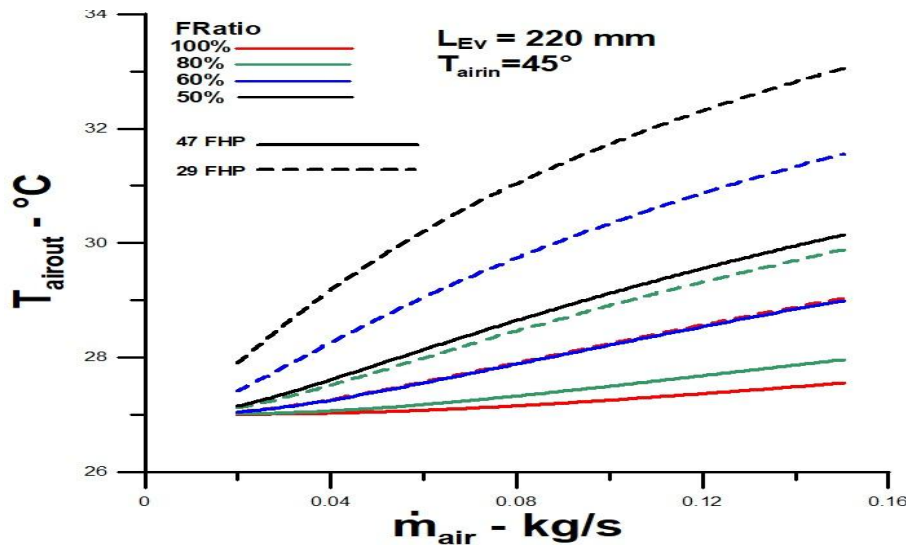


Figure 11

Air outlet temperature versus air mass flow rate and with filling ratio as a parameter



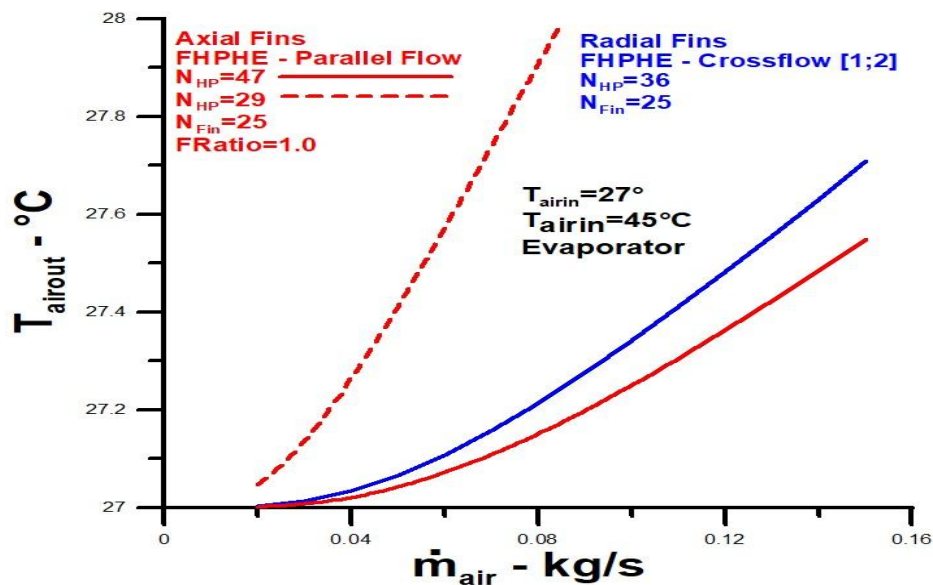
The current design, with axially finned heat pipes, is compared with the design of radially finned heat pipes, whose theoretical-experimental study is described through the work presented by Ragil Sukarno et al. [1], and a comparative theoretical study, through the Thermal Efficiency Method, carried out by Élcio Nogueira [9].

The results of the comparison performed in this work are shown in Figure 12, for air outlet temperature as a function of flow rate. It can be observed that the axial design with 47 finned heat pipes presents better thermal performance than the radial configuration, for a fill ratio of 100%. However, for an effective comparison, the heat exchange areas of each heat exchanger design must be analyzed: For 29 axially finned heat pipes, with 25 fins per tube, the total heat exchange area in the evaporator is 0.17 m²; for 47 axially finned heat pipes, with 25 fins per tube, the total heat exchange area in the evaporator is 0.27 m²; in the case of radially finned heat pipes, the total heat exchange area in the evaporator is 0.39 m². In terms of thermal performance in the evaporator, the axially finned tube design offers better performance, as it provides superior results for a smaller heat exchange area.

The results and analyses presented for thermal performance, in the evaporator, validate and demonstrate better thermal performance for the current configuration.

Figure 12

Air outlet temperature versus air mass flow rate for radial and axial finned heat exchanger configurations



A heat exchanger analysis, which takes into account the cost-benefit in terms of thermal/viscous performance, is presented below for the evaporator.

Figure 13 presents the coefficient of friction results for the two designs analyzed in this work: axially finned heat pipes with 29 tubes and 47 tubes, both with 25 fins per tube. Since the design with the greater number of tubes and fins has a larger area, it would be expected to have a significantly higher coefficient of friction. However, it can be seen that the velocity (Figure 2) is lower for the greater number of tubes, since the air passage area is larger. This characteristic balances the coefficient of friction results, making the result obtained for 47 tubes slightly higher than the result obtained for 29 heat pipes. As will be discussed later, this result has a positive impact on thermal/viscous performance in the current configuration.

Figure 13

Friction factor versus air mass flow rate

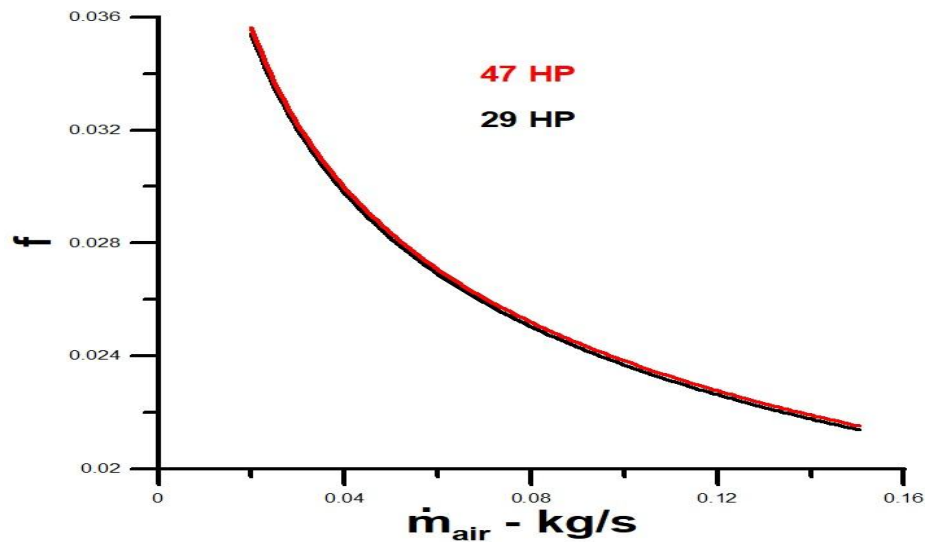
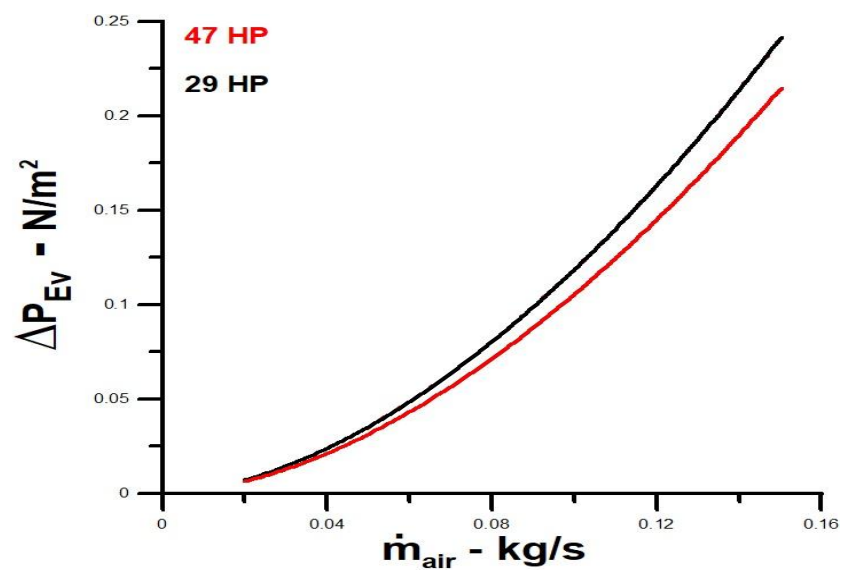


Figure 14

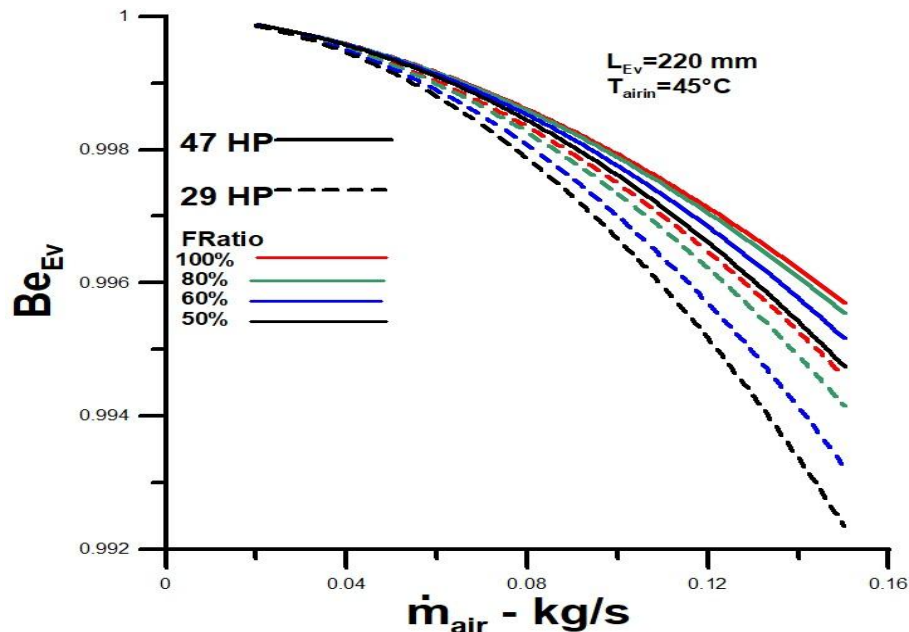
Pressure drops versus mass flow rate



The results for evaporator pressure drop are shown in Figure 14. The pressure drop for the 47-tube configuration shows a lower pressure drop than that for the 29-tube configuration. These results reflect what was observed for internal velocities in the heat exchanger, since the larger the number of tubes, the larger the air passage area.

Figure 15

Bejan number versus mass flow rate with working fluid filling ratio as parameter



The results for the evaporator's Bejan number are presented in Figure 15 for the two configurations under analysis: 29 and 47 axially finned heat pipes. Initially, the significant superiority of the 47-heat pipe design can be observed, as it offers a higher Bejan number for a given air mass flow rate. In this case, the result reflects higher thermal performance and lower pressure loss for the 47-heat pipe configuration. However, what is very favorable, in terms of cost-benefit, is that the value obtained is extremely high for both cases. These results demonstrate that the heat exchanger designs analyzed are extremely promising, as they offer high heat transfer rates and low pressure drops.

3.2 CONDENSER

This section presents results for thermal and viscous performances related to the condenser of the axially finned heat pipe heat exchanger, for configurations with 29 and 47 heat pipes.

Figure 16

Average air velocity in the condenser versus air mass flow rate

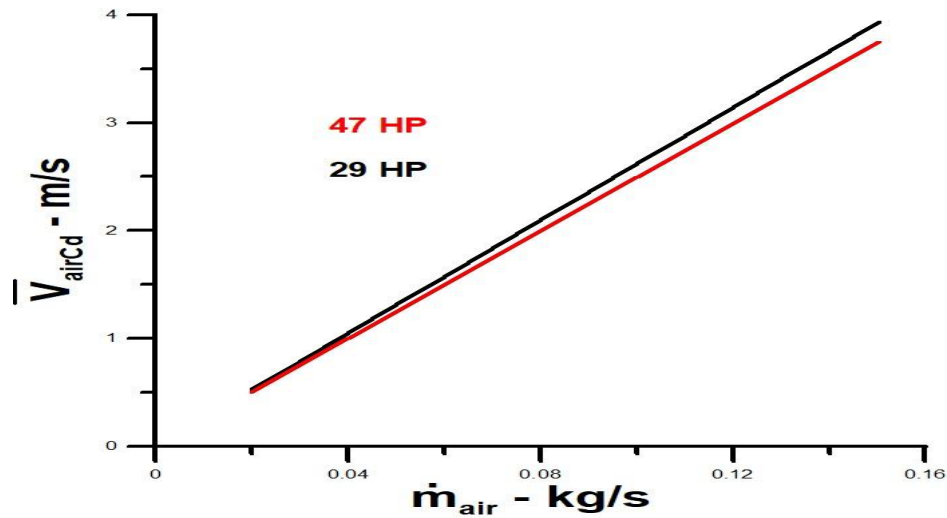
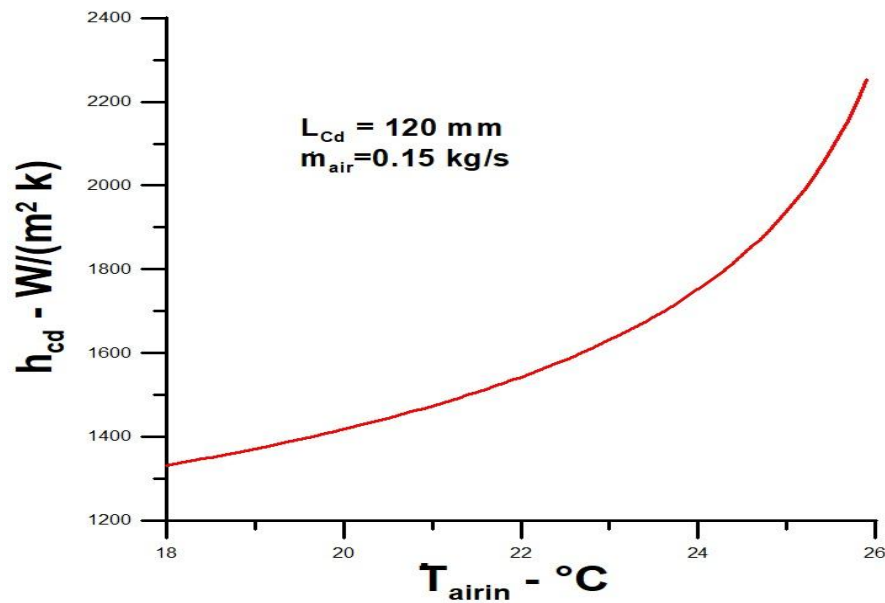


Figure 17

Heat transfer coefficient by condensation versus air input temperature



The results obtained for the condenser are very similar to those obtained for the evaporator. Numerically, however, they present different values, since the length of the condenser is equal to half the length of the evaporator, and the temperature differences between the air inlet temperature and the saturation temperature are smaller. The air inlet temperature to the evaporator varies between 18°C and 26°C.

The air velocity values inside the condenser (Figure 16) are lower than those observed for the evaporator, due to the condenser's smaller hydraulic diameter. The velocity values for the 47-heat pipe configuration, which has a larger air passage area, are reflected in lower velocity values.

Figure 17 presents result for the condensation heat transfer coefficient. The values are lower than those obtained for the boiling coefficient, due to the high heat transfer resistance presented by the water vapor fraction inside the heat pipes. This result is expected to impact the condenser's thermal performance.

Figure 18

Condenser heat transfer rate versus air mass flow rate

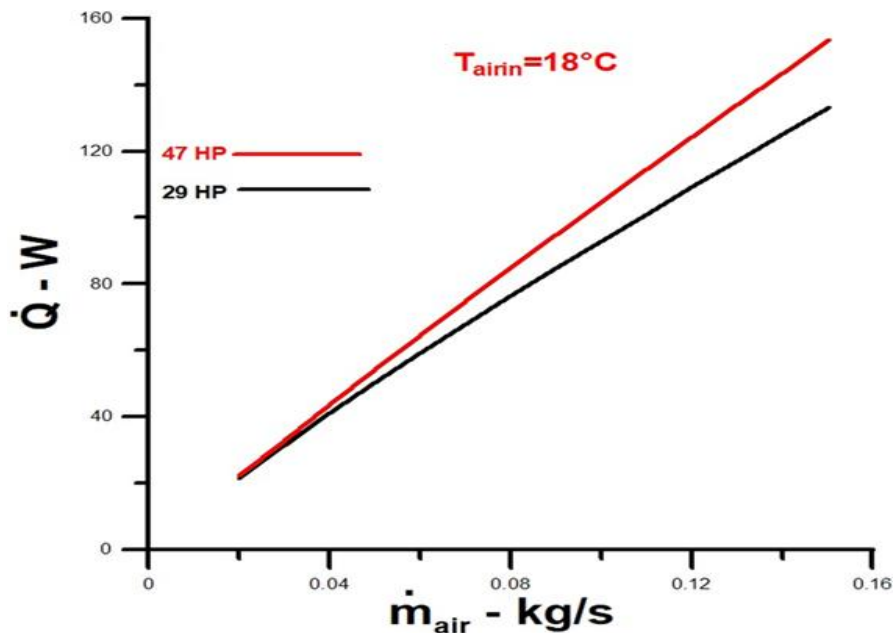


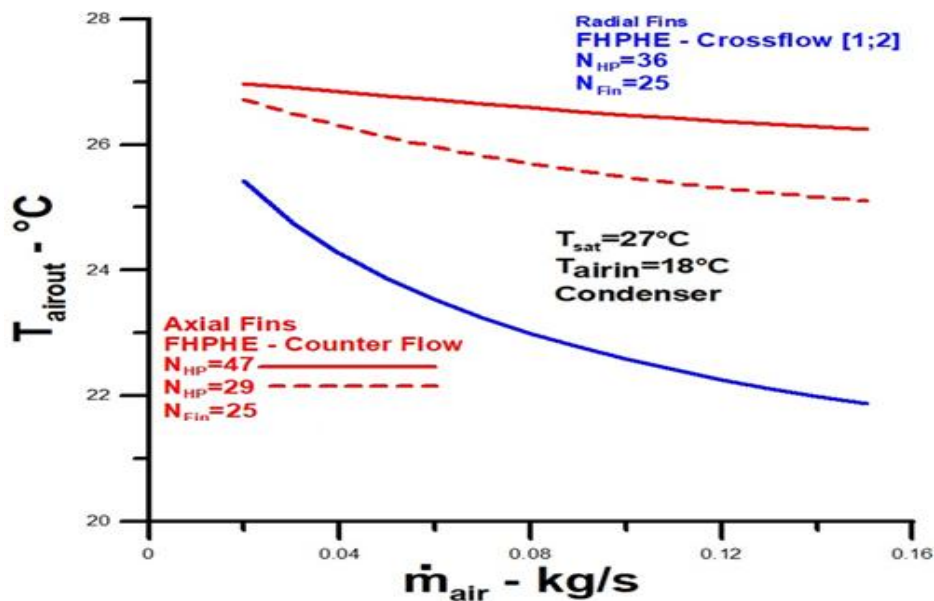
Figure 18 presents the results for the condenser heat transfer rate as a function of the air mass flow rate for the two configurations under analysis. The input parameter is an air temperature of 18°C. The condenser heat transfer rate is higher for the 47-heat pipe design due to the larger heat exchange area.

A comparison between axially finned and radially finned heat pipe designs for evaporator outlet air temperature is shown in Figure 19. The thermal performance of the axially finned heat pipe configurations is significantly superior for both 29-tube and 47-tube configurations. The results obtained for the condenser are qualitatively different from those obtained for the evaporator. The numerical superiority of the 47-tube heat pipe configuration

is explained by the larger heat exchange area. The superiority of the 29-tube configuration can be explained by the heat exchanger configuration, which in the condenser is counterflow, which has superior thermal performance to the parallel flow configuration, as in the evaporator.

Figure 19

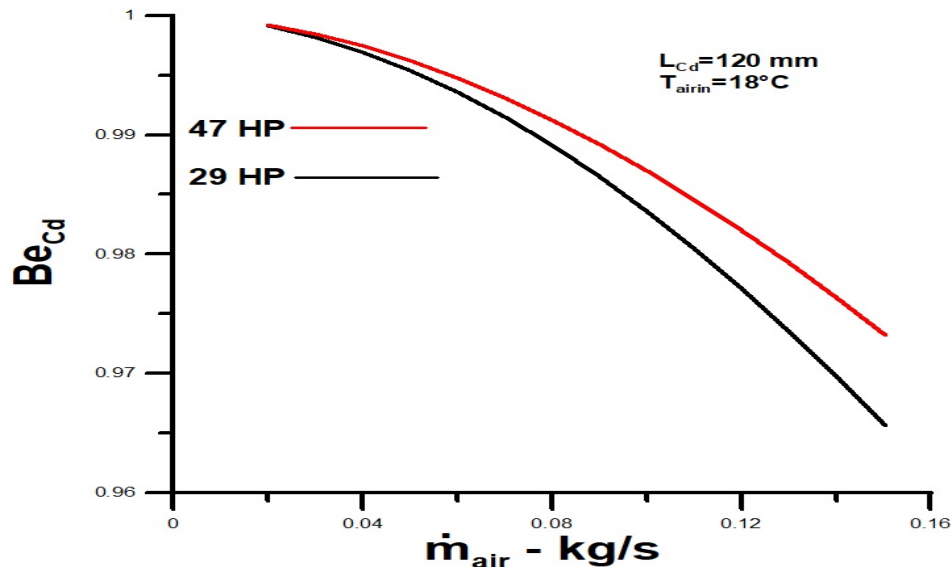
Comparison of condenser outlet air temperature versus air mass flow rate for radial and axial fin configurations



The results presented for the Bejan number in the condenser are represented in Figure 20. As expected, based on what was already discussed for the evaporator, the Bejan number is higher for the 47-tube configuration because it has a larger heat exchange area and air passage area. However, what is noteworthy, once again, is the thermal performance versus viscous dissipation, which is extremely high for both configurations analyzed. In this sense, the cost-benefit associated with the heat exchanger is very favorable, due to its high thermal performance.

Figure 20

Bejan number in the condenser versus air mass flow rate



3.3 CONSIDERATIONS ON THE CURRENT AF THE CONFIGURATION

The air outlet configurations in the heat exchanger under analysis, represented in Figures 2.a, 2.b, and 2.c, are highlighted in the last one, as it more functionally encompasses the first two. Despite this, it cannot yet be considered definitive for two reasons: four air outlets, despite resulting in a completely symmetrical and functional configuration, are not a practical option when directing cooled or heated air to a given installation; and to achieve the final solution, due to the air-directing curves, it was necessary to extend the length of the adiabatic region (200 mm). This length does not correspond to the length of the adiabatic region (120 mm) considered in the simulation, since it was decided to maintain the dimensions of the heat exchanger that had already demonstrated satisfactory experimental results and was the subject of comparison in this work.

4 CONCLUSION

This paper presents graphical results for an axially finned heat pipe heat exchanger in two configurations: 29 and 47 heat pipes, in the evaporator and condenser. Furthermore, a comparison is presented between two distinct heat exchangers with very similar physical characteristics in terms of air mass flow rate, air inlet temperatures, working fluid and saturation temperature. The significant differences between the two types of heat exchangers relate to the physical arrangement of the fins on the heat pipes and the number of heat pipes.

The work used for comparison consists of radially finned heat pipes. Furthermore, the results used for comparison were validated by different numerical models and experimental results.

The analysis method used in this work consists of an analytical model called the Thermal Efficiency Method, already consolidated, based on numerous theoretical-experimental comparisons carried out over the last few years.

The analysis concludes that the thermal and viscous performance of the heat exchangers designed is very promising. These results are reflected in the high Bejan number obtained for the two configurations under analysis: 29 and 47 axially finned heat pipes. The Bejan number ultimately represents the relationship between thermal performance and the overall performance of the heat exchanger.

Thermal performance is high compared to viscous dissipation, resulting in a very favorable cost-benefit ratio for the heat exchanger under analysis.

The results demonstrate significant potential for the construction and testing of a heat exchanger with axial fins to obtain experimental results and for theoretical and experimental comparisons of parameters related to the heat exchangers under analysis.

It is important to note, however, that pressure drops across the air outlets were not considered in the simulation, and the results presented for viscous dissipation were applicable only to the evaporator and condenser dimensions. Air outlets, when finally installed, are expected to have a low economic impact on the heat exchanger.

In summary, the current theoretical project presents promising results and should be used in the experimental implementation of an air conditioning system for surgical rooms.

5 NOMENCLATURE

A_{sec} - cross-section area, [m^2]

A_{tr} - heat transfer area, [m^2]

C_p - specific heat, [$\frac{J}{kg K}$]

C - thermal capacity, [$\frac{W}{K}$]

C_{min} - minimum thermal capacity, [$\frac{W}{K}$]

$C^* = \frac{C_{min}}{C_{max}}$

D_h – hydraulic diameter, [m]

Fa – fin analogy

h – coefficient of heat convection, [$\frac{W}{m^2 K}$]

k – thermal conductivity, [$\frac{W}{m K}$]

K - Kelvin

k_w – thermal conductivity of the tube, [$\frac{W}{m K}$]

k_{Fin} – thermal conductivity of the fin, [$\frac{W}{m K}$]

L – vertical or horizontal length, [m]

$\dot{m}_{air}$ – mass flow rate of the air, [$\frac{kg}{s}$]

N_{Fin} – number of fins

Nu – Nusselt number

Pr – Prandtl number

$\dot{Q}$ – actual heat transfer rate, [W]

$\dot{Q}_{max}$ – maximum heat transfer rate, [W]

Re – Reynolds number

T – temperatures, [$^{\circ}C$]

U_o – global heat transfer coefficient, [$\frac{W}{m^2 K}$]

Subscripts

boil – ebulição

Cd – Condenser

Cond - Condenser

effect – effective

Ev – Evaporator

ext - external

HP – heat pipe

H - horizontal

in – inlet

int – internal

out – outlet

sat - saturation

Greek symbols

α – thermal diffusivity, $\left[\frac{m^2}{s}\right]$

β – the relationship between areas

ρ – density of the fluid, $\left[\frac{kg}{m^3}\right]$

μ – dynamic viscosity of fluid, $\left[\frac{kg}{m\ s}\right]$

ν – kinematic viscosity of the cold fluid, $\left[\frac{m^2}{s}\right]$

ε_T – thermal effectiveness

η_T – thermal efficiency

ΔT – a difference of temperatures, $[^{\circ}C]$

Acronyms

FHPHE – Finned heat pipe heat exchanger

Ev – Evaporators

Cd – Condenser

NHP – Number of Heat Pipes

NFin – Number of Fins

Nrows – Number of rows

NTU – number of thermal units

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INTERACTIVE VISUAL NARRATIVES IN QUECHUA: AN ARTISTIC AND TECHNOLOGICAL STRATEGY TO STRENGTHEN LINGUISTIC IDENTITY IN NURSING STUDENTS WITHIN A FORMATIVE RESEARCH CONTEXT

NARRATIVAS VISUAIS INTERATIVAS EM QUÉCHUA: UMA ESTRATÉGIA ARTÍSTICA E TECNOLÓGICA PARA FORTALECER A IDENTIDADE LINGÜÍSTICA DE ESTUDANTES DE ENFERMAGEM EM UM CONTEXTO DE PESQUISA FORMATIVA

NARRATIVAS VISUALES INTERACTIVAS EN QUECHUA: UNA ESTRATEGIA ARTÍSTICO-TECNOLÓGICA PARA FORTALECER LA IDENTIDAD LINGÜÍSTICA EN ESTUDIANTES DE ENFERMERÍA EN CONTEXTOS DE INVESTIGACIÓN FORMATIVA

 <https://doi.org/10.56238/sevened2025.036-129>

Ronald Paucar-Curasma¹

ABSTRACT

The incorporation of Indigenous languages into higher education represents both a challenge and an opportunity to strengthen cultural identity and improve communication in professional fields such as health. This study aimed to develop an interactive visual narrative in the Quechua language as an artistic and technological resource within a formative research process involving nursing students at a public university in Peru. The proposal was grounded in the Problem- and Technology-Based Research (IBPT) approach and employed block-based programming in mBlock along with a STEM educational kit to design interactive simulations addressing air quality in households that use firewood stoves—a common health concern in Andean communities. A total of 64 students participated by designing a Quechua-language digital narrative connected to environmental sensors and completing a post-test assessing linguistic comprehension and perceptions of using Quechua in educational and technological contexts. Results showed a medium-high level of Quechua comprehension (mean score of 3.58/5 on content questions) and a highly positive perception of integrating the language into academic activities (average scores above 4.0 on perception items). Findings indicate that interactive visual narratives are effective tools for integrating technology, art, and Indigenous language, fostering meaningful learning, strengthening cultural identity, and enhancing the social relevance of health education. The study concludes that incorporating Indigenous languages into context-based technological projects supports epistemological decolonization, the development of digital competencies, and intercultural professional training in nursing students.

Keywords: Interactive Visual Narrative. IBPT. Quechua. Linguistic Identity. Formative Research. Nursing Students. Mblock.

RESUMO

A incorporação de línguas indígenas no ensino superior representa tanto um desafio quanto uma oportunidade para fortalecer a identidade cultural e melhorar a comunicação em áreas

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profissionais como a saúde. Este estudo teve como objetivo desenvolver uma narrativa visual interativa na língua quéchua como recurso artístico e tecnológico no âmbito de um processo de pesquisa formativa envolvendo estudantes de enfermagem de uma universidade pública do Peru. A proposta fundamentou-se na abordagem de Pesquisa Baseada em Problemas e Tecnologia (IBPT) e utilizou programação em blocos no mBlock, juntamente com um kit educacional STEM, para projetar simulações interativas relacionadas à qualidade do ar em residências que utilizam fogões a lenha — um problema de saúde comum em comunidades andinas. Participaram do estudo 64 estudantes, que elaboraram uma narrativa digital em quéchua conectada a sensores ambientais e responderam a um pós-teste que avaliou a compreensão linguística e as percepções sobre o uso do quéchua em contextos educacionais e tecnológicos. Os resultados indicaram um nível médio-alto de compreensão do quéchua (pontuação média de 3,58/5 nas questões de conteúdo) e uma percepção altamente positiva da integração da língua em atividades acadêmicas (médias superiores a 4,0 nos itens de percepção). Os achados demonstram que narrativas visuais interativas são ferramentas eficazes para integrar tecnologia, arte e língua indígena, promovendo aprendizagem significativa, fortalecimento da identidade cultural e maior relevância social da educação em saúde. Conclui-se que a incorporação de línguas indígenas em projetos tecnológicos contextualizados contribui para a descolonização epistemológica, o desenvolvimento de competências digitais e a formação profissional intercultural de estudantes de enfermagem.

Palavras-chave: Narrativa Visual Interativa. IBPT. Quéchua. Identidade Linguística. Pesquisa Formativa. Estudantes de Enfermagem. MBlock.

RESUMEN

El uso de las lenguas originarias en la educación superior constituye un desafío y, al mismo tiempo, una oportunidad para fortalecer la identidad cultural y mejorar la comunicación en sectores como la salud. El presente estudio tuvo como objetivo desarrollar una narrativa visual interactiva en lengua quechua como recurso artístico y tecnológico en un proceso de investigación formativa con estudiantes de enfermería de una universidad pública del Perú. La propuesta se enmarcó en el enfoque IBPT (Investigación Basada en Problemas y Tecnología) y empleó programación visual en mBlock y un kit educativo STEM para diseñar simulaciones interactivas vinculadas a la calidad del aire en hogares con cocina a leña, problemática común en comunidades andinas. Participaron 64 estudiantes, quienes diseñaron una narrativa digital en quechua articulada con sensores ambientales y realizaron una posprueba que evaluó la comprensión lingüística y la percepción del uso del idioma en contextos educativos y tecnológicos. Los resultados mostraron un nivel medio-alto de comprensión del quechua (media de 3.58/5 en las preguntas de contenido) y una valoración altamente positiva hacia su incorporación en procesos formativos (promedios superiores a 4.0 en ítems de percepción). La experiencia evidenció que las narrativas visuales interactivas constituyen un medio eficaz para articular tecnología, arte y lengua originaria, promoviendo aprendizajes significativos, fortaleciendo la identidad cultural y ampliando la pertinencia social de la formación en salud. Se concluye que integrar lenguas indígenas en proyectos tecnológicos contextualizados favorece la descolonización epistemológica, el desarrollo de competencias digitales y la formación intercultural en estudiantes de enfermería.

Palabras clave: Narrativa Visual Interactiva. IBPT. Quechua. Identidad Lingüística. Investigación Formativa. Estudiantes de Enfermería. Mblock.

1 INTRODUCTION

The integration of Quechua in nursing education is essential to ensure adequate health care for Quechua-speaking communities, especially in Andean regions of Peru, where the use of the language is predominant. Spoken by millions of people in Latin America, Quechua has historically been considered an underrated language in academia, making it difficult for health professionals and the indigenous population to communicate effectively (. In this sense, it is crucial that future nursing professionals develop language and cultural skills to overcome language barriers and improve the quality of care, especially in a rural context where discrimination and stereotypes are frequent (. In the Huancavelica region of Peru, 50% of people communicated in Quechua; previously they spoke more than 80% of this language, which is due to the factor of globalization, technology, migration; Most adolescents spoke it, however, today less than 40% of adolescents practice it (. Alarcón La Torre, 2023) DNLO, 2013) Asto & ventura, 2020)

Nursing personnel today face a great challenge when taking advantage of new technological resources to perform their work more efficiently and effectively. It is essential that academic nursing programs and universities review their curricula in accordance with technological advances in digital health, promoting the development of digital and computer skills necessary for professional performance, according to international recommendations (. It is critical that nurses and nursing students acquire competencies to successfully use information and communication technologies in their education and practice, in order to benefit patients and improve their own practice (. There is limited published literature on the use of ICT by nursing and health personnel in general in Peru. Topaz et al. 2016) Curioso & Oscuivilca-Tapia, 2021)

The integration of digital art in educational processes not only expands the expressive possibilities of students, but also strengthens cultural and linguistic ties that have been historically marginalized. In contexts where the Quechua language has been displaced by the effects of globalization, migration and the hegemony of Spanish, it is urgent to revitalize it through means that connect with the younger generations. In this scenario, interactive visual narratives in Quechua represent an innovative form of artistic and pedagogical expression, capable of contributing to professional training with sociocultural identity and commitment. (Palacios et al., 2018; Shen et al., 2024)

The use of visual and interactive technologies makes it possible to represent in a symbolic and sensory way the social and health problems of Andean communities,

promoting active learning, intercultural communication and the preservation of the native language. Visual programming, through environments such as mBlock, offers students an accessible and creative means to build digital scenarios in the Quechua language, where art, technology and the reality lived in their environment are articulated (Castillo, 2024; Herrera, 2022; Murrugarra, 2023) (Córdor et al., 2025; Paucar-Curasma et al., 2025)

In the case of nursing education, these digital narratives allow health problems to be addressed from a community perspective, recognizing that language is a fundamental component in intercultural care. The absence of health professionals with language skills in Quechua has generated barriers in communication, affecting the quality of services and encouraging risky practices such as self-medication. Therefore, it is a priority to incorporate pedagogical approaches that integrate linguistic identity into the professional training process. (Shimabuku Azato et al., 2018) (Santos-Revilla, 2016)

The formative research approach is conceived as a pedagogical strategy that promotes the development of scientific and technological competencies from the early stages of university education, through the execution of contextualized projects. In this framework, the nursing students developed an interactive visual narrative in Quechua, linked to a real health problem in their community, using a STEM educational kit and a block programming environment in the Quechua language. This process not only strengthened their technical and communication skills, but also led to the revaluation of their cultural identity through the use of visual art and digital resources. (Magdaleno & Málaga, 2024; Restrepo Gómez, 2017)

1.1 LANGUAGE BARRIERS IN HEALTH CARE

Peru is one of the countries that is characterized by having a wide linguistic diversity, so it officially has three languages: Spanish spoken by the majority (83.92%), Quechua, including its variants (13.21%), and Aymara, used by a smaller percentage (1.76%). In addition, more than 40 aboriginal languages are spoken in the highlands and jungle regions. As for Quechua, there are 3,262,137 speakers throughout the country, which represents a significant population that uses this native language. This panorama reflects not only linguistic diversity, but also the challenge and importance of promoting policies that ensure the conservation and strengthening of these native languages in the face of globalization and trends of cultural homogenization. (UNICEF, 2013)

In the field of health, establishing effective communication with patients is essential, as it directly influences the quality of care and clinical outcomes. According to studies carried out by , the impact of Quechua and other indigenous languages on community health in Peru is significant. Adequate communication in these languages is crucial to provide quality health care, however, the lack of personnel trained in Quechua and other indigenous languages limits the effectiveness of health services, leading to poor care and encouraging self-medication among Quechua speakers, who, in the face of linguistic and cultural barriers, they often resort to traditional practices. (Areche et al. (2020)

On the other hand, language barriers between health personnel and users affect the quality of public and private services, since both do not share or understand the same language, as pointed out (. This problem, despite its relevance, continues to be invisible by public and private institutions of higher education, as well as by the health sector in Peru. The lack of preparation and awareness of this reality causes misunderstandings that negatively impact health care and outcomes. Finally, they highlight the importance of health professionals, especially those who carry out the Rural and Marginal Urban Service (SERUMS), mastering Quechua as a second language in areas with a high Quechua-speaking population. Ricalde 2024) Oyola García & Quispe-Illanz, 2016)

1.2 FORMATIVE RESEARCH IN UNIVERSITY STUDENTS

In the field of higher education, various actions have been implemented aimed at incorporating formative research into university courses, using strategies that are effective for students to develop key competencies, strengthening their knowledge and research skills. From the pedagogical approach, formative research is based on teaching practices and methods that various institutions and university teachers have applied, showing positive results, encouraging the active participation of students and teachers within the university. (Restrepo Gómez, 2017) (Lapa-Asto et al., 2019)

Problem- and Technology-Based Research (PPTR) is an educational approach that is based on the problem-solving method proposed by , with the aim of strengthening research competencies in students through a process organized in four stages: understanding the problem, elaboration of activities, execution of activities and review of the solution. This proposal combines active strategies focused on problem-solving with the use of easily accessible educational technologies, such as STEM kits, sensors, and visual

programming platforms. Pólya (1945) (Paucar-Curasma et al., 2025) (Paucar-Curasma, Cerna-Ruiz, et al., 2023; Paucar-Curasma, Villalba-Condori, et al., 2023)

The IBPT proposal is not limited to guiding the student in the formulation and resolution of contextualized problems, but also promotes an active connection between scientific thinking and technological application. In this sense, the student not only examines a problematic situation, but also designs, implements and verifies solutions through experimentation with technological resources, giving rise to specific products such as models, prototypes or functional applications. This approach is particularly relevant in disciplines such as Nursing, where learning must transcend the purely theoretical and promote the ability to face real problems in the environment. By integrating the research process with specific technological tools, the IBPT turns formative research into an enriching experience, interdisciplinary in nature and with a strong innovation component.

Numerous studies have demonstrated the effectiveness of this type of methodology, pointing out that they contribute to a more favorable attitude towards research, strengthen logical thinking and stimulate autonomy in the learning process. Likewise, the implementation of the IBPT approach with the support of STEM educational kits promotes the development of digital skills, fundamental in contemporary vocational training. The phases that make up the IBPT approach are described below. (Fronza et al., 2019; Ortega & Asensio, 2021)

- Understanding the problem: This stage involves the exploration of scientific and technological information, the analysis of contextualized situations and the graphic representation of cause-effect relationships through visual organizers. Its purpose is to develop skills in observation, critical thinking, and researchable questioning.
- Elaboration of activities: In this phase, students plan the research process, review relevant background information and organize tasks in a logical way. Competencies related to the methodological structuring of formative research are reinforced.
- Execution of activities: Participants interact with technological devices such as sensors and actuators, programming their operation through visual environments such as mBlock. This phase encourages active experimentation, the application of technical knowledge and teamwork.
- Review of the solution: Finally, the developed proposal is verified and optimized, promoting critical reflection, continuous improvement and metacognition. The relevance and impact of the solution in the face of the initial problem is analyzed.

1.3 INTERACTIVE VISUAL NARRATIVE IN EDUCATION: AN ARTISTIC AND CULTURAL APPROACH

Interactive visual narratives are a contemporary pedagogical strategy that allows creativity, critical thinking and digital technology to be integrated into teaching-learning processes. Unlike traditional narratives, these include visual, sound and interaction elements, where the user or student is not only a receiver of the information, but also an active builder of meaning. This characteristic makes them powerful tools to strengthen participation, meaningful learning and cultural appropriation, especially in educational contexts with linguistic and sociocultural diversity. (Moreira-Chóez, 2021)

From the semiotic and pedagogical perspective, visual narratives enable the construction of knowledge from symbolic representations, which favors the development of cognitive and emotional competencies in students. By combining images, text, audio, and movement, these narratives transform the educational environment into an immersive space that stimulates multiple ways of learning. In addition, its aesthetic dimension allows it to connect with the interests, emotions and experiences of the students, creating a closer relationship with the curricular content. (Chávez et al., 2021)

In the context of health education, the use of visual narratives in indigenous languages, such as Quechua, represents a valuable tool to strengthen linguistic identity, promote intercultural communication, and address real problems in communities from a critical and creative perspective. Using visual programming environments such as mBlock, students can create interactive simulations in Quechua, where situations related to environmental health, disease prevention, or care in rural areas are represented. This process not only contributes to the learning of disciplinary content, but also allows the revaluation of the native language as a vehicle of knowledge, affection and belonging. (Gutiérrez & Tyner, 2012)

In contemporary digital culture, interactive narratives represent an emerging form of multiple literacy, where computational thinking, visual design, and narrative construction converge. Its implementation in the classroom encourages narrative thinking and the ability to solve problems from a multimodal and participatory logic. Thus, in educational projects such as the one developed in this research, where nursing students design an interactive application in Quechua for the dissemination of information on air quality, the value of visual narratives as artistic, technological and cultural expressions that enrich education with a social and transformative sense is evidenced. (León, 2018)

1.4 VISUAL PROGRAMMING TOOLS IN QUECHUA

Digital applications are transforming health education, offering information, tools and educational resources in a more accessible and personalised way; from apps that allow you to consult medical information to platforms that facilitate communication between patients and professionals (. Araújo-Girão et al, 2021)

The use of tools in health projects is transforming the way healthcare challenges are addressed. From digital platforms that facilitate collaboration between professionals and data management, technological tools are boosting the efficiency, accuracy, and accessibility of health services. . Its impact is reflected in the improvement of the quality of care, the reduction of errors, the optimization of resources and the creation of new opportunities for the research and development of innovative solutions. (Huilcatoma-García, 2020)

Within the framework of the use of Information and Communication Technologies (ICT) to strengthen indigenous languages, he proposed a methodology that consists of the creation of videos in indigenous languages through workshops aimed at the development of educational materials. Similarly, several authors point out that ICT contributes to optimizing language teaching, making learning more enjoyable, interactive and motivating, while promoting the development of technological skills in students. (Pinto, 2019)

The use of various technological tools facilitated the learning of vocabulary in Quechua, allowing students to improve their communication skills and encourage reading and writing, increasing interest in learning their language. Likewise, it improved the learning of the Ashaninka language through interactive comics developed in the Scratch program; Integrating this type of technology is essential to strengthen the use of educational resources for cultural revitalization. Fernández (2020) (Ríos-Colmenárez, 2020)

The progress in the students' oral expression was achieved through the creation of audios and videos, in which they narrated short stories or recounted their cultural traditions. it incorporated riddles and tongue twisters to enrich the production of written texts, as well as songs, stories and ancestral games to strengthen oral expression, contributing to the revaluation of the language and the cultural identity of the students. Another prominent strategy to promote the daily use of Quechua is the use of television as an integrating medium within ICTs. Similarly, they recommend that teachers use software as an alternative resource to strengthen paragraph writing. Huamaní (2019) Alotaibi & Alzu'bi (2022)

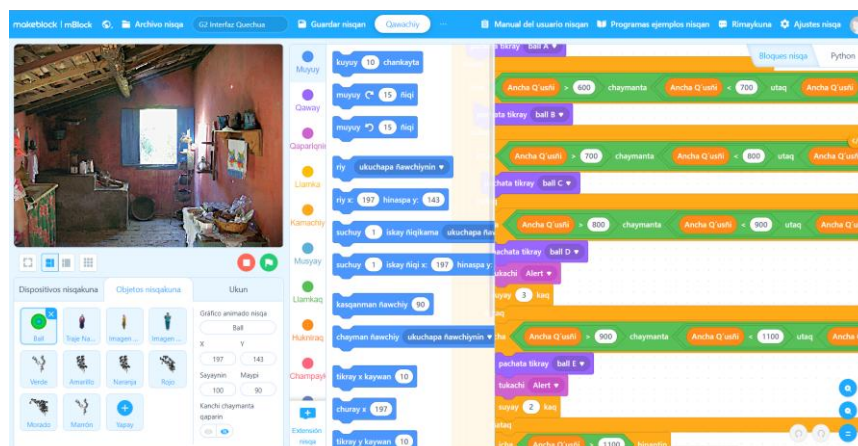
The development of applications in indigenous languages drives cultural inclusion and the revitalization of marginalized languages, such as Quechua, through digital tools. Teaching programming in these languages fosters multilingualism and strengthens cultural identity. In addition, the use of technologies such as augmented reality in Quechua-speaking communities not only improves learning, but also facilitates access to key information in areas such as health, reducing language barriers and empowering communities to actively participate in digital environments and modern services. (Ojeda et al., 2022) (Cárdenas-Valdivia et al, 2023)

Commercial products available to develop interactive programs or applications have limitations regarding the use of Quechua and other native languages. Faced with this situation, a customized solution has been developed: the STEM Educational Kit and its visual programming environment based on the mBlock software. This kit incorporates sensors and actuators, and uses an open-source microcontroller with the ATmega328P microchip as a base. In addition, it has a visual programming environment that includes blocks in Quechua and Spanish, designed to interact with sensors and actuators. These blocks were developed using Python libraries and the mBlock environment. (Paucar-Curasma et al., 2022) (Makeblock Education, 2024)

The STEM Educational Kit allows various research activities aimed at community problems, such as the monitoring of environmental parameters; for example, air quality, turbidity and water temperature, or soil moisture. Figure 1 shows the visual programming environment in Quechua based on mBlock.

Figure 1

Visual programming environment in Quechua



Source: Authors, 2025.

2 OBJECTIVE OF THE RESEARCH

To develop an interactive visual narrative in the Quechua language as an artistic expression and pedagogical tool in a formative research process, with the purpose of strengthening linguistic and cultural identity in nursing students through the use of visual programming and contextualized educational technologies.

3 METHODOLOGY

3.1 RESEARCH APPROACH AND PARTICIPANTS

The present research adopts a quantitative design of a descriptive type, with a single post-test approach, using a non-probabilistic sampling of an intentional type. The participants were students of the Information Management course of the Nursing career of a public university in Peru, enrolled in the second academic semester of 2024. The sample was made up of 64 students, of which 53 were women and 11 men. Most of the participants were younger than 21 years old.

3.2 DATA ASSESSMENT AND ANALYSIS TOOL

To evaluate the impact of the use of interactive visual narrative in Quechua on students' language comprehension and perception, a post-test survey was applied at the end of the intervention. The instrument consisted of two sections: the first assessed the comprehension of messages in Quechua through five multiple-choice questions based on the screens designed by the students; the second measured the perception and attitude towards the use of Quechua in educational and technological environments, through five Likert-type items (scale from 1 to 5).

The data obtained were organized in a matrix of SPSS and analyzed with descriptive statistics. Measures of central (mean) tendency and frequency distribution were calculated for both sections. The maximum score in comprehension was 5 points. Table 1 presents the items used in the post-test instrument applied to assess the understanding of Quechua and the students' perception:

Table 1

Proposal for a formative research project and programming blocks in Quechua

Section	Item	
Understanding Quechua	P1	What does the word "allin kawsaypaq" mean?
	Q2	If a screen shows the phrase "Saykuy, uma nanay", what does it indicate?
	Q3	What is the color shown when the air does not pose a health risk?
	Q4	"Warma machukunaqa uchuy nanaykunawan rikurinku" may refer to:
	Q5	What message was shown when air quality exceeded 1100 ppm?
Perception and attitude	Q6	I understood the messages in Quechua that appeared on the screens.
	P7	I learned new words in Quechua thanks to the activity.
	P8	Using Quechua in the app helped me better understand the health issue.
	P9	I would like to continue using Quechua in health or technology projects.
	P10	I consider it important to use Quechua in professional training.

Source: Authors, 2025.

3.3 PROPOSAL FOR A FORMATIVE RESEARCH PROJECT IN THE CLASSROOM

Table 2 presents the formative research projects developed in groups by nursing students, under the advice of the classroom teacher. Each project is linked to real health problems in the local context where the students live, and has been addressed through the use of sensors and cards from the STEM educational kit, programmed in an mBlock visual environment with blocks in the Quechua language.

During the execution of these research activities, the students designed interactive visual narratives in Quechua aimed at the prevention of common diseases in their communities, integrating technology, health, and culture. These narratives were built from the programming of visual blocks that allow simulating health scenarios and showing relevant information in the Quechua language, thus facilitating the understanding of risks and care by users.

Likewise, Table 2 summarizes the titles of the formative research projects together with the programming blocks in Quechua used for the creation of the interactive visual narratives in each project.

Table 2

Proposal for a formative research project and programming blocks in Quechua

ID	Formative research project	Programming blocks in Quechua
1	Monitoring of humidity in vegetable crops to prevent anemia in school-age children in the district of Acraquia of the province of Tayacaja.	

2	Monitoring of air quality in homes with wood-burning stoves for the prevention of respiratory problems in the district of Andaymarca in the province of Tayacaja.	Concentración (PPM) nisqa Qallariy sensor chay allin kasqan wayrata chayta pin nisqawan A2 ▼
3	Monitoring of guinea pig breeding against predators to prevent the spread of salmonella in the community of Santa Rosa in the province of Tayacaja that would affect the human consumption of guinea pig meat.	ñawinchay sensor de ultrasonido nisqanta 1 pin nisqa 1 temporizador nisqanta kutipay yapamanta pacha yupaypi
4	Monitoring of water quality to prevent stomach infections in the inhabitants of the district of Ustuna in the province of Tayacaja.	Ñawinchay chay datos nisqakuna manam procesado kay pin nisqawan A0 ▼ Datos procesados nisqakuna (Voltios nisqa) Turbidez nisqa
5	Monitoring of the water temperature of the fish farm of "La Cabaña" to prevent the death of trout and possible consumption of contaminated meat by the inhabitants of the province of Tayacaja.	Qallariy DS18B20 chay 4 ▼ Temperatura nisqawan chay °C Allichaykuy chay sensores nisqakuna
6	Monitoring of children's body temperature to prevent fever outbreaks at the Mariscal Cáceres El in the district of Daniel Hernández Morillo in the province of Tayacaja.	Qallariy Termómetro Infrarrojo nisqata Temperatura kay ambiente niqawan °C Temperatura kay objeto niqawan °C

Source: Authors, 2025.

3.4 DEVELOPMENT OF FORMATIVE RESEARCH IN THE CLASSROOM

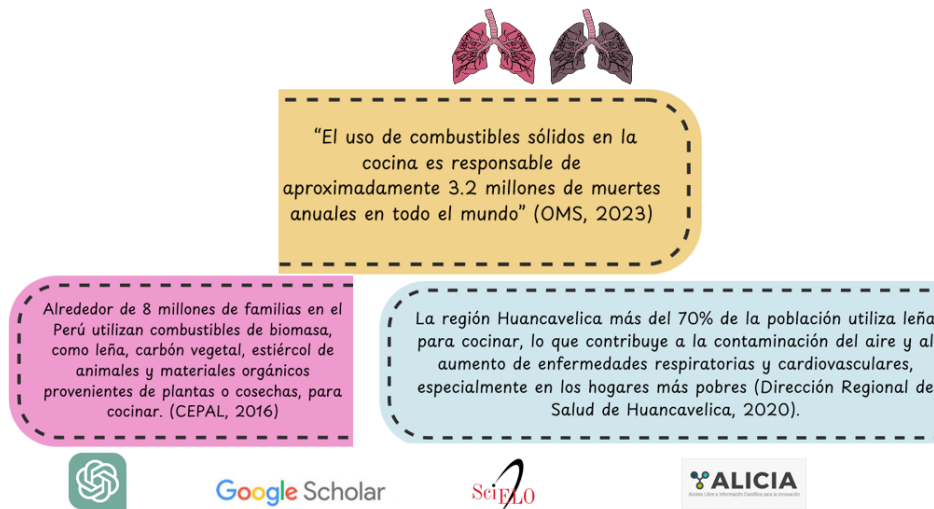
The formative research was developed in the classroom following the 4 phases of the Problem-Based Research and Technology (PPTR) approach: understanding the problem, elaboration of activities, execution of activities and review of the solution. The activities carried out in each phase are detailed below.

3.4.1 Understanding the problem

During the phase of understanding the problem, the students carried out a systematic search for scientific information in sources such as Scopus, Google Scholar, Scielo and Redalyc, with the aim of analyzing the health problem raised. Based on the analysis and synthesis of the information collected, they developed a detailed description of the problem and graphically represented the cause-and-effect relationship using a visual organizer. As an example, Figure 2 shows the problems of air quality in homes with wood stoves that affect the health of the inhabitants of the province of Tayacaja in Peru.

Figure 2

Representation of the problematic situation



Source: Authors, 2025.

3.4.2 Development of activities

During this phase, the students researched the background related to the proposed research topics, reviewing various scientific sources such as Scopus, Google Scholar, Scielo, Redalyc, among others. After collecting and analyzing the information, they identified similar experiences and good practices that served as the basis for formulating a list of activities aimed at solving the problem of air quality in homes with wood-burning stoves. The activities proposed by the students to address the problem of air quality in homes with wood-burning stoves were the following:

- ☐ Implement a scenario composed of the Pachamama card and the MQ135 air quality sensor;
- ☐ Recognize and understand the programming blocks in Quechua corresponding to the MQ135 sensor;
- ☐ To develop an interactive visual narrative in Quechua for air quality monitoring and the prevention of respiratory diseases;
- ☐ Build a model that represents a typical home with a wood-burning stove, where the sensor is integrated; and
- ☐ Test the operation of the proposed solution, verifying its response to different levels of smoke concentration.

3.4.3 Implementation of activities

In this phase, the students addressed the problems identified through the execution of the activities designed in the previous stage. To do this, they began a process of familiarization with the operation of electronic boards, sensors, actuators and the visual programming environment in Quechua based on mBlock. Once this knowledge was acquired, they began to design and program interactive visual narratives in Quechua, aimed at monitoring air quality through the use of the MQ135 sensor.

These narratives were developed by integrating visual elements, digital characters, programming logic and simulation of real scenarios, such as homes with wood-burning stoves. This process allowed students to combine technical skills with their own cultural and linguistic expressions. Table 3 shows the development of the interactive screens made in mBlock, as part of the visual narrative in the Quechua language.

Table 3

Development of interactive screens of visual narrative in Quechua using mBlock

1. They represented the physical space of a rural house with a wood-burning stove, as the main setting for the visual narrative.	2. They designed the characters of the narrative: child, nurse, mother, and smoke particles, using representative visual and cultural resources.	3. They programmed the system's logic in mBlock, associating the values of the air quality index with messages and visual responses in Quechua.
		
4. They developed interactive screens in Quechua to communicate the health risks of smoke, integrating graphic elements, texts, sound and colors.	5. They built an educational model that recreates the domestic environment with a wood-burning stove, serving as a tangible support for interaction with the system.	6. They integrated the visual narratives programmed in mBlock with the STEM Educational Kit within the model, achieving a complete interactive experience.



Source: Authors, 2025.

3.4.4 Solution Review

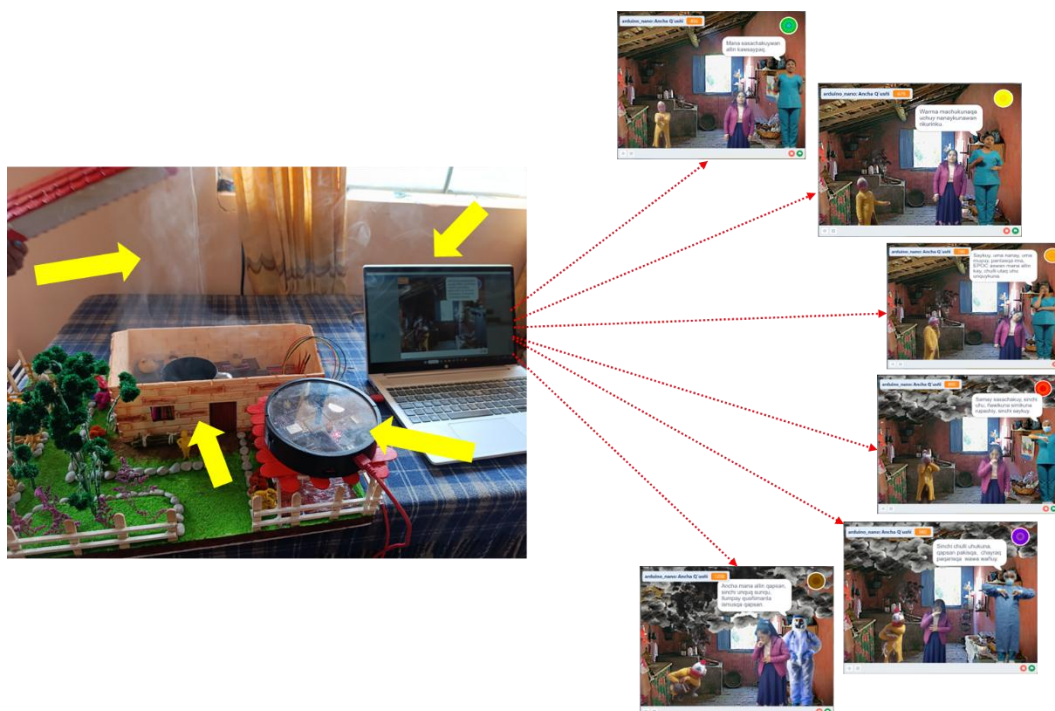
In this phase, the students validated the results obtained during the execution of the research activities in the classroom. To do this, they evaluated the integral functioning of the models after integrating the electronic cards of the STEM educational kit with the interactive visual narratives in Quechua developed in the mBlock programming environment.

The review of the solution consisted of simulating the operation of a wood-burning stove inside the model and observing the responses generated by the system. The interactive screens, previously programmed, showed the levels of smoke concentration in units of particles per million (ppm) and their respective effects on human health, expressed through visual and textual messages in the Quechua language. These dynamic responses were accompanied by graphic representations of characters and alert colors, which facilitated the interpretation of the level of risk.

Figure 4 shows this simulation in action: you can see the model in operation, the sensor capturing the data from the environment, and the different screens activated according to the air quality values recorded.

Figure 4

Simulation of the operation of the interactive system in Quechua in a model of a wood-burning stove



Source: Authors, 2025.

4 RESULTS

4.1 DESCRIPTION OF INTERACTIVE VISUAL NARRATIVE IN QUECHUA

Table 4 presents the screens that make up the interactive visual narrative developed by nursing students, as part of the formative research process. This narrative, created in the mBlock programming environment, aims to raise awareness about the effects of air quality in homes with a wood-burning stove and its impact on human health. Each screen is activated according to the value recorded by the MQ135 air quality sensor, expressed in units of particles per million (ppm), and displays messages in the Quechua language accompanied by visual elements such as characters, alert colors and everyday scenarios, which allow risk levels to be interpreted in an accessible and culturally meaningful way.

Table 4

Representation of interactive screens in Quechua for the dissemination of information on air quality and community health

Screenshot of the interactive visual narrative in Quechua	Description of the content and visual message in the context of health
	The figure shows one of the screens of the interactive visual narrative in Quechua, activated when the sensor detects an air quality value between 400 and 600 ppm. At this level, the app displays the message "Mana sasachakuywan allin kawsaypaq," which means that air does not pose a health risk. In addition, the green light comes on, which indicates healthy conditions of the environment. The characters (the child, the mother and the nurse) appear with happy or relaxed facial expressions, visually reinforcing the state of general well-being.
	This display is activated when the sensor records air quality levels between 600 and 700 ppm. In this case, the nurse shows the message in Quechua "Warmamachukunaqa uchuy nanaykunawan rikurinku", which warns of possible mild discomfort for sensitive people, such as asthmatic patients. Yellow light is illuminated, which represents moderately good air quality. Visually, the mother and child maintain expressions of tranquility, while the nurse appears in an attentive posture, emphasizing the beginning of a precautionary situation.
	The figure shows a screen of the interactive visual narrative, activated when the air quality sensor registers a value between 700 and 800 ppm. At this level, the nurse shows the message in Quechua: "Saykuy, uma nanay, uma muyuy, pantasqa ima, COPD aswan mana allin kay, chulli utaq uhu unquykuna", which warns that the air is polluted and represents a considerable risk for people with respiratory conditions. As an alert signal, the orange light comes on. In the scene, the characters (the mother and the child) appear with expressions of discomfort, evidencing symptoms such as coughing or discomfort, while the nurse adopts a reflective posture, conveying concern about the situation.

	The figure shows a display of the interactive visual narrative when the sensor detects air quality between 800 and 900 ppm. At this level, the nurse presents the message in Quechua: "Samay sasachakuy, sinchi uhu, ñawikuna simikuna rupachiy, sinchi saykuy", which refers to symptoms such as shortness of breath, lung inflammation and bronchial obstruction. This value indicates that the air is unfavorable for health, activating a red warning light. Visually, the characters (the mother and the child) show expressions of discomfort or persistent cough, while the nurse appears with a mask and a warning gesture, transmitting a message of care and urgency.
	This display is activated when the sensor measures a range between 900 and 1100 ppm. At the scene, the nurse communicates the message in Quechua: "Sinchi chulli uhukuna, qapsan pakisqa, chayraq paqarisqa wawa wañuy", which indicates a very high level of air pollution, with possible serious consequences such as severe lung infections or death in young children. The purple light illuminates, a symbol of critical alert. The characters (mother and child) show visible signs of respiratory involvement, while the nurse appears wearing a full protective suit, representing an extreme situation of health risk.
	The figure shows the interactive visual narrative screen that is activated when the sensor registers an air quality value greater than 1100 ppm. At this critical level, the nurse communicates the message in Quechua: "Ancha mana allin qapsan, sinchi unquq sunqu, llumpay qusñimanta ismusqa qapsan", which warns that the air is extremely polluted, with the risk of causing pneumonia, heart attacks or lung cancer in case of prolonged exposure. In this emergency situation, the brown light comes on, which represents the highest level of alert. The characters (the mother and the child) appear visibly affected by the smoke, with expressions of intense coughing, while the nurse is shown in a full protective suit and mask, symbolizing a critical and highly dangerous health environment.

Source: Authors, 2025.

Screenshot of the interactive visual narrative in Quechua Description of the content and visual message in the context of health

The figure shows one of the screens of the interactive visual narrative in Quechua, activated when the sensor detects an air quality value between 400 and 600 ppm. At this level, the app displays the message "Mana sasachakuywan allin kawsaypaq," which means that air does not pose a health risk. In addition, the green light comes on, which indicates

healthy conditions of the environment. The characters (the child, the mother and the nurse) appear with happy or relaxed facial expressions, visually reinforcing the state of general well-being.

This display is activated when the sensor records air quality levels between 600 and 700 ppm. In this case, the nurse shows the message in Quechua "Warma machukunaqa uchuy nanaykunawan rikurinku", which warns of possible mild discomfort for sensitive people, such as asthmatic patients. Yellow light is illuminated, which represents moderately good air quality. Visually, the mother and child maintain expressions of tranquility, while the nurse appears in an attentive posture, emphasizing the beginning of a precautionary situation.

The figure shows a screen of the interactive visual narrative, activated when the air quality sensor registers a value between 700 and 800 ppm. At this level, the nurse shows the message in Quechua: "Saykuy, uma nanay, uma muyuy, pantasqa ima, COPD aswan mana allin kay, chulli utaq uhu unquykuna", which warns that the air is polluted and represents a considerable risk for people with respiratory conditions. As an alert signal, the orange light comes on. In the scene, the characters (the mother and the child) appear with expressions of discomfort, evidencing symptoms such as coughing or discomfort, while the nurse adopts a reflective posture, conveying concern about the situation.

The figure shows a display of the interactive visual narrative when the sensor detects air quality between 800 and 900 ppm. At this level, the nurse presents the message in Quechua: "Samay sasachakuy, sinchi uhu, ñawikuna simikuna rupachiy, sinchi saykuy", which refers to symptoms such as shortness of breath, lung inflammation and bronchial obstruction. This value indicates that the air is unfavorable for health, activating a red warning light. Visually, the characters (the mother and the child) show expressions of discomfort or persistent cough, while the nurse appears with a mask and a warning gesture, transmitting a message of care and urgency.

This display is activated when the sensor measures a range between 900 and 1100 ppm. At the scene, the nurse communicates the message in Quechua: "Sinchi chulli uhukuna, qapsan pakisqa, chayraq paqarisqa wawa wañuy", which indicates a very high level of air pollution, with possible serious consequences such as severe lung infections or death in young children. The purple light illuminates, a symbol of critical alert. The characters (mother and child) show visible signs of respiratory involvement, while the nurse appears wearing a full protective suit, representing an extreme situation of health risk.

The figure shows the interactive visual narrative screen that is activated when the sensor registers an air quality value greater than 1100 ppm. At this critical level, the nurse communicates the message in Quechua: "Ancha mana allin qapsan, sinchi unquq sunqu, llumpay qusinmanta ismusqa qapsan", which warns that the air is extremely polluted, with the risk of causing pneumonia, heart attacks or lung cancer in case of prolonged exposure. In this emergency situation, the brown light comes on, which represents the highest level of alert. The characters (the mother and the child) appear visibly affected by the smoke, with expressions of intense coughing, while the nurse is shown in a full protective suit and mask, symbolizing a critical and highly dangerous health environment.

4.2 ANALYSIS OF QUANTITATIVE RESULTS

In order to evaluate the understanding of the Quechua language and the perception of the students after the use of interactive visual narrative, a post-test survey was applied to 64 nursing students. This survey included five multiple-choice questions aimed at verifying Quechua linguistic comprehension (P1–P5) and five Likert-type items (P6–P10) to assess the attitude and perception of language use in health and technology settings.

4.2.1 Understanding Quechua

The results of the comprehension questions showed an overall average of 3.58 correct answers out of 5, which indicates a medium-high level of comprehension. The distribution of scores was as follows:

- ☐ 1 correct answer: 1 student (1.6%)
- ☐ 2 correct answers: 7 students (10.9%)
- ☐ 3 correct answers: 19 students (29.7%)
- ☐ 4 correct answers: 28 students (43.8%)
- ☐ 5 correct answers: 9 students (14.1%)

This result reveals that more than 58% of the group (37 students) answered correctly at least 4 of the 5 questions posed, suggesting that the visual narrative facilitated the semantic understanding of the messages in Quechua linked to air quality levels and their impact on health.

4.2.2 Perception of the use of Quechua

Regarding the perception items (Likert scale from 1 to 5), the averages obtained were as follows:

- Q6: I understood the messages in Quechua – 4.23
- Q7: I learned new words in Quechua – 3.73
- Q8: Quechua helped me better understand the health problem – 3.98
- Q9: I want to continue using Quechua in projects – 4.20
- P10: I consider Quechua important in my professional training – 4.06

These results show a highly positive assessment of the Quechua language in technological educational contexts. In particular, the high score in items P6, P9 and P10 reveals that students not only understood the messages, but also value the language as part of their professional training and show willingness to use it in future educational and health service experiences.

5 DISCUSSIONS

The results of this research show that the use of an interactive visual narrative in the Quechua language, developed through programming in mBlock, was an effective strategy to promote both the understanding of the native language and the analysis of a real health problem of the students' community. With an average of 3.58 correct answers in the linguistic comprehension questions and averages above 4 in the perception items, a double educational gain is observed: on the one hand, the students strengthened their bond with Quechua as a language of academic use; on the other, they developed digital skills applied to community health. (León, 2018)

This finding confirms that educational technologies should not be limited to technical teaching, but can become cultural tools that enable new ways of thinking, representing and acting from local knowledge. In this case, the mBlock programming environment allowed students to construct visual narratives in Quechua, contextualized in real scenarios such as wood-burning stoves in rural areas, where air pollution represents a public health problem. (Papert & Harel, 2002)

The combination of an objective understanding of the language with a positive attitude towards its use indicates that interactive visual narrative in Quechua was effective as an intercultural pedagogical strategy. This experience aligns with research that highlights

the role of indigenous languages in the construction of meanings in the classroom, as well as with the recommendations of UNESCO, which promotes the use of mother tongues in education systems to ensure inclusion, relevance, and equity. (Kvietok & Hornberger, 2023) (Rebaza & Seminario, 2018)

In addition, the design of interactive screens and digital characters in Quechua responds to the approaches of , who argues that visual languages in digital media not only represent data, but also configure cultural imaginaries. Here, the responses of the programmed application not only emitted smoke concentration data, but also did so in Quechua, with body expressions, colors and faces that represented states of health alert, generating a significant and culturally situated learning experience. Manovich (2002) (Paucar-Curasma et al., 2025)

From a critical perspective, the experience also challenges the homogenizing educational model that has historically relegated indigenous languages to informal or marginal spaces. On the other hand, this proposal demonstrates that Quechua can occupy a leading place in educational and scientific contexts, dialoguing with technology and contributing to the production of knowledge from the margins. (Ojeda et al., 2022)

Finally, this research provides evidence on how formative research methodologies, when combined with intercultural approaches and accessible technologies, can transform the classroom into a space of cultural and linguistic empowerment. It is recommended to replicate similar experiences in other disciplines, as well as to design more specific instruments to assess language acquisition and technological appropriation in intercultural contexts. (Paucar-Curasma et al., 2024)

6 CONCLUSIONS

The present research demonstrates that the use of an interactive visual narrative in Quechua, designed by nursing students through mBlock programming, constitutes an effective pedagogical strategy to integrate technological, linguistic and cultural knowledge in professional training contexts. The results obtained reflect an adequate level of understanding of the Quechua language and a positive attitude towards its use in educational and health settings, which confirms the potential of the intercultural approach in higher education.

This experience allowed students not only to develop skills in programming and interactive systems design, but also to revalue their native language as a legitimate means

of communicating scientific information and promoting public health. It was evident that digital technologies, when culturally contextualized, can become tools for linguistic revitalization, critical appropriation of knowledge and the strengthening of professional identity with a territorial approach.

In this sense, the methodological proposal based on formative research and the IBPT (Problem- and Technology-Based Research) approach favored the construction of meaningful learning, collaborative work, and critical thinking from the local context. It is recommended to implement similar experiences in other areas of knowledge and to strengthen the assessment of indigenous language learning with specific instruments.

Finally, this study provides empirical evidence on the value of incorporating indigenous languages in the development of applied technological solutions, and contributes to the debate on the decolonization of knowledge in training spaces.

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**CIRCUMCISION IN MOZAMBIQUE, DIALOGUE BETWEEN TRADITIONS,
BIOETHICS AND BIOMEDICINE**

**CIRCUNCISÃO EM MOÇAMBIQUE, DIÁLOGO ENTRE TRADIÇÕES, BIOÉTICA
E BIOMEDICINA**

**CIRCUNCISIÓN EN MOZAMBIQUE, DIÁLOGO ENTRE TRADICIONES,
BIOÉTICA Y BIOMEDICINA**

 <https://doi.org/10.56238/sevened2025.036-130>

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ABSTRACT

This paper is part of a qualitative research, based on an ethnographic study, carried out with the Makonde ethnic group, in southern Mozambique. It reflects on the traditional practice of circumcision as an initiation ritual among the Makonde and the influence it suffered in contact with other ethnic groups and religions and with the biomedicine paradigm. It develops a brief historical characterization of circumcision in the cultural traditions of different ethnic groups in the country and points out challenges of the practice of traditional circumcision in dialogue with biomedical interventions related to HIV prevention. It highlights the role of health workers, bioethicists, and anthropologists in the understanding of singular stories of native ethnic groups and their forms of resistance or adherence to epistemologies from contemporary scientific medicine. Also argues the need to address informed consent and human rights of young males who participate in this type of intervention.

Keywords: Male Circumcision. Cultural Tradition. Biomedicine. HIV.

RESUMO

Este artigo é um recorte de pesquisa de natureza qualitativa, baseada num estudo etnográfico, realizada junto ao grupo étnico Makonde, que habita no sul de Moçambique. Reflexiona sobre a prática tradicional da circuncisão como ritual de iniciação entre os Makonde e a influência que sofreu no contato com outros grupos étnicos e religiões e com o paradigma da biomedicina. Desenvolve uma breve caracterização histórica da circuncisão nas tradições culturais de diversos grupos étnicos do país e aponta para os desafios da prática da circuncisão tradicional em diálogo com as intervenções biomédicas relacionadas com a prevenção do HIV. Destaca o papel dos sanitaristas, bioeticistas e antropólogos para a compreensão das histórias singulares dos povos originários e suas formas de resistência ou de adesão aos saberes provenientes das medicinas científicas contemporâneas e da observância do consentimento informado e o respeito aos direitos humanos dos jovens que realizam estes processos de intervenção.

Palavras-chave: Circuncisão. Práticas Tradicionais. Biomedicina. HIV.

RESUMEN

Este artículo es un recorte de una investigación cualitativa, basada en un estudio etnográfico, que se llevó a cabo con el grupo étnico Makonde, que habita en el sur de Mozambique.

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Reflexiona sobre la práctica tradicional de la circuncisión como ritual de iniciación entre los Makonde y la influencia que sufrió en contacto con otras etnias y religiones y con el paradigma de la biomedicina. Desarrolla una breve caracterización histórica de la circuncisión en las tradiciones culturales de las diferentes etnias del país y señala los desafíos de la práctica de la circuncisión tradicional en diálogo con las intervenciones biomédicas relacionadas con la prevención del VIH. Destaca el papel de los profesionales de la salud, bioeticistas y antropólogos en la comprensión de las historias singulares de los pueblos originarios y sus formas de resistencia o adhesión a los saberes de la medicina científica contemporánea y la observancia del consentimiento informado y el respeto a los derechos humanos de los jóvenes que las realizan estos procesos de intervención.

Palabras clave: Circuncisión Masculina. Prácticas Tradicionales. Biomedicina. VIH.

1 INTRODUCTION

Male circumcision is the most frequent surgery among men¹ and, among some ethnic groups, it is a ritual practice that symbolizes the passage from childhood to adulthood². It can be interpreted as the moment of attribution of social roles to men in many traditions³. This is a subject widely debated in the medical literature, either because of its correlation with the reduction in the risk of HIV infection⁴ or because of bioethical debates about autonomy and limits of body manipulation⁵.

In African countries, circumcision is a traditional practice in more than 400 communities or ethnic groups⁶ and needs to be understood from cultural perspectives and traditional medicine in its encounter with colonizing practices, whether resulting from the expansion of non-original religions (such as Islam or Christianity) or from contemporary medical practices related to HIV^{7 8}.

In publications on the health practices of peoples in sub-Saharan Africa, there is a tendency, according to more critical researchers⁹, to structure narratives from the perspective of the dominator. Thus, sanitarians, bioethicists and anthropologists must be aware of the unique histories of native peoples and the forms of resistance or adherence to the knowledge coming from contemporary scientific medicines. With regard to circumcision, it is not uncommon for medical interventions unrelated to traditional practice to be refused¹⁰.

This article presents some results of an ethnographic approximation study carried out among the Makonde ethnic group residing in Mozambique. The sociocultural context of circumcision in the autochthonous tradition and the influence it suffered in contact with other traditions are analyzed. At the end, some reflections on public health and bioethics on the subject are made.

2 COLONIAL PERIOD

Mozambique is a country on the east coast of Africa that, over time, has been occupied by peoples of different origins and cultures, Africans, Arabs, Indians and Europeans. The country is predominantly inhabited by the descendants of the Bantu, a large ethnolinguistic group that populates almost all of sub-Saharan Africa sharing sociolinguistic similarities in beliefs, rituals and customs¹¹. According to Firmino¹², in Mozambique there are thirteen ethnic groups: (1) Swahilis, (2) Makuas, (3) Lomués, (4) Makondes, (5) Yao or Ajaua, (6) Maraves or Nyanja, (7) Sena, (8) Chuabo, (9) Chonas

including the Ndaus, (10) Angonis or Nguni, (11) Tsongas (divided into Ronga, Changane and Vatswa), (12) Chopes, (13) Bitongas.

Circumcision is a traditional African practice that goes far beyond a simple cut of the foreskin. It implies a conception of the world and requires techniques, instruction processes and transmission of skills for its execution. Circumcision is a cultural symbol that is nourished by religious and ethnic values and expresses mechanisms of insertion in the various societies where it is in force¹³. In Mozambique, it is practiced for ethnic-religious reasons by the Swahilis, Makondes, Yao or Ajaua, Makuas-Lomués, Sena, Chuabo, Chopes, Bitongas and Vatswa. The Rongas and Changanas abandoned the rite by Nguni imposition and on the side of the Arab/Persian influence that wanted to impose their circumcision, but were prevented by the Portuguese.

The Portuguese and the Catholic Church tried to extinguish the initiatory rituals of the traditional African religion and part of the Muslim traders encouraged Africans to maintain their cultural traditions and beliefs in opposition to the hegemonic role of evangelization and Portuguese civilization^{14 15}. Traditional circumcision was only effectively extinguished by the Ngunes when they subjected the Rongas and Changanas in southern Mozambique to domination and the consequent replacement of the practice by the rite of piercing the ear lobe using a penknife, as a new symbol of identity of those submissive to Emperor Manikusse or Sochangana of Gaza.

Schwartz¹⁶ observes that the enslaved Africans taken to the Americas were not prevented from maintaining the practice of rites of passage, even though circumcision was advised against by the clerics who submitted them to baptism, which required adherence to Christianity. However, there were forms of resistance and cultural and religious perpetuation through the maintenance of traditional African practices in captivity. Sweet¹⁷ points out that at the beginning of the eighteenth century, in Brazil, there were reports of slaves refusing to have sexual relations with uncircumcised people who could be considered uninitiated or ritually impure.

3 POSTCOLONIA PERIOD

The end of Portuguese colonial domination, with the foundation of the Republic of Mozambique in 1975, represented the emergence of a new conception of nation, of forms of political, economic, cultural and religious organization that imprinted new directions on the emerging society. In this new context, there is a revival of cultural pluriethnic resistance,

of the oral traditions of local peoples who resist processes of colonial deterioration of their sacred universe, creating strategies for maintaining traditions. Ngole¹⁸, in his anthropological analysis of the Makondes, attests that there were political tensions for religious reasons, mainly related to the imposition of the Catholic faith during Portuguese domination.

4 DJANDO YA VAMAKONDE AND YAO

The Makondes are described as invincible, indomitable and hardened warriors, for their resistance against all forces that oppose their beliefs and traditions¹⁹. The protection of the bodily practices imposed on other ethnic groups in the *Likumbi* initiatory experience is a demonstration of how much they extend their ethnic supremacy beyond their borders. In the oral tradition, the Makonde consider themselves to have a deep kinship relationship with the Yao, sharing aspects of social organization and initiation rites²⁰. The Yao can be initiated into *Likumbi* and their ritualization can be validated by them. The Makondes, on the other hand, do not accept to be initiated into the *Unhango rite* of the Yao and do not validate it.

The Makondes keep their centuries-old traditions alive and have not allowed changes with regard to circumcision. With the HIV pandemic, some choose to take their children to medical circumcision. However, most do not fail to submit them to circumcision done through the use of knives and without anesthesia to comply with the rite of passage. The use of local anesthesia in traditional circumcision is rejected insofar as pain and bleeding are considered important experiences at the initiate's entry into adulthood.

The research revealed that some *Nalombwos* (masters of the rite) and young people who were already initiated, did not fully assume the introduction of biomedical procedures such as the individualized use of a cutting blade for each initiate. Previously, the *Nalombwos* reused cutting blades on initiates who did not bring their own blade. Throughout the fieldwork developed in the data collection of this article, it was verified that this still happened, evidencing the complexity of the dialogue between biomedical interventions and traditional practices.

Initiation is an ethnic socialization for both the Yao and the Makonde, although it is a practice carried out differently in each group²⁰. For example, there are changes between circumcision in the *Lupanda* Yao ritual before the Arab/Islamic influence and the current

Unhango. However, despite the similar structural composition of the Yao and Makonde rituals, the categorization of the preputial cut may differ from biomedical practice²¹.

However, it is important to be aware of some similar procedures. Yao circumcision is also performed by *Angaliba*, the initiation master, using a single instrument that serves all initiates and without sterilization as described in the reports of Yao participants²². This author describes one of the initiatory structural differences between *Unhango* and *Likumbi*. At *Unhango*, parents enlist the neophytes and, after confirmation, communicate it to the *regulus*, a local traditional authority, who in turn addresses the invitation to the Association of Traditional Doctors of Mozambique (AMETRAMO). It is up to him to indicate *Ngaliba*, master of traditional circumcision, who is not only in charge of the surgery, but also of inviting health professionals for any adverse episodes in the procedure. It is up to *Nakanga* to be in charge of learning and initiatory coordination.

This composition is more democratic among the Yao, as it involves the community and its structure. In the Makondes who moved to the south of Mozambique, the participation of parents and the community is notorious, but it does not involve AMETRAMO or the *regulus*. The entire initiatory process is circumscribed to the functions of *Nalombwo*, the surgical master, his power in initiation is absolute.

Likumbi begins at dusk, and some of the rites that precede it are surrounded by taboos and secrecy, which is why its realization is not always announced in advance. For example, circumcision is performed suddenly on the way to *Likuta* because, in the Makonde conception, *Likuta* is an impure and unsafe place for surgery if the sorcerers anticipate setting a trap to infect the surgery of *the Vawali*, initiates²¹. On the contrary, the Yao, according to Namuholopa²², enter the initiatory place at dawn, after invocation of the ethnic ancestors.

5 KUSOKA AND ISLAM

Kusoka is circumcision in the Bantu languages; even before the *Nguni invasion* of southern Mozambique it was a common ritual practice. The introduction of Islam and Arab/Persian culture in Africa in the mercantile era would have fascinated Balta²³. Black Islam inserted in the daily life of the communities assumed African values and traditions in their devotion, incorporating local autochthonous beliefs and practices into Islamic doctrine. Islam is rigid in the observance of its doctrinal principles, but in return, it is flexible to incorporate cultural practices and customs, except in the belief in a single god, *Allah, wāḥid*,

aḥad (one – first and only), pious and omnipotent. Their devotion rests on *Sunna* or tradition, analogical judgment *Qiyas* and *Ijma community consensus*, aimed at social embodiment and cohesion where religious life is not separated from everyday social life. This is the respect that is shown for the uniqueness of Islamic law, which serves both to legislate civil and religious life²⁴.

The *Kusoka custom* in the indigenous traditions of Mozambique currently predominates in all the native peoples of the provinces, with the exception of Tete, Manica and Maputo. According to Alpers²⁵, these traditions have been influenced over time by Islamic cultural and religious influence. This fact has occurred since the beginning of the seventh century in the region, when the action of Arab and Persian traders and navigators gave rise to the commercial centers of Sofala, Ilha de Moçambique, Quiloa and Pemba.

Mozambique has an undeniable and diverse presence of Muslims, who, according to reports by Newitt²⁶, would have been descendants of Islamists from different parts of the world and from branches of Islam. The cities of Mafia, Zanzibar, Mombasa, Gedi, Melinde, Manda, Lamu, Pate, Faza Brava, Merca, Mogadishu and the states of Comoros, Madagascar, Socotra, Mecca, Yemen, Oman, Persia, India, Ceylon, Indonesia, were part of the Indian Ocean trade network in the twelfth and seventeenth centuries before the Portuguese presence.

The permanence of Muslims on the coast of Mozambique has cooperated with the expansion of an Islam of denominations and attributes of diverse geographical origins. Amide²⁷ explains that the Arabs altered the cultural and religious scenario of the Yao by making them Muslims and made changes in the *Unhango*, an initiatory rite. In such a way, *Unhango* became *Shahada*, the initiation rite of the Islamic faith formerly called *Lupanda*, the male rite, and *Chiputo*, the female ritual. Amaral²⁸ considers that the majority of the Yao have lost the traditional meaning of initiation into Islamic devotion and have transformed rituals from their tradition to the *um*, a community of Muslim religious life.

Maivasse²⁹, in a study he carried out in the Neighbourhood of the Popular Forces for the Liberation of Mozambique (FPLM), one of the largest urban centres in the city of Maputo, shows that the practice of traditional circumcision is intricate in tradition and religion. On the other hand, the high urban social class has given it transformations, adjusting them to its elite status. The Islamic surgical and religious ritual with medical intervention to prevent the occurrence of HIV infections in this group of the urban center, according to the author, is a recent phenomenon.

This is where the predominance of ethnic circumcision ceases, in groups syncretized with Islam, as described in the Yao tradition. The Makondes are the only ones who separate the space of the *Djando*, ethnic circumcision, from the tradition of the *Shahada*, Islamic circumcision. They do not accept that the Islamic tradition imposes itself on the ethnic tradition. The *Djando* takes place in *Likuta*, sacred forest. Marcos³⁰ says that the Makonde who accept Islamization attend *Mwalimo*, a traditional Koranic school that teaches the theological basis of the Koran to initiates.

6 HIV ERA AND MEDICAL CIRCUMCISION

The overview of circumcision presented here reflects the social context in which the rite is circumscribed in the cultural traditions of the peoples of Mozambique. Some effects will be seen below in the context of the HIV/AIDS epidemic and the practice of biomedical circumcision.

The recommendation of male circumcision to reduce the risk of HIV infection by the World Health Organization (WHO) and the Joint United Nations Programme on HIV/AIDS (UNAIDS) published in 2007, precipitated the debate around why traditional circumcision is not part of the same strategy. According to this document, observational studies showed in various contexts of countries on the African continent that the prevalence of HIV was lower among men who had undergone circumcision.

In search of more substantiated scientific evidence, three randomized clinical trials were carried out in Kenya, Uganda and South Africa, which analyzed the efficacy, safety and acceptability of the strategy, the results show that the procedure reduces the risk of contracting HIV by 60% in circumcised women³¹. At the same time, studies have shown that male circumcision does not completely protect against acquiring HIV infection and, therefore, does not dispense with the use of other prevention strategies. Considering these findings, it was possible to incorporate male circumcision performed by trained medical professionals as another component of the range of prevention measures available to reduce heterosexual HIV infection in men. It has been determined that proper communication of this strategy is critical and culturally sensitive. It calls for the dissemination of clear messages, accompanied by the need to take other preventive measures concomitantly with male circumcision, with a view to comprehensive HIV prevention, including sexual abstinence within six weeks of circumcision.

From a sociocultural point of view, the WHO recommendation³¹ recognizes the role of circumcision in communities and in some religions such as Islamic and Jewish. In this sense, the health services that will offer this intervention need to be properly structured for the appropriate execution of this strategy, which involves safe scenarios for clinical practice in aseptic conditions, adequate equipment and team skills. And, in terms of human rights and ethical and legal principles, the document warns that this intervention raises concern. It is up to health services to guarantee informed consent to participants, informing them in detail of the risks and benefits of the intervention, as well as avoiding coercion and discrimination against users, as part of adherence to good medical practices.

These recommendations also extend to young people and adolescents with whom it is necessary to contemplate aspects of their maturity in carrying out the informed consent process. In addition, the WHO/UNAIDS document urges countries to be careful that the circumcision procedure does not promote non-consensual sex, domestic violence or link male circumcision to female genital mutilation. Male circumcision needs to be seen as an opportunity to strengthen sexual and reproductive health and to expand access to health services for young people and men.

Preventive medical circumcision of HIV in Mozambique has brought about two new social models of ritual practice. The first was to shift massive initiatory circumcision from ethnic traditions to medicine. Second, clinical practice has come to be guided by the principlism of Beauchamp and Childress, following four principles of Bioethics that underlie the obligation to sign the *free and informed consent form* (ICF)³². The informed consent form is important because it imposes rigor in safeguarding the patient's autonomy, proves the knowledge and agreement of their participation in medical acts, clarifies the objectives of the clinical intervention and the communication of risks and benefits of their free and conscious participation in the procedure³³.

Medical circumcision in Mozambique is recommended for children as young as 10 years old. In practice, it is carried out without signing the ICF and without respect for the principles of Bioethics. Children and their parents/guardians are unaware of the likely negative effects of circumcision, such as loss of sexual sensation, disabling complications, medical marketing to attract patients, and forced HIV testing. Such aspects raise criticism. Circumcision of minors without the consent of parents/guardians does not guarantee that children under 10 years of age will be excluded from the program, constituting another violation of bioethical principles³⁴. Two-thirds of medical circumcisions occurred among

men aged 10 to 19 years in Africa³⁵. In the district of Chókwé-Mozambique, 19,201 men aged 10 years or less were circumcised in the period from 2014 to 2019. This fact raises serious questions about the possible experimentation of adult circumcision on children without consent, according to Hines⁴, based on Jhpiego's work.

The parents described that their children were mobilized by teachers and nurses at the school, taken to the circumcision posts by health agents. Thus, under no circumstances should they refuse because it was an order of teachers and health professionals. They feared that their refusal to be circumcised could lead to punishment, barring them from attending school, as well as acts of discrimination and stigma in the school environment (*Nguyama, 56 years old*).

When it comes to specific patients, Miziara³⁶ says that only at risk of death, medical intervention can be performed with tacit consent, and this is not the case. Svoboda³⁷ believes that if circumcision of children is an HIV control strategy, the idea is that it should be applicable close to the age of initiation of sexual activity. For Dua³⁸ circumcision should be postponed until adulthood, so that men can give consent for the excision of the foreskin autonomously, choosing the type of procedure. Only in these circumstances is there no violation of the rules of medical ethics.

Paternity does not attribute ownership to children, as they are beings with individual will and originality, constituting subjects of actions that guide their existence. Their choices are no longer an inheritance of cultural traditions, they are acts of personal sovereignty and the individual's own decision, who have their own will, rights and different degrees of autonomy³⁹.

In another scenario, traditional circumcision has been pointed out as a risk practice for HIV infection, considering the limitations to ensure asepsis in the procedure, as well as the type of incision and tissue removal that is made. A challenge posed to biomedicine and traditional medicine with regard to circumcision is to find points of convergence for a dialogue that gives rise to the understanding of the medical pluralism that already exists in societies⁴⁰. That is, the use of various mechanisms for the health care of people that may or may not be complementary, concomitant or excluding. It is necessary to recognize the existence and legitimacy of traditional knowledge and practices and the various etiological and therapeutic conceptions that subsist in societies, which cannot necessarily be classified in terms of efficacy and safety as predicted by biomedicine. Therefore, there is a structured tension between the official health systems and the traditional systems based on the

rationalities of the procedures that are of a very different nature and that only make sense in the specificities of their respective sociocultural references.

Hence, the success of medical male circumcision programs should not be based solely on the number of men circumcised without consent. Ensuring the protection and safety of minors should be the priority, as well as assessing the psychosocial effects, their quality of life, depression, the quality of services provided, and the stigma arising from the perceived difference between circumcised and uncircumcised children. In some circumstances, the high number of circumcised individuals who did not comply with all procedures seeks to meet the goals of the program's funders on time⁴¹.

The success of medical circumcision programs contrasts with the increasing number of negative events associated with this procedure that translate into stigma and discrimination, calling into question the cost-effectiveness of global circumcision campaigns⁵.

7 THE AGE OF CONSENT IN THE WORLD

The age of consent is legitimized in people legally competent to consent to sexual activity, it varies from 11 - 21 years around the world⁴². The universal stance on consent is a practice to be adopted in Mozambique's circumcision strategies. It would also be a legal support for minors to decide about their sex life. Many countries around the world are concerned about children's legal age of consent as part of guaranteeing their rights to health. In cases of HIV, the age of consent is a social protection of patients against discrimination and stigma. At the same time, it is a guarantee of access to health care for adolescents in prevention, treatment and care⁴³. Such recognition would be a reflection of the country's commitment to the inclusion of ethnic minorities, children in vulnerable situations, and the protection of their health rights. Studies by Hein⁴⁴ and Coyne⁴⁵ argue that children have the capacity to decide about their health care.

Adherence to the circumcision program showed that children and parents/guardians do not have autonomy over the health of their children. It is alienated from the interests of third parties who act in the name of safeguarding health against HIV.

8 RISKS AND BENEFITS

The evaluation of risks and benefits in circumcision is analyzed from the perspective of surgical massification in the presumption of reducing the chances of HIV infection. The

risks should be measured based on the therapeutic effects and not by the non-therapeutic surgical massification that did not imply a discussion about the loss of the foreskin, the value it represents for the circumcised and the incalculable bodily and psychological damage it causes⁴⁶. What justifies circumcision of sexually inactive children? The theory of reducing the transmission of sexually transmitted infections through circumcision is valid from the first sexual intercourse³⁸, which begins on average at 18 years of age⁴⁷. Arruda⁴⁸ indicates that active sexual life begins between 7 - 18 years of age in men and in women between 7 - 17 years of age. HIV infection among men occurs more frequently between 20 and 30 years of age⁴⁹.

The principle of non-maleficence stipulates that acts that may cause useless harm to children and without immediate benefits should not be performed, in this case, in the removal of functional body tissue^{50 51}. Non-therapeutic circumcision imposes on the healthy child the risk of harm without benefit. This would then constitute an evil act. It also upholds the principle that physicians cannot take orders from the parents or guardians of children because the physician's duty is to the patient⁵². Non-maleficence is contradicted when a child is circumcised without the consent of the parents and under duress when doing something that may be considered malicious and superfluous, such as the removal of the foreskin.

The national circumcision protocol, adapted from the recommendations of the Joint United Nations Programme on HIV/AIDS (UNAIDS) and the President's Emergency Plan for AIDS Relief (PEPFAR), does not yet apply to mass surgeries in the country. It is likely that the local context may not be suitable for the ethical application of the ICF³². For Vaughn⁵³, the absence of consent can only be justified by the inability of a minor, mental illness, psychic disturbances, anguish, fear, pain, and the inability to make decisions, as he does not always know the implications of medical acts for his health.

9 FINAL CONSIDERATIONS

The specter that non-therapeutic male circumcision is a beneficial procedure because it protects against HIV transmission fuels the debate around whether this practice should be performed on children without the consent of the children or their parents. For apologists for circumcision without consent, there is no association that balances surgery and ethics, as uncertainties are reduced to life-saving medical acts. If there is an

association between surgery and practical medical ethics, there must be a policy that results from long years of doctor/patient relationship in its actions.

The circumcision policy of the Mozambican Ministry of Health, inspired by the recommendations of UNAIDS⁴⁹ of 2007, may be hampered in its implementation, according to Junqueira⁵⁴, due to the lack of an ethical culture of professional-patient consent before the era of preventive circumcision of HIV. This is a difficulty inherent to the introduction of a new technology, whether light or hard.

However, there is no circumstance that justifies parents enjoying the right to choose what is best for their children's health. Nor should this decision of the parents be made by the doctors. However, the existence of ethical laws and procedures dispels the omission of medical-professional responsibility.

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**EVOLUTION OF LEARNING AMONG SECOND-GRADE ELEMENTARY
SCHOOL STUDENTS IN THE MUNICIPAL EDUCATION NETWORK OF
MORENO/PE IN THE POST-COVID-19 PANDEMIC CONTEXT**

**EVOLUÇÃO DA APRENDIZAGEM DOS ESTUDANTES DO SEGUNDO ANO DO
ENSINO FUNDAMENTAL DA REDE MUNICIPAL DE ENSINO DE MORENO/PE
NO CONTEXTO PÓS-PANDEMIA DA COVID 19**

**EVOLUCIÓN DE LOS APRENDIZAJES EN ESTUDIANTES DE SEGUNDO
GRADO DE PRIMARIA DE LA RED EDUCATIVA MUNICIPAL DE MORENO/PE
EN EL CONTEXTO POST PANDEMIA DE COVID-19**

 <https://doi.org/10.56238/sevened2025.036-131>

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ABSTRACT

The second year of elementary school is a crucial phase for students' development towards mastering reading and writing. It is during this period that children need to consolidate essential skills for achieving literacy. In this sense, this research focuses on the results of second-grade classes in the Municipal Education Network of Moreno/PE, which made efforts and developed short- and long-term strategies with teachers to minimize the gaps identified in the students' literacy process due to the school distancing caused by the COVID-19 pandemic. The results of the Diagnostic Assessments of the Municipal Network for the years 2022, 2023, and 2024 were analyzed. Through document analysis (Ludke and André, 1986), the collected data were processed and analyzed in dialogue with the theoretical framework relevant to the theme of literacy: Ferreira (1999); Moraes (2012); Soares (2022; 2023). The results revealed that in 2022, only 41.2% of students who completed the 2nd grade reached the alphabetic writing hypothesis (they had completed the last year of Early Childhood Education and the 1st grade using activity books during the pandemic), while in 2024 this number rose to 68% (they completed the first year of Early Childhood Education using activity books during the pandemic). These data reinforce the importance of ongoing teacher training and monitoring of learning throughout this process.

Keywords: Literacy. Learning Gaps. Reading and Writing.

RESUMO

O 2º ano do Ensino Fundamental é uma fase importantíssima para o desenvolvimento dos estudantes rumo à apropriação da leitura e da escrita. É nesse período que as crianças precisam consolidar habilidades essenciais para a concretização da alfabetização. Nesse sentido, a presente pesquisa fez um recorte, analisando os resultados das turmas de segundo ano da Rede Municipal de Ensino de Moreno/PE, a qual envidou esforços e

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desenvolveu estratégias de curto e longo prazo junto aos professores a fim de minimizar as lacunas identificadas no processo de alfabetização dos estudantes devido ao distanciamento escolar ocasionado pela pandemia da COVID 19. Foram analisados os resultados das Avaliações Diagnósticas da Rede Municipal referente aos anos de 2022, 2023 e 2024. Por meio da análise documental (Ludke e André, 1986), os dados coletados foram tratados e analisados dialogando com o referencial teórico pertinente à temática da alfabetização: Ferreiro (1999); Moraes (2012); Soares (2022;2023). Os resultados revelaram que em 2022 apenas 41,2% dos estudantes que concluíram o 2º ano chegaram à hipótese de escrita alfabética (eles haviam cursado o último ano da Educação Infantil e o 1º ano por meio de cadernos de atividades no período da pandemia), já em 2024 este número subiu para 68% (eles cursaram o primeiro ano da Educação Infantil por meio de cadernos de atividades durante a pandemia). Esses dados reforçam a importância da formação docente continuada e do monitoramento das aprendizagens ao longo desse processo.

Palavras-chave: Alfabetização. Lacunas na Aprendizagem. Leitura e Escrita.

RESUMEN

El segundo año de la educación primaria es una fase crucial para el desarrollo de los estudiantes hacia el dominio de la lectura y la escritura. Es durante este período que los niños necesitan consolidar habilidades esenciales para alcanzar la alfabetización. En este sentido, esta investigación se centra en los resultados de las clases de segundo grado de la Red Municipal de Educación de Moreno/PE, que realizaron esfuerzos y desarrollaron estrategias a corto y largo plazo con los docentes para minimizar las brechas identificadas en el proceso de alfabetización de los estudiantes debido al distanciamiento escolar causado por la pandemia de COVID-19. Se analizaron los resultados de las Evaluaciones Diagnósticas de la Red Municipal para los años 2022, 2023 y 2024. Mediante el análisis de documentos (Ludke y André, 1986), los datos recopilados se procesaron y analizaron en diálogo con el marco teórico relevante para el tema de la alfabetización: Ferreiro (1999); Moraes (2012); Soares (2022; 2023). Los resultados revelaron que en 2022, solo el 41,2 % del alumnado que completó 2.º de primaria alcanzó la hipótesis de escritura alfabética (habían completado el último curso de Educación Infantil y 1.er curso utilizando cuadernos de actividades durante la pandemia), mientras que en 2024 esta cifra ascendió al 68 % (completaron el primer curso de Educación Infantil utilizando cuadernos de actividades durante la pandemia). Estos datos refuerzan la importancia de la formación docente continua y el seguimiento del aprendizaje durante todo este proceso.

Palabras clave: Lectoescritura. Brechas de Aprendizaje. Lectura y Escritura.

1 INTRODUCTION

Since the pandemic caused by COVID 19, education, in general, has encountered numerous challenges for the reorganization of curricula and student learning. Due to social distancing and the impediment of face-to-face classes across the country, many children returned to school with gaps in learning and emotional development that brought a new problem: the recomposition of these learnings.

We found that in the municipality of Moreno, located in the Metropolitan Region of Recife, students had their link with the school maintained through non-face-to-face activities during the years 2020 and 2021, returning to face-to-face classes only in 2022. In this context, there was a great challenge related to the guarantee of learning rights since, after two years of distance schooling through activity books and some contacts via *whatsapp* with teachers, children were greatly disadvantaged in terms of the content of various areas of knowledge.

In this sense, we identified reparative propositions made by the Municipal Department of Education which, through the adoption of diversified strategies, sought to overcome these learning gaps. As a first reparative measure, the Municipal Education Network promoted diagnostic evaluations in the network in order to identify the most urgent needs related, mainly, to literacy. Based on the results of the diagnostic evaluations, the coordination of the initial years of Elementary Education reorganized the continuing teacher training in order to offer support to teachers in the process of recovery and recomposition of these learnings, dealing intensely and systematically with the heterogeneity in the classrooms.

In view of this evidence, we established as a general objective of this research to analyze the data of the second year classes of the Municipal Education Network of Moreno/PE related to literacy. As specific objectives, we seek to:

- Compare the progress in the appropriation of the writing of second-year students for the years 2022, 2023 and 2024;
- Evaluate the importance of carrying out periodic diagnostic evaluations as a means of monitoring consolidated learning;
- Analyze the effects of a teaching practice planned based on the most immediate needs of students.

2 THEORETICAL FOUNDATION

The "literacy cycle" is the three-year period in which children must learn to read and write, that is, from the 1st to the 3rd year of Elementary School. This period aims for children to build their knowledge continuously, respecting their rhythms and ways of expressing themselves. However, the National Common Curriculum Base (BNCC) establishes that, by the end of the 2nd year, they must complete this cycle.

Although we know the importance of reading and the need to guarantee this right to all children, it is necessary to keep in mind that the literacy process is individual and can vary from child to child. Furthermore, historically, there is a loss in terms of learning to read and write at the national level.

When the focus turns to the Northeast, it is perceived that there is a real discrepancy between children from the lower classes of society and those from the middle and upper classes. These differences in opportunities and guarantee of rights reflect the unjust social inequality that exists in our country. In this sense, bringing forward the "literacy cycle" to two years does not seem to us to be a fair and sensitive decision to the many realities in which our children, from popular backgrounds, are inserted.

As for learning to read and write, Soares (2020) argues that all children can consolidate these skills. For the author, planning should focus on learning and, from there, systematize teaching, carrying out a constant evaluation of what they (children) already know and what they are already capable of learning, at the age they are.

Regarding the ways of teaching the language, from the 1980s onwards, research by Emília Ferreiro and Ana Teberosky (1999) gave space to the discussion on the Psychogenesis of Written Language. These studies were carried out in order to understand how children learned the written language and the growth of these discussions provided a new way of conceiving alphabetic notation and, consequently, the teaching of the Alphabetic Writing System (SEA).

In this context, Ferreiro (1990) breaks with the empiricist and associationist conception in force until then and argues that alphabetic writing is not a mere code, but rather a notational system. This means that the learner elaborates a series of hypotheses about what writing notes (or 'represents', 'writes') and how writing creates these notations (or 'representations').

Morais (2012) points out that the Psychogenesis of Written Language has brought great contributions to language teaching because it has weakened traditional teaching methods (which assume that the student learns by repeating and memorizing) because,

when formulating his hypotheses about writing, the learner uses strategies and reflections from previous knowledge that he acquires throughout his life.

These theoretical contributions have revolutionized the teaching of the language, since it is understood the paths that people follow until they appropriate SEA and formal reading. Brandão and Silva (2023) also argue that, before learning to read, children can learn to assume the posture of readers who think about the texts they hear and who strive to extract and produce meanings.

Thus, we argue that the period destined to the consolidation of literacy should be carefully planned, in order to help students understand and reflect on the language.

3 METHODOLOGY

In this study, we performed documentary analysis (LUDKE and ANDRÉ, 1986) in order to investigate more assertively the data provided by the Municipal Department of Education, prioritizing the second-year classes and their evolution over the years 2022, 2023 and 2024 regarding the appropriation of the SEA. We chose this school year because it is the year in which the children should already have the initial literacy process well underway to, in the third year, complete the literacy period (cycle).

We analyzed the diagnostic evaluations of entry and exit carried out in the Municipal Education Network, establishing a counterpoint on the results obtained in each of them. Next, we will evaluate the impacts caused by continuing education on the teaching practice of literacy teachers in the Network.

This study is presented with a qualitative-quantitative nature, conceiving the methodological procedures as the path of thought and practice exercised in the approach to reality (MINAYO, 2001, p.16) because, although the data collected are quantitative and are systematized in tables and Figures within this perspective, we cast a qualitative look at these results, analyzing what is beyond the numbers.

4 ANALYSIS AND DISCUSSION OF THE RESULTS

Initially, we analyzed the results for the year 2024, among which we were able to observe advances and gaps. We analyzed the participation rate in the evaluations in order to verify whether the results matched the reality and the variables in the writing hypotheses (the data had already been obtained through the investigation based on the Psychogenesis of

Written Language). Table 1 presents the participation rate in 2024 in the diagnostic assessments of entry (ADE) and exit (ADS) of the Municipal Education Network.

Table 1

Participation rate of 2nd year students in network evaluations in 2024

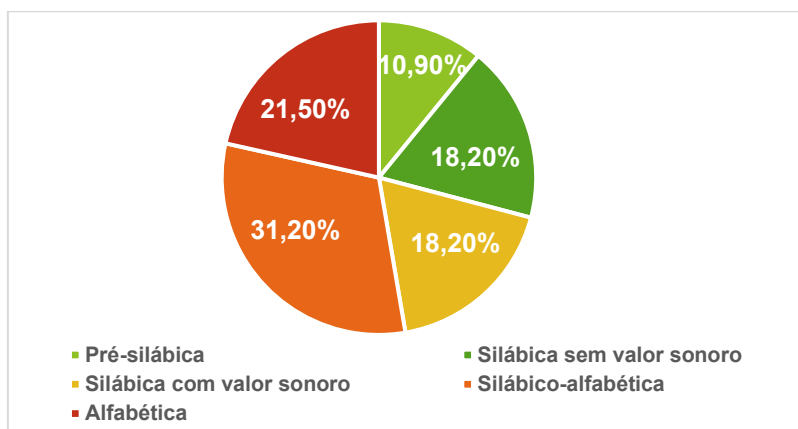
March 2024 - ADE	December 2024 - ADS
98%	96,3%

Source: Authors.

As we can see, most of the students were evaluated, which guarantees greater reliability of the data. In view of this, we begin the analysis of the evolution regarding the appropriation of the Alphabetic Writing System (writing hypotheses), the results of which are presented in the following Figures.

Figure 1

Evolution of Writing Hypotheses in the Diagnostic Entry Assessment



Source: Authors.

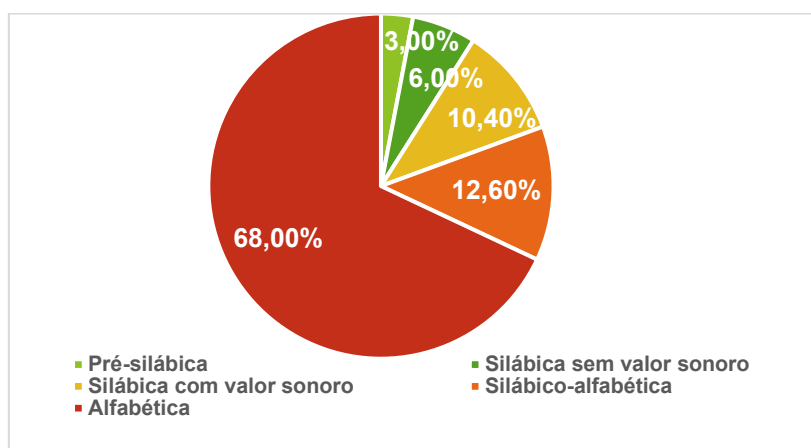
As we can see in the Figure above, the second-year classes at the beginning of 2024 were quite heterogeneous. In particular, students who revealed a pre-syllabic script added up to almost 11% of the total of the Network. We consider this an alarming data, since these students, in their majority, had experienced three years of schooling between Early Childhood Education and the first year of Elementary School.

Another fact that caught our attention is that more than 18% of the students also presented a syllabic script with no sound value. We consider that, in order to have a good performance in the second year, it would be ideal for students to enter this year of schooling having overcome the pre-syllabic and syllabic hypotheses without sound value.

Through the coordination of the initial years of the Municipal Department of Education, we identified that, throughout the year, there were several training courses aimed at overcoming these results, during which specific guidelines were given for this purpose. When we analyze the same data regarding the exit evaluation, we notice a very interesting movement, as we can see in Figure 2.

Figure 2

Evolution of Writing Hypotheses in the Diagnostic Exit Evaluation



Source: Authors.

The evolution of these students at the end of 2024 is significant. As we can see, only 3% of the students, who totaled almost 11% at the beginning of the year in pre-syllabic writing, completed the year at the same stage. Of the almost 18% who had syllabic writing without sound value, only 6% were unable to evolve. Another fact that draws our attention is that 68% of the students completed the second year with an alphabetic writing. These results show that the development of a pedagogical practice supported by the identification of the real learning needs of students and that has defined goals to be achieved in each year of schooling produce significant learning results.

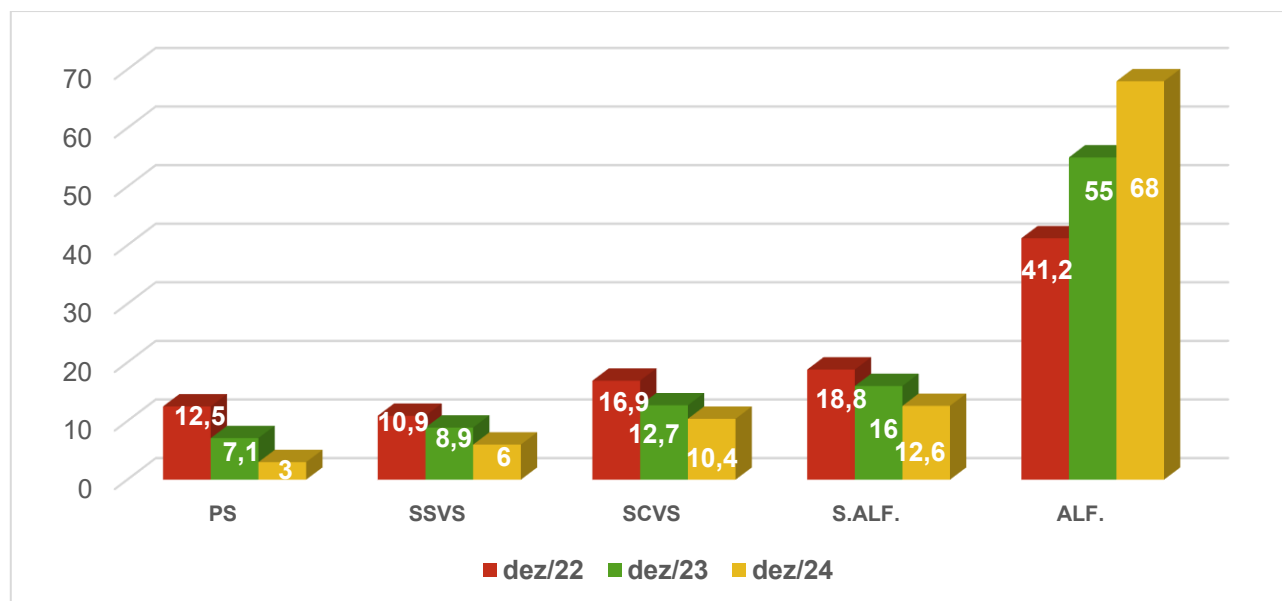
Although we recognize the qualitative leap that occurred throughout the year, we understand that it would be important that the 9% of students who completed the year in the pre-syllabic and syllabic hypotheses with no sound value had already overcome these hypotheses.

In order to deepen our understanding of the Municipal Education Network's efforts with teachers in order to recompose learning, we decided to analyze the results obtained in 2022 (right after the pandemic, when second-year students had only attended school at the age of 4 and returned in 2022, at the age of 7 years old already in the second year) and in the year

2023, whose students had not experienced Early Childhood Education, but had attended the 1st year of Elementary School in person, at school. The comparative results between the three years are presented in Figure 3 below:

Figure 3

Evolution of writing hypotheses in the years 2022, 2023 and 2024



Source: Authors.

The comparative results above point to a growing evolution of students in the writing hypotheses over the years observed. Considering that in 2022 second-year students had not experienced school experiences in person neither in early childhood education Group 3 – 5 years old nor in the first year, the deficit of these children in relation to the appropriation of alphabetic writing is notorious. This year, we noticed that 12.5% completed the year in the pre-syllabic hypothesis, signaling a great challenge to be overcome by the Municipal Education Network. Another alarming fact, still in 2022, was the large percentage of students in the syllabic hypothesis without sound value (10.9%), further increasing the need to recompose the learning of these students in the following year.

In 2023, second-year students had attended the first year in person and already had the prospect of recomposing learning through the reparative measures instituted by the Department of Education. As a result, we can already see that, in 2023, there was a better performance related to the comprehension of the Writing System, as 7.1% of students completed the pre-syllabic hypothesis and 8.9% in the syllabic without sound value. We

noticed that the scenario, although still challenging, began to become milder, adding up to 16% of students in these hypotheses.

When we look at the results of the year 2024, we observe that the movement of recovery and repair of learning has become more evident, since, adding the pre-syllabic and syllabic hypotheses without sound value, the results pointed to 9% of the students. Looking closely, in the pre-syllabic hypothesis, there was only 3%. A relevant point is that 68% of the children completed the year in the alphabetic hypothesis.

5 FINAL CONSIDERATIONS

In view of the analyses, we realized that the teaching practices mediated by the investments of continuing education were essential for the evolution of the students. In this regard, Marinho (2020) draws attention to the need for teachers to be clear about what they want to achieve when planning their classes, in this case, it is important to trace a path in order to conduct systematic teaching and promote reflection on the language.

We consider that the decisions made by the Education Network constituted a differential that significantly interfered in the results obtained in the period from 2022 to 2004. By investing in a restructuring of continuing education, as well as in the definition of clear and accessible goals for the literacy teacher, there was a redirection of pedagogical practice, culminating in very satisfactory learning results.

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**EMERGING DIGITAL TECHNOLOGIES IN ENGINEERING EDUCATION:
PEDAGOGICAL POTENTIAL FOR ACTIVE LEARNING AND COMPETENCY
DEVELOPMENT**

**TECNOLOGIAS DIGITAIS EMERGENTES NO ENSINO DE ENGENHARIA:
POTENCIAL PEDAGÓGICO PARA APRENDIZAGEM ATIVA E
DESENVOLVIMENTO DE COMPETÊNCIAS**

**TECNOLOGÍAS DIGITALES EMERGENTES EN LA ENSEÑANZA DE LA
INGENIERÍA: POTENCIAL PEDAGÓGICO PARA EL APRENDIZAJE**

 <https://doi.org/10.56238/sevened2025.036-132>

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ABSTRACT

Engineering education in the 21st century requires continuous modernization, driven by digital technologies and the demands of Industry 4.0. This article investigates how emerging technologies—virtual and remote laboratories, 3D printing, the Internet of Things, and immersive realities—contribute to active learning and competency development in engineering education. The study is based on an integrative literature review with a qualitative approach, analyzing 80 studies published between 2010 and 2025 through thematic content analysis. The results indicate that virtual and remote laboratories expand access to and safety in experimentation; 3D printing supports prototyping and the integration of theory and practice; IoT enables instrumentation, automation, and data analysis; and immersive realities enhance visualization and safe training. It is concluded that integrating these technologies with active methodologies, such as Project-Based Learning, is strategic for pedagogical innovation, provided it is supported by intentional curriculum planning and adequate faculty development.

Keywords: Engineering Education. Digital Technologies. Active Learning. Industry 4.0. Competencies.

RESUMO

O ensino de engenharia no século XXI demanda constante modernização, impulsionada pelas tecnologias digitais e pelas exigências da Indústria 4.0. Este artigo investiga como tecnologias emergentes — laboratórios virtuais e remotos, impressão 3D, Internet das Coisas e realidades imersivas — contribuem para a aprendizagem ativa e o desenvolvimento de competências no ensino de engenharia. A pesquisa baseia-se em uma revisão integrativa de literatura, de abordagem qualitativa, analisando 80 estudos publicados entre 2010 e 2025, por meio de análise de conteúdo temática. Os resultados indicam que laboratórios virtuais e remotos ampliam o acesso e a segurança na experimentação; a impressão 3D favorece a prototipagem e a integração entre teoria e prática; a IoT apoia a instrumentação, a automação e a análise de dados; e as realidades imersivas aprimoram a visualização e o treinamento seguro. Conclui-se que a integração dessas tecnologias com metodologias ativas, como a Aprendizagem Baseada em Projetos,

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é estratégica para a inovação pedagógica, desde que acompanhada de planejamento curricular intencional e formação docente adequada.

Palavras-chave: Ensino de Engenharia. Tecnologias Digitais. Aprendizagem Ativa. Indústria 4.0. Competências.

RESUMEN

La enseñanza de la ingeniería en el siglo XXI requiere una modernización constante, impulsada por las tecnologías digitales y las demandas de la Industria 4.0. Este artículo investiga cómo las tecnologías emergentes—laboratorios virtuales y remotos, impresión 3D, Internet de las Cosas y realidades inmersivas—contribuyen al aprendizaje activo y al desarrollo de competencias en la enseñanza de la ingeniería. El estudio se basa en una revisión integradora de la literatura, con un enfoque cualitativo, que analiza 80 estudios publicados entre 2010 y 2025 mediante un análisis de contenido temático. Los resultados indican que los laboratorios virtuales y remotos amplían el acceso y la seguridad en la experimentación; la impresión 3D favorece la prototipación y la integración entre teoría y práctica; la IoT apoya la instrumentación, la automatización y el análisis de datos; y las realidades inmersivas mejoran la visualización y el entrenamiento seguro. Se concluye que la integración de estas tecnologías con metodologías activas, como el Aprendizaje Basado en Proyectos, es estratégica para la innovación pedagógica, siempre que esté acompañada de una planificación curricular intencional y de una adecuada formación docente.

Palabras clave: Enseñanza de la Ingeniería. Tecnologías Digitales. Aprendizaje Activo. Industria 4.0. Competencias.

1 INTRODUCTION

The twenty-first century imposes an unprecedented pace of transformation on engineering education, catalyzed by the exponential advance of digital technologies, the globalization of knowledge and the new and dynamic demands of the labor market. This scenario requires higher education institutions to constantly reevaluate and modernize their pedagogical approaches, with a growing focus on innovation, interdisciplinarity, and the promotion of active and meaningful learning (KENSKI, 2012; MORAN, 2018).

Traditionally, engineering education has been marked by expository methodologies and the transmission of content, a model that has been criticized for not keeping up with the rapid pace of technological innovation (FREIRE, 1996; PRINCE; FELDER, 2006). In this context, the strategic incorporation of technological resources emerges as one of the most relevant trends for the contemporary training of engineers. Tools such as virtual and remote laboratories, computer simulation environments, 3D printers, intelligent sensors (IoT), and immersive realities are not mere accessories, but structuring elements capable of fundamentally transforming teaching and learning processes (ABENGE, 2020; FELDER; BRENT, 2016).

The relevance of these technologies lies in their ability to enhance active methodologies, which, in turn, promote student protagonism, the practical application of knowledge, and meaningful learning. As Moran (2018) and Valente (2019) emphasize, the pedagogical use of digital technologies should not be limited to the simple replacement of traditional tools, but rather to the construction of interactive learning environments where the student is challenged to investigate, create, and solve real problems.

Given this conjuncture, the main objective of this article is to investigate and discuss how emerging digital technologies – specifically virtual and remote laboratories, 3D printing, Internet of Things (IoT) and immersive realities – enhance active learning and the development of skills in engineering education. To this end, this study synthesizes theoretical and empirical evidence from an integrative literature review, highlighting the main pedagogical benefits and the ways in which these innovations contribute to an education more aligned with the demands of Industry 4.0.

2 THEORETICAL FRAMEWORK

The theoretical framework underpins the analysis of the pedagogical potential of digital technologies in engineering education from the articulation between digital

education, active methodologies and learning theories. The role of emerging technologies — such as virtual and remote laboratories, 3D printing, Internet of Things (IoT) and immersive realities — in promoting active learning and the development of skills aligned with Industry 4.0 is highlighted.

2.1 DIGITAL EDUCATION AND ACTIVE METHODOLOGIES IN ENGINEERING EDUCATION

The digital transformation in engineering education implies more than the adoption of new tools, requiring the review of pedagogical practices and the valorization of student protagonism, autonomy and integration between theory and practice. In this context, active methodologies such as the flipped classroom, Project-Based Learning (PBL) and inquiry-based learning have been consolidated in the Brazilian scenario, as evidenced by Valença (2023).

Empirical studies indicate that the adoption of these methodologies contributes to engagement and learning, including in remote contexts, as demonstrated by Medeiros and Neto (2024) and Damasceno (2022). These results converge with the principles of Education 4.0, which emphasize experimentation, practical learning, and collaboration as formative axes to meet the demands of Industry 4.0 (CARVALHO NETO apud ABENGE, 2025). The literature also points out that emerging digital technologies act as structuring elements of these methodologies, favoring the development of skills such as problem solving, prototyping, data analysis and technical communication.

2.2 FUNDAMENTALS OF LEARNING AND THE ROLE OF TECHNOLOGIES

Active methodologies supported by digital technologies are supported by classical theories of learning. Bloom's taxonomy guides the definition of progressive educational objectives, especially relevant in engineering education, which demand practical application and complex problem solving.

In the cognitive field, strategies such as prior organizers, concept maps, and formative assessments favor meaningful learning. Felder and Brent (2016) highlight the importance of continuous formative assessments, structured feedback, and authentic tasks, often articulated with physical or virtual laboratory activities. The integration between interactive technologies, laboratories and training strategies is, therefore, a central axis to enhance learning and consolidate the technical reasoning of engineering students.

2.3 EMERGING DIGITAL TECHNOLOGIES AND THEIR PEDAGOGICAL POTENTIAL

Engineering education has been driven by the incorporation of digital technologies that expand the possibilities for experimentation, visualization, and the development of practical skills. Each technology contributes in a specific way to the training of the contemporary engineer.

2.3.1 Virtual and remote labs

Virtual (LV) and remote (LR) laboratories have consolidated themselves as relevant alternatives in the face of infrastructure limitations, especially in public institutions. These environments expand access to experimentation, reduce costs and increase safety, in addition to enabling the repetition and personalization of experiments (HERADIO et al., 2016; MENDES et al., 2021). Systematic reviews indicate that the integration of immersive technologies in these laboratories enhances engagement and understanding of complex content (SLR, 2024). Evidence indicates that its effectiveness is amplified when associated with active methodologies and qualified teacher mediation.

2.3.2 3D Printing and Rapid Prototyping

3D printing has stood out as a pedagogical resource for curricular modernization, by allowing rapid prototyping and the development of iterative projects. This technology brings theory and practice closer together, strengthens design thinking, and favors contextualized learning (FLORES; SILVA; OLIVEIRA, 2016; CHONG et al., 2018). Studies demonstrate its applicability in different educational contexts, including during the COVID-19 pandemic (GÓMEZ et al., 2020; KUMAR; JHA; SINGH, 2022), contributing to the development of technical, analytical and collaborative skills.

2.3.3 Internet of Things (IoT)

The Internet of Things (IoT) stands out in engineering education for enabling instrumentation, automation, and real-time data collection activities, in line with the principles of Industry 4.0. Research indicates that IoT expands student autonomy and the practical applicability of knowledge, especially in remote laboratories and multidisciplinary projects (ZUTIN; LOWE; GÜTL, 2018; FAEZIPOUR; KARR, 2018; ZHAO et al., 2020; KIM; PARK, 2023). By enabling the monitoring and analysis of connected systems, IoT contributes to the development of analytical and problem-solving skills.

2.3.4 Immersive Environments and Virtual Reality (VR)

Immersive environments and virtual reality (VR), although still in the consolidation phase, have high pedagogical potential in engineering education. These technologies favor spatial visualization, simulation of complex processes, and safe training in risk scenarios (DEDE, 2009). Recent studies point to improvements in motivation, conceptual understanding and student retention with the use of VR (ALALWAN; ALZAHRANI, 2020; GÓMEZ; MENENDEZ; GARCÍA, 2021). Applications in different areas of engineering, including Software Engineering and Mechanical Engineering, indicate its potential for immersive hands-on experiences and hands-on learning (ANDRADE et al., 2022; ROHR et al., 2022; PEREZ; KELEŞ, 2025).

3 METHODOLOGY

This article is based on an integrative literature review, according to the model proposed by Whittemore & Knafl (2005). The research was designed with a qualitative approach, of a theoretical and documentary nature, with the objective of identifying, analyzing and synthesizing, in a systematic way, the existing evidence on the use of virtual and remote laboratories, 3D printing, Internet of Things (IoT) and immersive realities in engineering education. The main focus was on the context of public higher education institutions, where these resources are strategic to overcome structural challenges and promote pedagogical innovation.

The stages of search, selection, extraction, and synthesis of the data were guided and reported according to the guidelines of the PRISMA 2020 protocol (Page et al., 2021), adapted for integrative reviews, aiming to maximize the transparency and reproducibility of the process. According to Mendes-da-Silva (2019), integrative reviews are particularly effective in articulating different types of studies, providing a comprehensive and comparative understanding of the phenomenon investigated.

3.1 GUIDING QUESTION AND PCC STRATEGY

The review was guided by the following guiding question: How have virtual and remote laboratories been used in engineering education to promote active learning, experimentation and pedagogical innovation in public institutions?

To structure the question, the PCC (Population-Concept-Context) strategy was used:

- Population (P): engineering students and professors;

- Concept (C): virtual and remote laboratories (including related technologies: 3D printing, IoT, VR/AR, simulations);
- Context (C): public institutions of higher education.

3.2 SEARCH STRATEGY

The searches were carried out between January and September 2025 in the following databases: *SciELO*, *ERIC*, *Scopus*, *ScienceDirect*, *IEEE Xplore*, and *Google Scholar*. To ensure comprehensiveness and relevance, descriptors in Portuguese and English combined with Boolean operators (AND/OR) were used. The general strings used included, among others, the following:

- **Portuguese:**
("engineering education" OR "engineering education") AND ("virtual labs" OR "remote labs" OR "virtual learning environments") AND ("active learning" OR "active methodologies" OR "project-based learning")
- **English:**
("engineering education") AND ("virtual laboratories" OR "remote labs" OR "virtual experimentation environments") AND ("active learning" OR "project-based learning" OR "problem-based learning")

In addition to these, specific strings and filters were applied by base (summarized examples):

- **SciELO** (search in Jan/2025) — filters: 2010–2025; articles; languages: PT/EN/ES.
- **ERIC** (Feb/2025) — filters: 2010–2025; types: journal article, dissertation, report; language: English.
- **Scopus** (Mar/2025) — filters: 2010–2025; types: article, review, conference paper; languages: PT/EN/ES.
- **ScienceDirect** (Apr/2025) — filters: 2010–2025; article/review; language: English.
- **IEEE Xplore** (May/2025) — filters: 2010–2025; journals/conferences; language: English.
- **Google Scholar** (Sep/2025) — filters: 2010–2025; include citations; exclude patents; PT/EN/ES.

3.3 SELECTION AND ORGANIZATION OF STUDIES

The selection process followed the PRISMA 2020 protocol (Page et al., 2021). The stages were:

1. Identification: initial survey in the selected databases — $n = 412$ records.
2. Screening: removal of duplicates and reading of titles/abstracts; deleted 189 records.
3. Eligibility: full reading of 223 potential studies; 143 were excluded because they did not meet the criteria.
4. Inclusion: final selection of 80 studies that composed the corpus of the analysis.

3.4 INCLUSION CRITERIA

- Published between 2010–2025;
- Peer-reviewed research (with the exception of relevant reports from public universities);
- Studies directly related to engineering education;
- Research on core technologies (LV, LR, 3D printing, IoT, VR/AR, simulations);
- Languages: Portuguese, English and Spanish.

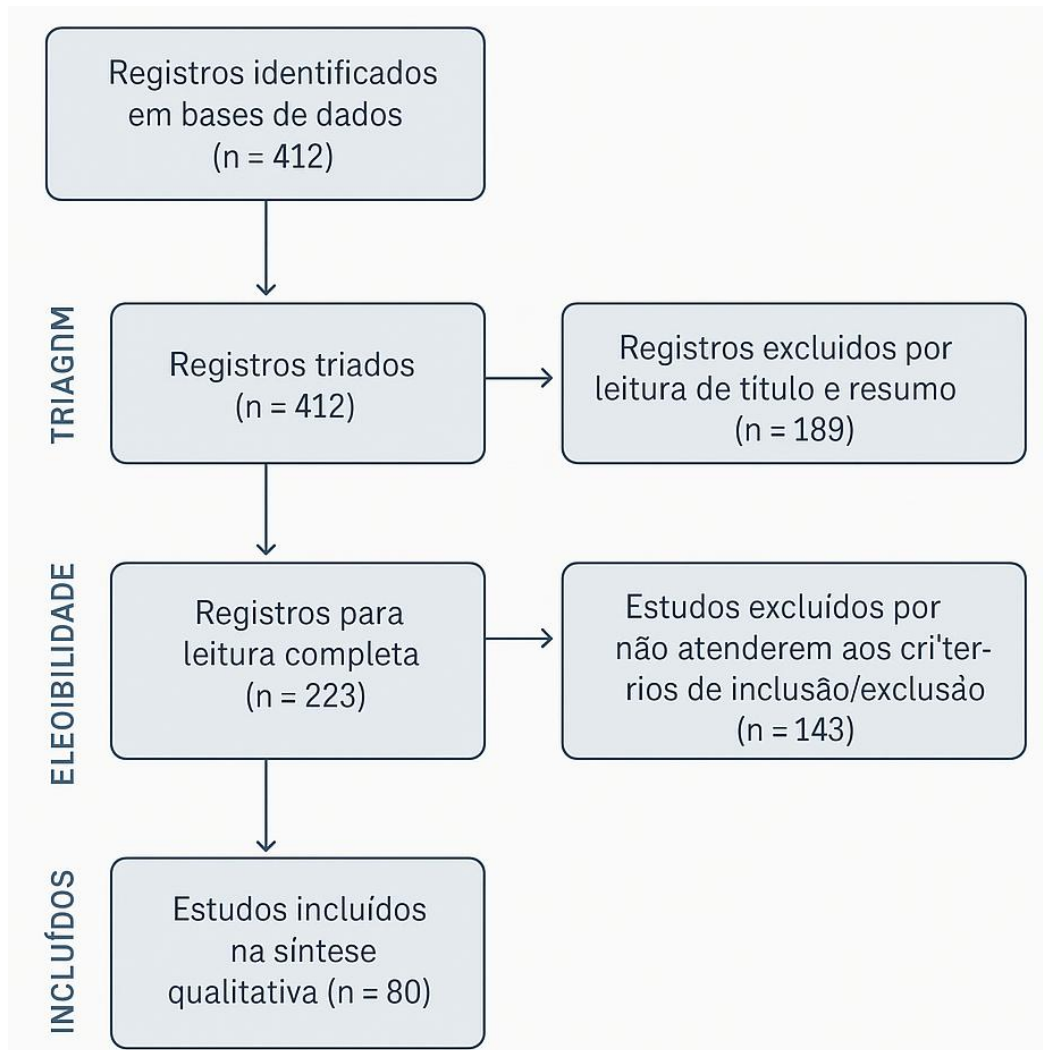
3.5 EXCLUSION CRITERIA

- Publications prior to 2010;
- Productions without peer review (except specific reports from public universities);
- Studies without direct link to engineering education;
- Technologies not related to experimentation or outside the defined scope;
- Texts without access to the full content.

The management of references was performed with *the Zotero®* software; data extraction was recorded in spreadsheets containing, at least: Author, Year, Country, Type of Study, Technology, Method and Main Findings.

Figure 1

PRISMA 2020 flowchart of the study selection process



Source: Authors.

3.6 DATA ANALYSIS

The qualitative analysis of the 80 studies followed the thematic content analysis technique of Bardin (2011), in three phases:

1. **Pre-analysis:** exploratory reading and preliminary organization of the material;
2. **Exploration of the material:** identification and thematic categorization (pedagogical practices, infrastructure, teaching challenges, impact on learning);
3. **Interpretation:** analytical synthesis, identification of emerging trends and integration with the theoretical framework.

The findings were grouped into three analytical categories: (a) pedagogical potential of virtual and remote laboratories; (b) technical and institutional limits and challenges; and (c) implementation strategies in public institutions.

3.7 VALIDITY AND RELIABILITY

Procedures were adopted to ensure methodological rigor, according to Kitchenham (2004) and Whitemore & Knafl (2005):

- Traceability: complete record of search strings, stages and dates of searches;
- Explicit criteria: transparent application of inclusion/exclusion criteria;
- Theoretical triangulation: integration of engineering literature, education and digital technologies;
- Cross-review and divergence resolution: two independent evaluators on screening and eligibility; divergences resolved by consensus, with consultation with a third researcher in deadlocks;
- Systematic record: continuous documentation of all methodological decisions.

4 RESULTS AND DISCUSSIONS

This section presents and discusses the results of the integrative literature review, highlighting the pedagogical potential of emerging digital technologies for active learning and the development of competencies in engineering education. The analysis of the 80 studies published between 2010 and 2025 revealed consistent patterns regarding the effectiveness of these technologies in the training of engineers.

4.1 SELECTION PROCESS AND CHARACTERIZATION OF STUDIES

The selection of studies strictly followed the PRISMA 2020 protocol (PAGE et al., 2021), resulting in the inclusion of 80 articles from an initial universe of 412 publications. There was a significant growth in publications from 2016 onwards, reflecting the consolidation of Industry 4.0 benchmarks and the expansion of the use of digital technologies in engineering education, as highlighted by Heradio et al. (2016) and Zhang et al. (2020).

Geographically, the studies are concentrated in Europe (38%), Latin America (27%), Asia (22%) and North America (13%). In Brazil, scientific production reveals a strong role of public universities, aligned with curriculum modernization policies and the National Curriculum Guidelines for Engineering, according to ABENGE. Initiatives described by

Fernandes Brum, Purcidonio and Azevedo Ferreira (2017) and Mendes, Ferreira and Campos (2021) illustrate this movement.

4.2 DIGITAL TECHNOLOGIES AS CATALYSTS FOR ACTIVE LEARNING

The thematic analysis identified four core technological categories that act as catalysts for pedagogical innovation: virtual and remote labs, 3D printing, IoT, and immersive environments. Although distinct, these technologies converge in the promotion of experimentation, student engagement and the development of skills.

4.2.1 Virtual and Remote Labs (LV/LR)

VL/LR are the most recurrent category, present in 43% of the studies. The literature highlights its ability to expand access to experimentation, reduce costs and risks, and enable repeatable and personalized practices. Empirical evidence points to significant gains in autonomy, motivation and conceptual performance of students (HERADIO et al., 2016; MENDES et al., 2021).

Classic and recent studies emphasize that VL/LR complement physical laboratories, especially when integrated with active methodologies and mediated by qualified professors (BALAMURALITHARA; WOODS, 2009; DE LA TORRE; SANCHEZ; DORMIDO, 2013; SLEEPING; VARGAS; SÁNCHEZ, 2015; NAKAYAMA; YAMAMOTO, 2021; KELLER; MARTINS; SILVEIRA, 2022).

4.2.2 3D Printing and Rapid Prototyping

3D printing appears in 31% of the studies, standing out for integrating theory and practice through iterative cycles of design, modeling, prototyping and testing. This approach strengthens project-based learning, design thinking, and problem-solving (FLORES; SILVA; OLIVEIRA, 2016; CHONG et al., 2018; TORRES et al., 2022).

Applications reported by Gómez et al. (2020) and Kumar, Jha, and Singh (2022) show their effectiveness even in adverse contexts, such as the pandemic, contributing to the development of technical, analytical, creative, and collaborative skills.

4.2.3 Internet of Things (IoT)

IoT was identified in 24% of the studies, mainly in instrumentation, automation, and data analysis activities. The literature highlights its role in collecting data in real time,

remotely monitoring systems, and supporting formative evaluations and multidisciplinary projects (ZUTIN; LOWE; GÜTL, 2018; FAEZIPOUR; KARR, 2018; ZHAO et al., 2020; KIM; PARK, 2023).

In addition, recent studies point to the use of IoT as a support for continuous feedback and authentic assessments, strengthening active learning and data-driven decision-making (FERREIRA; OLIVEIRA; MATOS, 2019; ABREU; MACHADO; TORRES, 2024; PADILLA et al., 2025).

4.2.4 Immersive Environments and Virtual Reality (VR)

Although less frequent (12% of studies), VR demonstrates a high pedagogical impact, especially in spatial visualization, simulation of complex processes, and safe training in risk scenarios (DEDE, 2009; ALALWAN; ALZAHRANI, 2020; GÓMEZ; MENENDEZ; GARCÍA, 2021).

Research in different areas of engineering indicates increased motivation, better conceptual understanding, and support for practical learning, including applications in Software Engineering and Mechanical Engineering (ANDRADE et al., 2022; ROHR et al., 2022; PEREZ; KELEŞ, 2025; KELEŞ; PEREZ, 2025).

4.3 INTEGRATION WITH ACTIVE METHODOLOGIES AND SKILLS DEVELOPMENT

The studies analyzed converge in indicating that digital technologies act as facilitators of active methodologies, and not as ends in themselves, corroborating Moran (2018) and Kenski (2012). Its integration enhances approaches such as PBL, flipped classroom, and inquiry-based learning (VALENÇA, 2023; FERREIRA; OLIVEIRA; MATOS, 2019; MEDEIROS; NETO, 2024).

This articulation contributes directly to the development of essential competencies of contemporary engineering, such as complex problem solving, iterative prototyping, data analysis, collaborative work, and technical communication (CHONG et al., 2018; KIM; PARK, 2023; MENDES et al., 2021; VALENTE, 2019). Such competencies are essential to meet the demands of Industry 4.0 (SPINELLI; LEMOS; BARBOSA, 2022).

4.4 INTEGRATED DISCUSSION

The results indicate that engineering education is at a turning point, in which emerging digital technologies play a central role in redefining the learning experience. The

predominance of LV/LR confirms its consolidation as an effective solution for experimentation, while the growing adoption of 3D printing, IoT and VR signals the evolution towards more immersive and contextualized environments.

The pedagogical potential of these technologies lies in their ability to enable active learning, promoting student protagonism and the integration between theory and practice. However, studies reinforce that its benefits depend on intentional curriculum planning and articulation with active methodologies. Thus, the synergy between digital technologies and innovative pedagogical approaches emerges as the most promising path for a relevant engineering education aligned with the challenges of the twenty-first century.

5 CONCLUSION

This integrative review delved into the transformative pedagogical potential of emerging digital technologies—virtual and remote labs (LV/LR), 3D printing, Internet of Things (IoT), and immersive realities (Virtual/Augmented Reality)—in engineering education. Our primary focus was to understand how these tools promote active learning and the development of core competencies, positioning future engineers for the complex and dynamic challenges of Industry 4.0.

The results consolidate the evidence that digital technologies significantly expand access to experimentation, providing safe, flexible and often more cost-efficient learning environments. LV/LR, in particular, allow continuous (24/7) and personalized access to practice, overcoming geographical and structural barriers. 3D printing, in turn, enables rapid prototyping, fluidly integrating theory and practice and fostering iterative design. IoT emerges as an indispensable pillar for instrumentation, automation, and real-time data collection, aligning student training with the demands of intelligent systems and data analysis. Concurrently, virtual reality provides immersive experiences that substantially enhance spatial visualization and enable safe training in high-risk scenarios, without the implications of the actual physical environment.

The integration of these technologies with active methodologies is not only a crucial factor, but a symmetrical and enhancer factor. They act as powerful facilitators for approaches such as Project-Based Learning (PBL) and the flipped classroom, in which the student transcends the role of mere receiver, becoming an active protagonist of his or her learning process, engaging in real problem solving, experimentation, and creation. This synergy robustly fosters the development of a set of multidisciplinary competencies

indispensable for the modern engineer, including the ability to solve complex problems, expertise in prototyping and iterative design, proficiency in data analysis and interpretation, the ability to work collaboratively in multidisciplinary teams, and effective technical communication.

However, the full realisation of this potential is intrinsically linked to overcoming significant institutional and structural challenges.

The review highlighted persistent barriers such as insufficient teacher training for the new tools and methodologies, limitations in the technological infrastructure of institutions, and the urgent need for robust institutional policies that ensure the democratization of access and the sustainable integration of these innovations. Addressing these issues, especially in public institutions, is critical to ensuring the equity and quality of engineering education in the country.

In short, the answer to the question that guided this study is affirmative and multifaceted: emerging digital technologies are undeniably strategic and powerful resources for pedagogical innovation in engineering education. They enhance active learning and the development of skills, creating more dynamic, engaging learning environments aligned with the complex demands of the twenty-first century.

However, its enduring success requires not only technological adoption, but also intentional curriculum planning, continued investment in teacher training, and the development of institutional policies that promote articulation with collaborative practices and comprehensive formative assessment, ensuring that technology serves as a strategic means to well-defined educational objectives and to the training of professionals able to innovate and lead.

5.1 STUDY LIMITATIONS

It is important to recognize that this article, being derived from an integrative review, inherits some of the limitations intrinsic to the original research. The methodological heterogeneity of the included studies—although characteristic of this type of review—and the restriction of the search to indexed databases may have influenced the breadth and depth of the evidence collected, potentially omitting other relevant experiences.

In addition, the temporality of the data (2010-2025) means that very recent innovations may not yet have been fully incorporated into the literature analyzed here, suggesting a field in constant evolution.

5.2 IMPLICATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

The findings of this study have significant implications for educators, academic managers, and public policy makers. For educators, we suggest broader and more informed adoption of digital technologies, with an unwavering focus on their synergistic integration with active methodologies. For academic managers, the urgency of investing in the continuing education of teachers and in the improvement and maintenance of technological infrastructure is emphasized. For policymakers, it is crucial to develop strategies that mitigate regional and institutional inequalities while ensuring equitable access to these resources.

For future research, we recommend:

The realization of longitudinal empirical studies that evaluate the long-term impact of these technologies on the development of engineering skills and on the professional trajectory of graduates.

In-depth comparative analyses between different types of institutions (public vs. private, large vs. small) to understand the nuances of implementation and the specific challenges faced.

Research focused on teacher training, investigating the most effective strategies to train teachers in the pedagogical and methodological use of these technologies.

Detailed case studies on the implementation of successful institutional policies for the integration of digital technologies, identifying replicable models.

The exploration of other emerging technologies or the combination of multiple technologies in engineering learning environments, deepening the understanding of the mechanisms that enhance complex learning.

By addressing these gaps and following these recommendations, the scientific community and educational institutions will be able to contribute even more significantly to the advancement of engineering education, ensuring that future generations of professionals are fully equipped for the technological and societal challenges of the 21st century.

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**BETWEEN THE PRESERVATION OF FREEDOM AND RATIONALITY:
ANALYSES BY JOHN DEWEY AND HERBERT MARCUSE**

**ENTRE A PRESERVAÇÃO DA LIBERDADE E A RACIONALIDADE: ANÁLISES
DE JOHN DEWEY E HERBERT MARCUSE**

**ENTRE LA PRESERVACIÓN DE LA LIBERTAD Y LA RACIONALIDAD:
ANÁLISIS DE JOHN DEWEY Y HERBERT MARCUSE**

 <https://doi.org/10.56238/sevened2025.036-133>

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ABSTRACT

This article aims to present, starting from Chapter 1 (The Problem of Liberty) of one of Dewey's works entitled "Liberalism, Liberty and Culture," where he uses the idea of liberty to arrive at two basic questions: first, the tension he exposes throughout, between the foundations of liberty and its preservation. And second, the idea of the principles or possible relationships between liberty and social cohesion or solidarity, which are the issues at stake in the first two paragraphs of the text, grouping several questions around these references. In the second part of the work, we analyze the introduction and Chapter 1 of Herbert Marcuse's work "The Ideology of Industrial Society." For Marcuse, modern industrial society imposes a technological rationality of mass domination and oppression, of control over human consciousness. The man who finds himself inserted in the society of artificiality is not free; on the contrary, he is an automaton, incapable of opposing the system of the technological apparatus. There is a satisfaction of false needs, which causes the so-called "mechanics of conformity." This paper seeks to reproduce and reflect upon the critical social theory developed by Marcuse regarding the new ideology of advanced technological society.

Keywords: John Dewey. Herbert Marcuse. Freedom.

RESUMO

Este artigo tem como objetivo apresentar, a partir do capítulo 1 (O Problema da Liberdade) de uma das obras de Dewey intitulada "Liberalismo, Liberdade e Cultura", onde ele usa a idéia de liberdade para chegar a duas questões básicas: primeiro, a tensão que ele expõe todo momento, dos fundamentos da liberdade e de sua conservação. E depois, a idéia dos princípios ou relações possíveis entre liberdade e coesão social ou solidariedade que são as questões que estão em jogo nos dois primeiros parágrafos do texto que agrupam várias perguntas em torno dessas referências. Na segunda parte do trabalho, analisamos a introdução e capítulo 1 da obra "A Ideologia da Sociedade Industrial", de Herbert Marcuse. Para Marcuse, a sociedade industrial moderna impõe uma racionalidade tecnológica, de dominação e opressão em massas, de controle das consciências humanas. O homem que se encontra inserido na sociedade do artificialismo não é livre, ao contrário, é um ser

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autômato, incapaz de se opor ao sistema do aparato tecnológico. Há uma satisfação das necessidades falsas, que ocasiona a denominada “mecânica do conformismo”. O presente trabalho busca reproduzir e pensar a teoria social crítica, desenvolvida por Marcuse sobre a nova ideologia da sociedade tecnológica avançada.

Palavras-chave: John Dewey. Herbert Marcuse. Liberdade.

RESÚMEN

Este artículo se propone presentar, a partir del Capítulo 1 (El Problema de la Libertad) de una de las obras de Dewey titulada "Liberalismo, Libertad y Cultura", donde utiliza la idea de libertad para abordar dos cuestiones fundamentales: primero, la tensión que expone a lo largo del texto entre los fundamentos de la libertad y su preservación. Y segundo, la idea de los principios o posibles relaciones entre la libertad y la cohesión social o la solidaridad, que son los temas que se abordan en los dos primeros párrafos del texto, agrupando varias preguntas en torno a estas referencias. En la segunda parte del trabajo, analizamos la introducción y el Capítulo 1 de la obra de Herbert Marcuse "La Ideología de la Sociedad Industrial". Para Marcuse, la sociedad industrial moderna impone una racionalidad tecnológica de dominación y opresión masiva, de control sobre la conciencia humana. El hombre que se encuentra inmerso en la sociedad de la artificialidad no es libre; al contrario, es un autómata, incapaz de oponerse al sistema del aparato tecnológico. Se produce una satisfacción de falsas necesidades, lo que da lugar a la llamada "mecánica del conformismo". Este artículo busca reproducir y reflexionar sobre la teoría social crítica desarrollada por Marcuse respecto a la nueva ideología de la sociedad tecnológica avanzada.

Palabras clave: John Dewey. Herbert Marcuse. Libertad.

1 INTRODUCTION

John Dewey (1859-1952) is the most recognized American educator of the twentieth century. In a prolific career that spanned seven decades, Dewey focused on a wide range of concerns, especially and notably in the fields of philosophy, education, psychology, sociology and politics. Both during his lifetime and after his death, Dewey's writings and public positions have been subject to interpretation and reinterpretation by various scholars. There is a voluminous literature on him, or written by himself, with profoundly different assessments of the nature and impact of his work.

Herbert Marcuse (1898 – 1979) was a German philosopher of Jewish origin, naturalized American during the Nazi period. Marcuse was, along with Adorno and Horkheimer, one of the founders of the Frankfurt School. Much of his work was based on two central theses: the analogy between the liberation of the masses (alienated by capitalism) and the erotic liberation of the unconscious (repressed by the conscious).

The objective of this reflection is to analyze studies by John Dewey and Herbert Marcuse from the perspective of freedom, bringing a correlation from the proximity of psychological and psychoanalytic theories. To do so, we used two texts by the authors to reflect on the possibilities of freedom in each writing, and bringing the readings closer together through content analysis.

The first question in Dewey arises from the idea of the foundations of freedom and its conservation that are linked in the sequence of the author's discussion, the genesis of a society that fights against oppression, which in this case is American society. And the second is about the possible relations between freedom around social cohesion or solidarity. From the first we find a very interesting point that will connect with Marcuse's text, but with a little more particularities or particularisms. But what is interesting in both cases is to see how a liberal author, such as Dewey, discusses issues that advance to principles that are then reworked from the perspective of an author of critical theory, of the Frankfurt School, such as Herbert Marcuse.

The idea that allows the two "theories" to be brought together is based on two factors that are recognizable in the texts. One is the question of thinking about the idea of freedom as a counterpoint to a conception of totalitarianism or a totalizing conception. In the case of Dewey, he reflects on the Totalitarian State, because he is thinking about the crisis of the Totalitarian State, his text is from 1939. In the case of Marcuse, the 1964 text reflects on the totalizing society, which is the Social Welfare State.

So there are elements that separate these two texts: one is the issue that totalitarianism is not the same thing as totalizing, but the second element perhaps that we should think is the dimension of the influences of psychological and psychoanalytic theories in the reading of the two authors. In Dewey's case, psychological theory and, in Marcuse's case, the question of psychoanalysis. This implies putting the dimension of the individual or individualities at stake in these relationships. This helps to understand how these two dialogues, even thinking that they are authors of very different schools, arrive at conceptions of a certain correlation.

2 METHODOLOGY

The analysis proposed in this study was based on the hermeneutic-dialectical method, appropriate for investigations that seek to understand the interaction between meanings, social practices and power structures. This approach, inspired by the interpretations of Habermas' (1987) studies on communicative action and by the hermeneutical bases developed by Gadamer (GONZALES, 1987), allows for the critical articulation of objective and subjective elements present in the construction of the concepts of freedom, rationality and technology discussed by John Dewey and Herbert Marcuse in their works by DEWEY, John, *Liberalism, Freedom and Culture* (1970) and MARCUSE, Herbert, *The Ideology of Industrial Society* (1964).

The adoption of the hermeneutic-dialectical method was justified by the interpretative nature of the problem investigated. As Minayo (2002) points out, this method makes it possible to examine social phenomena based on the interdependence between language, experience and historical context, understanding that all meaning is constituted through symbols — discourses, norms, values and categories — that structure human action. Thus, this study treated the texts of Dewey and Marcuse as symbolic units loaded with intentionality, whose interpretation requires considering their historical conditions of production and the ways in which they articulate meanings about freedom and technology.

The analytical process was carried out in three main stages:

1. Comprehensive reading and reconstruction of the authors' discourse, seeking to identify categories present in the analyzed works of Dewey and Marcuse. This stage allowed us to recognize the main nuclei of meaning presented by the authors.
2. Hermeneutic interpretation, in which the conceptual content was analyzed in the light of the meanings attributed by the authors themselves and the theoretical tradition in

which they are inserted. Language was treated as a mediator of action in the world, as defended by Gonzalez (1987), allowing us to understand how each author articulates his conception of freedom in relation to the social and technological conditions of his time.

3. Dialectical integration of categories, considering the tension between the perspectives of Dewey — who understands freedom as an experimental and free process — and the criticisms of Marcuse — who problematizes the capture of subjectivity by technical rationality. At this stage, the analysis sought to show how objectivity and subjectivity are intertwined in the theoretical formulation of both authors, as suggested by Minayo (2002), and how this relationship produces different meanings about the possibility of autonomy in the technological society.

With this approach, it was possible to understand freedom not only as an abstract concept, but as a historical and symbolic process, configured by the production, interpretation and dispute of meanings. The hermeneutic-dialectic methodology, therefore, allowed us to deepen the understanding of the differences and convergences between Dewey and Marcuse, highlighting how both conceive freedom from the relationship between subject, language and social context.

3 DISCUSSION OF THE RESULTS

In the following pages, we show the issue of freedom in each author, John Dewey and Herbert Marcuse, and then make the intended approximations.

3.1 FREEDOM IN DEWEY

From this set of initial positions, we start from Dewey, the foundations of freedom and its conservation and the idea of possible relations between freedom and cohesion, in the first paragraphs, where it is possible to develop the analysis of the conditions made possible by political freedom in his time (1939), based on the crisis of the Totalitarian State. When he writes about the crisis of the Totalitarian State, he refers to the Soviet states, on the one hand, the dimension that is somewhat confused with the conception of the Totalitarian State, but already with several denunciations in this period, of the abuses caused by the Soviet socialist regime. But he is also thinking of the pre-World War II period (rise of Nazism in Germany, fascism in Italy). I mean, Dewey is thinking of a framework

where totalitarian regimes are present. This framework will also be discussed, later by the Frankfurt School, but from a different logic, emphasizing much more the dimension of psychology, which is the idea of the authoritarian personality (Adorno-Horkheimer). This is a period of threat from totalitarianism to democratic life. It is in this context that Dewey is thinking about political freedom.

Dewey begins by analyzing that the conception of freedom is thought of in America as an impulse of human nature that founds society itself. The author refers to "it is in our tradition to be the love of freedom inherent in its structure" (Dewey, 1970, p. 99), at this point in the text Dewey is thinking about the writings of Thomas Jefferson, the issue of the still rural conception of an American society that fought for independence, sought to free itself from oppression, and which is based on the conception of a natural right to freedom, conceptions of an American democracy.

Dewey will unfold in the text, from the perspective that it is the structural tradition of American society to love freedom, a belief to the ethics that political democracy is a moral right and that the laws on which it is based are fundamental moral laws to which any and all forms of social organization must obey. In a kind of what he calls the popular psychology of democracy. Dewey, in the quotation from Thomas Jefferson's correspondence with John Adams, highlights the disbelief that Thomas Jefferson makes explicit in public opinion as a practical factor that destroys the legal affirmation of freedom.

He identifies the influence of public opinion in the context of the theoretical foundations based on the laws that guarantee freedom as a natural right. As public opinion, Dewey thinks of the press, the dissemination of customs, a model of transformation of American society that is gradually moving from an agrarian society to an urban society. And as for this, from his conception (Thomas Jefferson), it distorts that original conception of freedom as a right inscribed in human nature. From this perspective, Dewey questions the possibility of political freedom being maintained without freedom of culture. From his perspective, political freedom is insufficient to explain the proper functioning of political institutions.

Since,

[...] the relationships that exist between people, outside political institutions, relations of industry, communication, science, art, religion, affect daily associations and contacts and, therefore, profoundly affect the attitudes and habits expressed by the government and norms of law (DEWEY, 1970, p. 100).

So, he says, Thomas Jefferson's conception seems to be one in which government should govern according to natural laws, outside the influence of public opinion. That is subject to cultural changes. Dewey wonders to what extent it is possible, then, for democratic institutions to preserve naturalized conceptions of freedom exempt from cultural changes. For him, cultural changes condition changes in the form of social organization. "The freedom from oppression and repression, which existed previously, marked a necessary transition, but transitions are only bridges to something different" (DEWEY, 1970, p. 101).

Starting from the idea of the reference of militancy, the reference of social struggle that constituted a certain generation of Brazilian society that fought against the dictatorship, sometimes remains without necessarily understanding how the democratic transition occurred and how the democratic transition presents itself, the struggles for the inscription of achievements, of demands, in the text of the law or in the constitutional text, they are only a bridge to something that Dewey calls "something different". So sometimes the criticism of the absence of militancy that would be, in the view of some authors, especially in Brazil, something extremely important to understand the achievements of the process of redemocratization of Brazilian society, and a criticism is made of these new collective actions and social struggles, as if they were devoid of social criticism. As if they were devoid of a broader awareness of the historical needs that led to the process of democracy in Brazilian society.

Dewey's conception, in this sense, helps to understand that the transition only liberates forms that the struggle against oppression absorbed into an abstract homogeneity. When the struggle against oppression passes, and there is no longer a common enemy for society as a whole, it is proper that differences appear, as for example, in the post-constituent period, in Brazil, when the muffled differences, in the homogeneous struggle of all against oppression, begin to manifest themselves. More important than the transition is often to understand the differences that appear and how the transition served as a bridge to these differences.

Dewey takes up Thomas Jefferson and his fear of public opinion, to develop arguments of two kinds of relations: on the one hand, it is possible to perceive, for example, in the West, but also in America in general, from where he is thinking, an industrial development, an urban development, which corresponds in a certain way, to the physical

and material principle of development that explains the reason and the information that accompany the changes operated by the economy and science.

On the other hand, it is possible to recognize a development of emotions and imagination that accompanies the areas (much less valued). So this material, physical dimension that is present as the great influencer of the principles or cultural factors that condition public opinion, which Thomas Jefferson feared so much, which must be complemented, according to Dewey, by the understanding of how the emotions and imagination that accompany cultural changes developed. From this perspective, the author says that the references of freedom are composed from the scientific-economic bases and the cultural bases of democracy. And that these bases are corresponding and inseparable in the analysis of democratic or totalitarian political institutions. If the physical or material development of society makes it possible to clarify or measure the exteriority of human relations, which can be captured, for example, by the idea of growth, by the idea of industrialization, by the idea of urbanization, by the idea of contrasts produced by the apprehension of laws and several other possibilities. The development of values arising from cultural bases also makes it possible to clarify human relations. In other words, in the case of Dewey this will be evident in the analysis of totalitarian regimes, as a material command and of the imagination and in the way in which in the imagination and with it all the emotional impulses that we are accustomed to calling *interior* (Dewey, 1970, p. 104), are controlled.

For him, there are a variety of factors involved in the problem of human freedom (Dewey, 1970, p. 107), on which the need to perceive whether any factor is so predominant that it has causal force. In the first text, Dewey, in summary, explains that in the reason with which the idea of freedom is thought of as a natural right, as something that is the foundation of a concept of society, there is a whole development that is intended to be immutable to cultural influences. This is not possible without understanding the influences of cultural factors, of cultural changes, in the political life of society, one does not understand what is understood as freedom in a society, because it is loaded with values and these values are defined from the changes and influences that these cultural changes cause in political institutions. The norms change, the laws change, the form of government changes, which is updated at least to this principle.

Dewey explains why these changes are difficult to understand in democracy. According to him, the ideal of democracy is based on the assumption that the idea of

freedom is natural, in American society, where he analyzes it. To this end, he goes to the analysis of the Totalitarian State to show that for the Totalitarian State to be established, it stifles the individual impulses and motives of the subjects. It psychologically affects the subjects by controlling impulses and motives. And it is this control that allows totalitarianism, in a certain way, to reproduce itself in the stifling of individuality. So the idea of imagination, material command and imagination are complementary in the analysis of relations and conceptions of freedom, which exists in a certain society.

Now there are a variety of factors that need to be highlighted from this variety, the issue of culture, various conceptions, such as religion, art, theater, music, which in a way directly influences the way people start to read the world, to have worldviews that value people's possibilities of fulfillment in very different ways. The ideal of freedom varies with this and is not just a matter of determination or physical and material conditioning. At this point, Dewey makes a criticism of the Marxist conception that sees the question of the preponderance of the economic in these relations.

It poses new problems in the sequence. One is about the datum of psychological control – control of the emotional pulses that we usually call interior. Which ultimately seeks to stifle people's imagination. Another thing he will say is, if the issue of freedom varies according to the factors involved in his problem, it is important to try to understand if a factor is preponderant in a way that can oppose its causal force. Dewey, analyzing at the time he is writing (1939), says that the belief in economic predominance prevails, hence his dialogue with Marxism. He says that today it has become fashionable to say that the economy is the cause of this or that. But he remembers that it cannot be forgotten that at the time of the Enlightenment reason was preponderant. Then, in a passage, he goes back to the Middle Ages to say that religion was preponderant. If we go back to antiquity, the preponderant were myths and rituals as a way of controlling these drives of the subject, of individuals, which are stifled as a function of a collective, and of the norms that govern collective cohesion in these societies.

In the case of Totalitarian States, Dewey highlights another order of relations between the factors that act on political institutions and the organization of psychologically-based social life, which indicate the direction of a logic of pluralist analysis. So these conceptions such as the Marxist conception, the Enlightenment conception, or the medieval conception, were *monist conceptions* (Dewey, 1970, p. 107), that is, they dated the question of freedom from a preponderant factor that had causal force. For Dewey, it is

necessary, then, to expand this to a pluralistic analysis, showing that culture conditions the idea of individuality and thus modifies the human problem of thinking about freedom. In the end, he highlights an interesting conception that the world would have to be divided into an option for capitalism (freedom from liberalism, without equality) or an option for a socialist project (individual freedoms for equality and collective freedom).

In this antagonism, between the 1950s and the 1980s, some historical movements that were constituted in the conception of the emancipation of the working classes, commanded from the point of view of reform, of the revolution of some contexts of society, a transformation to another principle of freedom. They proposed this because of several projects, (e.g. Cuba).

What Dewey will show is that these new conceptions of freedom are the fact that, if we consider that cultural factors, then, condition the idea of individuality and modify the thought of freedom, and this would be the contribution of psychological theory, it would be necessary, ultimately, to conceive that the cultural bases of democracy condition the correlations between constitutive elements of a society, through the cooperative spirit (Dewey, 1970, p. 115), so that the development of each constituent element serves to liberate and mature the other. Dewey works with the idea that freedom acts and is culturally conditioned by the perspective of functioning as a cooperative spirit, otherwise it is not freedom.

It is different from a liberal conception that thinks of the idea of freedom only from the physical and material constraints, or from the preponderance of the economic. Hence the idea of a philosophical monism, which presupposes that my freedom ends where the freedom of the other begins. That individual freedoms would be the guarantors of a space that is totally autonomous from the principle of collective life. Dewey will state that it is not, freedom does not exist to create individuals. Freedom exists to ensure the integrity of individualities within a cooperative spirit, where each one is a constitutive element that serves to give freedom and mature to the other. There are individual reasons for seeking autonomy that are fundamental to thinking about freedom. But in collective life, these impulses have to be aggregated in the reason of this cooperative spirit in a way that gives freedom to one, but also helps to liberate the other, and in this context, both mature. This part is important when one starts to think about the public sphere (education, religion, politics), Thomas Jefferson's idea of public opinion and the case of autonomy that implies

at some point the exercise of freedom that helps to establish democratic institutions, called the public sphere by Habermas (maturing one's own *self*, according to Taylor).

Whether passing through the path of liberalism, or passing through the path of critical theory, and today through these so-called post-structuralist or post-modern conceptions, two things that are shown in the genesis of these conceptions, are not resolved because they are only founding tensions of the conception of freedom. The first is the question of the individual: What is the place of the individual in society? Adorno and Horkheimer will say that it is an extremely unresolved thing because the individual is a social invention. The other question is beyond the place of the individual, if it is possible to establish a universal principle of autonomy. Since cultural changes shape individualities or condition individualities in such a way that, if there is diversity of cultures, there can be no universality. If it is possible to think about freedom through the particularities of each culture, how far can we exchange, exchange experiences about the conception of freedom in a society that is increasingly culturally differentiated? There is no place in the world, according to Dewey, that freedom does not mean freeing oneself from oppression.

From Dewey's point of view, which differentiates it from Marcuse's point of view, which is the fact that what is established as freedom and principle does not matter so much, but the way in which it is realized. If it is in accordance with the values of a society, if it is corresponding to this liberation between the constituent elements, so that it configures a cooperative spirit. It is not positivity that guarantees, from the point of view of the idea of freedom, its effectiveness. But the way it is carried out, how individuals mature and organize themselves based on these conditionings of the values they place for democratic institutions. The cultural bases of democracy are as important to think about as the economic-scientific bases (physical and material development of society).

To understand the connection with Marcuse and see how this has repercussions from the point of view of human action, of social action, and how he can reflect on the conception of contemporary actors and see that these are always unresolved issues, or that they are not yet resolved. This idea of controlling emotional pulses that we have come to call interiors, which ultimately seek to control the imagination of individuals is important. This is the *link* to the issue with Marcuse. Thus, when you control these impulses, these motives, and the very imagination of individuals, you also control the material and physical basis of society.

3.2 FREEDOM IN MARCUSE

Marcuse will affirm that, from the point of view of the criticism he makes of the Welfare State, this State is not totalitarian, but it is totalizing. And that the totalizing character is precisely in the control of needs. To the extent that, in order to meet the needs of individuals, the State accumulates such a great diversity and particularity of information about individuals that it begins to control better. When you know all the needs of individuals and satisfy them, in a certain way, you know how the individual functions, and in doing so, you manage to control the production of needs itself in such a way that what is directed as the satisfaction of needs is nothing more or less than the creation of false needs that control the impulse and motives of the individual's own life and the way in which they associate and associate with each other. the reasons why they associate in collective life. By doing this, we stifle tensions, we stifle the very characteristic impulses of a model of social imagination that tends towards ruptures, that tends towards transformations, so it does not have the same logic with which, in the last instance, it emancipated the subjects because it made possible small "surpluses" in the basic deprivations of existence, a freedom is given to them that is false freedom.

And how does this issue happen? It will happen by internalization (in the psychoanalytic principle – idea of the control of desire). The control of the State will operate by internalizing the needs of these conceptions that unfold in the logic of freedom within capitalist society, especially thinking about the Social Welfare State.

If Dewey is going to affirm what totalitarian societies allow us to understand, it is that, if they control desires so that the imagination does not create a new society, what we have in the Welfare State is that the individual internalizes needs as a form of repression of impulses, closing the possibility of the individual having impulses for the new as he feels satisfied. The creation of the idea of satisfaction is to be in this relationship.

From Marcuse's point of view,

[...] "totalitarian" is not only a terrorist political coordination of society, but also a non-terrorist technical-economic coordination that operates through the manipulation of needs by vested interests (MARCUSE, 1964, p. 24-25).

Marcuse also uses the more correct term, which is *introjection* (Marcuse, 1964, p. 13), which is more appropriate from the point of view of psychoanalysis. Opposing Dewey's interiorization.

In the text, Marcuse summarizes these new forms of control operated since the Welfare State at the end of the 1960s. The Welfare State understood that "fulfilling the needs", but carrying out through this control information about individuals and their own needs would be very important. That is, it is not realized from the desire of individuals, but from a certain distribution of resources stipulated in the reason of a government that plans needs. And when it does, the realization cancels the premises, that is, everything that was previously discussed in Dewey is canceled. And in a certain way, teleology, which is operated by the imagination about the new, about changes, about ruptures, the possibilities of the emergence of other realizations, are stifled by the principle of realization. An extremely effective form of control that occurs not by refusing access to fulfillment, but by achieving satisfaction.

In this context, the idea of non-conformism occurs, the impulse, the motives, which lead people to seek fulfillment are controlled to the extent that it is produced by *introjection*, needs that, from the point of view of a model of society, can and are satisfied institutionally.

Marcuse states that this model of control is placed as

[...] the most effective and resistant form of war against liberation is the implantation of material and intellectual needs that perpetuate obsolete forms of the struggle for existence (MARCUSE, 1964, p. 26).

So the intensity, satisfaction and even the character of human needs above the biological level have always been preconditioned, that is, they vary according to the social context, with the culture.

The fact that the possibility of doing or leaving aside, enjoying or destroying, possessing or rejecting something is or is not taken out of *necessity* depends on whether or not it can be seen as desirable and necessary to common social interests and institutions (Marcuse, 1964, p. 26).

So when needs are created that are overexposed to the individual by particular social interests, they become false to the extent that they repress individuals and do not liberate, according to Marcuse. The idea that these needs operated in the forms of control are not controlled by the individuals themselves.

The logic with which Marcuse discusses this idea, in the case of Europe, was given by the destruction and the need to rebuild countries. In the United States, no. The United

States did not suffer the mass destruction. In the case of Europe, mass planning took place. Mass planning is not just about rent. Mass planning necessarily implies freeing subjects from some needs in order to instill others. So that these other needs become more important and, as time goes by, they become institutionalized, one can do as they did in neoliberalism, which is that basic need guaranteed to be mischaracterized (education is no longer a duty of the State, but enter into the logic of the market, of innovation,...).

Marcuse will state in relation to this, that

The judgment of needs and their satisfaction, under the given conditions, involves standards of *priority* —standards that refer to the optimal development of the individual, of all individuals, under the optimal utilization of the material and intellectual resources at man's disposal. The resources are calculable. (MARCUSE, 1964, p. 27).

On the one hand, there is a society under reconstruction, the idea of social planning that tries to ensure the satisfaction of needs, to provide the basic conditions for individuals to free themselves in search of their optimal development. However, having the protective security (Welfare State) that is ontological, the prospect of this optimal development is stifled to the extent that it minimizes the need to use the imagination to overcome conditions of deprivation. So a certain homogenization of access to resources is assumed as a way of stifling these drives for transformation and rupture, which are imaginary drives. What Castoriadis (1982) would call the "instituting imaginary" is stifled and the instituted imaginary of society is reinforced. As resources are calculable, these priority patterns lead us to another important logic to be recognized, which Marcuse will say is characteristic

[...] The distinctive feature of developed industrial society is the stifling of needs that demand liberation while maintaining and absolving the destructive power and repressive function of affluent society (MARCUSE, 1964, p. 28).

Some needs are satisfied to stifle others. What cannot be used is the creative way of getting out of deprivation, as an instituting logic of a political imaginary, for example, because there the contexts that Dewey will call the cooperative spirit are corrupted.

Another important point of Marcuse is that of the equalization of class distinctions and the ideological function of this equalization.

If the worker and his boss watch the same television program and visit the same picturesque spots, if the typist is as attractively painted as the boss's daughter, if the black man owns a Cadillac, if everyone reads the same newspaper, this assimilation does not indicate the disappearance of classes, but the extent to which the needs and satisfactions that serve the preservation of the establishment are shared by the underlying population (MARCUSE, 1964, p. 29).

That is to say, this idea of equalization of distinctions is excessively shared. Thus, the elements that are profound in the processes of distinction are not recognized. Since, it operates by introjection, it presupposes

[...] a variety of relatively spontaneous processes by which an "I" (Ego) transfers the "outside" to the "inside." Thus, introjection implies the existence of an inner dimension distinct from and even antagonistic to external demands—an individual consciousness and an individual unconscious *separate* from public opinion and behavior. The idea of "inner freedom" has its reality here: it designates the private space in which man can become and remain "himself" (MARCUSE, 1964, p. 30).

This is the idea of intimacy, which for Simmel (2005) is the asocial sphere of the individual. This perspective of when external needs overlap this intimate forum around thinking and valuing life, that intimacy in a certain way, is lost due to the way in which needs are satisfied.

To what extent does the individual's ability to think about himself constitute him as a subject and allow him to act, reflect and change? When needs and forms of control are created that act back on this individual disposition to think about oneself and one's needs, tensions of the imaginary are stifled and drives that would be proper to the action of change are stifled. For Marcuse, these forms of control are not only unconscious, but they are conscious. The dimension of surveillance that Marcuse indicates in the text, which will always be present and which is another dimension.

From the point of view of society, this is extrapolated through the demand that people make when they reach a certain degree of satisfaction of needs. Then one begins ideologically to share not only the form of satisfaction, but also judgments about the way in which satisfaction is adequate or not to needs. Thus, if that need is imposed from the outside and the individual shares this context, he is one of those who watch. So these forms of control participate precisely in the fact that to the extent that they satisfy or are intended to satisfy everyone, control over satisfaction is important to ensure that everyone has it.

Marcuse's basic idea is when society acquires control over the state, it acquires control of the satisfaction of its needs. And from there, it controls itself. Marcuse states that

the Welfare State, even though it arose from another conception that was not through the mass demands of Europeans to control the State, was due to the collapse, after World War II, but created a social planning that satisfies the needs produced in the cultural sphere within achievable cultural standards, and from this it generates a control mechanism operated by surveillance over people. This nullifies the *introjection* that guarantees, in a certain way, the maintenance of an autonomous spirit of the individual, as himself, capable of imagining and thinking about his projects and achievements.

Although they are distinct theoretical and political conceptions, these post-war records, the polarities placed in the post-war period, and the possibilities of realization around these polarities, ultimately made the thinkers of the time move around the same questions. They gave different answers according to their conceptions of policies and traditions, but they did not get out of this tendency to think about the technical-scientific bases (freedom) and the cultural bases. This integration of materialist or idealist theories in the development of history, and on the other hand of psychological or psychoanalytic conceptions of the relations of realization of the individual, of the drives and of the control of these drives.

Ultimately, the question that arises in Marcuse is that as every need is satisfied by the advent of the industrial society model, and this industrial society is based on the capacity for technical-scientific innovation, it is this principle of technical-scientific innovation that starts to dictate the new reasons for needs from the point of view of control models. And as a result, it starts to generate a pattern of thought that generates what Marcuse will call a one-dimensional behavior (Marcuse, 1964, p. 34). In which the ideas, aspirations and objectives that by their content transcend the established universe of word and deed, are repeated or reduced to terms of that universe. They operate by recursion. They are redefined by the rationality of the given system and its quantitative extension. It is this logic that then begins to operate around the theme of progress that is at the basis of the ideological support of the Welfare State.

This logic is what allows the principle of satisfaction to be recognized as common to all and this is what operates the pattern of vigilance so that this satisfaction remains common among the subjects. In this context, associated with the model of progress, of technical-scientific development, which justifies the ideas of increasing modernization in this model of society, something is defined that is at the basis of the theory and practice of this model of control that Marcuse calls operationalism. And this "operationalism becomes,

in theory and practice, the theory and practice of *containment*" (Marcuse, 1964, p. 36). That is, the subjects are contained, the subjects are not explosive in the sense of the drives (eros). Realization as a form of control is based on an operationalism that is defined by containment, that is, it only fulfills its desire by containing the desire of the other.

If one takes this idea that for Marcuse operates as a technological rationality, since it is industrial, of innovation from the point of view of environmental resources, for example, it will operationalize within an existing rationality. When they think from the perspective of generation, they think about environmental goods from a perspective that technological rationality does not reach. The great difficulty when it is said, resources are finite, but technology is not. It is true that the resources will run out one day, but by then the technology will find a way. So the need to calculate resources is transferred to something else. If the subject has a closer relationship with nature, he will not think so. You won't think about shifting your responsibility to technology.

4 FINAL CONSIDERATIONS

In summary, Marcuse, in the text on the paralysis of criticism: society without opposition (2015), points out that the mass media had a preponderant role in this process, since they stimulated the collective adhesion of individual projects. The enrichment of society and its growing rationalization, although they were not converted into concrete improvements extended to the entire population, were the banner that guaranteed the conformation of the masses and their consequent disarticulation. Technical progress would have been able to reconcile social structures with their opposing forces, both inebriated by the developmentalist perspective that was announced on the horizon of history. The scientific mastery of nature had inaugurated a new form of conquest of man himself, now subjected to the illusion of freedom that made him the servant of progressive ideology.

To question the way society was structured, even how to reverse the course of progress, was to question the very status of Western rationality, supported by the discourse of improving life linked to the technical-scientific project. It was necessary to understand the domination of man by man and other projects of power supported by scientific rationality as elements of the order of unreason. Industrial society was eminently irrational, to the extent that the imperative of productivity ended up reaping the freedoms and possibilities of human self-determination (Marcuse, 1964). In this sense, imagination was pointed out

as the only potentially transformative attitude, in a context in which the bankruptcy of traditional forms of political reaction was proclaimed.

This perspective has to do with what Dewey argued is only possible in a concept of cooperative spirit. To enable this dimension and extension of freedoms. Here, as this operationalism that is defined by containment, it is the surveillance assumed as a form of control that makes it possible that my need will only be fulfilled or satisfied if I control the satisfaction of the other. Since Marcuse is holding to the idea of progress, and since the idea of progress is related to scientific-technical innovation, the welfare state was containment in the sense of "contain and wait for progress." So that one gradually ascends to conceptions that can become infinite. The basic element for Marcuse is that this operates through an absurd incrementalism, which does not take into account the fact that resources are calculable. Because those who control know this and satisfy the needs within a certain standard. It operates on the principle of annulment of the drive so that the subject feels satisfied with what he has.

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**GREEN HYDROGEN, LOGISTICS HUBS AND REGIONAL DEVELOPMENT IN
BRAZIL: AN INTEGRATIVE LITERATURE REVIEW**

**HIDROGÊNIO VERDE, HUBS LOGÍSTICOS E DESENVOLVIMENTO REGIONAL
NO BRASIL: UMA REVISÃO INTEGRATIVA DA LITERATURA**

**HIDRÓGENO VERDE, HUBS LOGÍSTICOS Y DESARROLLO REGIONAL EN
BRASIL: UNA REVISIÓN INTEGRATIVA DE LA LITERATURA**

 <https://doi.org/10.56238/sevened2025.036-134>

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ABSTRACT

The growing relevance of green hydrogen in the context of the global energy transition has intensified debates on its economic, territorial, and institutional impacts. Beyond its role in decarbonization, green hydrogen has been associated with the reorganization of production chains and the formation of logistics hubs and corridors, with implications for regional development. This article analyzes how the structuring of these arrangements has been related to regional development in recent scientific literature, with emphasis on emerging economies and Brazil. Methodologically, an integrative literature review was conducted, guided by the PRISMA 2020 guidelines and the PCC strategy. A total of 49 studies published between 2020 and 2025 were analyzed, identified through a structured search in international and regional scientific databases. The results indicate that green hydrogen hubs can foster green reindustrialization, attract investments, and strengthen local productive capacities, provided they are associated with integrated public policies, territorial planning, and multilevel governance. However, the literature also highlights risks of energy enclaves in contexts of weak institutional coordination.

Keywords: Green Hydrogen. Logistics Hubs. Logistics Corridors. Regional Development. Energy Transition.

RESUMO

A crescente relevância do hidrogênio verde no contexto da transição energética global tem ampliado o debate sobre seus impactos econômicos, territoriais e institucionais. Para além de seu papel na descarbonização, o hidrogênio verde tem sido associado à reorganização de cadeias produtivas e à formação de hubs e corredores logísticos, com implicações para o desenvolvimento regional. Este artigo analisa como a estruturação desses arranjos tem sido relacionada ao desenvolvimento regional na literatura científica recente, com ênfase em países emergentes e no Brasil. Metodologicamente, adotou-se uma revisão integrativa da literatura, orientada pelas diretrizes do PRISMA 2020 e pela estratégia PCC. Foram analisados 49 estudos publicados entre 2020 e 2025, identificados por meio de busca estruturada em bases científicas internacionais e regionais. Os resultados indicam que hubs de hidrogênio verde podem impulsionar reindustrialização verde, atração de investimentos e fortalecimento de capacidades produtivas locais, desde que associados a políticas públicas integradas, planejamento territorial e governança multiescalar. Contudo,

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a literatura aponta riscos de enclaves energéticos em contextos de frágil coordenação institucional.

Palavras-chave: Hidrogênio Verde. Hubs Logísticos. Corredores Logísticos. Desenvolvimento Regional. Transição Energética.

RESUMEN

La creciente relevancia del hidrógeno verde en el contexto de la transición energética global ha intensificado los debates sobre sus impactos económicos, territoriales e institucionales. Más allá de su papel en la descarbonización, el hidrógeno verde se ha asociado con la reorganización de las cadenas productivas y la formación de hubs y corredores logísticos, con implicaciones para el desarrollo regional. Este artículo analiza cómo la estructuración de estos arreglos se ha relacionado con el desarrollo regional en la literatura científica reciente, con énfasis en economías emergentes y en Brasil. Metodológicamente, se realizó una revisión integrativa de la literatura, guiada por las directrices PRISMA 2020 y la estrategia PCC. Se analizaron 49 estudios publicados entre 2020 y 2025, identificados mediante una búsqueda estructurada en bases científicas internacionales y regionales. Los resultados indican que los hubs de hidrógeno verde pueden impulsar la reindustrialización verde, atraer inversiones y fortalecer las capacidades productivas locales, siempre que estén asociados a políticas públicas integradas, planificación territorial y gobernanza multinivel. Sin embargo, la literatura también señala riesgos de enclaves energéticos en contextos de débil coordinación institucional.

Palabras clave: Hidrógeno Verde. Hubs Logísticos. Corredores Logísticos. Desarrollo Regional. Transición Energética.

1 INTRODUCTION

The intensification of climate change and international commitments to carbon neutrality have driven a structural reconfiguration of global energy systems, with a growing emphasis on solutions capable of decarbonizing industrial and logistics sectors that are difficult to electrify directly. In this context, green hydrogen — produced by electrolysis of water from renewable sources — has been widely recognized as a strategic energy vector for the energy transition, especially in industrial, chemical, and heavy and maritime transport applications (DAWOOD et al., 2023; WANG et al., 2023).

Recent studies indicate that the economic viability of green hydrogen has advanced significantly due to the reduction in the costs of solar and wind generation, the technological progress of electrolyzers, and the expansion of public incentive policies in different regions of the world (AJANOVIC; HAAS, 2023; IEA, 2024). According to Wang et al. (2023), countries with high availability of renewable resources and access to strategic logistics infrastructure tend to occupy central positions in future global hydrogen value chains, especially in the international trade of derivatives such as green ammonia and synthetic fuels.

In this scenario, Brazil stands out as a potentially relevant actor, due to its mostly renewable electricity matrix, high solar irradiation, favorable wind regimes and extensive coastline with ports suitable for export. Recent research indicates that these characteristics place the country in a competitive position for the production of green hydrogen on a large scale, especially in the Northeast and Southeast regions, where emerging projects for integrated energy parks and dedicated port terminals are concentrated (RIBEIRO et al., 2024; SILVA; MILK; FERREIRA, 2023).

Contemporary literature emphasizes that the consolidation of green hydrogen as a development vector strongly depends on the territorial organization of production and logistics. Concepts such as hydrogen hubs and green logistics corridors emerge as central elements of this structuring, by integrating renewable generation, production, storage, industrial consumption, and export into coordinated territorial arrangements. As argued by Ajanovic and Haas (2023) and Heuser et al. (2024), hubs allow for gains in scale, infrastructure sharing, and risk reduction, while logistics corridors connect these hubs to national and international markets, increasing commercial predictability and attractiveness for investments.

From the perspective of regional development, the implementation of green

hydrogen hubs and corridors has the potential to induce processes of economic dynamization, territorial reindustrialization, and the generation of qualified jobs. Recent studies indicate that these projects can strengthen local production chains, stimulate technological innovation, and increase tax revenues in historically peripheral regions (RIBEIRO et al., 2024; WANG et al., 2023). However, the literature also warns that such benefits are not automatic, depending on integrated public policies, strategic territorial planning, and governance mechanisms capable of avoiding the concentration of gains and the reproduction of regional inequalities (SANTOS; PEREIRA, 2024).

In Brazil, projects under development in ports such as Pecém (CE) and Açu (RJ) have been analyzed as emblematic cases of the articulation between renewable energy, port infrastructure and strategies for the country's international insertion in the hydrogen economy. Recent empirical studies highlight both the potential of these arrangements for regional development and the regulatory, institutional, and logistical challenges that still exist, especially with regard to federative coordination, environmental licensing, and transportation and storage infrastructure (SILVA; MILK; FERREIRA, 2023; RIBEIRO et al., 2024).

In this context, this article aims to analyze how the structuring of green hydrogen hubs and logistics corridors can contribute to regional development in Brazil. To this end, an integrative review of recent scientific literature (2023–2025) and open access technical documents is adopted, seeking to identify evidence on socioeconomic impacts, infrastructure requirements, and governance models capable of enhancing the territorial benefits associated with the energy transition based on renewable hydrogen. Unlike reviews focused on technological or market aspects, this study contributes by integrating the literature on green hydrogen with regional development and territorial governance approaches, with a focus on Brazil.

2 THEORETICAL FRAMEWORK

The theoretical framework of this study articulates contributions from the literature on energy transition, political economy of energy, economic geography and regional development, with the aim of establishing a clear analytical bridge between the conceptual foundations of green hydrogen and the empirical evidence observed in different territorial contexts, especially in Brazil and Latin America. The section was structured in a more synthetic and integrated way, seeking to avoid conceptual overlaps and reinforce the

connection between theory and practice.

2.1 GREEN HYDROGEN AND ENERGY TRANSITION: FOUNDATIONS AND EVIDENCE

Recent literature recognizes green hydrogen as a strategic vector for the decarbonization of energy-intensive sectors that are difficult to electrify directly, such as steel, heavy chemicals, shipping, and aviation (DAWOOD et al., 2023; VAN DER ZWAAN et al., 2023). More than an isolated technological solution, green hydrogen has been interpreted as a structuring element of a systemic reconfiguration of energy and production systems, associated with the advance of renewable energies and sector coupling.

Recent empirical studies show that the competitiveness of green hydrogen is strongly conditioned by territorial factors, such as the availability of renewable resources, existing infrastructure, access to water, and proximity to consumer markets or export routes (MENDELEVITCH; HUENTELER; OSSENBRINK, 2023; AJANOVIC; HAAS, 2023). This evidence reinforces approaches to economic geography that highlight the role of territory in shaping new competitive advantages in the energy transition.

In the Latin American context, research indicates that countries such as Brazil, Chile, and Argentina have favorable natural conditions for the production of green hydrogen on a large scale, but face institutional and policy coordination challenges to transform this potential into sustained economic development (QUITZOW et al., 2024; GÓMEZ et al., 2024; LÓPEZ et al., 2023). These empirical studies corroborate the theoretical literature by showing that the hydrogen-based energy transition tends to reproduce or reconfigure preexisting spatial inequalities, if it is not accompanied by deliberate regional development policies.

2.2 HYDROGEN HUBS AND LOGISTICS CORRIDORS: TERRITORIAL ARRANGEMENTS AND EMPIRICAL EVIDENCE

The consolidation of green hydrogen as an economic vector depends on the territorial organization of the production, storage, transport and consumption infrastructure. In this sense, the international literature highlights hydrogen hubs as territorial arrangements capable of reducing costs, sharing risks, and accelerating the formation of markets, through the spatial concentration of energy and industrial assets (HEUSER et al., 2024; TRINOMICS, 2024).

Empirical evidence from Europe and Australia indicates that integrated hubs favor

economies of scale, technological learning, and investment attraction, especially when associated with local industrial demands and long-term contracts (SCHOLTEN; CRIKEMANS; VAN DE GRAAF, 2024). However, studies applied in emerging countries warn that, in the absence of coordination between energy, logistics and industrial policy, these hubs may be limited to export platforms with weak local production chains (GLENK; REICHELSTEIN, 2023).

In the Brazilian case, empirical analyses of the ports of Pecém (CE) and Açú (RJ) show that the proximity between renewable sources, port infrastructure, and industrial zones creates favorable conditions for the formation of green hydrogen hubs, but highlights bottlenecks related to federative governance, environmental licensing, and complementary logistics infrastructure (SILVA; MILK; FERREIRA, 2023; RIBEIRO et al., 2024). These findings reinforce the need to interpret hubs not only as technical solutions, but as institutional and territorial constructions.

Green logistics corridors play a complementary role in connecting production hubs to national and international markets. Recent studies show that logistical predictability and regulatory standardization are decisive factors to enable the trade of hydrogen derivatives, such as green ammonia, especially in exporting countries (QUITZOW et al., 2024).

2.3 GREEN HYDROGEN, GOVERNANCE AND REGIONAL DEVELOPMENT

The relationship between green hydrogen and regional development has been analyzed from the political economy approaches of the energy transition, which emphasize the role of governance, public policies, and local institutional capacities. The literature converges in indicating that the territorial benefits of green hydrogen are not automatic, depending on how the projects are inserted into broader regional and industrial development strategies (BALL; LEMA, 2024; SOVACOOOL et al., 2023).

Empirical studies in emerging countries show that export-oriented projects tend to generate energy enclaves, with limited impacts on local employment, innovation, and income. In contrast, experiences associated with local content policies, labor training, and integration with regional production chains have greater potential to induce green reindustrialization and economic diversification (SANTOS; PEREIRA, 2024; RIBEIRO et al., 2024).

In the Brazilian context, recent literature highlights that green hydrogen can act as a strategic instrument for regional development, especially in the Northeast, as long as it is

articulated with territorial policies, long-term planning, and multi-scale governance involving the Union, states, municipalities, and private actors (FURTADO et al., 2023; NASCIMENTO et al., 2023).

In summary, the theoretical framework shows that green hydrogen should be understood as a socioeconomic and territorial phenomenon, whose ability to promote regional development depends on the articulation between infrastructure, governance, and public policies. This perspective guides the empirical analysis developed in the following sections. These elements underlie the methodological strategy adopted in the integrative review, described below.

3 METHODOLOGY

This research adopts an integrative literature review, an appropriate methodological approach to synthesize and critically analyze evidence from empirical studies, theoretical studies and technical-institutional documents in emerging and interdisciplinary fields. The choice of this methodology is justified by the still recent and multifaceted nature of the debate on green hydrogen, logistics hubs and regional development, in which economic, territorial, institutional and public policy analyses coexist (WHITTEMORE; KNAFL, 2005; TORRACO, 2020).

The review was conducted in accordance with the PRISMA 2020 guidelines, adapted to the scope of integrative reviews, with the aim of ensuring transparency, traceability, and reproducibility of the search, selection, and analysis process of studies (PAGE et al., 2021). The adoption of PRISMA, although originally aimed at systematic reviews, is widely recommended to strengthen methodological rigor in integrative reviews, especially in areas in consolidation (SNYDER, 2019).

3.1 RESEARCH QUESTION AND JUSTIFICATION OF THE PCC STRATEGY

The review was guided by the following research question:

How has the structuring of green hydrogen hubs and logistics corridors been associated with regional development in recent scientific literature, especially in the context of emerging countries and Brazil?

To structure this issue and coherently guide the search strategy, the PCC (Population, Concept, and Context) model was adopted, recommended for scoping and integrative reviews because it allows greater conceptual flexibility compared to more

restrictive models (PETERS et al., 2020).

The choice of the PCC strategy is justified by the territorial and institutional nature of the phenomenon analyzed, which is not restricted to a specific population group, but involves regions, production systems and spatial arrangements. Thus, it was defined:

Population (P): regions, territories, and production systems affected by the deployment of green hydrogen infrastructure;

Concept (C): green hydrogen, hydrogen hubs, logistics corridors, energy infrastructure and value chains;

Context (C): regional development, energy transition and emerging economies, with emphasis on Brazil.

This structure allowed the alignment of the research question, the descriptors used and the selection criteria, ensuring coherence between the objectives of the study and the corpus analyzed.

3.2 DATABASES AND SEARCH STRATEGY

Bibliographic searches were carried out between January and September 2025 in the Scopus, Web of Science, SciELO, and Google Scholar databases (as a complementary source). The choice of these databases is based on criteria of thematic coverage, academic relevance and regional representativeness.

Scopus and Web of Science were selected for their broad international coverage and strong indexing of journals in the areas of energy, regional economics, and public policy. The SciELO database was included to capture Latin American and Brazilian scientific production, which is often underrepresented in international databases. Google Scholar was used in a complementary way, with limitation to the first 200 entries ordered by relevance, in order to identify qualified gray literature and relevant institutional reports.

The search strategies combined descriptors in Portuguese, English and Spanish, Boolean operators and truncations, as shown in the example:

("green hydrogen" OR "renewable hydrogen") AND ("hydrogen hub" OR corridor* OR infrastructure OR "value chain") AND ("regional development" OR "territorial development") AND (Brazil OR Brazil)

Filters were applied for period (2020–2025), languages (Portuguese, English, and Spanish), and document type (peer-reviewed articles, reviews, and technical reports from recognized institutions). The option for publications from 2020 onwards is justified by the

recent nature of the consolidation of green hydrogen as a public policy agenda and object of applied research, ensuring the timeliness and relevance of the findings.

3.3 INCLUSION, EXCLUSION AND SELECTION PROCESS CRITERIA

The inclusion criteria included: (i) studies that explicitly addressed green hydrogen; (ii) analyses that relate infrastructure, hubs, logistics or value chains to territorial or regional impacts; (iii) peer-reviewed publications or institutional technical reports; and (iv) availability of the full text.

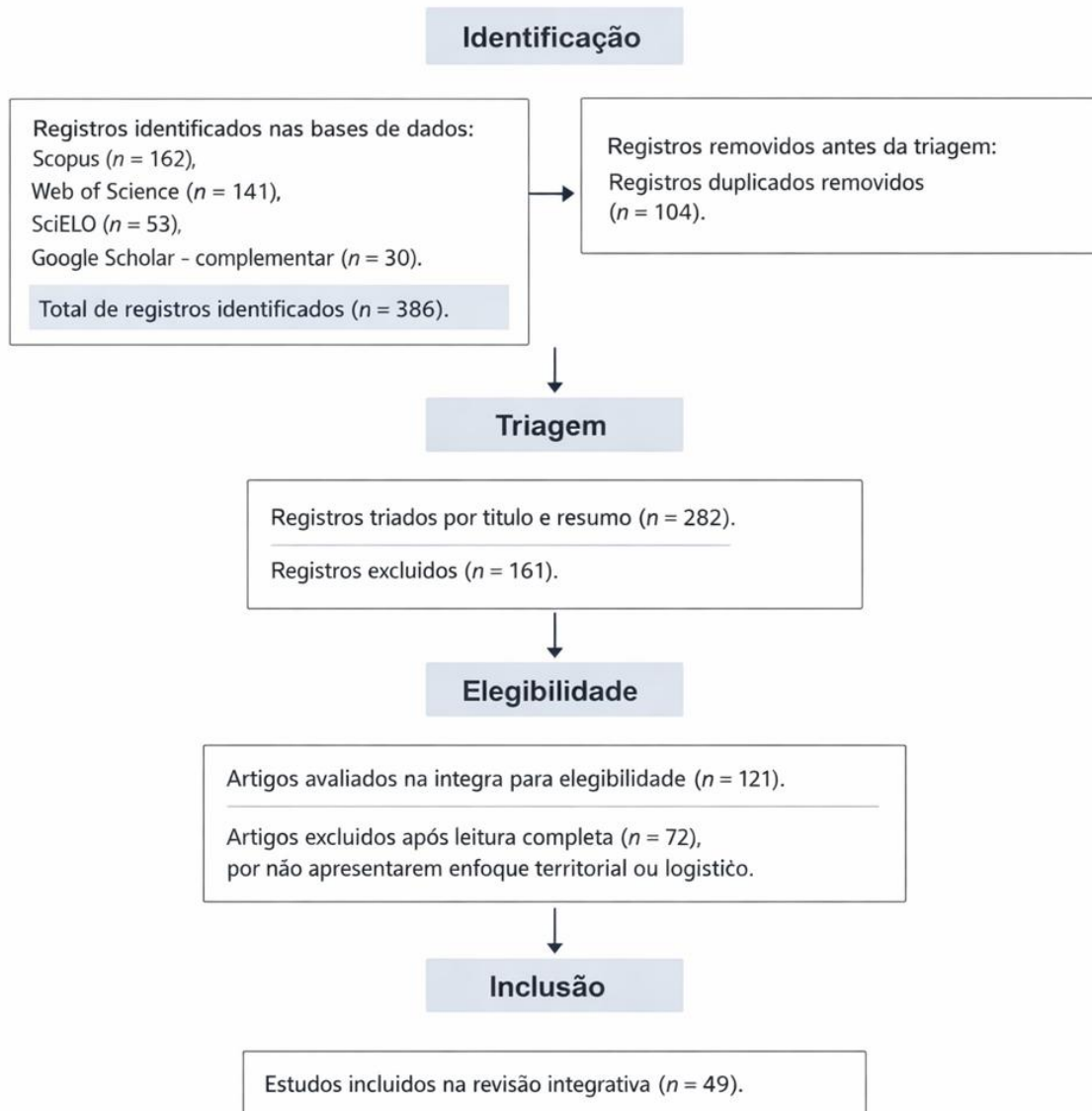
Studies focused exclusively on fossil or blue hydrogen, strictly laboratory research with no territorial connection, duplicate publications, and texts without full access were excluded.

The selection process followed the four stages of PRISMA 2020: identification, screening, eligibility and inclusion. Initially, 386 records were identified. After removing 104 duplicates, titles and abstracts were read ($n = 282$), resulting in the exclusion of 161 out-of-scope records. Of the 121 studies evaluated in full, 72 were excluded because they did not have sufficient adherence to the territorial and logistical approach, culminating in a final corpus of 49 studies.

The process of identification, screening, eligibility, and inclusion of studies followed the PRISMA 2020 guidelines, as illustrated in Figure 1.

Figure 1

PRISMA 2020 flowchart of the selection process of the integrative review studies



Source: Prepared by the authors (2025), based on the PRISMA 2020 guidelines.

The screening was carried out ensuring reliability to the selection process (KITCHENHAM et al., 2020).

3.4 DATA EXTRACTION, ANALYSIS AND ARTICULATION WITH RESULTS

Data extraction was carried out using a standardized spreadsheet, containing information on authorship, year, country, type of study, empirical object, type of infrastructure analyzed (hubs, ports, corridors) and main results.

The qualitative analysis followed the thematic content analysis technique (BARDIN, 2011), allowing the identification of recurrent analytical categories, such as: (i) hydrogen

hubs as vectors of green reindustrialization; (ii) logistics corridors and international insertion; (iii) governance, public policies and risks of energy enclaves.

These categories directly guided the presentation of the results in Section 4, in which concrete examples of green reindustrialization associated with logistics hubs and ports — such as the cases of Pecém (CE) and Açu (RJ) — identified in the analyzed literature are discussed. In this way, the methodology not only organizes the corpus, but analytically structures the discussion of the practical impacts of green hydrogen on regional development.

To ensure methodological rigor, criteria of transparency, analytical coherence, and traceability were adopted, as recommended by Torraco (2020) and Snyder (2019).

4 RESULTS AND DISCUSSIONS

The integrated analysis of the 49 studies included in the review shows that green hydrogen has been increasingly interpreted in the literature not only as a technological solution for decarbonization, but as a structuring element of new territorial, productive and institutional arrangements.

However, the discussion of the results allows us to move beyond the identification of potentialities, deepening a critical reading of the limits, gaps and constraints that shape the effects of green hydrogen on regional development.

Table 1 summarizes the main analytical categories and evidence identified in the reviewed literature, relating hydrogen hubs, logistics corridors, and regional development.

Table 1

Analytical synthesis of the main findings of the literature on green hydrogen, logistics hubs and regional development

Analytics Category	Key evidence identified in the literature	Implications for regional development	Representative references
Green hydrogen hubs as vectors of green reindustrialization	The literature indicates that integrated green hydrogen hubs favor economies of scale, infrastructure sharing, and risk reduction, in addition to stimulating the attraction of industrial investments and technological innovation, especially when associated with local industrial demands (steel, fertilizers, chemicals). Studies highlight that logistics corridors are essential to enable the transport and export of hydrogen derivatives (especially green ammonia), increasing commercial predictability and international competitiveness. However, regulatory bottlenecks and the absence of intermodal planning limit its effectiveness in emerging countries.	Potential for green reindustrialization, regional productive diversification and generation of qualified jobs, conditioned to the articulation with industrial and technological policies.	Heuser et al. (2024); Ribeiro et al. (2024); Ajanovic and Haas (2023); Furtado et al. (2023)
Green logistics corridors and international insertion		Expansion of the international insertion of producing regions, with the risk of export dependence if there is no integration with domestic markets and local production chains.	Quitow et al. (2024); Wang et al. (2023); Scholten et al. (2024); Trinomics (2024)

Multi-Scale Governance and Institutional Coordination	The literature converges in pointing out that the institutional fragmentation between energy, industrial, environmental, and logistics policies compromises the territorial benefits of green hydrogen projects. Multi-scalar governance arrangements and federative coordination are considered critical determinants of success.	Regions with greater institutional capacity and coordination tend to capture greater socioeconomic benefits; Absence of integrated governance increases risks of projects that are not very inclusive.	Ball and Lema (2024); Sovacool et al. (2023); Santos and Pereira (2024); Nascimento et al. (2023)
Risks of energy enclaves and concentration of benefits	A significant part of the literature warns that projects predominantly oriented to exports can generate energy enclaves, with weak local productive chains, low job generation and limited transfer of technological capacities.	Possible reproduction of regional inequalities and peripheral insertion in global hydrogen value chains, if there are no deliberate instruments of productive inclusion.	Ball and Lema (2024); Santos and Pereira (2024); López et al. (2023); Gómez et al. (2024)
Integration with local production chains and industrial policies	Evidence indicates that the positive impacts of green hydrogen are amplified when projects are integrated into existing industrial clusters and accompanied by local content policies, workforce training, and innovation support.	Strengthening regional productive capacities, greater retention of economic value in the territory and stimulation of green industrial innovation.	Ribeiro et al. (2024); Furtado et al. (2023); UNIDO (2024); Nascimento et al. (2023)

Territorial infrastructure and locational advantages	The territorial competitiveness of green hydrogen depends on the availability of renewable resources, port infrastructure, access to water and logistical connectivity. Coastal regions with structured ports have comparative advantages, but face regulatory and environmental challenges.	Consolidation of strategic regional hubs (especially in coastal regions), provided that it is accompanied by territorial planning and efficient environmental licensing.	Silva, Leite and Ferreira (2023); Mendelevitch et al. (2023); IEA (2024); Hansen et al. (2024)
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Source: Prepared by the authors (2025), based on the integrative literature review.

The detailed characterization of the included studies can be found in Appendix A (Table A1).

A first critical aspect concerns the recurrent decoupling between technological ambitions and territorial strategies. Although most studies recognize the role of hydrogen hubs as inducers of economies of scale and cost reduction, a significant portion of the literature points out that these arrangements have been conceived predominantly from energy and industrial logics, with limited integration into regional development policies. This gap results, in many cases, in projects strongly oriented to exports, with weak local productive chains and reduced capacity to generate employment and income in the territories where they are implemented.

The literature also highlights recurring flaws in the governance models associated with green hydrogen projects. Empirical studies indicate that institutional fragmentation — expressed in the low coordination between energy, industrial, environmental and logistics policies — compromises the materialization of the expected territorial benefits. In emerging countries, this fragmentation tends to be aggravated by asymmetries in state capacity between levels of government, resulting in centralized decision-making processes and limited participation of regional and local actors.

Another critical point concerns the logistical and institutional infrastructure. Although ports and logistics corridors are often presented as strategic assets, the literature reveals that regulatory bottlenecks, regulatory uncertainties, and the absence of intermodal

planning limit the operationalization of these corridors. In the Brazilian case, studies on Pecém and Açú show that, despite the locational advantages, challenges persist related to environmental licensing, rail and road integration, and the definition of specific regulatory frameworks for the transport and export of hydrogen derivatives.

With regard to green reindustrialization, the results suggest that its potential remains conditioned by the existence of explicit industrial policies. The literature identifies incipient experiences in which hydrogen hubs are articulated with existing industrial clusters — such as steel, fertilizers, and chemicals — generating productive diversification and innovation effects. However, such experiences are still exceptions, and not the rule, especially in countries that export natural resources, where the risk of reproducing a peripheral insertion in global hydrogen value chains prevails.

In summary, the discussion of the results indicates that the gaps identified in the literature do not result from technological limitations of green hydrogen, but from institutional, governance, and territorial articulation failures. These findings reinforce the need to understand green hydrogen as a development policy, and not just as an energy agenda.

5 CONCLUSION

This article analyzed, through an integrative review of the scientific literature, how the structuring of green hydrogen hubs and logistics corridors has been associated with regional development, with an emphasis on emerging countries and the Brazilian context. The analysis of 49 studies published between 2020 and 2025 allowed us to systematize evidence on the economic, territorial, and institutional potential of green hydrogen, as well as to identify critical constraints for the effective materialization of its regional benefits.

In summary, the results indicate that green hydrogen can act as a vector for green reindustrialization, attracting investments and strengthening local productive capacities, especially when organized in integrated territorial arrangements, such as hubs and structured logistics corridors. However, the literature converges in demonstrating that such benefits are not automatic and depend on the deliberate articulation between energy, industrial, logistics and regional development policies. Projects that are predominantly export-oriented, without mechanisms of productive inclusion and long-term territorial planning, tend to reproduce dynamics of energy enclaves and concentration of benefits.

In the Brazilian case, the studies analyzed show a unique combination of

opportunities and challenges. The abundance of renewable resources and the presence of strategic port infrastructure position the country competitively in global green hydrogen value chains. However, limitations associated with institutional coordination, multi-scale governance, and the definition of public policy instruments capable of promoting local productive chains and greater socioeconomic inclusion persist, especially in peripheral regions such as the Northeast.

In light of these findings, the article points out relevant implications for the formulation of public policies. The need to explicitly integrate the green hydrogen agenda into regional and industrial development policies is highlighted, avoiding its isolated conduct as an exclusively energy policy. In addition, it is essential to strengthen multi-scale governance arrangements that articulate the Union, states, municipalities, the private sector, and local science and technology institutions, as well as to prioritize the formation of local productive chains through instruments such as local content policies, strategic public procurement, labor training, and integrated planning of logistics corridors, considering intermodal infrastructure, regulatory frameworks and long-term territorial impacts.

As limitations of the study, the predominance, in the literature analyzed, of prospective, conceptual and scenario-based approaches stands out, reflecting the still emerging character of the green hydrogen sector. The scarcity of ex-post empirical evaluations of projects in operation limits the measurement of effective socioeconomic impacts at the regional and local levels.

In this sense, the article points to a clear agenda for future research. There is a need for in-depth empirical studies on green hydrogen projects in the implementation or operation phase, focusing on their effects on employment, income, production chains, and regional innovation. Comparative studies between Brazilian regions and between emerging countries can contribute to identifying more effective institutional arrangements and governance models. In addition, future research can deepen the analysis of specific public policies — such as national and state hydrogen strategies, financing instruments, and local content mechanisms — evaluating their coherence, effectiveness, and territorial impacts.

In summary, green hydrogen emerges in the literature as a strategic opportunity to align energy transition, economic competitiveness, and regional development. However, its effective contribution depends less on the technology itself and more on the way it is institutionally organized, territorially planned, and politically governed. By highlighting these constraints and gaps, the present study contributes to the advancement of the academic

debate and offers relevant analytical subsidies for researchers and public policy makers.

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APPENDIX A – STUDIES INCLUDED IN THE INTEGRATIVE REVIEW

This appendix presents the detailed version of the characterization of the studies that make up the final corpus of the integrative review (n = 49), as described in Section 3 – Methodology. The works were identified from a structured exploratory search in international and regional scientific bases, considering the period from 2020 to 2025.

Table 2

Studies included in the integrative review on green hydrogen, logistics hubs and regional development

No.	Author(s)	Year	Country/Region	Type of study	Main theme
1	Sovacool et al.	2023	Global	Critical review	Energy transition and hydrogen
2	Ball; Motto	2024	Emerging countries	Institutional analysis	Regional development
3	Quitow et al.	2024	Global	Analytical review	Global Value Chains
4	Scholten et al.	2024	Global	Geopolitics of energy	Corridors and addiction
5	Glenk; Reichelstein	2023	Global	Economic modeling	Costs of green hydrogen
6	Heuser et al.	2024	Europe	Applied study	Hydrogen hubs
7	Mendelevitch et al.	2023	Global	Economic analysis	Territorial competitiveness
8	International Energy Agency (IEA)	2024	Global	Technical Report	Hydrogen market
9	World Bank	2025	Global	Technical Report	Shared infrastructure
10	Trinomics	2024	Europe	Policy report	Hubs and planning
11	Silva; Milk; Ferreira	2023	Brazil	Case Study	Ports and hydrogen
12	Ribeiro et al.	2024	Brazil	Regional analysis	Territorial development
13	Santos; Pereira	2024	Brazil	Critical analysis	Regional inequalities
14	Wang et al.	2023	Global	Systematic review	Supply chains
15	Dawood et al.	2023	Global	Technical review	Production and use of hydrogen
16	Van der Zwaan et al.	2023	Global	Energy modeling	Sector coupling
17	Ajanovic; Haas	2023	Europe	Economic analysis	Hydrogen market
18	Peters et al.	2020	Global	Methodological	Scoping Review
19	Snyder	2019	Global	Methodological	Integrative review
20	Torraco	2020	Global	Methodological	Integrative review
21	Bardin	2011	France	Methodological	Content analysis
22	Monteiro et al.	2021	Global	Scientometrics	Scientific databases
23	Page et al.	2021	Global	Methodological	PRISMA 2020
24	Peters; Godfrey	2022	Global	Methodological	PCC Strategy
25	Furtado et al.	2023	Brazil	Public policy	Energy transition
26	Oliveira et al.	2024	Brazil	Planning	Energy infrastructure
27	Costa et al.	2023	Brazil	Regional study	Northeast Brazil
28	Lima; Rock	2024	Brazil	Territorial analysis	Local development
29	Souza et al.	2023	Brazil	Applied study	Port logistics
30	Ferreira et al.	2024	Brazil	Narrative review	Hydrogen chain
31	International Renewable Energy Agency (IRENA)	2023	Global	Technical Report	Green hydrogen

32	OECD	2023	Global	Policy report	Regional development
33	UNITED	2024	Global	Technical Report	Green industrialization
34	REN21	2023	Global	Technical Report	Renewable energy
35	Peters et al.	2021	Global	Methodological	Integrative review
36	Calvo et al.	2023	Spain	Case Study	Industrial hubs
37	Fratini et al.	2024	Italy	Logistics analysis	Green corridors
38	Müller et al.	2023	Germany	Empirical study	Hydrogen infrastructure
39	Hansen et al.	2024	Denmark	Planning	Energy ports
40	López et al.	2023	Chile	Territorial study	Hydrogen export
41	Gómez et al.	2024	Argentina	Energy policy	Hydrogen strategies
42	Nascimento et al.	2023	Brazil	Regional analysis	Production chains
43	Araujo et al.	2024	Brazil	Applied study	Regional hubs
44	Pereira et al.	2023	Brazil	Industrial policy	Energy transition
45	Batista et al.	2024	Brazil	Logistic study	Ports and exports
46	Rocha et al.	2023	Brazil	Planning	Logistics infrastructure
47	Almeida et al.	2024	Brazil	Critical review	Regional development
48	Costa; Lima	2023	Brazil	Economic analysis	Energy and territory
49	Figueiredo et al.	2024	Brazil	Empirical study	Hydrogen and industry

Source: Prepared by the authors (2025), based on the integrative literature review.

**BIOETHICS OF EVERYDAY LIFE AND THE PRACTICE OF OBSTETRICS
BASED ON ETHICAL AND MORAL PRINCIPLES: A CASE STUDY OF THE
MIDWIFE OF AUSCHWITZ**

**BIOÉTICA DO COTIDIANO E O EXERCÍCIO DA VOCAÇÃO OBSTETRÍCIA
BASEADA EM PRINCÍPIOS ÉTICOS E MORAIS, ESTUDO DE CASO DA
PARTEIRA DE AUSCHWITZ**

**BIOÉTICA DE LA VIDA COTIDIANA Y LA PRÁCTICA DE LA OBSTETRICIA
BASADA EN PRINCIPIOS ÉTICOS Y MORALES: UN ESTUDIO DE CASO DE
LA PARTERA DE AUSCHWITZ**

 <https://doi.org/10.56238/sevened2025.036-135>

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ABSTRACT

Everyday bioethics, especially in the context of obstetrics, addresses the ethical and moral dilemmas that healthcare professionals face in the exercise of their duties. This area highlights the importance of fundamental ethical and moral principles, such as autonomy, beneficence, non-maleficence, and justice, which guide daily decisions in the care of pregnant women and newborns. In the exercise of their duties, they often encounter complex situations, such as managing risks during pregnancy and childbirth, making decisions about medical interventions, and providing emotional support to pregnant women. Patient autonomy is essential, as it involves respecting their choices and beliefs, even if they may diverge from medical recommendations. Finally, everyday bioethics in obstetrics is permeated by an unwavering commitment to the dignity and rights of women, challenging professionals to balance their vocation with ethical responsibilities in constantly changing environments. A prime example of an icon embodying the essence of bioethics in practice is Stanisława Leszczyńska, known as the Midwife of Auschwitz. She faced immense ethical and moral challenges while working as a midwife in inhumane conditions. As part of the Nazi concentration camp system, she was forced to deal with the reality of unwanted pregnancies and childbirths in an environment of horror. Her commitment to life and human dignity stood out amidst the genocide. Her main ethical challenges included the obligation to perform deliveries under extreme conditions, often without adequate resources. The women she attended were mostly prisoners, and many faced death after childbirth. She had to choose between saving the mother and the child, a choice that put her own safety at risk, since the Nazis showed no compassion for these women, and she became a symbol of humanism in the face of horror, leaving lessons about the importance of acting with integrity. Her testimony challenges us to reflect on how phenomena of pressure and oppression impact ethical issues in medicine and other professions.

Keywords: Bioethics. Obstetrics. Dignity. Ethics. Morality. Medicine.

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RESUMO

A bioética do cotidiano, especialmente no contexto da obstetrícia, aborda os dilemas éticos e morais que profissionais da saúde enfrentam no exercício de suas funções. Esta área destaca a importância de princípios éticos e morais fundamentais, como a autonomia, beneficência, não maleficência e justiça, que guiam as decisões diárias no cuidado a gestantes e recém-nascidos. E no exercício de suas funções muitas vezes se deparam com situações complexas, como o manejo de riscos durante a gravidez e o parto, decisões sobre intervenções médicas e apoio emocional a gestantes. A autonomia da paciente é essencial, pois envolve respeitar suas escolhas e crenças, mesmo que possam divergir das recomendações médicas. Por fim, a bioética do cotidiano na obstetrícia é permeada por um compromisso inabalável com a dignidade e os direitos das mulheres, desafiando os profissionais a equilibrar sua vocação com responsabilidades éticas em ambientes de constante mudança. E um primoroso exemplo de um ícone da essência da bioética na prática é a “Stanisława Leszczyńska”, conhecida como a Parteira de Auschwitz, enfrentou desafios éticos e morais imensos durante sua atuação como parteira em condições desumanas. Como parte do sistema de campos de concentração nazistas, ela foi forçada a lidar com a realidade de gravidezes indesejadas e partos em um ambiente de horror. Seu compromisso com a vida e a dignidade humana destacou-se em meio ao genocídio. Seus principais desafios éticos como a obrigação de realizar partos sob condições extremas, muitas vezes sem os recursos adequados. As mulheres que ela atendia eram, na sua maioria, prisioneiras, e muitas vezes enfrentavam a morte após o parto. Ela tinha que decidir entre salvar a mãe e o filho, uma escolha que colocava sua própria segurança em risco, uma vez que os nazistas não demonstravam compaixão por essas mulheres, e se tornou um símbolo de humanismo em frente ao horror, deixando lições sobre a importância de agir com integridade, seu testemunho nos desafia a refletir sobre como fenômenos de pressão e opressão impactam questões éticas na medicina e em outras profissões.

Palavras-chave: Bioética. Obstetrícia. Dignidade. Ética. Moral. Medicina.

RESUMEN

La bioética cotidiana, especialmente en el contexto de la obstetricia, aborda los dilemas éticos y morales que enfrentan los profesionales de la salud en el ejercicio de sus funciones. Esta área destaca la importancia de principios éticos y morales fundamentales, como la autonomía, la beneficencia, la no maleficencia y la justicia, que guían las decisiones diarias en el cuidado de las mujeres embarazadas y los recién nacidos. En el ejercicio de sus funciones, a menudo se enfrentan a situaciones complejas, como la gestión de riesgos durante el embarazo y el parto, la toma de decisiones sobre intervenciones médicas y el apoyo emocional a las mujeres embarazadas. La autonomía de las pacientes es esencial, ya que implica respetar sus decisiones y creencias, incluso si pueden discrepar de las recomendaciones médicas. Finalmente, la bioética cotidiana en obstetricia está impregnada de un compromiso inquebrantable con la dignidad y los derechos de las mujeres, lo que desafía a los profesionales a conciliar su vocación con las responsabilidades éticas en entornos en constante cambio. Un ejemplo destacado de un icono que encarna la esencia de la bioética en la práctica es Stanisława Leszczyńska, conocida como la Matrona de Auschwitz. Se enfrentó a inmensos desafíos éticos y morales mientras trabajaba como partera en condiciones inhumanas. Como parte del sistema de campos de concentración nazi, se vio obligada a lidiar con la realidad de embarazos y partos no deseados en un entorno de horror. Su compromiso con la vida y la dignidad humana se destacó en medio del genocidio. Sus principales desafíos éticos incluyeron la

obligación de realizar partos en condiciones extremas, a menudo sin los recursos adecuados. Las mujeres que atendió eran en su mayoría prisioneras, y muchas enfrentaban la muerte después del parto. Tuvo que elegir entre salvar a la madre y al niño, una decisión que puso en riesgo su propia seguridad, ya que los nazis no mostraron compasión por estas mujeres. Se convirtió en un símbolo del humanismo frente al horror, dejando lecciones sobre la importancia de actuar con integridad. Su testimonio nos reta a reflexionar sobre cómo los fenómenos de presión y opresión impactan en las cuestiones éticas de la medicina y otras profesiones.

Palabras clave: Bioética. Obstetricia. Dignidad. Ética. Moralidad. Medicina.

1 INTRODUCTION

1.1 BIOETHICS OF EVERYDAY LIFE IN OBSTETRICS: REFLECTIONS IN THE LIGHT OF MEDICAL PRACTICE

Bioethics, as a multidisciplinary field that deals with the ethical implications of medical practice, plays a fundamental role in obstetrics, where decisions have a direct impact on the lives of mothers and newborns. Obstetric practice is not restricted to delivering babies, but involves a complex set of decisions that require an improved understanding of bioethics in everyday life.

Within this context, it is essential to consider the work of Professor Nilo Agostini, who incisively addresses the ethical issues that permeate medical practice. In his book "Bioethics: Fundamentals and Applications", Agostini discusses the importance of autonomy, beneficence and non-maleficence – pillars that should guide the performance of health professionals, especially in obstetrics.

One of the main ethical principles in obstetrics is women's autonomy. The right to make decisions about your body and your birth is fundamental. However, this autonomy is often challenged by cultural issues and hospital practices that impose standards. Agostini (2020) argues that women's empowerment should be a priority in obstetric care. This implies not only respecting their choices, but also providing clear and safe information so that they can make informed decisions.

Health professionals, in turn, face the daily dilemma of balancing patient autonomy with the need for interventions that ensure safety. The concept of beneficence, which refers to the obligation to act for the good of the patient, can generate conflicts. For example, the recommendation of elective cesarean sections, in some cases, may be more of a physician's choice than a clinical necessity, leading to discussion about the real intention behind these interventions (Lima, 2022).

In situations where the health of the mother or fetus is at risk, bioethics becomes more complex. The principle of non-maleficence requires the doctor to act to avoid harm, but the consequences of decisions need to be weighed. Case studies in obstetrics often reveal the need to address issues such as fetal viability and the risks associated with procedures, respecting the mother's wishes, whenever possible (Andrade, 2021).

Communication is a fundamental aspect in obstetric practice and an ethical principle that must be emphasized. According to Agostini, open dialogue between doctor and patient

is essential for building a relationship of trust. The use of accessible language and active listening are essential for women to feel valued in their experiences and decisions.

Another crucial point of bioethics in obstetrics concerns issues involving the beginning of life. The ethical dilemmas that arise in cases of fetal anomalies or situations involving the possibility of suffering the newborn are complex and require careful and respectful discussion between doctors, patients, and family members (Cruz and Oliveira, 2023). The responsibility of providing guidance on the available options, always respecting the dignity of life, is a task that demands sensitivity and understanding.

In summary, bioethics in obstetrics should always be present in the reflections of daily medical practice. Professor Nilo Agostini's work offers a solid basis for the understanding and application of ethical principles in clinical practice, emphasizing the importance of autonomy, communication, and respect for patients' choices. Continuous training and openness to dialogue are fundamental to ensure obstetric care centered on life and human dignity, thus reflecting a truly ethical and responsible practice in contemporary medicine.

2 THE ETHICAL MANAGEMENT OF OBSTETRIC EMERGENCIES IN CONTEXTS: MODERN HOSPITAL VERSUS MIDWIVES IN EXTREME CONDITIONS

Continuing the analysis of the bioethical principles presented above, emergency management is the field in which ethics assumes the most decisive role, as it involves quick actions, imminent risk of death, and the need to balance principles even under adverse conditions. Analyzing this management in contrasting contexts — the modern hospital environment and the performance of midwives in extreme conditions, allows us to understand how ethics manifests itself in different ways, but equally profound, depending on historical, social and structural circumstances.

In the modern hospital context, contemporary hospitals and obstetric emergencies are managed within a strongly structured environment, with technological resources, multidisciplinary teams, and well-established, evidence-based protocols. The physician performs critical functions, such as drug administration, emergency surgical interventions, and therapeutic decision-making, which are essential for maternal and fetal stabilization and safety (Brasil, 2014). Specialized training and continuous education are essential to ensure quick and effective responses in highly complex scenarios (Ferreira, 2019).

The presence of trained professionals in obstetric emergency units is associated with better maternal and neonatal outcomes, contributing to the reduction of mortality and morbidity related to obstetric complications (Brito & Fortes, 2021). In addition, evidence-based practice ensures the application of up-to-date protocols, while interdisciplinary collaboration between physicians, nurses, and other professionals promotes integrated and effective care (Sousa et al., 2021; WHO, 2020).

Among the main obstetric emergencies in a hospital context are: postpartum hemorrhage, preeclampsia/eclampsia, acute fetal distress, uterine rupture, umbilical cord prolapse and shoulder dystocia (WHO, 2017; FIGO, 2022). All require quick and reasoned decisions, combining technical knowledge and evidence, in addition to respect for the dignity of the pregnant woman.

Technology, such as fetal monitoring, portable ultrasound, electronic recording systems, and telemedicine, helps in the early identification of complications and in making more assertive decisions, although it does not replace the technical knowledge, experience, and communication skills of the health professional as described. Thus, the ethical management of obstetric emergencies in hospitals and modern health systems combines technical preparation, continuous updating, and interdisciplinary cooperation, ensuring safe and humanized care for mothers and newborns.

In contrast, the work of midwives in extreme conditions, environments of precariousness or violence, such as communities without resources, concentration camps or war regions, ethical management takes on another proportion.

Without resources, without staff or under surveillance, ethics is not based on protocols, but on humanity and internal moral duty. The midwife without adequate instruments resorts to practical experience and body knowledge. Each decision is driven by an attempt to preserve the minimum of dignity and life, even in the face of the impossibility of favorable results.

Obstetric practice becomes an act of moral resistance. Care in the midst of horror is, in itself, an "ethical protest". It seeks to evaluate suffering, avoid despair and protect those women as best you can, an ethics based on the human bond and their faith, often deeper than any protocol. Showing that the value of the profession is not only in technical knowledge, but in the ability to act with courage, empathy, and moral responsibility even in the face of severe limitations.

The recognition of midwives is essential, not only in terms of professional appreciation, but also because they offer emotional support, guidance and humanized care, establishing a deep bond with the pregnant woman, a fundamental role in maternal health, especially in contexts of vulnerability, resource constraints or extreme situations. The work of midwives and health professionals in extreme situations reveals the essence of obstetric care: protecting life and humanity even when everything around is inhumane.

Both professionals, doctors and obstetric nurses in adverse conditions, seek to preserve the life and dignity of women and newborns. The modern obstetrician deals with technical pressure; The midwife in extreme conditions deals with existential pressure and risk to personal life. In the hospital, technology is used to help guide ethics; In extreme adversity, ethics depends radically on the moral strength of the individual. In the safe and contemporary environment, autonomy is operationalized via informed consent; while in contexts, such as those discussed, autonomy is limited or unfeasible, prevailing the ethics of protection.

Therefore, understanding these differences broadens the reflection on professional performance in obstetrics and reinforces the need to recognize ethical limits, adapt decisions in adverse scenarios, and preserve human dignity as a central element of care, regardless of structural conditions. As Hippocrates said: "Where there is love for the art of medicine, there will also be love for humanity."

To replicate the practice reported above, it was opportune to expose a summarized approach to an iconic and rich example in the history of a woman who faced all the challenges in the midst of the Nazi regime, in the Auschwitz concentration camp, and exercised her profession with ethics and values above what was imposed on her, A great example for everyday bioethics of what a professional obstetrics really is exercising her principles and preserving the dignity of the human person in hostile and chaotic environments.

3 STANISŁAWA LESZCZYŃSKA: BIOGRAPHY, FAITH AND PROFESSIONAL TRAINING

Stanisława Leszczyńska was born on May 8, 1896, in the city of Łódź, Poland, into a deeply Catholic working-class family, a context that shaped his social and ethical conscience from an early age. Daughter of a carpenter and a dedicated mother, her moral formation was marked by an environment of discipline, faith and solidarity. During his youth,

his family temporarily emigrated to Brazil, returning to Poland shortly before the outbreak of World War I. Back in Łódź, she married Bronisław Leszczyński, with whom she had four children, while also pursuing professional qualifications (Gabryel, 1989).

Her career as a midwife formally began in 1920, when she entered the obstetrics course at the University of Warsaw, completing her studies in 1922 with honors. According to *Midwifery in Poland* (Nagórska; Zych; Lesińska-Sawicka, 2024), the teaching of obstetrics in the interwar period was deeply influenced by humanist principles, being centered on the integral care of women and the appreciation of life. Leszczyńska adopted these principles with conviction and began to practice the profession in her community with enormous recognition. Their performance was based not only on technical competence, but on deep respect for pregnant women, regardless of their social status or religion (Dobrowolska et al., 2011).

Christian spirituality profoundly guided his professional conduct. She saw motherhood as a sacred expression of human dignity and interpreted childbirth as an act of grace, whose defense of life could not be relativized even in the face of war. As Olczyk and Król (2017) point out, Leszczyńska believed in the sanctity of life from conception, which was the basis for her unconditional refusal of any practice that threatened the unborn child. This Christian ethic was not restricted to the private sphere, but was lived daily in his profession, as a form of moral commitment to God and to the vulnerable.

Engagement with the weakest intensified during the Nazi occupation of Poland. As recorded by Kłodziński (1975), Stanisława and his family participated in the resistance, sheltering Jews and collaborating with the Łódź ghetto support network, which led to his arrest by the Gestapo in 1943. Deported with her daughter to the Auschwitz-Birkenau concentration camp, she received the number 41335. There, she was assigned to the maternity ward, where she worked as a midwife under direct orders from the SS and doctor Josef Mengele. Even in absolutely inhumane conditions — without instruments, hygiene or medicines — she performed about three thousand births, without any woman dying under her care (Tierling-Śledź, 2021).

His performance at Auschwitz was marked by firm ethical resistance. She vehemently refused to obey orders of systematic infanticide, even when confronted directly by Mengele. In his testimony, Leszczyńska (1991) states: "No, never! Children should not be killed", a phrase that summarizes his posture of fidelity to the dignity of human life, even if this implied a direct risk to his own survival. The moral pedagogy contained in her attitude

was analyzed by Olearczyk (2023), who considers her an expression of practical virtue and an example of ethical training for future midwives and health professionals.

Stanisława Leszczyńska therefore represented the convergence of technique, faith and ethics. His pre-war training, already grounded in Christian and humanist principles, was put to the test in the extreme context of Auschwitz, where his obstetric practice became an act of resistance against the logic of death. As Gliński (2021) observes, her biography challenges the boundaries between the ordinary and the heroic, and is inscribed in the field of memory as a testimony of a professional who, in the face of barbarism, unconditionally chose life. The understanding of his trajectory requires, therefore, a reading that goes beyond the biographical: it is an incarnate ethic, lived on the border between care and horror.

4 THE PRACTICE OF THE MIDWIFE AT AUSCHWITZ: ETHICAL RESISTANCE AND HUMANIZATION IN HELL

Stanisława Leszczyńska's performance in the Auschwitz-Birkenau extermination camp constituted a singular mark of moral resistance in the midst of the collapse of ethical and sanitary structures promoted by the Nazi regime. In Block 24 of the BIIe sector, intended for pregnant women, there was a supposed "maternity hospital" without any adequate medical support, where births took place on improvised boards, in the midst of dirt, cold, hunger and total absence of asepsis or anesthesia. The scarcity of resources was extreme: there was a lack of gloves, instruments, medicines, clean clothes and drinking water. The parturients, in turn, were severely malnourished, sick, and physically and emotionally exhausted by forced labor and the daily brutality of the camp (Dobrowolska et al., 2011; Tierling-Śledź, 2021; Bitencourt, 2012).

Against this backdrop of absolute dehumanization, Leszczyńska's obstetric practice emerged as a space of radical ethical resistance. Alone, without formal medical help, she attended the birth of approximately 3,000 children, adamantly refusing to cooperate with the genocidal practices imposed by the Nazis, especially systematic infanticide. The order from the camp authorities—especially Dr. Josef Mengele—was clear: no Jewish child was to survive. Many of the collaborationist midwives, under the command of SS officers, followed the protocol of drowning newborns in buckets of water or injecting lethal substances immediately after delivery (Corkran, 2021; Galle, 2011; Posner; Ware, 2019).

Stanisława, however, held firm to his professional and spiritual conduct. When questioned by Mengele about the reason for her disobedience to orders, she replied with conviction: "No, never. You cannot kill children" (Leszczyńska, 1991). This intransigent stance in the face of the culture of death was not limited to a religious position – although his Catholic faith played a central role – but also reflected a deep commitment to the ethics of care and to the inalienable principle of human dignity (Olczyk; Król, 2017; Olearczyk, 2023). Her active refusal was not directly punished, perhaps because of the Nazis' belief that the resistance of a Catholic, Polish woman and prisoner was irrelevant in the face of the scale of the extermination, or, as speculated by Glinski (2021), because her discreet performance did not directly confront the camp's power structure.

Even though she could not prevent the murders committed by the SS and collaborators, Leszczyńska recorded each birth in small hidden notebooks, baptized the children — using water or saliva — and tried to preserve the bond between mother and baby as much as possible, even if only for a moment. It is estimated that about 2,500 children born in the camp were executed shortly after birth, while only about 30 survived, generally those who had physical traits considered "Aryan" and, therefore, were assigned to Germanization programs promoted by the regime (Gabryel, 1989; Rubenfeld, 2010; Mccrary, 2022).

The humanization of care practiced by Leszczyńska acquired, in that context, subversive contours. Every assisted birth, every gesture of comfort, every whispered prayer to the mother or the newborn, constituted a symbolic negation of the Nazi logic of annihilation. The space of "motherhood" was thus transformed into a place of silent moral resistance, where the preservation of life assumed the value of ethical denunciation (Wasserman; Yoskowitz, 2019; Santos, 2024).

Leszczyńska was released in 1945, returning to her practice as a midwife in Łódź, Poland. Even after the war, he kept silent for years, until he recounted his experience in the text "Nie, nigdy! Nie wolno zabijać dzieci" (Leszczyńska, 1991), in which he accurately documents the horrors witnessed, the omission of many, and the limits of possible resistance. Her work began to be studied not only as a biographical episode, but as a pedagogical and ethical reference for the training of midwives, nurses and health professionals in general (Klodziński, 1975; Nagórska; Zych; Lesińska-Sawicka, 2024).

Stanisława Leszczyńska's legacy lives on as an expression of the possibility of care even in the most extreme conditions of degradation. Her obstetric practice, grounded in

faith, compassion, and professional ethics, not only saved lives, but withstood barbarism with the silent force of humanity.

5 ETHICAL LEGACY, RECOGNITION AND IMPLICATIONS IN HEALTH EDUCATION

Stanisława Leszczyńska's testimony does not end at Auschwitz-Birkenau. Her experience of ethical resistance, based on the dignity of life and the unwavering commitment to the principles of obstetric practice, reverberates to this day in the fields of bioethics, historical memory and professional training in health. The posthumous publication of the *Raport położnej z Oświęcimia* (Report of the Auschwitz Midwife), written by Leszczyńska herself in 1957, constitutes not only a memorial record, but a document of profound ethical and political relevance. In the text, she recounts in detail the conditions of births in the camp, her systematic refusal of infanticide ordered by SS authorities — including Josef Mengele — and the effort to maintain a minimum of humanity in the midst of institutionalized horror (Leszczyńska, 1991; Mccrary, 2022).

The report, widely disseminated and translated, is now the object of study in the fields of the history of medicine and applied bioethics. Her narrative strength and testimonial value were also recognized by the Catholic Church, which began the process of beatification of Leszczyńska as a servant of God, highlighting her life as an example of heroic virtues. The institutional recognition of his figure also occurs in secular contexts: several nursing schools and professional training centers in Poland adopt his biography as a transversal content, promoting the discussion on ethics, care, and resistance (Gliński, 2021; Tierling-Śledź, 2021; Dobrowolska et al., 2011).

The pedagogical character of Stanisława's trajectory is widely analyzed by Olearczyk (2023), who argues that the moral posture of the midwife configures a model of ethical training for future generations of health professionals. This perspective is shared by studies that deal with secular spirituality as a form of resistance and pedagogy of care, such as those by Olczyk and Król (2017), which place Leszczyńska in a lineage of figures who transformed the technical exercise into a moral mission. The presence of his history in disciplines such as History of Medicine, Professional Ethics and Collective Health highlights the transversality of his legacy, whose influence goes beyond obstetrics and reaches doctors, nurses, psychologists and professionals of contemporary bioethics (Rubenfeld, 2010; Wasserman; Yoskowitz, 2019).

Leszczyńska's contribution to vocational training does not lie only in her biographical example. Their work evidenced, in a concrete way, the possibility of building clinical practices based on humanization, even in scenarios of total dehumanization. As the studies by Corkran (2021) and Santos (2024) demonstrate, the obstetric care provided by her, in the midst of the absence of supplies, institutional violence, and constant threat of death, constitutes a radical form of resistance and reaffirmation of life. The impact of this testimony is visible in training projects that prioritize the centrality of the dignity of the person and the valorization of the professional-patient bond as the axis of clinical practice.

In addition, the recognition of the role of women in confronting Nazi barbarism, as highlighted by Bitencourt (2012), broadens the understanding of obstetric practice as a political gesture of confrontation and denunciation. Leszczyńska, by not submitting to Mengele's orders, not only survived the camp's perverse logic, but subverted its codes, transforming the delivery room at Auschwitz into one of humanity's last refuges. As Gabryel (1989) points out, his story is a continuous appeal to professional conscience, reminding us that technical knowledge should never be dissociated from ethics and compassion.

Finally, the insertion of her trajectory in the literature on bioethics and medicine after the Holocaust, as attested by Rubenfeld (2010) and Wasserman and Yoskowitz (2019), consolidates Leszczyńska as a paradigmatic figure in the critical training of health professionals. His legacy is not reduced to a heroic memory, but is projected as a formative requirement: to educate to resist, to care to transform, to bear witness so as not to repeat. In times of health and ethical crises, its history continues to challenge the present, calling on new generations to reaffirm the non-negotiable value of life, even – and above all – in the face of darkness.

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APPLICATIONS OF FUZZY LOGIC, SENSING, AND IOT TECHNOLOGIES IN THE MONITORING OF ENVIRONMENTAL CONDITIONS IN LAYER POULTRY HOUSES: A SCOPING REVIEW

APLICAÇÕES DA LÓGICA FUZZY, SENSORIAMENTO E TECNOLOGIAS IOT NO MONITORAMENTO DA AMBIÊNCIA EM AVIÁRIOS DE POSTURA: UMA REVISÃO DE ESCOPO

APLICACIONES DE LA LÓGICA DIFUSA, EL SENSADO Y LAS TECNOLOGÍAS IOT EN EL MONITOREO DEL AMBIENTE EN GALLINEROS DE POSTURA: UNA REVISIÓN DE ALCANCE

 <https://doi.org/10.56238/sevened2025.036-136>

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ABSTRACT

Given the relevance of layer poultry farming to Brazilian agribusiness and the need to ensure adequate environmental conditions for bird welfare and productive performance, it is pertinent to investigate how technologies and intelligent models have been applied to the housing environment of poultry facilities. This study aims to identify, map, and characterize research that integrates, individually or in combination, fuzzy logic, environmental sensing, and IoT technologies in the monitoring of the environment in layer poultry houses. A scoping review was conducted according to JBI methodology and PRISMA-ScR guidelines, including database searches, rigorous study selection, and data extraction. A total of 52 studies published between 2020 and 2025 were included. Most research was carried out in Indonesia and China, with a predominance of field studies. Temperature and humidity were the most frequently monitored variables, whereas gas measurements appeared less frequently. Low-cost sensors from the DHT and MQ families and hardware platforms such as ESP and Arduino were predominantly employed. Fuzzy logic was the main artificial intelligence technique identified, although many systems operated without intelligent models. Most proposals were integrated with cloud-based solutions, but few employed long-range wireless networks. The review also identified many studies focused on broiler chickens, limited adoption of environmental classification, and an almost complete absence of validation using recognized environmental indices. It is concluded that, despite the technological advances observed, important gaps remain regarding environmental classification and validation, the use of artificial intelligence, gas monitoring, long-range communication, and the development of solutions specifically tailored to layer poultry houses.

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Keywords: Fuzzy Logic. Animal Environment. Internet of Things (IoT). Layer Poultry Farming. Environmental Sensing.

RESUMO

Considerando a relevância da avicultura de postura para o agronegócio brasileiro e a necessidade de assegurar condições ambientais adequadas ao bem-estar e ao desempenho produtivo das aves, torna-se pertinente investigar como tecnologias e modelos inteligentes têm sido aplicados na ambiência de aviários. O objetivo deste estudo é identificar, mapear e caracterizar pesquisas que integrem, de forma isolada ou combinada, lógica fuzzy, sensoriamento ambiental e tecnologias IoT no monitoramento da ambiência em aviários de postura. Para tanto, realizou-se uma revisão de escopo conforme metodologias do JBI e PRISMA-ScR, com buscas em bases científicas, seleção criteriosa e extração de dados. Foram incluídos 52 estudos publicados entre 2020 e 2025. Observou-se predominância de pesquisas conduzidas na Indonésia e na China, com maior ocorrência de estudos de campo. Temperatura e umidade foram as variáveis mais monitoradas, enquanto a medição de gases apareceu em menor escala. Sensores de baixo custo das séries DHT e MQ e plataformas como ESP e Arduino foram majoritariamente empregados. A lógica fuzzy foi a técnica de inteligência artificial predominante, embora muitos sistemas tenham operado sem modelos inteligentes. A maioria das propostas integrou-se à nuvem, mas poucas utilizaram redes sem fio de longa distância. Identificaram-se ainda muitos estudos para frangos de corte, baixa adoção de classificação ambiental e quase inexistência de validação por índices reconhecidos. Conclui-se que, apesar dos avanços tecnológicos observados, persistem lacunas relacionadas à classificação e validação ambiental, uso de inteligência artificial, monitoramento de gases, comunicação de longo alcance e desenvolvimento de soluções específicas para aviários de postura.

Palavras-chave: Lógica Fuzzy. Ambiência Animal. Internet das Coisas (IoT). Avicultura de Postura. Sensoriamento Ambiental.

RESUMEN

Considerando la relevancia de la avicultura de postura para el agronegocio brasileño y la necesidad de asegurar condiciones ambientales adecuadas para el bienestar y el desempeño productivo de las aves, resulta pertinente investigar cómo las tecnologías y los modelos inteligentes se han aplicado a la ambiencia de los aviarios. El objetivo de este estudio es identificar, mapear y caracterizar investigaciones que integren, de forma aislada o combinada, lógica difusa, sensoriamento ambiental y tecnologías IoT en el monitoreo de la ambiencia en aviarios de postura. Para ello, se llevó a cabo una revisión de alcance conforme a las metodologías del JBI y PRISMA-ScR, con búsquedas en bases científicas, selección rigurosa y extracción de datos. Se incluyeron 52 estudios publicados entre 2020 y 2025. Se observó predominio de investigaciones realizadas en Indonesia y China, con mayor ocurrencia de estudios de campo. La temperatura y la humedad fueron las variables más monitoreadas, mientras que la medición de gases apareció en menor escala. Sensores de bajo costo de las series DHT y MQ y plataformas como ESP y Arduino fueron empleados de forma predominante. La lógica difusa fue la principal técnica de inteligencia artificial identificada, aunque muchos sistemas funcionaron sin modelos inteligentes. La mayoría de las propuestas se integró a la nube, pero pocas utilizaron redes inalámbricas de largo alcance. Asimismo, se identificó un número elevado de estudios con pollos de engorde, baja adopción de clasificación ambiental y casi inexistente validación mediante

índices reconocidos. Se concluye que, a pesar de los avances tecnológicos observados, persisten brechas relacionadas con la clasificación y la validación ambiental, el uso de inteligencia artificial, el monitoreo de gases, la comunicación de largo alcance y el desarrollo de soluciones específicas para aviarios de postura.

Palabras clave: Lógica Difusa. Ambiencia Animal. Internet de las Cosas (IoT). Avicultura de Postura. Sensado Ambiental.

1 INTRODUCTION

Laying poultry stands out as one of the most important activities in the Brazilian livestock sector, contributing significantly to food security and the national economy. In 2024, Brazil produced 57.6 billion eggs, reaching a per capita consumption of 269 units per inhabitant, positioning itself as the fifth largest producer in the world, with a gross production value of R\$ 26.1 billion (Brazilian Association of Animal Protein - ABPA, 2025). These data show the relevance of the activity and, consequently, the need to improve processes involving animal welfare and productivity.

The productive performance of the birds is strongly conditioned by the environmental variables present inside the poultry houses. According to Baêta and Souza (2010), variables such as temperature, humidity, radiation and ventilation make up the thermal environment and influence the comfort and health of birds. Situations of heat stress or poor air quality can compromise important physiological functions, affecting the growth, immune resistance and feed efficiency of laying hens. The maintenance of homeothermy, especially within the thermoneutral zone, the ideal range of ambient temperature for maximum production efficiency, is crucial to avoid production losses and ensure animal welfare (Silva, 2001).

The breeding of laying hens is divided into three distinct phases, breeding, rearing and production, each with specific requirements regarding animal welfare and the ideal environment. The recommended ranges of temperature, humidity and gas concentration vary according to the age of the birds, however the technical literature presents divergences in these values, which reinforces the need for a careful and standardized approach to environmental control (Silva; Abreu; Mazzuco, 2020).

Faced with these challenges, the use of digital and intelligent technologies in poultry farming has gained prominence. Sensors, actuators, microcontrollers, wireless networks and software have been integrated into poultry production for continuous monitoring of the environment and health of birds. In the field of artificial intelligence, fuzzy inference models have been successfully applied to deal with uncertainties and assist in data-driven decision-making, with the potential to simulate human reasoning and generate adaptive responses in real time (Simões; Shaw, 2007; Abreu, 2022).

Despite the advances achieved by these solutions, the technical-scientific literature still shows considerable heterogeneity regarding the fuzzy models employed, the monitoring technologies adopted, the environmental variables analyzed, and the ideal

ranges recommended for these variables. In particular, it is verified that the use of fuzzy logic integrated with environmental sensors, data transmission by technologies such as LoRa network and cloud storage, has not yet been comprehensively mapped in poultry production, especially in laying hen aviaries. In view of this, a scoping review is necessary and appropriate to identify, map and characterize existing studies, allowing us to understand the extent and nature of scientific production on the subject, in addition to revealing opportunities for advancement in areas still under consolidation.

A preliminary search was carried out to identify existing scoping reviews and systematic reviews on the use of fuzzy logic, sensing and IoT technologies applied to the monitoring of the environment in laying hen aviaries. This search took place on August 29, 2025, using the following scientific platforms and databases: IEEE Xplore, Scopus, Science Direct, Scielo, Web of Science, CAPES Journals, and Google Scholar. No reviews were identified that addressed these elements in an integrated manner, which highlights the originality and relevance of the present proposal.

Therefore, the objective of this scoping review is to identify, map and characterize studies that integrate fuzzy logic, environmental sensors and data transmission and analysis technologies, in the monitoring of the environment in laying hen aviaries, seeking to understand how these elements have been combined in the scientific literature and what gaps still persist to support future innovations and research in the area.

2 METHODOLOGY

This scoping review was conducted according to the methodology proposed by the Joanna Briggs Institute (JBI) (Peters *et al.*, 2020), following the guidelines of the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) (Tricco *et al.*, 2018). The complete protocol of this review was previously registered in the Open Science Framework (OSF) platform, under DOI: 10.17605/OSF.IO/YQ6BG.

According to Arksey and O'Malley (2005), scoping reviews aim to comprehensively map the literature, characterizing trends and identifying gaps in broad or underexplored fields, thus offering a comprehensive view of the state of the art and guiding future research, however, they generally do not evaluate the methodological quality of the studies. Its conduction follows five stages: (1) formulation of the research question; (2) identification of

relevant studies; (3) selection of studies; (4) mapping and data extraction; and (5) synthesis and presentation of the results.

As advised by the Joanna Briggs Institute, the acronym PCC (Population, Concept and Context) was used to prepare the research question. In this model, Population refers to laying hens; the Concept covers the monitoring of the environment associated with the use of fuzzy logic, environmental sensing, low-cost IoT technologies, data transmission and cloud storage; and the Context corresponds to commercial aviaries intended for laying production. Thus, the following research question was defined: What are the approaches, technologies and parameters used in studies that apply fuzzy logic and IoT technologies in monitoring the environment of laying aviaries? Additional questions were also formulated, namely: Which environmental variables (temperature, humidity, gases) are most frequently monitored? How is environmental data collected, transmitted, and processed in these studies?

The stage of identifying relevant studies was conducted comprehensively, through searches in scientific databases recognized for their academic rigor, including IEEE Xplore, Scopus, Science Direct, SciELO, Web of Science and the CAPES Journals portal, as well as gray literature, such as Google Scholar, in order to capture studies not indexed in traditional databases. The consultations were carried out on August 29, 2025, using the publication filters between 2020 and 2025 and inclusion of texts in Portuguese, English or Spanish. The search strategy was elaborated based on the elements of the acronym PCC, using descriptors combined by Boolean operators, such as: (fuzzy) AND (chickens OR laying OR hens OR broilers OR poultry house OR layer house OR poultry shed) AND (temperature OR humidity OR environmental OR conditions OR monitoring OR thermal OR comfort) AND (iot OR sensing OR sensor OR smart OR wireless OR lora OR network OR communication OR cloud OR computing OR processing). According to the specificities of each database, some terms and operators needed to be adapted, as described in the protocol of this review.

Eligibility criteria were defined to ensure the selection of studies aligned with the proposed objective. As an inclusion criterion, studies that address the monitoring of the environment in poultry houses through the use of fuzzy logic, sensing or data transmission, in isolation or in combination, were considered. In turn, the exclusion criterion included studies that do not deal with the monitoring of the environment of poultry houses with the

application of fuzzy logic or sensing or data transmission technologies, as well as review articles, texts without access to full content, and duplicate publications.

Although the focus of this scoping review is the monitoring of the environment in laying aviaries, it was decided to include studies conducted in broiler systems whenever they addressed technologies, sensing methods, IoT architectures or computational models applicable to environmental control in poultry facilities. This methodological decision was adopted due to the recognized similarity of environmental requirements (temperature, humidity, gases and ventilation) between the production systems, as well as the scarcity of specific studies directed to the laying poultry industry identified during the search phase.

In the study selection stage, all records obtained in the searches carried out in the databases were imported into the free software StArt (State of the Art through Systematic Review), developed by the Software Engineering Research Laboratory at UFSCAR (LAPES, 2025), which assisted in the organization and management of the screening process. The selection took place in two phases: in the first, titles, abstracts and keywords were evaluated to verify adherence to the inclusion criteria; in the second, potentially relevant studies were analyzed in full to confirm eligibility. The entire procedure was performed by two independent researchers, and any disagreements were resolved by consensus or with the help of a third researcher.

The mapping and data extraction stage was carried out based on the included studies, using structured extraction tables prepared by the authors themselves. These tables included the following fields: author, year of publication, country of origin, study objective, methodological design (experimental, field, or case study), technologies employed (such as microcontrollers, sensors, communication networks, and cloud storage systems), monitored environmental variables (temperature, humidity, and gases), artificial intelligence techniques used (fuzzy logic, neural networks, or decision tree), actuator control, environmental classification, evaluated species (laying or beef hens) and main results observed. Data extraction was conducted independently by two researchers, and any divergences were resolved by consensus or, when necessary, with the mediation of a third evaluator.

In the synthesis and presentation of the results stage, the extracted data were organized and presented in tables and Figures, in line with the objective of the review and with the established guiding questions. The descriptive analysis included the interpretation of the results, the methodological characterization of the included studies, and the

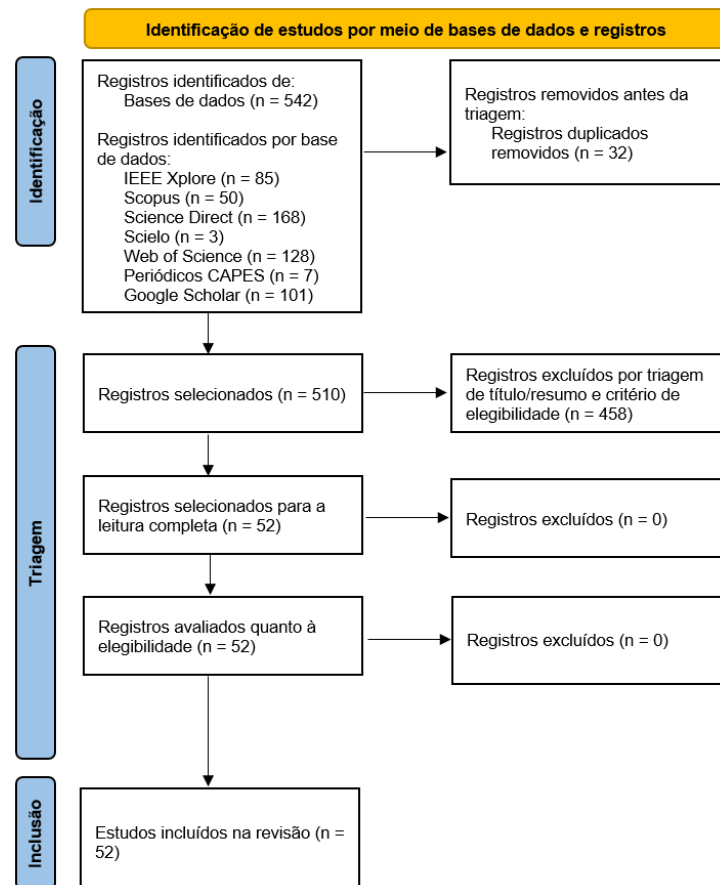
identification of gaps in the scientific literature. This process involved the identification of the most monitored environmental variables, the types of sensors and IoT technologies used, the artificial intelligence techniques used, and the strategies for collecting, transmitting, and processing environmental information.

3 RESULTS

The search carried out in databases and sources of gray literature identified a total of 542 records. After the removal of 32 duplicate records, 510 studies were retained for the initial screening by title and abstract, of which 458 were excluded because they did not meet the eligibility criteria. Subsequently, 52 articles were evaluated in full, resulting in the final inclusion of 52 studies that made up the set of studies included in this review. Figure 1 presents the PRISMA-ScR flowchart, which describes in detail the process of identification, screening, eligibility and inclusion of evidence sources.

Figure 1

PRISMA-ScR flowchart of the study selection process



Source: Prepared by the authors.

Among the selected studies, it was observed that part of the research was focused on broiler chickens. Although they did not directly represent the target population of this review, these studies were maintained because they met the eligibility criteria, especially with regard to the use of fuzzy logic, sensing, and IoT technologies applied to environmental monitoring. These works contributed to broadening the understanding of the technological solutions available in the poultry sector.

Table 1 presents the general characterization of the 52 studies included, with regard to the distribution by country, most of the studies were carried out in Indonesia, with 23 studies (44.2%), followed by China, with 8 (15.4%). Brazil, India, and Morocco presented 4 studies each (7.7%). Malaysia contributed 3 studies (5.7%), while Pakistan and Bangladesh recorded 2 each (3.9%). Colombia and Cyprus appeared with only 1 study each (1.9%).

Regarding the methodological design, it was observed that most of the studies included corresponded to field studies, totaling 27 studies (51.9%). Next, experimental studies were identified, represented by 23 studies (44.3%). Only one study was classified as a case study (1.9%) and another as a modeling and simulation study (1.9%).

Regarding the databases consulted, it was found that most of the studies included were identified in Google Scholar, which gathered 36 studies (69.2%). IEEE Xplore contributed with 10 studies (19.2%), while Scopus presented 4 (7.8%) and CAPES Journals recorded 2 studies (3.8%). Studies from the Science Direct, SciELO or Web of Science databases were not selected.

Table 1

General characterization of the included articles

Author / Year / Country	Objective of the Study	Main results
Liani <i>et al.</i> , 2021 Indonesia	Monitor temperature and humidity in poultry houses using LoRaWAN and fuzzy logic to assess the thermal comfort of broiler chickens.	The system transmitted temperature and humidity data via LoRaWAN, and the fuzzy model identified optimal thermal conditions for the broiler birds.
Lashari <i>et al.</i> , 2023 Pakistan	Implement an IoT system to monitor temperature, humidity, O ₂ , CO ₂ , CO and NH ₃ in broiler houses.	The IoT system monitored six environmental parameters in a real-world scenario, detecting acceptable levels of O ₂ , CO ₂ , NH ₃ and CO.
Silva <i>et al.</i> , 2025 Brazil	Develop an embedded fuzzy system with web application for thermal control of broiler aviaries.	The IoT system with fuzzy logic achieved 98% accuracy and performed automatic thermal control via the web
Ali <i>et al.</i> , 2024 Pakistan	Develop an intelligent environmental control system for poultry houses, based on IoT and machine learning.	The Decision Tree model achieved 99.97% accuracy and allowed the automation of temperature, humidity, water, light and gases control in the aviary.

Malika <i>et al.</i> , 2021 Malaysia	Develop an IoT system to monitor temperature and humidity in aviaries with automatic activation.	The system monitored temperature, humidity and activated heating and ventilation automatically, sending alerts to the user.
Lehaa T. <i>et al.</i> , 2025 India	Develop an IoT system to monitor and control temperature, humidity, ammonia gas, and water in poultry houses.	The system maintained temperature and humidity within the ideal range; Reduced ammonia and accurately automated actuators.
Adha <i>et al.</i> , 2022 Malaysia	Propose and test an IoT framework to monitor temperature, humidity and ammonia in poultry houses.	The prototype validated the sensor readings, with data displayed on the website in a stable and reliable way.
Reddy <i>et al.</i> , 2024 India	Develop an IoT - CNN system to optimize temperature, humidity and air quality in poultry houses.	CNN reduced environmental deviations, increased stability, and outperformed PID, Fuzzy, and MPC methods.
Liu <i>et al.</i> , 2022 China	Evaluate the environmental quality of poultry houses using fuzzy logic and correlate with laying rate.	The fuzzy logic revealed environmental variations and a strong correlation with the laying rate.
Pranta; Islam; Khan, 2025 Bangladesh	Create and test an online decision-tree-based AI model integrated with sensors to control heat stress in layers.	The system reduced temperature and UTI, increased egg production (14.5%) and acted with 100% accuracy and low cost.
Santos; Borges, 2022 Brazil	Develop a low-cost IoT system to monitor temperature and humidity in small poultry houses.	The system monitored temperature and humidity, sent data for local and remote viewing, demonstrating practical feasibility.
Rubio; Ortiz, 2021 Colombia	Implement an IoT system to monitor and control environmental variables in poultry houses.	The system monitored temperature, humidity, ventilation, NH ₃ gas, and automated fogging and drinking fountains, sending data to the cloud.
Husein; Kharisma, 2020 Indonesia	Develop a fuzzy-IoT system to control temperature and humidity in broiler houses.	The system kept the temperature and humidity close to ideal, displayed real-time data, and improved the weight uniformity of the chickens.
Prasetia; Dahlan; Lifwarda, 2024 Indonesia	Develop an IoT system to monitor temperature and humidity in broiler chicken coops.	The system with microcontroller and sensor, monitored temperature, humidity, activated ventilation, light and buzzer according to variations, maintaining conditions close to ideal.
Sanjaya; Fadlil, 2023 Indonesia	Develop an IoT system to monitor and control temperature and humidity in broiler houses.	The system activated ventilation, fogging and heating according to temperature and humidity, presented low reading error and sent data to the cloud.
Perdanasari; Etikasari; Rukmi, 2023 Indonesia	Develop an IoT system to monitor and control temperature, humidity and ammonia in real time in laying aviaries.	The system monitored temperature, humidity, and NH ₃ gas stably for 16 days, with automatic actuator triggering and consistent sensor readings.
Suprianto; Pristiyaningrum; Prasetyo, 2022 Indonesia	Develop an IoT system with fuzzy logic (Sugeno) to control temperature and humidity in a prototype broiler aviary.	The system kept the temperature around 30.3 °C and the humidity around 70.5 percent, controlling the actuators by fuzzy logic and displaying the environmental data in real time.
Fahrurrozi <i>et al.</i> , 2024 Indonesia	Develop an IoT system integrated with the Random Forest model to predict environmental conditions of the aviary.	The Random Forest AI model with temporal variables achieved 96.66% accuracy and worked integrated with the web system.
Ishak <i>et al.</i> , 2024 Indonesia	Develop an IoT system to monitor temperature, humidity and ammonia at different points on the farm, evaluating accuracy and usability.	The system measured temperature, humidity, and ammonia with low error (0.5–3.1%), detected NH ₃ concentration peaks, and recorded everything in real time on the dashboard and LCD.

Shanmugapriya; Sangeethadevi; Kalaivani, 2022 India	Develop an IoT system with a wireless sensor network to monitor temperature, humidity, air quality and safety in poultry houses.	The system maintained a temperature close to 32 °C and stable humidity around 60%; The exhaust fan reduced pollutants and the alerts and dashboard worked in real time.
Susanto <i>et al.</i> , 2023 Indonesia	Design IoT system to monitor temperature and trigger lamp automatically in pre-defined ranges.	The system measured the temperature accurately; the lamp turned on below 28°C and turned off above 31°C; and the control operated stably by ThingSpeak.
Syafar; Anwar; Ridwansyah, 2021 Indonesia	Develop an IoT system to monitor temperature, humidity, and ammonia, sending data to the smartphone.	The system monitored temperature, humidity and ammonia with the DHT22 and MQ-135 sensors; sent the data via GSM to the smartphone; and activated exhaust fan, heating and cooling.
Nalendra <i>et al.</i> , 2021 Indonesia	Evaluate the effectiveness of an IoT system to monitor temperature, humidity, and gas by observing the reaction of birds.	The system measured temperature, humidity and gas with sensors; showed small differences for the thermohygrometer; and maintained adequate conditions, with normal reaction of the birds.
Budiarto <i>et al.</i> , 2020 Indonesia	Implement an IoT system to monitor temperature, ammonia and food, with automatic alerts.	The system controlled the temperature by fuzzy logic, monitored ammonia and food accurately, and sent data to the server, with SMS alerts.
Setiadi; Arifiandi, 2024 Indonesia	Develop automatic feeder and IoT system to monitor temperature in aviary.	The system released feed at the defined times, displayed temperature and humidity on the LCD, activated a fan above 30 °C and a lamp below 25 °C, and maintained a Wi-Fi connection up to 10 m.
Saputra <i>et al.</i> , 2020 Indonesia	Implement fuzzy control in IoT module to regulate temperature and humidity in simulated heating environment for chicks.	The system sent data to the cloud; the actuators were controlled by fuzzy logic; and the PWM of the fan and heater showed a low error (0.11% and 0.22%) in relation to the MATLAB.
Adek <i>et al.</i> , 2024 Indonesia	Develop and evaluate an IoT system with fuzzy controller to regulate temperature, humidity and ammonia in chick rearing box.	Fuzzy control maintained low temperature and humidity, stabilized ammonia between 8–12 ppm, and reduced energy consumption, improving chick performance.
Arief; Damayanti, 2022 Indonesia	Develop a fuzzy system to optimize temperature in the early stage of chick rearing	The fuzzy control maintained the reference temperature for 14 days, showed responses close to the MATLAB, and regulated the temperature effectively with heating and cooling.
Fadhliana; Suryawan; Ariyadi, 2021 Indonesia	Develop a fuzzy microcontroller system to control temperature and humidity in quail cages.	The system showed a minimal difference between MATLAB and Arduino, adjusted temperature and humidity according to the fuzzy rules and obtained a very low average deviation (0.0438).
Mulya <i>et al.</i> , 2024 Indonesia	Evaluate the performance of an IoT system on a real farm to monitor temperature, humidity, electrical voltage and CCTV images.	The system collected real-time data, displayed measurements and videos on the web, and recorded a temperature of 27–35 °C, humidity of 60–90%, and voltage of 143–218V.
Rosikin <i>et al.</i> , 2023 Indonesia	Develop a fuzzy system to automate temperature, humidity and ammonia control with spray drive.	The system controlled the variables by fuzzy logic, sent data to the cloud and showed 100% accuracy, but low sensitivity and accuracy, indicating the need for improvements.
Manju <i>et al.</i> , 2024 India	Develop an IoT system to monitor and control temperature, humidity, water level, ammonia and waste on the farm.	The system monitored variables in real time, triggered ventilation, exhaust and water replenishment, sent data to the web

		and operated stably, reducing manual intervention.
Praing <i>et al.</i> , 2025 Indonesia	Develop an IoT system with fuzzy to automatically control the temperature in broiler sheds.	The system adjusted fan and lamp as per the fuzzy rules, displayed the data in the cloud, the DHT22 sensor showed high accuracy, and the control maintained the proper temperature.
Lahlouh <i>et al.</i> , 2020 Morocco	Implement and evaluate a fuzzy controller to regulate temperature, humidity and gases in a chicken rearing system.	The fuzzy controller reduced errors and flicker, decreased CO ₂ and NH ₃ gases, increased bird weight gain and reduced energy consumption by up to 43%.
Liu <i>et al.</i> , 2024 China	Develop and test an intelligent IoT platform for environmental monitoring and management in poultry houses.	The platform operated for more than 500 days with high data integrity and validity (>94%), monitored environment, consumption, and production, sent alerts, and maintained stable web integration.
De-Sousa <i>et al.</i> , 2023 Brazil	Develop and validate a fuzzy model to classify the vulnerability of broiler systems to heat stress.	The fuzzy model showed high accuracy and sensitivity (>0.9) in comfort and high stress, moderate performance in thermal discomfort and predictions consistent with the literature and weather forecasts.
Panagi <i>et al.</i> , 2025 Cyprus	Develop and validate an integrated platform with AI and multiple sensors for environmental and behavioral monitoring, productivity prediction and decision support in laying farms.	The system monitored temperature, humidity, audio and video; generated environmental alerts and forecasts; and AI modules showed high accuracy, including egg counting with 100% accuracy in the field.
Zheng <i>et al.</i> , 2021 China	Develop a sensor-based and cloud-based poultry management system for environmental and operational monitoring.	The system integrated environmental sensors, transmitted data via WSN to the cloud, and enabled real-time monitoring and disease diagnosis.
Kaimujjaman; Hossain; Khatun, 2023 Bangladesh	Develop and test an automatic system to monitor and control temperature and humidity in broiler aviaries.	The system controlled temperature and humidity, reduced mortality and improved feed conversion, production efficiency and economic performance compared to the conventional system.
Aulia; Kurniawan, 2024 Indonesia	Develop an automatic system with fuzzy logic to control the temperature in a mini house for newborn chicks.	The system stabilized the temperature using automatic heating and ventilation and showed high sensor accuracy (99.62%).
Kandarsamy; Mashori, 2024 Malaysia	Develop a smart chicken coop with automation to monitor and control temperature, humidity, light, food, water, and cleanliness.	The system maintained adequate environmental conditions, automated feeding, water and cleaning, improved safety and sustained good growth of the birds.
Wijaya; Hartati, 2024 Indonesia	Implement automatic temperature and humidity control using fuzzy logic to improve the thermal comfort of broilers.	The system reduced temperature and humidity, improved the ITU from 27.6% to 50.56%, increased the productive performance of the birds and stored the data in the cloud.
Lorencena <i>et al.</i> , 2020 Brazil	Propose a system for automatic control and environmental supervision of poultry houses.	The system controlled temperature and humidity, improved thermal distribution in simulations, and allowed remote supervision.
Yu <i>et al.</i> , 2025 China	Build an environmental monitoring system and propose a fuzzy model to evaluate the comfort of laying sheds.	The system monitored six environmental variables and generated fuzzy evaluations in real time; Adequate conditions increased posture.

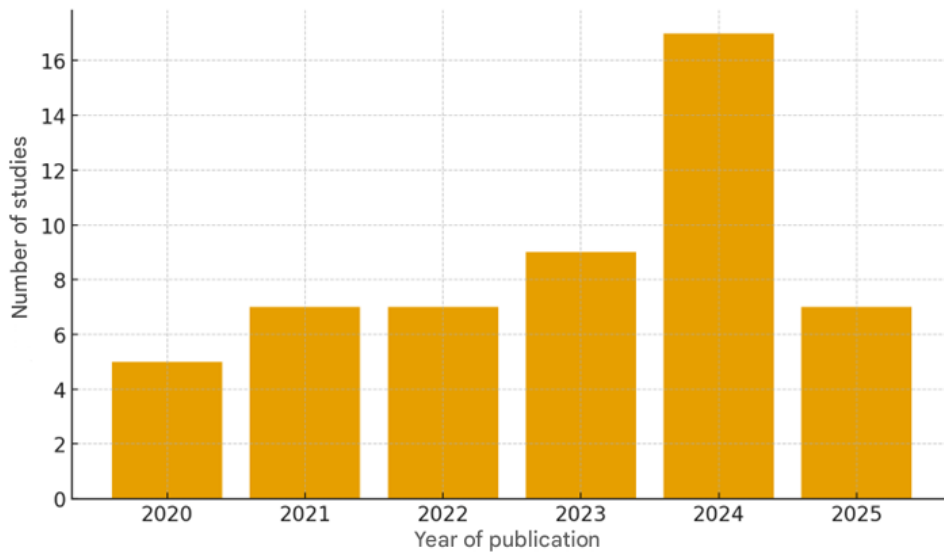
Gao <i>et al.</i> , 2022 China	Build a microclimatic model of rearing aviary and develop a decoupled fuzzy control strategy.	The model reproduced temperature and humidity with good accuracy, and the fuzzy control reduced environmental deviations compared to manual control.
Zhang; Ma; Khadka, 2024 China	To develop an adaptive system to predict multiple environmental factors in poultry houses using Multif-LSTM.	The Multif-LSTM predicted temperature, humidity and NH ₃ with greater accuracy, reducing errors and increasing the R ² in relation to the RNN and LSTM models.
Lahlouh <i>et al.</i> , 2024 Morocco	Develop and validate a state-space model to predict temperature and humidity in mechanically ventilated poultry houses.	The model predicted temperature and humidity with high accuracy (R ² 0.93–0.95) and low errors, reproducing well the environmental variations at different ages and ventilation modes.
Li <i>et al.</i> , 2023 China	Apply adaptive fusion and the Dempster–Shafer Theory of Evidence to integrate multiple sensors and improve environmental assessment in laying aviary.	The multisensory fusion system monitored temperature, humidity, light, and NH ₃ , and the adaptive and evidence algorithms increased the accuracy of the environmental assessment.
Elghardouf <i>et al.</i> , 2023 Morocco	Develop and validate mathematical models for air velocity and differential pressure in an air-conditioned aviary.	The model predicted air velocity and pressure with high accuracy (error < 1.1%), and measurements in real aviary showed good fit in natural, mixed and tunnel modes.
Elghardouf <i>et al.</i> , 2024 Morocco	Develop and compare environmental control strategies optimized by evolutionary algorithms to regulate temperature, humidity, NH ₃ and CO ₂ in poultry houses.	The control by active rejection of disturbances, optimized by particle swarm, showed better performance than the integral proportional derivative control. Genetic and gray wolf algorithms have brought smaller gains.
Rachmanita <i>et al.</i> , 2025 Indonesia	Implement a solar-powered, IoT-integrated environmental control system in broiler poultry house.	The system monitored temperature, humidity and NH ₃ in real time, triggered exhaust fans, reduced energy costs by around 10% and improved productivity and mortality.
Li <i>et al.</i> , 2024 China	Apply multivariate analysis to characterize the microclimate of poultry houses in winter using data from multiple sensors.	It identified key variables and, with principal component analysis and fuzzy grouping, characterized indoor areas by air quality with greater accuracy.

Source: Prepared by the authors.

In 2020, 5 studies (9.5%) were identified, a number that increased to 7 studies in 2021 (13.5%) and remained the same in 2022, also with 7 studies (13.5%). In 2023, 9 studies were published (17.3%), while 2024 had the highest volume, with 17 studies (32.7%). Finally, 2025 recorded 7 studies (13.5%). Figure 2 shows the distribution of the 52 studies included by year of publication.

Figure 2

Distribution of studies by year of publication



Source: Prepared by the authors.

Table 2 presents a general summary of the 52 selected studies, covering the following indicators: poultry species evaluated, environmental variables monitored, type of environmental sensor used, type of hardware platform used, type of wireless data transmission network, type of artificial intelligence technique applied, use of storage systems and/or cloud data consultation, automatic control of actuators, environmental classification and validation of results with recognized environmental indexes. It should be noted that the same study may employ more than one indicator within each category, for example, combining different hardware platforms or multiple types of network. Thus, the frequencies and percentages presented reflect the number of occurrences and do not necessarily total 100% within each group.

Table 2

General synthesis of the selected studies

Collection indicators	Key findings
Type of species evaluated.	Laying hen – 13 (25%) Broiler – 39 (75%)
Environmental variables monitored.	Temperature – 52 (100%) Humidity – 49 (94.2%) Gases – 26 (50%) Others – 17 (32.7%)
Type of environmental sensor used.	DHT Series (Temperature/Humidity) – 29 (55.7%) SHT Series (Temperature/Humidity) – 3 (5.7%)

	MQ Series (gas) – 18 (34.6%) Others – 25 (48%) None – 6 (11.5%)
Type of hardware platform used.	ESP Series – 22 (42.3%) Arduino – 18 (34.6%) Raspberry – 9 (17.3%) Others – 10 (19.2%) None – 7 (13.4%)
Type of wireless data transmission network used.	Wi-Fi – 26 (50%) LoRa – 4 (7.7%) Mobile (3G/4G/5G) – 4 (7.7%) Others – 3 (5.7%) None – 18 (34.6%)
Type of artificial intelligence technique used.	Fuzzy logic – 19 (36.5%) Neural networks – 2 (3.8%) Decision trees – 2 (3.8%) Others – 10 (19.2%) None – 21 (40.3%)
Did you use a cloud data storage and/or consultation system?	Yes – 32 (61.5%) No – 20 (38.5%)
Did the system perform automatic actuator control?	Yes with Artificial Intelligence – 17 (32.7%) Yes without Artificial Intelligence – 21 (40.4%) Did not perform – 14 (26.9%)
Did the system make an environmental classification (e.g., good, moderate, critical)?	AI-powered Yes – 13 (25%) Yes without Artificial Intelligence – 5 (9.6%) Did not do so – 34 (65.4%)
Was there validation of the results with recognized environmental indexes?	Yes – 2 (3.8%) No – 50 (96.2%)

Source: Prepared by the authors.

The synthesis of the main indicators raised in the included studies allowed us to visualize the diversity of technological approaches applied to environmental monitoring in poultry systems. It was observed that several surveys used more than one hardware platform, environmental sensor, or communication technology simultaneously. Overall, temperature and humidity were the most monitored variables, followed by gas detection, while the ESP series and Arduino stood out among the hardware platforms employed. As for the sensors, the use of the DHT and MQ series predominated, although other environmental sensors were also applied. It was also found that the distribution of the studies shows a predominance of research carried out in broiler systems (75%), while only 25% directly address laying aviaries. This result points to a relevant gap in the scientific literature, indicating that, despite the economic and productive importance of laying poultry, there is less investment in research specifically aimed at automated monitoring of the environment in this production system.

The Wi-Fi network was the most recurrent means of data transmission, although some studies have explored LoRa communication or cellular connections. Fuzzy logic was

the most used artificial intelligence technique, either for environmental classification or to support actuator control, while a portion of the studies were limited to monitoring without the application of an artificial intelligence method. In addition, it was observed that most of the systems incorporated cloud storage and that few studies validated their results with recognized ambience indexes. These findings provide a technological and methodological overview of the studies analyzed, serving as a basis for discussion in the following section.

4 DISCUSSION

The results of this scoping review show a significant growth in research involving fuzzy logic, sensing, and IoT technologies applied to monitoring the environment in poultry systems between 2020 and 2025. There was a gradual increase in the number of publications throughout the period, especially in 2024, which concentrated the largest number of studies included. This behavior suggests that the theme goes hand in hand with the recent expansion of digital and smart solutions in livestock production, as well as the growing interest in continuous monitoring systems and data-driven decision-making on commercial farms.

From a geographical point of view, the distribution of studies revealed a strong concentration especially in Indonesia and China, followed by Brazil, India, Morocco and other countries. This predominance may be related to the economic importance of poultry farming in these regions, the advancement of policies to encourage agriculture 4.0, and the greater availability of technical labor for the development of prototypes and low-cost IoT platforms. At the same time, the lower representation of other egg and chicken meat producing countries indicates an opportunity to expand investigations in environmental and production contexts, particularly in laying systems.

Although the focus of this review is on laying aviaries, most of the studies included were conducted with broilers, as exemplified by Liani *et al.* (2021), Husein and Kharisma (2020) and Sanjaya and Fadlil (2023), among others. On the other hand, a smaller number of investigations addressed laying hens, as in the works of Liu *et al.* (2022), Perdnasari, Etikasari and Rukmi (2023) and Panagi *et al.* (2025). This asymmetry highlights an important gap, considering that the longevity of birds, their sensitivity to environmental variations, and the specific welfare demands in laying aviaries, justify the need to expand technological solutions dedicated to this segment.

Regarding the methodological design, field studies predominate, as demonstrated by Lashari *et al.* (2023), Fahrurrozi *et al.* (2024) and Mulya *et al.* (2024). Next, experimental research, carried out in controlled environments, as in Lehaa *et al.* (2025), Silva *et al.* (2025) and Adha *et al.* (2022). A case study was also identified (Malika *et al.*, 2021) and another based on modeling and simulation (Elghardouf *et al.*, 2024). This profile indicates that a large part of the technological proposals have been tested in real production conditions, which favors the practical validation of monitoring and control systems. At the same time, the relevant presence of experimental and simulation studies demonstrates the importance of prototyping and calibration steps in controlled environments, before implementation on a commercial scale. The combination of both designs strengthens the reliability of the results, but also highlights the need for detailed methodological descriptions to allow replication and comparison between studies.

With regard to the environmental variables monitored, it was observed that temperature and humidity are present in practically all studies, while the measurement of gases, such as ammonia and carbon dioxide, is even less frequent. This predominance was expected, as temperature and relative humidity are the main indicators of thermal comfort and are relatively simple to measure with widely available sensors. However, the lower emphasis on gas monitoring represents a critical point, since air quality is directly related to the respiratory health of birds, productive performance and the working conditions of employees. In this sense, the expansion of the use of specific sensors for NH₃, CO₂ and other contaminants, as well as the integration of these parameters in decision models, sets an important direction for future research.

The analysis of the types of sensors and the hardware platforms employed reveals a preference for widely available low-cost sensors, especially the DHT and MQ series, and for affordable microcontrollers, such as ESP32 and Arduino, as observed in Syafar, Anwar and Ridwansyah (2021), Nalendra *et al.* (2021) and Ishak *et al.* (2024). This combination reflects the search for affordable solutions, easy to program, and with good integration with wireless networks, which favors the construction of modular and scalable IoT systems. However, the adoption of more accurate SHT series sensors and more robust hardware architectures may be necessary in applications that require higher accuracy reliability, read stability, and service life.

In the field of communication technologies, the Wi-Fi network was the most widely used form of wireless transmission, appearing in studies such as that of Shanmugapriya,

Sangeethadevi and Kalaivani (2022), Setiadi and Arifiandi (2024) and Prasetya, Dahlan and Lifwarda (2024). While long-range and low-consumption networks, such as LoRa, emerged in a much smaller proportion, being mentioned in few studies, such as the one by Liani *et al.* (2021), Santos and Borges (2022) and Rubio and Ortiz (2021). This scenario indicates that many systems still rely on the restricted-range local area network. The low adoption of LoRaWAN reveals room for advancement, especially in limited or extensive connectivity properties with multiple warehouses. Expanding the use of LoRa network or other technologies can help overcome these limitations and expand the coverage of real-time monitoring.

Following the example of Suprianto, Pristiyaningrum and Prasetyo (2022), Saputra *et al.* (2020) and Adek *et al.* (2024), fuzzy logic stood out as a widely used artificial intelligence technique, both for classifying environmental conditions and for supporting the automatic activation of actuators. Other intelligent models, such as neural networks and decision trees, appeared in much smaller quantities, recorded in Zhang, Ma and Khadka (2024), Reddy *et al.* (2024) and Pranta, Islam and Khan (2025). However, a significant number of studies did not use artificial intelligence, being limited to monitoring and automation by fixed rules, as in Susanto *et al.* (2023), Manju *et al.* (2024) and Zheng *et al.* (2021). This result shows that, although fuzzy logic is consolidated as a promising tool to treat uncertainties and translate the knowledge of experts in inference systems, its use is not yet predominant in the entire set of IoT applications in poultry farming, thus indicating that the transition to truly intelligent systems is still in progress. In addition, the integration between fuzzy logic and other artificial intelligence methods, such as predictive models based on time series or multivariate classification algorithms, appears in few studies, which opens space for more sophisticated hybrid proposals.

As demonstrated in Kandarsamy and Mashori (2024), Aulia and Kurniawan (2024) and Kaimujjaman, Hossain and Khatun (2023), it was found that most of the systems described in the studies perform automatic actuator control. Among these, a slightly larger portion employs artificial intelligence techniques to support the decision process, while another part performs the triggers only based on fixed temperature and humidity thresholds, without the use of artificial intelligence.

Regarding the environmental classification, identified in the research of Liu *et al.* (2022), Pranta, Islam and Khan (2025) and De-Sousa *et al.* (2023), only a small portion of the studies explicitly categorized the conditions, adopting terms such as "comfortable",

"moderate" or "critical". Among these studies, some used artificial intelligence techniques, such as fuzzy logic or other models, while the others performed classification without the support of artificial intelligence. This gap is significant, as the translation of numerical data into understandable language classes is critical to support decision-making by technicians and producers. This process becomes even more efficient when carried out with the support of artificial intelligence techniques, which allow converting continuous information into interpretable categories in a consistent and adaptive way, in addition to facilitating the integration of these outputs into web interfaces and mobile applications.

Another point identified is that a very small number of studies validated the results with recognized indices of thermal comfort or environmental quality, as happened in the works of Wijaya and Hartati (2024) and Pranta, Islam and Khan (2025). Few studies have compared the responses of their systems with literature indexes, which limits comparability between approaches and makes it difficult to assess the real impact of the proposed technologies on animal welfare and productive performance.

Finally, it is noteworthy that most studies implemented some type of cloud data storage or consultation (Liani *et al.*, 2021; Lashari *et al.*, 2023; Silva *et al.*, 2025), which reinforces the trend of digitization and centralization of environmental information on remotely accessible platforms. Still, an important fraction of the work remains limited to on-premise solutions, without remote exploitation of real-time data (Ali *et al.*, 2024; Malika *et al.*, 2021; Liu *et al.*, 2022).

In general, the analyzed studies demonstrate significant advances in the area of environment in poultry sheds, but also reveal important challenges identified. Thus, the findings of this review provide a solid basis to guide and support future investigations in the development of intelligent environmental monitoring systems in poultry houses.

5 CONCLUSION

This scoping review highlighted three central quantitative findings. First, only 25% of the studies analyzed directly address laying aviaries, while 75% focus on broiler systems, indicating a relevant gap in the scientific literature specifically focused on egg production. Secondly, it was found that practically 100% of the studies monitor the environmental variables temperature and humidity, while 50% of the studies also monitor parameters related to air quality, such as gases and particulate matter, indicating a growing concern with environmental impacts and animal welfare. Finally, it was observed that about 40.3%

of the studies do not use artificial intelligence or machine learning techniques, being limited to descriptive analyses or monitoring systems without automated decision-making support.

In the technological field, it was verified the majority use of low-cost temperature, humidity and gas sensors, especially the DHT and MQ series, as well as accessible hardware platforms, such as ESP series microcontrollers and Arduino boards, usually associated with communication via Wi-Fi. Long-range and low-consumption data transmission technologies, such as the LoRa network, have been little explored, pointing to opportunities for advancement in rural scenarios with multiple warehouses and restricted connectivity. Fuzzy logic stood out as the most used artificial intelligence technique, however, a considerable number of systems still operate without using intelligent models for both automatic actuator control and environmental classification. Classification, in particular, was very little used in the studies analyzed, despite its importance for translating numerical data into understandable linguistic categories, such as "comfortable", "moderate" or "critical". This type of classification makes the reading of environmental conditions more intuitive for technicians and producers, strengthening the decision-making process. It was also observed that, although many of the systems integrate cloud data storage and consultation solutions, this practice is not yet universal among research. The implementation of cloud platforms enables remote monitoring in real time and favors historical data analysis, so the use of this technology is an important opportunity to strengthen the intelligent management of poultry houses.

Regarding the validation of the results by means of recognized indices of thermal comfort or environmental quality, it was found that this practice was practically absent among the studies analyzed. This gap compromises the comparability of approaches and makes it difficult to assess the real impact of solutions on animal welfare and productive performance.

In view of these findings, it is concluded that the objective of this scoping review, which consists of identifying, mapping and characterizing studies that integrate, in isolation or combination, fuzzy logic, environmental sensors and IoT technologies in the monitoring of the environment in laying aviaries, was achieved. However, it is recommended that future investigations prioritize: (i) the expansion of the monitoring of variables related to air quality; (ii) the integrated use of fuzzy logic with other artificial intelligence techniques for prediction, classification, and decision-making; (iii) the validation of systems with consolidated environmental indexes; and (iv) the development of specific solutions for laying aviaries,

with a focus on low-cost IoT hardware, long-range wireless networks, full integration with cloud computing environments and intelligent data analysis. Such advances combined can contribute to consolidating intelligent environmental monitoring and control systems in laying poultry farming, promoting animal welfare, productive sustainability and greater efficiency in the use of resources.

ACKNOWLEDGMENTS

The authors thank the São Paulo State University "Júlio de Mesquita Filho" (UNESP), Tupã Campus, for the institutional support; to CAPES for granting the doctoral scholarship to the first author (L. C. T. Albuquerque); and CNPq for granting Research Productivity grants to L. R. A. Gabriel Filho (Proc. 317061/2023-2) and C. P. C. Gabriel (Proc. 316839/2023-0).

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THE INFLUENCE OF LEADERSHIP ON EMPLOYEE MOTIVATION
A INFLUÊNCIA DA LIDERANÇA NA MOTIVAÇÃO DOS COLABORADORES
LA INFLUENCIA DEL LIDERAZGO EN LA MOTIVACIÓN DE LOS COLABORADORES

 <https://doi.org/10.56238/sevened2025.036-137>

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ABSTRACT

The figure of the leader has become indispensable in organizations, as leaders can encourage their teams to strive for excellence, innovate, and create new ways of carrying out activities, managing unforeseen situations with calmness and creativity, and influencing people to achieve both their own goals and those of the organization. For these factors to occur, it is necessary that all those involved are motivated. Therefore, this study aims to understand, from the perspective of subordinates, how leadership influences the motivation of team members in a company within the metallurgical sector in Caxias do Sul, Rio Grande do Sul, Brazil. Regarding methodology, a questionnaire was administered to 69 employees from the administrative area of a company that manufactures machinery and equipment for the beverage, food, and chemical industries, in order to assess the level and orientation of motivation, as well as the leadership style perceived by subordinates. The results revealed that most respondents exhibit a high level of motivation and a success-oriented profile. In addition, their leaders demonstrate an integrative leadership style. On the other hand, it was identified that gender, length of service, and average salary do not statistically significantly influence employee motivation.

Keywords: Leadership. Motivation. Performance.

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RESUMO

A figura do líder se tornou indispensável nas empresas, pois ele pode impulsionar na sua equipe a vontade de fazer o melhor, de inovar, de criar novas formas de realizar as atividades, conduzindo os imprevistos com tranquilidade e criatividade, influenciando as pessoas a atingirem seus próprios objetivos e os da organização. Para que esses fatores ocorram, é necessário que haja motivação de todos os envolvidos. Portanto, esse trabalho tem como objetivo compreender, do ponto de vista do liderado, como a liderança influencia na motivação dos integrantes da equipe em uma empresa do segmento metalúrgico em Caxias do Sul - RS. Como metodologia, foi utilizado um questionário em 69 colaboradores da área administrativa de uma empresa fabricante de máquinas e equipamentos para o segmento de indústria de bebidas, alimentos e química, para averiguar o nível e orientação da motivação, assim como o estilo do líder percebido pelos liderados. Os resultados revelaram que existe um alto nível de motivação na maioria dos entrevistados e possuem uma orientação para o sucesso. Complementando, seus líderes revelam um estilo integrador. Por outro lado, identificou-se que o sexo, tempo de trabalho e média salarial não influenciam de forma estatisticamente significativa na motivação dos colaboradores.

Palavras-chave: Liderança. Motivação. Desempenho.

RESUMEN

La figura del líder se ha vuelto indispensable en las empresas, ya que puede impulsar en su equipo el deseo de hacer lo mejor, innovar y crear nuevas formas de realizar las actividades, afrontando los imprevistos con tranquilidad y creatividad, e influyendo en las personas para que alcancen tanto sus propios objetivos como los de la organización. Para que estos factores ocurran, es necesario que exista motivación por parte de todos los involucrados. Por lo tanto, este trabajo tiene como objetivo comprender, desde el punto de vista de los subordinados, cómo el liderazgo influye en la motivación de los integrantes del equipo en una empresa del sector metalúrgico en Caxias do Sul, Rio Grande do Sul, Brasil. Como metodología, se utilizó un cuestionario aplicado a 69 colaboradores del área administrativa de una empresa fabricante de máquinas y equipos para el sector de las industrias de bebidas, alimentos y química, con el fin de evaluar el nivel y la orientación de la motivación, así como el estilo de liderazgo percibido por los subordinados. Los resultados revelaron que la mayoría de los entrevistados presenta un alto nivel de motivación y una orientación hacia el éxito. Asimismo, sus líderes muestran un estilo integrador. Por otro lado, se identificó que el sexo, el tiempo de trabajo y el salario promedio no influyen de manera estadísticamente significativa en la motivación de los colaboradores.

Palabras clave: Liderazgo. Motivación. Desempeño.

1 INTRODUCTION

Job satisfaction and organizational commitment are influenced by leadership practices that, in addition to influencing employee morale by inference and implication, they influence the employee's work motivation, impacting knowledge and talent management (PARASHAR-CARVILLE; SHAW, 2016).

Some leaders are more effective than others, or feel more comfortable acting in this role than others. The most important characteristics of the individual for understanding the differences in the performance of leaders are skills and motivation. One of the skills that most arouses interest in the study of leadership is style (MAXIMIANO, 2017). The styles covered in this work will be autocratic, laissez-faire, democratic, and transformational-charismatic.

Administrative leadership has more influence, while political and administrative leaders must manifest stronger leadership qualities and cooperative behaviors (UGADDAN; PARK, 2017). The association between transformational leadership and employee motivation also depends on the perceived impact of employees, suggesting that some fall below others when leaders try to increase employee motivation (BRO; ANDERSEN; BØLLINGTOFT, 2017).

Therefore, the objective of this article is to understand, from the point of view of the subordinate, how leadership influences the motivation of team members in a company in the metallurgical segment in Caxias do Sul - RS. For this, a quantitative research was carried out with 69 employees in a company in the metallurgical sector, representing the population of the administrative area, that is, all employees of the administrative, financial, commercial and marketing management of the organization.

The article is composed of the theoretical framework on the concepts of leadership and motivation, the methodology, the analysis of the results of the quantitative research and the final considerations.

2 LITERATURE REVIEW

2.1 LEADERSHIP

To lead is to practice actions, some programmed and others spontaneous, with the aim of commanding, leading, influencing and inspiring people or groups to work towards achieving satisfactory personal and professional results, through organizational objectives (MADRUGA, 2014).

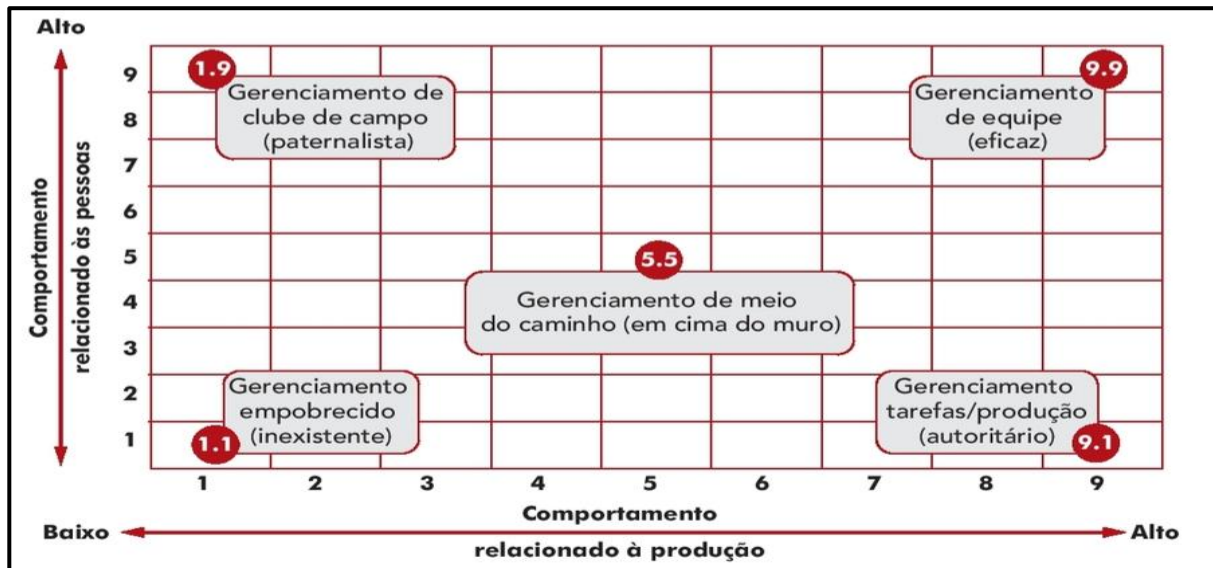
Among the main theories, the theory of traits is presented, focusing on the analysis of the behavioral profile of leaders. Behavioral theories, on the other hand, believe that leadership can be developed in people from continuous training and qualification. Fiedler's theory points out favorable and unfavorable situations for the leader. Finally, the path-goal theory focuses on the idea that subordinates need to be considered as well-intentioned people. In addition, the leader will only achieve success by helping them and fulfilling themselves (BERGAMINI, 2013; TAJRA et al., 2014).

Among leadership styles, the laissez-faire style is the type of leader who avoids conflict and tries to please everyone by giving complete freedom to individuals. The democratic style is one in which the leader allows the team to contribute to the achievement of the organization's objectives, valuing and stimulating people (ESCORSIN; WALGER, 2017). The sympathetic leader is characterized by always protecting people, is sociable, seeks to avoid conflicts and for him the result is something difficult and achieving it is beyond his capacity. The autocratic leader, on the other hand, is characterized by emphasizing the organization of work, sees the worker as a simple instrument, seeks to make decisions and is not very sociable. The middle leader is characterized by equating his priorities between people and production. Finally, the integrative leader is characterized by being concerned with both production and people, encourages the group's participation in decisions and stimulates creativity (RIBEIRO, 2016).

Scholars Robert R. Blake and Jane S. Mouton, supported by Likert's work, devised the leadership grid and published it in 1964. According to Silva (2013), these were the first studies that established two dimensions of leadership: production-oriented and people-oriented. In the grid, there are nine degrees of reference for each of the two variables, resulting in an array of 81 cells. Each of these cells represents a possible management style, of which 81, five are specially considered and named as shown in Figure 1.

Figure 1

Blake and Mouton Management Model



Source: adapted from Silva (2013).

2.2 MOTIVATION

The study of motivation basically involves the reasons why people behave in a certain way (SILVA, 2013). According to Tajra and Santos (2014), there are two types of motivation: intrinsic and extrinsic. The intrinsic ones are associated with emotions and instinctive reactions, it is the psychic energy that leads to an action to minimize or cease the tension-generating process. Extrinsic diseases are linked to the environment, they are generated by a process of reinforcement and punishment.

With each need met, a new one arises, with a progression and its intensity that varies according to each person. There are people who have never reached the highest levels of need for reasons related to the life they have. Based on the employee's needs, the company can use the correct means to motivate him/her, aiming to awaken a better performance (NELSON; QUICK, 2012).

Maslow's theory was one of the pioneering models of motivation, even though it failed to provide researchers with clear measurements of its concepts, it was the precursor of modern theories (WAGNER; HOLLENBECK, 2009). This theory predicts that the needs of the individual are classified into five levels: physiological needs (related to survival, they are basic and immediate of the human being); security needs (when the first-level needs have been met, they are related to the search for protection against threats and the escape from danger); social needs (this need arises after the

previous one is at least partially met, they are related to friendship, love, affection, participation and acceptance by the partners); esteem needs (involve self-respect, social approval, prestige, consideration and status, as it is about how the person sees and evaluates themselves) and self-actualization needs (they are at the top of the hierarchy, as they are the highest needs in which the person wants to be their best, so it is necessary that all previous needs are well met).

Alderfer's ERC theory supplemented Maslow's progression hypothesis. He presented three levels of need: existence, relationship, and growth. The theory establishes regression as the only component for frustration; thus, when a higher-level need is not met, the lower-level need can be considered motivating again (SILVA, 2013).

The two-factor theory, proposed by Herzberg, is a version of Maslow's theory of needs, as it differentiates between motivation at work and job satisfaction. The factors that lead to job satisfaction are called hygienic. These factors are linked to the conditions in which the work is performed and represent the needs to avoid pain in the environment. Motivational factors, on the other hand, are essentially related to the activity or work and directly influence the productivity of the company's employees, leading to satisfaction or non-satisfaction (SILVA, 2013). These factors are responsible for the increase in the result and prevent dissatisfaction (TAJRA; SANTOS, 2014).

David C. McClelland studied motivation for more than 20 years and presented the theory of achievements, also called the theory of acquired needs. This theory maintains that there are needs that are acquired and socially contracted when the individual interacts with the environment (SILVA, 2013). Among the types of needs are: need for fulfillment; need for affiliation and need for power (TAJRA; SANTOS, 2014).

2.3 MOTIVATION AND LEADERSHIP

The direct leader has the power to influence the motivation for the team's work, both in a positive and negative sense. However, no subordinate will talk to his leader about his motivational expectations if he does not convey confidence and does not allow a communication channel, showing interest (BERGAMINI, 2013).

Motivated leaders can be more effective in leadership roles (GILBERT et al., 2016). As a consequence, the behaviors of leaders and the associated influence can be important during the early phases of the leader-follower relationship, as they

motivate employees and embed work with meaning and purpose (BOTTOMLEY et al., 2016). However, this "infusion process" is not equally relevant in all organizational environments (BRO; ANDERSEN; BØLLINGTOFT, 2017), since there is a cognitive diversity of knowledge interacting with leadership that can influence the intrinsic motivation of the team (WANG et al., 2016). Therefore, in addition to motivating leaders, the company must equip them with the knowledge, skills, and other characteristics necessary to effectively lead the team to achieve organizational goals (FOWLER, 2018).

But what is observed today is that companies are increasingly dependent, not only on people's ability and motivation to continuously develop deep technical knowledge, but also to apply them in innovative ways and influence others to adopt new ideas (CHAN et al., 2017). In this way, the ability of senior administrators to properly use well-designed course content and select the right instructors to teach and facilitate training, improves employees' motivation to learn (ISMAIL; ZAINOL; AHMAD, 2017) and develop them professionally.

3 METHODOLOGY

The approach of this study is quantitative (SAMPIERI et al., 2013), descriptive in nature (MARCONI; LAKATOS, 2017), which aims to study the characteristics of a group, as in the case of this work, which will analyze the entire administrative sector of a given metallurgical company in Caxias do Sul.

The form of data collection in this research is of the survey type (Gil, 2010) and for this survey a questionnaire with closed questions was used (KLEIN, 2015), adapted from Lameiras (2010). The first part of the questionnaire consists of six groups of statements that aimed to measure the perception that employees have about the guidance that their leader has. The second part is made up of eighteen expressions, where they mention supposed situations that will lead the employee to recognize himself with them. In this part of the questionnaire, ordinal scales of the Likert type of seven points will be used. Finally, the third refers to the characterization of the researched. It is composed of the elements gender, age, marital status, if they have children, academic background, length of service, approximate monthly family income and they hold a leadership position.

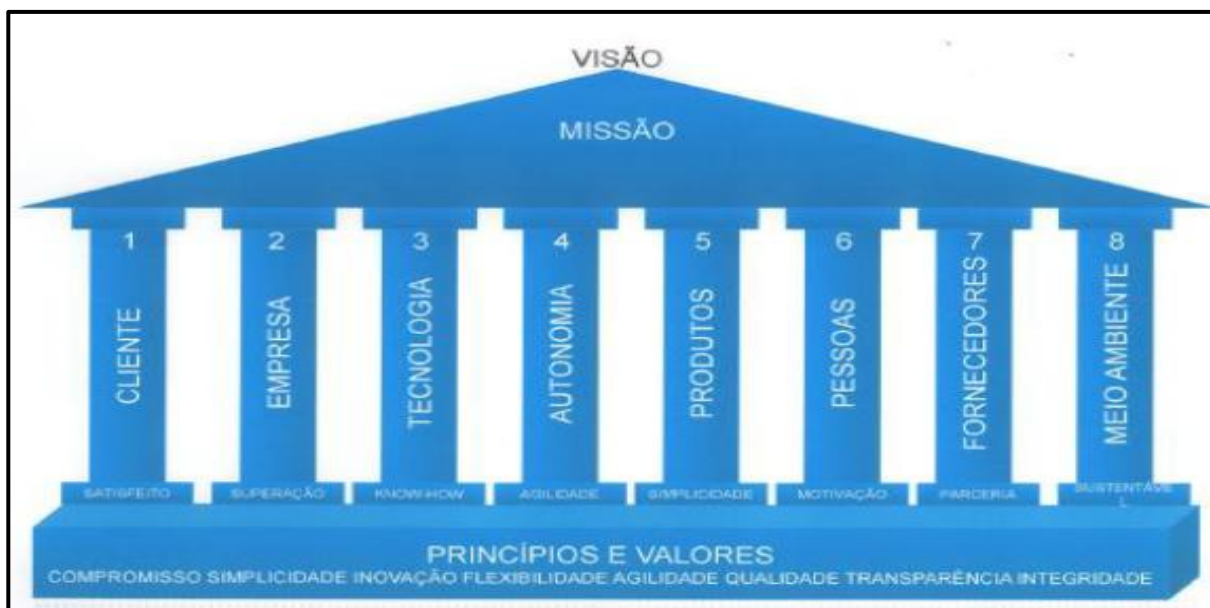
3.1 OBJECT OF STUDY

The research was carried out in a medium-sized company in the city of Caxias do Sul, in the state of Rio Grande do Sul, which employs approximately 409 employees, in addition to outsourced services such as reception, security, food, transportation and cleaning. The company is a manufacturer of machinery and equipment for the beverage, food and chemical industry segment.

The company's goal is sustainable growth, seeking to improve its internal processes and increase its revenue, gross profit and working capital. Based on this, the company created the breakdown of the guidelines of the strategic, operational and radar plans, which are pillars of support for its business (Figure 2). The focus of this research is in line with one of these pillars that sustain the organization: people – seeking to keep the team motivated in a work environment conducive to the development of its employees, cultivating transparency and integrity in relationships. One of the company's ways to achieve the expected result is the climate survey, carried out in the company, in order to identify points to be developed based on the opinions of employees.

Figure 2

Principles and values of the researched company



Source: company (2016).

In this study, data collection was done from the population, which are all employees of the organization's administrative, financial, commercial and marketing

management. The total number of employees in these areas is 69 employees.

The distribution and collection of questionnaires were carried out through printed questionnaires and delivered by hand to the respondents, in August and September 2017. A ballot box was also made available where the collaborators deposited their completed questionnaire in order to guarantee anonymity and allow greater freedom in the answers and less risk of the researcher influencing them.

For data analysis, descriptive statistics, frequency statistics and non-parametric tests (KLEIN, 2015) were performed with the help of the statistical software SPSS®20.

4 ANALYSIS OF THE RESULTS

Data analysis was performed in two moments: the first refers to the characterization of the sample, with information from the respondents; and the second moment refers to the analysis of the answers that contemplate the theoretical framework addressed of leadership and motivation.

4.1 SAMPLE CHARACTERIZATION

The responding population is composed of 64.71% men and 35.29% women. Regarding the average salary variable, the average salary from R\$ 3,001.00 to R\$ 5,000.00 is the majority, constituting 35.29%, and those from R\$ 1,001.00 to R\$ 3,000.00 and more than R\$ 5,000.00 constitute exactly the same percentage, 29.41%. The percentage of 5.88% corresponds to the average salary of up to R\$ 1,000.00, below when compared to the others. According to Walger, Viapiana and Monfort (2014), there is no other motivational incentive or technique that has as much initial influence on the employee's life as salary.

It is possible to see that the ages from 21 to 60 years old are balanced with 25% for people aged 21 to 30 years and 31 to 40 years, and 20.59% for people aged 41 to 50 years and 51 to 60 years each. However, employees under 20 years of age represent 7.35% of the interviewed population and the lowest percentage is found in people over 61 years of age, who represent 1.47% of the total number of employees.

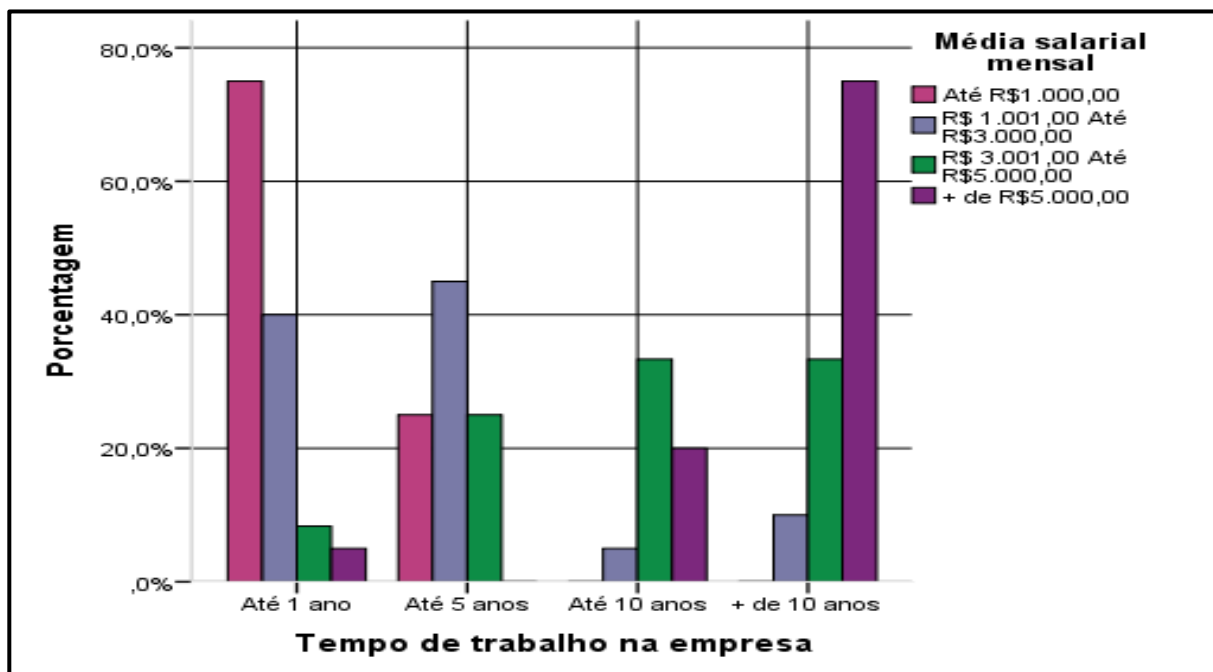
Relating the variables gender and age, among the women interviewed, most are aged between 31 and 40 years with 29.17%, followed by 25% of women who are between 21 and 30 years old. The 41 to 50 age group and 51 to 60 age group have the same percentage of the total number of women respondents with 16.67%, and the

lowest are 8.33% for those under 20 years old and 4.16% for those over 61 years old. Most of the men interviewed are between 21 and 30 years old, with a percentage of 25%. The percentage of 22.73% represents the groups of 31 to 40 years old, 41 to 50 years old and 51 to 60 years old. It is observed that only 6.81% are under 20 years old and there are no men interviewed over 61 years of age.

As for the variables length of work in the company and average monthly salary, the average salary increases according to the time that the employee remains in the company. For Walger, Viapiana and Monfort (2014), this attitude comes from the traditional remuneration system, in which people are paid for the time they have worked or for the position held. Most of the respondents have an average salary of up to R\$ 1,000.00 and have been with the company for up to one year or are employees who earn more than R\$ 5,000.00 and have been with the company for more than 10 years (both represent 75% of their range), as can be seen in Figure 3.

Figure 3

Distribution of the percentage values of the variables: length of work in the company and average salary



Source: data from the survey.

The group of employees who have been with the company for more than 10 years has all the respondents who have attended up to elementary school. This group

has the second lowest rate of postgraduates, with 18.18%. As for the group of those who have been in the company for up to one year, most have attended high school, with 30.43%, and none of the respondents have only completed elementary school. With 45.45%, the group of employees who have been in the company for one to five years has the highest percentage of those who have attended graduate school, and not only in this group, but this percentage is the highest of all the groups interviewed. The group of employees who have been in the company for five to ten years has the second highest percentage of people who have a postgraduate degree, with 27.27%, followed by 24.24% of those who have higher education. In this group, there are also no employees who only did elementary school.

In relation to holding a leadership position, a comparison with the time in the company is observed. It is verified that 90% of the respondents who hold a leadership position have been in the company for more than 10 years, and 100% of the employees who hold a leadership position have more than 5 years in the company. It can be concluded that the company does not usually hire new leaders, but rather values the people already belonging to the company. This can also be negative, as people without a profile for leadership can reach this position.

Continuing with the analysis of leadership, there is a big difference related to gender, in which 90% of respondents who hold leadership positions in the company are men, the rest are 10% are women. Related to this, Robbins (2015) reports that men do not have any advantage over women when it comes to leadership, and even so, it can be seen in the analysis that the company has a small portion of female leaders.

4.2 DESCRIPTIVE ANALYSES OF THE LEADERSHIP STYLE VARIABLE

The analysis of the variable of each leadership component was carried out based on the nominal scale used and named from A to E, each one corresponds to the styles of leader (laissez-faire, sympathetic, intermediate, autocratic and integrative), according to the managerial grid of Blake and Mouton (1964). In this part of the questionnaire, it was intended, through the perception of the subordinates, to measure the leader's orientation under six aspects: decisions, convictions, conflict, emotions, sense of humor and commitment.

Thus, an analysis of the means of each variable was carried out in relation to the leadership styles, and it can be observed that the highest average, with 31.57%, refers

to the integrative leader style. This style is positively associated with successful careers, productivity and profitability when compared to any other style (BLAKE; MOUTON, 1978). The lowest index is in the autocratic style, with 10.10%, which in turn is focused on tasks. He carefully supervises work methods, usually makes decisions without consulting his team and insists on the need to meet goals (MAXIMIANO, 2017). Table 1 shows the comparison of the leadership variables.

Table 1

Comparison of the variables of the leadership styles

Style	Percentage (%)						
	Decisions	Convictions	Conflict	Emotions	Sense of humor	Commitment	Average
Laissez-faire	6,10	16,70	18,20	19,70	12,10	10,60	13,90
Friendly	37,90	22,70	27,30	27,30	9,10	18,20	23,75
Intermediate	18,20	12,10	15,20	13,60	18,20	40,90	19,70
Autocratic	7,60	12,10	10,60	9,10	7,60	13,60	10,10
Integrator	28,80	34,80	28,80	28,80	51,50	16,70	31,57

Source: data from the survey.

Regarding the decisions made by the leader, the respondents claim that the leader supports decisions that promote good relationships, as he cares about people, characterizing the friendly style, with 37.88%. It is observed that 28.79% of employees attribute the leader as an integrator, indicating that the empowering leadership of supervisors is likely to increase psychological empowerment, thus promoting their intrinsic motivation, while authoritarian leadership has the opposite effect (MENG et al., 2015). The other styles of leader are considerably low: 18.18% for intermediate leader; 7.58% for autocratic; and 6.06% laissez-faire, compared to sympathetic.

The majority of employees attribute the integrative style to the leader with 34.85%, in relation to their convictions. This style of leader offers understanding, acceptance, and understanding, and its main characteristic is in helping. The friendly style obtained 25% and came soon after in the preference of the respondents. In conflict management, there is an approximation of the attributions of the leader styles. Most employees characterized them as integrative with 28.79% and sympathetic with 27.27%, with a small difference, indicating that the leader has a strong orientation towards people, as he is social and seeks to avoid conflict and solve it, promoting a pleasant and friendly work environment (RIBEIRO, 2016; ESCORSIN et al., 2017).

However, it is important to point out that conflict can be constructive when it

stimulates innovation and creativity, improves the quality of decisions, encourages the curiosity and interest of the group, providing an escape from tensions and generating an environment of self-evaluation and change (ROBBINS, 2015). Finally, 18.18% of the employees interviewed report that their leader is characterized as laissez-faire, 15.15% characterize the leader as an intermediary and 10.61% as autocratic.

Related to the leader's emotions, individuals in higher positions experience greater stress and anxiety and this can lead to low levels of motivation and commitment. In some cases, leaders have to follow laws and policies that they are not convinced of, which can reduce their motivation and lower their level of commitment (AL-SADA et al., 2017). For employees, the leader has an integrative profile with 28.79% and a sympathetic profile with 27.27%, similar to the conflict variable. Both styles are people-oriented and this type of leader helps his employees with their personal problems, is approachable and friendly, treating all his subordinates as equals and showing appreciation and support (ROBBINS, 2015).

In the leader's mood analysis, there is a visible majority of employees, with 51.52%, who assume that the leader has an integrative sense of humor. Regarding the leader's commitment, the majority attributed the intermediate style to the leader (40.91%). This indicates that leadership is also an important complement to motivation. The other styles of leader have lower and relatively close values. The results corroborate the authors Chan et al. (2017) who describe that motivation to lead is associated with the desire to promote change, challenge the status quo, and the willingness to influence others.

4.3 DESCRIPTIVE ANALYSES OF THE MOTIVATION VARIABLE

The second part of the questionnaire was composed of eighteen statements, which report presupposed situations, with the aim of inducing the respondent to identify himself in these situations. In addition to analyzing the frequency of each expression, the respondent's orientation towards success, affiliation or power was observed. Table 2 shows the comparison of the results between the motivation variables.

Table 2

Comparison of the motivation variable

Affirmation	Scale and percentage						
	Never	Almost Never	Rarely	By Times	Usually	Almost Always	Always
I like to constantly improve my personal skills	1,45	1,45	4,35	14,5	23,19	18,84	36,23
I like to be supportive of other people, even if they are not my relatives	1,45	2,9	5,8	10,15	21,74	27,54	30,43
I have a secret desire to get people's attention	30,43	20,29	20,29	18,84	8,7	1,45	0
I strive to improve on my previous results	2,90	2,90	1,45	7,25	14,5	30,43	40,58
I feel satisfaction when I see that a person who asked me for help is happy with my support	0	1,45	1,45	7,24	8,7	20,29	60,87
I insist on a certain opinion just to "not give up"	26,09	27,54	27,54	10,14	1,45	5,8	1,45
I like to know whether or not my work has been done well, in order to do better in the future	1,45	2,90	1,45	5,80	14,5	28,99	44,93
If I had to fire a person, I would try above all to understand their feelings and support them as much as possible	1,45	5,78	10,14	13,04	17,39	26,09	26,09
I have arguments with others because I tend to insist on what I think should be done	13,04	13,04	24,64	23,2	7,25	11,59	7,25
At work, I try to do better and better	2,90	4,35	0	2,90	15,94	23,19	50,7
At work, I like to be a kind person	1,47	5,88	4,41	16,18	23,53	26,47	22,06
I try to relate to influential people	7,25	11,59	21,74	23,2	15,94	13,04	7,25
I try to do my job in an innovative way	0	5,78	2,90	7,24	31,9	31,88	20,3
I feel satisfied to work with people who like me	4,35	2,9	5,80	4,35	24,64	31,88	26,09
If I can get people into my team's work, I look for the ones that allow me to exert the most influence	10,14	10,14	11,59	31,9	21,74	11,6	2,9
At work, I pay close attention to the feelings of others	0	5,8	8,7	29	23,19	20,29	14,04
When I participate in a gathering, I take the opportunity to influence others and get their support for what I want to do	7,25	14,49	20,3	26,1	15,94	11,59	4,35
I get worried when I feel that I have somehow contributed to the malaise of relationships at work	1,45	4,35	0	10,15	18,84	37,7	27,54

Source: data from the survey.

Most respondents say they always like to improve their skills, with 36.2%,

followed by 23.2% who usually like it. This result shows that individuals who are highly motivated by leadership acquired more leadership competencies during training, which results in more effective leadership behavior after training (STIEHL et al., 2015).

On the issue of being supportive of colleagues, most respondents increasingly say they like it. In the last three degrees of frequency, most of them are concentrated, with 79.7% of the total.

Employees (30.4%) do not have a secret desire to attract attention, followed by 20.29% each for those who "almost never" and "rarely" have the desire and 18.8% for those who answered "sometimes". This statement is aimed at identifying the collaborators who are power-oriented, and at this point, none of them checked the "always" box.

It was found that 40.6% of the employees stated that they always strive to improve their results, 30.4% stated that they almost always strive to improve their results and 14.5% usually make an effort. Individuals with stronger leadership motivation showed more team-related effectiveness, personal growth, and by tendency, position-related effectiveness, enabling an increase in performance in their area of responsibility (STIEHL et al., 2015).

The highest percentage of all questions about motivation is found at this point, in which 60.87% of the interviewed employees answered that they always feel satisfaction in helping a colleague who was happy with their support. There was no respondent who checked the "never" option. It is verified that most employees do not insist on an opinion so as not to give the "arm to twist", the first three have a similar percentage, adding to the total 81%.

The significant majority of employees say they like to know whether or not the work was well done, aiming to improve in the future. The sum of the last three points represents 88.4% of the total number of respondents. This question aims to identify people who have an orientation to success.

It is stated that, for the most part, if any employee had to fire a person, they would try to understand their feelings and support them as much as possible. It is observed that this statement follows an increasing form, reaching the largest scales that are "always" and "almost always", with 26% each.

Regarding the statement that the employee "has arguments with others because he insists on what he thinks", it was observed that 24.6% stated that he rarely insists,

and 23.2% sometimes has this behavior, followed by 13% each of those who have never and almost never had arguments because they insist on what they think. It is clear that most employees always try to do their job better and better, being 50.7%. The results converge with Fowler (2018) who described that new motivational leadership competencies based on the theory of self-determination are recommended to promote leadership behaviors that support people's psychological needs.

It is possible to verify that most employees like to be a kind person at work, since the sum of the last four points is 88.3%. This statement is related to identifying employees who have affiliation orientation.

On the other hand, the statement that the respondent seeks to relate to influential people is focused on power orientation. It was found that the majority sought this relationship moderately, "sometimes" having 23.2% of the answers, followed by 21.7% of those who answered rarely.

It was observed that the respondents stated that they usually and almost always try to do the work in an innovative way, with 31.9% each and 20.3% stating that they always try to do the work in an innovative way. Leadership transformation serves as a limiting condition for the effects of cognitive diversity on intrinsic motivation and team creativity (WANG et al., 2016).

The expression I feel satisfied to work with people who like me identifies people who have an orientation towards affiliation. It can be seen that the majority, referring to the last three points (totaling 82.6%), feel this satisfaction.

In the statement "if I can call people to the work of my team, I look for those who allow me to exert more influence", it is observed that the first three points that refer to those who do not seek or seek in a moderate way are practically equivalent with around 10% each. The majority, on the other hand, sometimes seek with 31.9%, usually with 21.7% and almost always with 11.6%. This behavior is associated with people who are power-oriented and seek to get people to behave in a way they would not normally do (AL-SADA et al., 2017).

Regarding "paying close attention to the feelings of others at work", most say that they pay attention sometimes with 30%, usually with 23.2%, almost always with 20.3% and always with 13%. The majority with 26.01% assume that, sometimes, in some conviviality, they take the opportunity to influence other people to get support, followed by 20.3% who assume that they rarely influence.

The last expression related to motivation represents that the majority of respondents, with 37.7%, are almost always concerned when they feel that they have contributed to the discomfort of relationships at work. Those who always worry represent 27.5% and those who usually worry represent 18.84%. At this point, most people are well focused on affiliation needs, as they reveal that they have a desire to have close and friendly relationships with colleagues (MENG et al., 2015).

Table 3 shows that in relation to motivation, most are concentrated between 4 and 6 points on a 7-point Likert scale, totaling 60 respondents. This means that only nine people are not within this average, demonstrating that the team is motivated as a whole. To achieve good results, motivational practices need to range from the praise and challenges proposed by managers to the participation of employees in the decision-making process, in profits or in the company itself, including awards, benefits, job growth programs and career plans. The leader just needs to know how to identify which of these practices motivates his employee the most (MAXIMIANO, 2017).

Table 3

Frequency of the average motivation

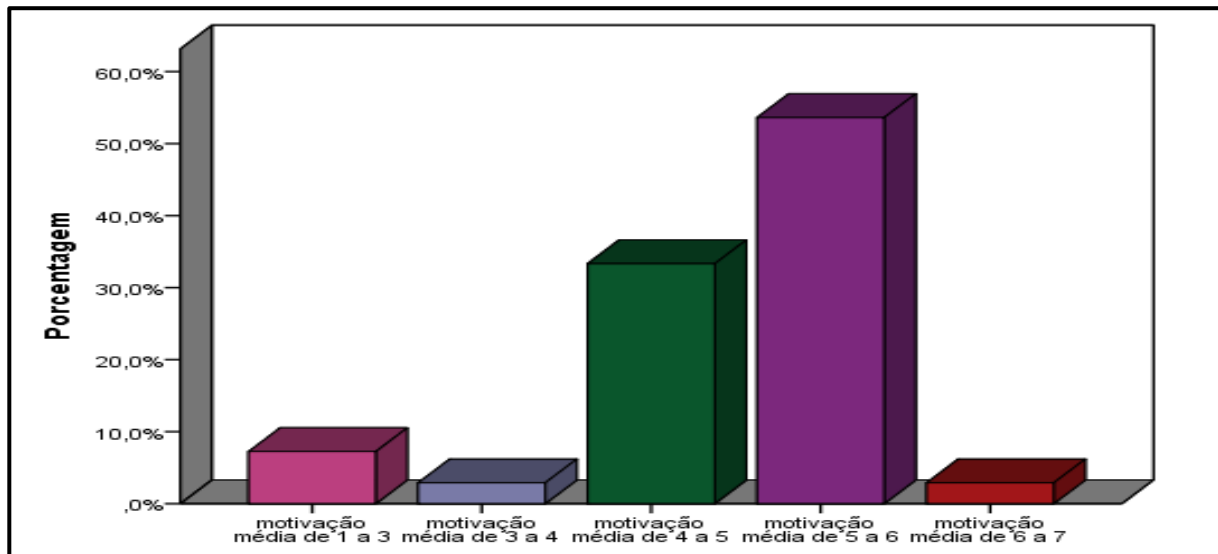
		Frequency	Percentage	Valid percentage	Accumulative percentage
Valid	Motivation from 1 to 3				
	Motivation from 3.01 to 4	5	7,2	7,2	7,2
	Motivation from 4.01 to 5	2	2,9	2,9	10,1
	Motivation from 5.01 to 6	23	33,3	33,3	43,5
	Motivation from 6.01 to 7	37	53,6	53,6	97,1
	Total	2	2,9	2,9	100
		69	100	100	

Source: data from the survey.

It is observed that 86.9% of the total respondents, as shown in Figure 4, have an average motivation between 4 and 6.

Figure 4

Analysis of average motivation



Source: data from the survey.

Figure 5 shows the mean of each expression of the motivation variable and also the overall mean of each of the three types of guidance. It is observed that the lowest averages are found in questions related to people who are power-oriented, with an overall average of 3.41.

The highest average is aimed at people who are success-oriented, with 5.72. Motivation and organizational commitment to measuring other variables such as work, satisfaction, organizational effectiveness and commitment, and productivity are significantly associated with dimensions of leadership and culture practices and can be improved with better workforce management and interaction techniques (PARASHAR-CARVILLE; SHAW, 2016).

Finally, an average of 5.45 is presented for those that are focused on affiliation.

Figure 5

Average of the motivation variables

Orientação	Estatísticas				
	Expressões	N		Média	
		Válido	Omisso		
Sucesso	Gosto de aperfeiçoar constantemente as minhas competências pessoais	69	0	5,45	5,72
	Esforço-me para melhorar os meus resultados anteriores	69	0	5,81	
	Gosto de saber se o meu trabalho foi ou não bem realizado, de modo a fazer melhor no futuro	69	0	5,96	
	No trabalho, procuro fazer cada vez melhor	69	0	5,97	
	Tento fazer o meu trabalho de modo inovador	69	0	5,42	
Afiliação	Gosto de ser solidário com as outras pessoas, mesmo que não sejam das minhas relações	69	0	5,52	5,45
	Sinto satisfação quando vejo que uma pessoa que me pediu ajuda fica feliz com meu apoio	69	0	6,28	
	Se tivesse de despedir uma pessoa, procuraria sobretudo compreender os seus sentimentos e apoiá-la no que fosse possível	69	0	5,22	
	No trabalho, gosto de ser uma pessoa amável	68	1	5,24	
	Sinto-me satisfeito por trabalhar com pessoas que gostam de mim	69	0	5,42	
	No trabalho, presto muita atenção aos sentimentos dos outros	69	0	4,83	
	Fico preocupado quando sinto que, de alguma forma, contribuí para o mal-estar das relações no trabalho	69	0	5,65	
Poder	Tenho um desejo secreto de chamar a atenção das pessoas	69	0	2,59	3,41
	Insisto numa determinada opinião apenas para “não dar o braço a torcer”	69	0	2,57	
	Tenho discussões com os outros porque costumo insistir naquilo que penso que deve ser feito	69	0	3,62	
	Procuro relacionar-me com pessoas influentes	69	0	3,97	
	Se puder chamar as pessoas para o trabalho da minha equipe, procuro as que permitam exercer mais influência	69	0	3,91	
	Quando participo de algum convívio, aproveito para influenciar os outros e obter o seu apoio para aquilo que quero fazer	69	0	3,81	

Source: data from the survey.

Some non-parametric tests were performed. They are methods that encompass procedures that allow the use of ordinal, nominal, or quantitative variables instead of continuous data. The Mann-Whitney U test was used, which is used to compare variables from two independent groups. This test was used in order to verify whether motivation changes according to the respondent's gender. According to Figure 6, ($p=0.4$) there is no difference in the mean motivation of the respondents in relation to gender.

Figure 6

Test for motivation and gender variables

Estatísticas de teste ^a	
	média_motiv ação
U de Mann-Whitney	467,000
Wilcoxon W	1457,000
Z	-,784
Significância Assint. (Bilateral)	,433
a. Variável de Agrupamento: Gênero	

Source: data from the survey.

The Kruskal-Wallis test was also performed. This procedure is recommended to compare a variable between three or more groups. It is verified that there is no difference in the average motivation of the employees in relation to the average salary ($p=0.2$), or in relation to the length of work, ($p=0.08$), as shown in Figure 7.

Figure 7

Test motivation and working time and test motivation and average salary

Estatísticas de teste ^{a,b}		Estatísticas de teste ^{a,b}	
	média_motiv ação		média_motiv ação
Qui-quadrado	6,591	Qui-quadrado	3,889
gl	3	gl	3
Significância Assint.	,086	Significância Assint.	,274
a. Teste Kruskal Wallis		a. Teste Kruskal Wallis	
b. Variável de Agrupamento: Tempo de trabalho na empresa		b. Variável de Agrupamento: Média salarial mensal	

Source: data from the survey.

5 CONCLUSION

The study aimed to understand, from the point of view of the subordinate, how leadership influences the motivation of team members in a given company. This objective was achieved and it can be concluded, through the bibliographic reference, that a higher or lower level of motivation, in addition to being connected to the person and his work, depends on the competence and empathy of the direct leader.

Regarding the analysis, it is also necessary to highlight some observations: it was found that all the interviewees who did not continue studying after elementary school have been in the company for more than 10 years, suggesting that these employees are accommodated and even unmotivated, and it is up to the leadership to

identify these people, in order to arouse interest in the search for knowledge and development. It was also identified that 90% of employees who hold leadership positions are men, which means that, although women are inserted in the labor market, they have not been recognized in the same way as men, and yet, related to this result, it is known that female characteristics are important within an organization, as it encompasses collaboration, Relationship and talent cultivation, however, men may have developed these traits, thus maintaining motivation. "Feminine sensitivity allows the team to act with synergy, obtaining creative solutions to unsolvable issues" (MANDELLI, 2015, p. 20).

Regarding this same question, it is observed that all interviewees who hold leadership positions have been in the company for at least 5 years, that is, it is not practiced to hire leaders from outside the company. Employees, over time, when they stand out, start to assume these positions, a chance promoted by the company to encourage growth and recognition, generating motivation and engagement, both on the part of leaders and subordinates.

Regarding leadership styles, the organization's employees consider that leaders have mostly integrative behaviors. This style seeks the best performance, achieving objectives and meeting your goals, but always with a broader view, managing differences, promoting dialogue, seeking understanding, involving and committing your team. In this way, the relationship between members is strengthened with the motivation of employees, influenced by the leader.

As for the motivation factor, it is found that the general average of employees is between 5 and 6, representing 53.6% of the total respondents, this average is good if it is observed that the highest value is 7. It was also identified that most respondents are focused on success, a profile that likes challenges and competitive situations. Employees who are motivated and enthusiastic to achieve goals, facing challenges and exceeding expectations, make a difference and provide a competitive advantage for the organization.

Associating the results of motivation with those of leadership styles, it is clear that, according to the theory studied, the profile of integrative leader exerts a positive influence on employees, as it is related to better levels of motivation. It is possible to confirm this relationship in the survey, as the results of the motivational average were high, and of these respondents, most identified that their leader has the style of

integrative leader. On the other hand, it was identified that gender, working time and average salary do not influence in a statistically significant way the motivation of employees.

With this work, it can be identified that it is necessary to break the paradigms about employees with a more integral people management, including bringing in its core themes such as motivation, which is significantly influenced by the leader, understanding aspirations, fears, desires, doubts, expectations, dreams and really caring about the other and cooperating with their challenges, In other words, in addition to worrying about activities, you need to worry about people and their development in the organization and outside it.

The investigation has some limitations, as the population analyzed is not sufficiently representative compared to a universe of companies in the same field in the region. There are also the limitations of the method of applying questionnaires, where the effect of the social desire of the answers can occur. An important limitation is the fact that it was not possible to carry out a qualitative approach that would allow a deeper understanding of the reasons that inform leadership styles and motivational factors.

It is suggested, for future research, studies taking into account the leader's perception of himself and his motivation, in order to work together on the issue of motivation of leaders and subordinates, including extending it to all areas of the company. It will also be interesting to apply the research in other companies to verify the different results and thus compare them in order to collaborate for a better understanding of the topics covered.

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**GENDER DYSPHORIA: GENETIC, EPIGENETIC, AND NEUROBIOLOGICAL
BASES OF SEXUAL IDENTITY**

**DISFORIA DE GÊNERO: BASES GENÉTICAS, EPIGENÉTICAS E
NEUROBIOLÓGICAS DA IDENTIDADE SEXUAL**

**DISFORIA DE GÉNERO: BASES GENÉTICAS, EPIGENÉTICAS Y
NEUROBIOLÓGICAS DE LA IDENTIDAD SEXUAL**

 <https://doi.org/10.56238/sevened2025.036-138>

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ABSTRACT

Gender dysphoria is a condition characterized by a profound incongruence between biological sex and gender identity, which may cause significant distress. Over recent decades, advances in genomics, neurobiology, and epigenetics have enabled the identification of multiple biological mechanisms involved in the determination of sexual identity. Current evidence suggests that gender dysphoria does not stem from a single cause, but rather from the interaction of genetic, endocrine, and environmental factors that modulate sexual differentiation of the brain. Polymorphisms in genes related to hormonal action, such as SRY, SOX9, AR, ER α , SRD5A2, and SULT2A1, may influence brain masculinization or feminization during fetal development. Likewise, neuroimaging studies reveal intermediate or mixed structural and functional brain patterns between cisgender men and women. Epigenetics emerges as an explanatory bridge between genetic and environmental factors through mechanisms of DNA methylation and histone modification. Understanding the biological basis of gender dysphoria is essential for comprehensive clinical care and for reducing social stigma.

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Keywords: Gender Dysphoria. Genetics. Epigenetics. Neurobiology. Sexual Identity.

RESUMO

A disforia de gênero é uma condição caracterizada por uma profunda incongruência entre o sexo biológico e a identidade de gênero, que pode gerar sofrimento significativo. Nas últimas décadas, os avanços na genômica, na neurobiologia e na epigenética permitiram identificar múltiplos mecanismos biológicos implicados na determinação da identidade sexual. As evidências atuais sugerem que a disforia de gênero não responde a uma única causa, mas sim à interação de fatores genéticos, endócrinos e ambientais que modulam a diferenciação sexual do cérebro. Polimorfismos em genes relacionados à ação hormonal, como SRY, SOX9, AR, ER α , SRD5A2 e SULT2A1, podem influenciar a masculinização ou feminilização do cérebro durante o desenvolvimento fetal. Da mesma forma, estudos de neuroimagem revelam padrões estruturais e funcionais cerebrais intermediários ou mistos entre homens e mulheres cisgênero. A epigenética emerge como uma ponte explicativa entre os fatores genéticos e ambientais, por meio de mecanismos de metilação do DNA e modificação de histonas. Compreender a base biológica da disforia de gênero é fundamental para uma abordagem clínica integral e para a redução do estigma social.

Palavras-chave: Disforia de Gênero. Genética. Epigenética. Neurobiologia. Identidade Sexual.

RESUMEN

La disforia de género es una condición caracterizada por una profunda incongruencia entre el sexo biológico y la identidad de género, que puede generar sufrimiento significativo. Durante las últimas décadas, los avances en la genómica, la neurobiología y la epigenética han permitido identificar múltiples mecanismos biológicos implicados en la determinación de la identidad sexual. La evidencia actual sugiere que la disforia de género no responde a una única causa, sino a la interacción de factores genéticos, endocrinos y ambientales que modulan la diferenciación cerebral sexual. Polimorfismos en genes relacionados con la acción hormonal, como SRY, SOX9, AR, ER α , SRD5A2 y SULT2A1, podrían influir en la masculinización o feminización del cerebro durante el desarrollo fetal. De igual forma, estudios de neuroimagen revelan patrones estructurales y funcionales cerebrales intermedios o mixtos entre hombres y mujeres cisgénero. La epigenética emerge como un puente explicativo entre los factores genéticos y ambientales, mediante mecanismos de metilación del ADN y modificación de histonas. Comprender la base biológica de la disforia de género resulta fundamental para el abordaje clínico integral y la reducción del estigma social.

Palabras clave: Disforia de Género. Genética. Epigenética. Neurobiología. Identidad Sexual.

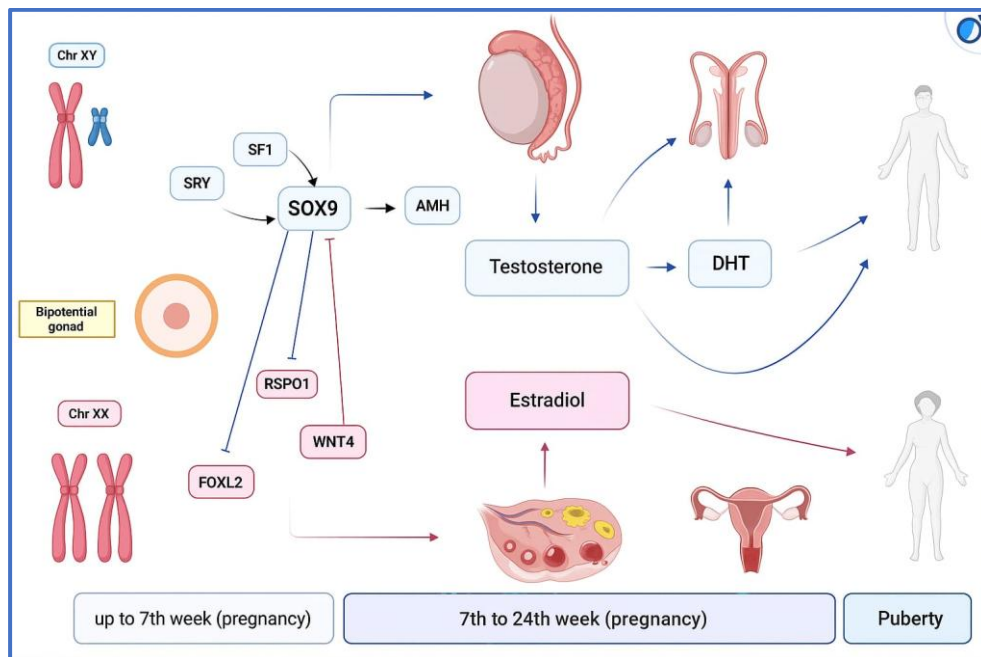
1 INTRODUCTION

Gender identity is defined as the internal, individual experience of the gender with which a person identifies, regardless of their sex assigned at birth. When there is a persistent discrepancy between the two, accompanied by clinically significant discomfort, it is called **gender dysphoria**, a term adopted by the *American Psychiatric Association* in the *DSM-5* and by the *World Health Organization* in the *ICD-11* (1,2). (Figure 1).

Traditionally, gender dysphoria has been interpreted from psychological or sociocultural perspectives. However, growing biological evidence suggests that the brain's sexual differentiation—and, by extension, gender identity—depends on genetic, epigenetic, and hormonal processes that occur during embryonic and fetal development (3,4).

Figure 1

Pathways of human gonadal sexual development. Until the seventh week of pregnancy, the gonad remains undifferentiated, which has the potential to develop into testicles or ovaries



The differentiation process is driven by specific genetic and hormonal signals. In the presence of the Y chromosome, the sex-determining gene for the Y region (*SRY*) is expressed. *SRY* subsequently initiates the male developmental pathway by promoting the expression of *SOX9*, a critical transcription factor. *SOX9* activation is further supported by steroidal factor 1 (*SF1*). Once activated, *SOX9* induces the production of anti-Müllerian hormone by Sertoli cells in the developing testes, which plays a vital role in inhibiting the

development of the female internal genitalia by causing regression of the Müllerian ducts. At the same time, the Leydig cells in the testes begin to produce testosterone under the influence of SOX9. Testosterone is essential for the development of the male internal genitalia. In addition, testosterone is converted to dihydrotestosterone, which is crucial for the formation of male external genitalia and the development of secondary sex characteristics during puberty. In the absence of the *SRY* gene, the female developmental pathway is initiated. Factors such as *RSPO1* and *WNT4* support ovarian development by inhibiting SOX9 and promoting gonad differentiation into ovaries. Together with *RSPO1* and *WNT4*, *FOXL2* plays an important role in supporting ovarian development and function. The developing ovaries produce estradiol, a hormone crucial for the development of the female reproductive organs and secondary sex characteristics. Hormonal influence continues from embryonic stages through puberty, shaping the development and function of the reproductive system (Loch Batista, 2024)

In this context, the differences observed in brain structures, sexually dimorphic gene expression and variations in hormone receptors could explain the diversity of sexual identities and orientations.

The aim of this review is to analyze the main genetic, epigenetic, and neurobiological findings related to gender dysphoria, integrating recent evidence supporting the existence of a complex biological basis in the determination of sexual identity.

2 SEX DETERMINATION: FUNDAMENTAL GENETIC MECHANISMS

Human biological sex is established from the chromosomal combination (46,XX or 46,XY) and the sequential activation of genes that determine gonadal and genital differentiation. The Y chromosome, although small, has key genes for male differentiation, the most important being the *SRY* gene (*sex-determining region Y*), located in Yp11.3 (5). This gene encodes a protein that acts as a transcription factor, inducing the expression of genes such as *SOX9*, *SF1* and *DMRT1*, essential for the formation of the testes (6,7) (Figure 2).

In the absence of *SRY*, sexual differentiation follows the female path by default, mediated by genes such as *WNT4*, *RSPO1*, and *DAX1*, which suppress testicular action and promote ovarian formation (8). Alterations in these genes can generate disorders of sex development (DSD) with ambiguous or discordant phenotypes with respect to the karyotype.

In addition, the *genes* *SOX9*, *WT1*, *NR5A1 (SF1)*, *CBX2* and *DHH* regulate different steps of gonadal differentiation. Duplications or mutations of these can cause gonadal dysgenics, testicular development in individuals 46,XX or testicular failure in 46,XY (9). These genetic variations, although classically related to DSDs, also offer a model for study to understand the mechanisms that could underlie gender dysphoria, by modifying hormonal action and brain signaling during fetal life.

3 DISORDERS OF SEX DEVELOPMENT AND THEIR RELATIONSHIP WITH GENDER DYSPHORIA

Disorders of sex development (DSD) are a heterogeneous group of disorders in which chromosomal, gonadal or anatomical differentiation does not follow the typical male or female pattern. These conditions represent a natural model for understanding how genetic and hormonal variations during embryogenesis can influence gender identity and sexual orientation (10).

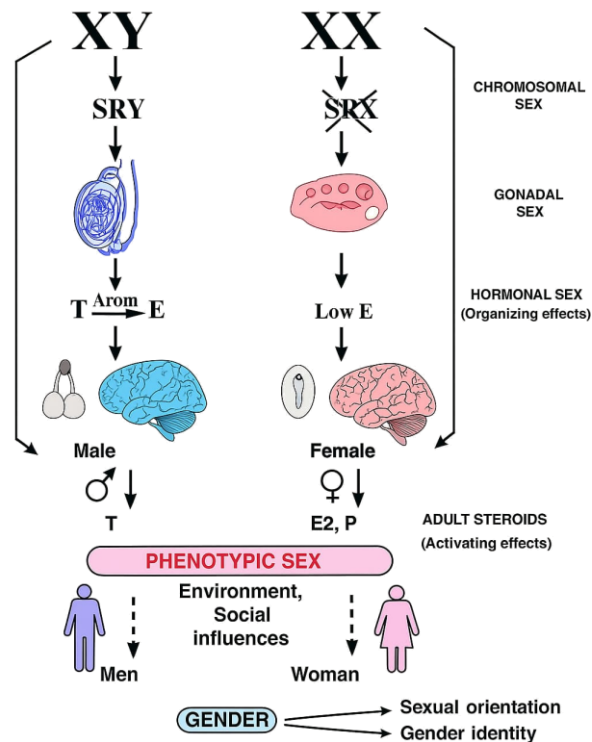
Among the most studied alterations are:

3.1 COMPLETE GONADAL DYSGENESIS 46,XY (SWYER'S SYNDROME)

Characterized by the presence of an XY karyotype with a female phenotype, it is due to mutations or deletions in the *SRY gene* or defects in regulatory genes such as *SOX9*, *WT1* or *NR5A1* (11). Individuals usually have female external genitalia, absence of functional gonads, and lack of pubertal development. Although their gender identity is usually female, variability in the perception of gender and sexual orientation has been observed, suggesting a role of brain signaling beyond karyotype.

Figure 2

Schematic presentation of the mechanisms that mediate the development of sex differences in mammals, including humans



The SRY gene on the Y chromosome induces the formation of testes that will secrete testosterone (T) that will act on their own or through aromatization (Arom) in estradiol (E2) to masculinize genital structures and the brain. The activational effects of steroids will complete the differentiation of the adult male and female phenotype. Genes can also induce sex differences in a more direct way that is not mediated by the action of sex steroids. Environmental and social influences will further modulate this sexual phenotype to determine an individual's gender, including their sexual orientation and gender identity. (Balthazart, 2020)

3.2 ANDROGEN INSENSITIVITY SYNDROME (AIS)

Caused by mutations in the androgen receptor (AR) gene, located in Xq11-12, AIS is expressed in varying degrees from complete forms (CAIS) to partial forms (PAIS). People with CAIS have a 46,XY karyotype, but a female phenotype and intra-abdominal or inguinal testes (12). Despite having normal or high levels of testosterone, the lack of tissue response to androgens conditions body and brain feminization. Neuroanatomical and behavioral

studies indicate that these individuals tend to develop a female gender identity, reinforcing the notion that fetal hormonal action plays a determining role in the organization of the sexual brain (13).

3.3 5-ALPHA-REDUCTASE TYPE 2 DEFICIENCY

The enzyme 5 α -reductase, encoded by the *SRD5A2* gene, converts testosterone into dihydrotestosterone (DHT), a potent androgen responsible for virilization of the external genitalia. Its congenital deficiency, more frequent in regions of the Caribbean and South America, produces ambiguous genitalia or female phenotypes in individuals 46,XY (14). However, during puberty, the increase in testosterone generates secondary virilization and, in many cases, **reversion of gender identity to the male**. This phenomenon shows that postnatal hormonal exposure can also modulate gender perception, although within preconfigured neurobiological limits (15).

3.4 CONGENITAL ADRENAL HYPERPLASIA (CAH)

Usually caused by 21-hydroxylase (*CYP21A2*) deficiency, CAH leads to an overproduction of adrenal androgens in female fetuses (46,XX), causing varying degrees of genital virilization (16). Various longitudinal studies show that most women with CAH maintain a female identity, but some have masculinized behaviors or preferences and a higher incidence of same-sex attraction (17). This suggests that partial masculinization of the brain could be mediated by prenatal androgen exposure.

Taken together, DSDs show that genetic and hormonal variations during critical periods of brain development can modify the structure and functionality of the sexually dimorphic nervous system. However, gender dysphoria is not always associated with obvious chromosomal or endocrine abnormalities, indicating that more subtle mechanisms—such as genetic polymorphisms and epigenetic regulation—may play a crucial role in shaping sexual identity (18).

4 NEUROBIOLOGY AND SEXUAL BRAIN DIFFERENTIATION

The human brain exhibits structural, functional, and molecular differences between males and females, resulting from the combined influence of sex genes, gonadal hormones, and epigenetic processes during embryogenesis and puberty. These differences, known as

brain sexual dimorphism, constitute the neurobiological basis on which gender identity is built (19).

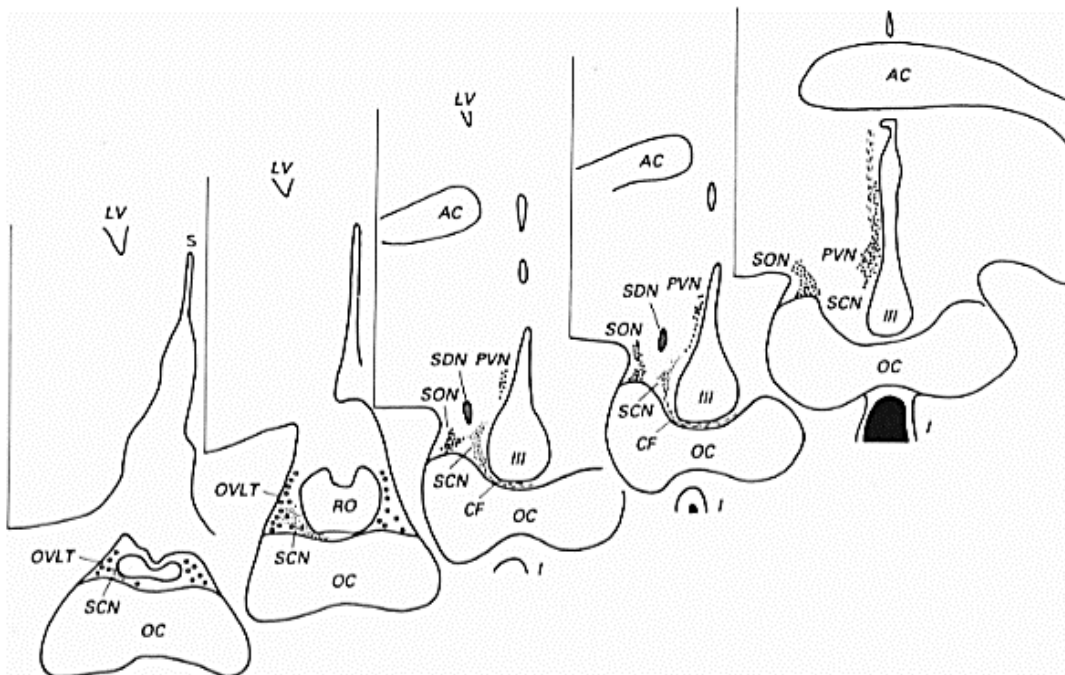
4.1 SEXUAL DIMORPHISM OF THE BRAIN

Various regions of the central nervous system exhibit a degree of sexual dimorphism. Among the most relevant are (Figure 3):

- **The interstitial nucleus of the anterior hypothalamus 3 (INAH3)**, described by LeVay (1991), which is larger in heterosexual males than in homosexual females or males (20).
- **The suprachiasmatic nucleus (SCN)**, which is larger in homosexual men compared to heterosexuals (21).
- **The nucleus bed nucleus of the stria terminalis, caudal part (BNSTc)**, a key region for gender identity. In transgender women (male-to-female), their size and neuronal density are similar to those of cisgender females, while in transgender males (female-to-male) they resemble those of cis males (22).

Figure 3

Topography of the sexually dimorphic nucleus (SDN) in the preoptic area of the human hypothalamus



Third ventricle, III; anterior commissure, AC; infundibulus, I; lateral ventricle, LV; optical chiasm, OC; organum vasculosum of the terminal lamina, OVLT; optical recess, RO; septum, S; suprachiasmatic nucleus, SCN; paraventricular nucleus, PVN; supraoptic nucleus, SON; commissural fibers of the suprachiasmatic nucleus, CF. (De Swaab & Fliers, 1985; copyright 1985 by AAAS.)

These findings suggest that gender identity is neuroanatomically represented and that structural differences are established early, probably under the influence of fetal testosterone and other genetic modulators.

4.2 FUNCTIONAL NEUROIMAGING EVIDENCE

Studies with functional magnetic resonance imaging (fMRI) and tensor diffusion (DTI) have shown that the brains of transgender people have patterns intermediate between those observed in cisgender men and women (23). For example:

- Cortical thickness and connectivity of the corpus callosum and insula show mixed or demasculinized traits in transgender women. (Figure 4)
- In transgender men, greater connectivity is observed in regions associated with body perception and sensory integration, similar to that of cisgender men (24).

These data support the hypothesis of brain differentiation incongruent with biological sex, rather than a mere sociocultural influence. Prenatal exposure to sex hormones and sensitivity to androgen and estrogen receptors appear to determine the pattern of brain development.

4.3 PRENATAL HORMONAL INFLUENCE

Sex hormones play an organizing role during critical stages of development. Intrauterine exposure to androgens or estrogens modulates brain structure and subsequent sexual behavior (25).

Animal studies have shown that the administration of testosterone to pregnant females masculinizes the behavior of their offspring, while androgenic inhibition in males produces feminizing effects (26). In humans, the relationship between prenatal exposure and sexual orientation has been supported by indirect biomarkers, such as the 2D:4D ratio (index and ring finger length), which differs significantly in transgender people (27).

4.4 BRAIN CONNECTIVITY AND BODY PERCEPTION

Savic and Arver (2008) demonstrated that the connections between the amygdala, the orbitofrontal cortex, and the insula differ according to sexual orientation and gender identity (28). In homosexual men and heterosexual women, the tonsillar projections are more extensive towards anterior cortical regions, while in heterosexual men and lesbian women connectivity with the striatum and thalamus predominates. In addition, brain activation in response to pheromone stimuli shows a crossover pattern: male pheromones stimulate the hypothalamus in heterosexual women and homosexual men, and female pheromones do so in heterosexual men and lesbian women (29). This indicates that sexual perception of the environment is biologically modulated.

4.5 NEUROGENETIC INTEGRATION

Evidence suggests that gender identity results from the interaction between genetic endowment and sexually dimorphic brain organization, rather than from simple hormonal influence. Genetic variations in androgen receptors (*ARs*), estrogens (*ER α* , *ER β*), progesterone (*PGRs*), and enzymes such as *SRD5A2* or *CYP17* could modify neuronal sensitivity to sex steroids, producing patterns of brain differentiation discordant with chromosomal sex (30).

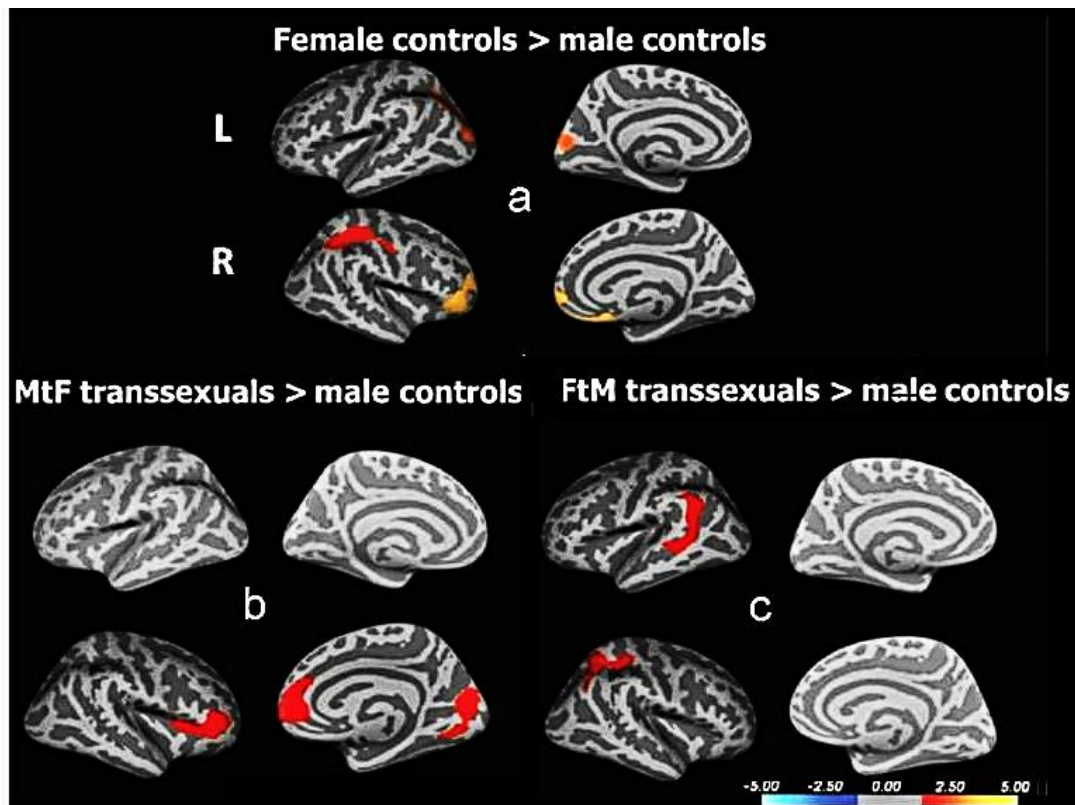
The neurobiology of gender dysphoria, therefore, is based on the convergence of genetic, endocrine and neurostructural mechanisms that shape the internal perception of one's own body and gender role. This perspective offers a scientific basis that complements—not replaces—the psychological and social factors involved in the transgender experience.

5 GENETIC FACTORS ASSOCIATED WITH GENDER DYSPHORIA

Research on the genetic determinants of gender dysphoria has progressed markedly over the past two decades. Although there is no single "gender gene," accumulating evidence suggests that sexual identity is shaped by a complex polygenic network, where multiple variants influence brain differentiation, hormonal action, and neuronal sensitivity to sex steroids (31).

Figure 4

Cortical thickness of untreated male-to-female (MtF) and female-to-male (FtM) transsexuals



Top panel: (a) comparison between male and female controls. Bottom panel: (b) comparison between MtF and male controls; (c) comparison between FtM and female controls. All significant comparisons showed the F > M pattern. Note that both MtF (b) and FtM (c) show a female pattern, although they differ in different regions of men than control women. L left hemisphere, R right hemisphere. Zubiaurre-Elorza, Junque, Gómez-Gil, Segovia, Carrillo & Guillamon, 2013, with permission.

5.1 POLYMORPHISMS IN ANDROGEN RECEPTOR (AR) GENES

The *AR* gene, located on chromosome Xq11-12, contains a polymorphic region with repeats of CAG triplets encoding glutamines. The length of this sequence modulates the sensitivity of the receptor to testosterone: a higher number of repeats is associated with lower transcriptional activity (32).

Several studies have found that transgender women (male-to-female) have a significant expansion in the number of CAG repeats, which could reduce the brain's

androgenic response during pregnancy and favor a more female pattern of sexual differentiation (33). This observation reinforces the hypothesis of prenatal brain submasculinization in this group.

5.2 ESTROGEN RECEPTORS (ERA AND ERB)

The *ESR1* (ER α) and *ESR2* (ER β) genes, located on chromosomes 6q25.1 and 14q23.2 respectively, encode nuclear receptors involved in the modulation of estrogen-dependent gene transcription.

Madeleine et al. (2020) identified a significant association between **polymorphisms in *ER α*** (rs9340799) and gender dysphoria, particularly in transgender women, where a higher frequency of the A allele was observed (34). Variation in *ER β* also appears to contribute to the degree of brain feminization or masculinization, modulating the estrogen response during fetal development (35).

5.3 HORMONE METABOLISM ENZYMES: SRD5A2, SULT2A1 AND STS

The *SRD5A2* gene, responsible for the conversion of testosterone to dihydrotestosterone (DHT), has polymorphisms that alter its enzymatic activity. Hypofunctional variants could generate less cerebral virilization in XY fetuses (36). In addition, the *SULT2A1* (sulfotransferase) and *STS* (steroid sulfatase) genes are involved in the inactivation or reactivation of sex steroids. Polymorphisms that modify their expression may influence the local availability of androgens and estrogens in the developing brain (37).

5.4 ASSOCIATED GENETIC COMBINATIONS

Madeleine et al. (2020) showed that certain **allelic combinations** are overexpressed in transgender women: *AR-ER β* , *AR-PGR*, *AR-COMT* and *CYP17-SRD5A2* (38). These patterns suggest functional interactions between genes that regulate the action and metabolism of sex hormones, generating **submasculinization or partial brain defeminization**.

The study proposed that such combinations could modulate the expression of steroid receptors in critical regions of the brain such as the hypothalamus and amygdala, influencing gender self-identification.

5.5 OTHER CANDIDATE LOCI

Recent genomic analyses have identified chromosomal regions potentially associated with gender identity, including:

- **Chromosome Xq28**, previously linked to male sexual orientation (39).
- **Chromosomes 7, 8 and 10**, where polymorphisms with greater concordance have been found in monozygotic twins compared to dizygotic twins (40).
- Variants in regulatory genes of the hypothalamic-pituitary axis, such as *NR3C1* (glucocorticoid receptor), which could interact with maternal prenatal stress affecting the expression of sex genes (41).

5.6 STUDIES IN TWINS AND FAMILIES

The genetic influence is also supported by studies in twins. Coolidge et al. (2002) and Bailey et al. (2016) demonstrated that the concordance for gender dysphoria is significantly higher in monozygotic twins than in dizygotic twins (42,43). It is estimated that about 50% of the variance in gender identity could be attributed to heritable genetic factors, although specific mechanisms remain under study.

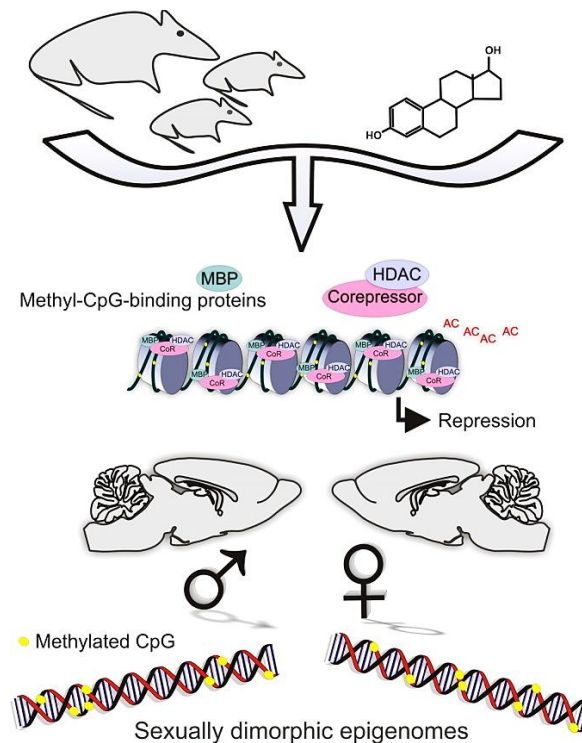
Taken together, these findings reinforce the notion that gender dysphoria has a **multifactorial polygenic basis**, where the sum of small genetic variations in genes that regulate hormonal action and brain differentiation generates intermediate sex phenotypes. The interaction of these variants with the fetal epigenetic and endocrine environment would ultimately determine the expression of gender identity in the adult individual.

6 EPIGENETICS AND REGULATION OF SEXUAL IDENTITY

Epigenetics is the bridge between inherited genetic information and the influence of the environment on gene expression. Through mechanisms such as **DNA methylation**, **histone modifications**, and the **action of microRNAs (miRNAs)**, cells adjust gene transcription without altering the nucleotide sequence. In the context of gender dysphoria, these processes appear to play an essential role in the **sexual differentiation of the brain** and the shaping of gender identity (44). (Figure 5).

Figure 5

Epigenetics of sex differences in the brain. Emerging evidence suggests sex differences in at least four related parameters: (1) DNA methylation patterns, (2) methyltransferases, (3) methylation-binding proteins, and (4) co-repressor proteins, all of which may contribute to long-lasting differences in brain and behavior. (McCarthy, 2009)



6.1 EPIGENETIC MECHANISMS OF SEXUAL DIFFERENTIATION

During embryonic development, brain cells undergo epigenetic programming that depends on chromosomal sex and the intrauterine hormonal environment. DNA-methyltransferase enzymes (DNMTs) establish specific methylation patterns that determine which genes are turned on or silenced based on sex (45).

DNA methylation is often associated with gene repression, while histone acetylation facilitates transcription. In animal models, differences in the methylation of estrogen (*ERα*) and androgen (*AR*) receptors in the hypothalamus have been shown to be determinants of the brain's sexual organization (46). In humans, these mechanisms could explain the appearance of intermediate phenotypes when methylation or acetylation occurs atypically during gestation.

6.2 INFLUENCE OF STRESS AND THE INTRAUTERINE ENVIRONMENT

Maternal environmental factors, such as prenatal stress, exposure to drugs or hormonal pollutants, can alter the epigenetic programming of the fetus (47). Elevated maternal cortisol acts on fetal glucocorticoid receptors, inhibiting sex steroid synthesis and modifying methylation patterns in key genes of gonadal and brain development (48). Studies in Berlin showed that sons of mothers with intense gestational stress showed a higher incidence of homosexual orientation or diverse gender identity (49). Similarly, exposure to endocrine disruptors, such as diethylstilbestrol (DES) or phenobarbital, has been associated with alterations in estrogen signaling and in the expression of genes related to sexual development (50).

6.3 ROLE OF MICRORNAS IN SEXUAL IDENTITY

MicroRNAs are small non-coding RNA molecules that regulate mRNA translation. In the brain, several miRNAs show differential expression based on sex and hormonal exposure.

miR-9, miR-132 and miR-212 have been identified as involved in neuronal maturation and synaptic plasticity, modulating circuits related to sexual behavior and the perception of one's own body (51).

In murine models, overexpression of certain feminizing miRNAs or inhibition of masculinizing miRNAs can reproduce atypical brain phenotypes, suggesting a direct epigenetic contribution to sexual identity (52).

6.4 EPIGENETIC, HORMONAL AND GENETIC INTEGRATION

The interaction between genetics, epigenetics and sex hormones forms a self-regulating system. The action of genes such as *SRY* and *SOX9* induces hormonal cascades that, in turn, modify the brain epigenome. This phenomenon explains why individuals with the same karyotype may present marked differences in sexual identity and orientation.

Likewise, epigenetics can generate **transgenerational heritability**: methylation patterns in hormonal genes can be partially transmitted to offspring, perpetuating predispositions to certain gender configurations or sexual behaviors (53).

Taken together, epigenetic evidence demonstrates that gender identity is the dynamic result of the interaction between the genome and the environment. Epigenetic

modifications provide a coherent explanation for individual variability, even among monozygotic twins, and reinforce the view of gender dysphoria as a biologically mediated rather than psychologically induced condition.

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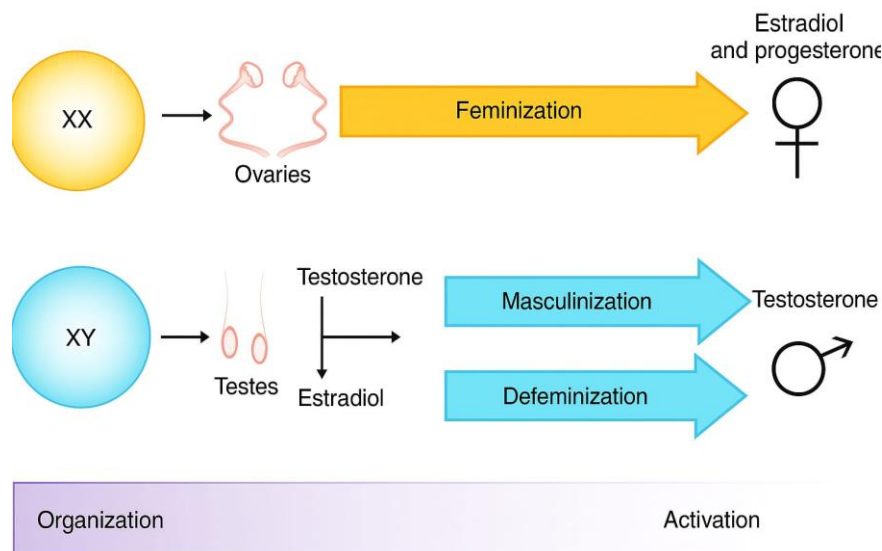
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Figure 6

Linear vision of sexual differentiation in the twentieth century. For the past 50 years, the prevailing view of the brain's sexual differentiation has been a linear model in which chromosomal sex determines gonadal sex, which in turn determines brain sex



Feminization of the brain is the default process that occurs in the absence of elevated levels of gonadal steroids during a perinatal sensitive period. Masculinization and defeminization are separate hormonal processes that organize the neural substrate to

promote typical male behaviors while suppressing typical female behaviors. The organized neural substrate is activated by gonadal steroids in adulthood and is necessary for typical sex behaviors to be expressed. This iconic model, based on the organizational/activational hypothesis, has proven to be a solid framework for elucidating some, but not all, aspects of the brain's sexual differentiation. (McCarthy, 2011)

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8 DISCUSSION

The current understanding of gender dysphoria has evolved from purely psychodynamic perspectives to an integrative biopsychosocial model, in which genetic, epigenetic and neurobiological components play a determining role. The reviewed findings support the hypothesis that gender identity has a multifactorial biological basis, modulated by the interaction between the genome, sex hormones and the intrauterine environment.

8.1 GENETIC AND ENDOCRINE INTERACTION

Studies on disorders of sex development (DSD) offer a window into understanding how genes and hormones influence the brain's sexual differentiation. Alterations in *SRY*, *SOX9*, *AR*, *CYP17*, and *SRD5A2* demonstrate that changes in androgenic or estrogenic

signaling during critical stages of embryogenesis can modify the neuroanatomical organization responsible for gender identity (54).

These observations suggest that gender dysphoria could be a consequence of a mismatch between gonadal sex and brain differentiation, caused by genetic or epigenetic variations that alter sensitivity to sex steroids.

8.2 CONVERGENT NEUROBIOLOGICAL EVIDENCE

Neuroimaging findings confirm that the brains of transgender people show structural and functional patterns intermediate between those of cisgender men and women (55). The size of the BNSTc and INAH3, as well as the connectivity of the amygdala and insula, reflect a brain configuration that does not depend exclusively on chromosomal sex.

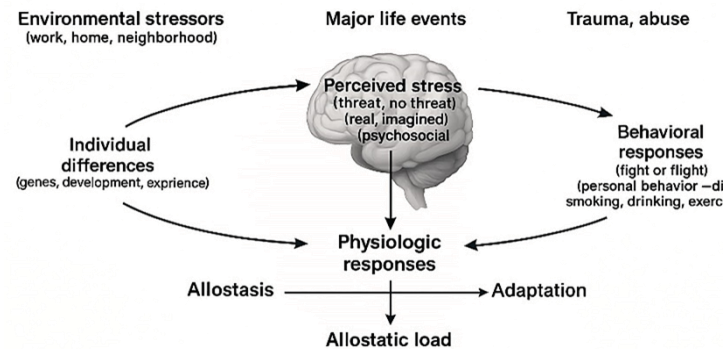
This evidence supports the concept that gender identity is established at the neurobiological level and that prenatal hormonal processes are determinants in its consolidation. However, postnatal brain plasticity may also contribute to gender experience, which explains variations in individual expression and experience.

8.3 CONTRIBUTIONS OF EPIGENETICS

Epigenetic mechanisms allow us to understand how environmental and hormonal factors influence gene expression without modifying the DNA sequence. DNA methylation, histone acetylation, and microRNA action modulate the transcription of genes related to sexual differentiation and gender perception (56). Figure 7.

Figure 7

Central role of the brain in the protective and damaging effects of stress mediators and adaptation that operate through the process of allostasis, which can lead to allostatic loading and overload when overused and dysregulated. Reproduced from reference 16, copyright (1998) Massachusetts Medical Society



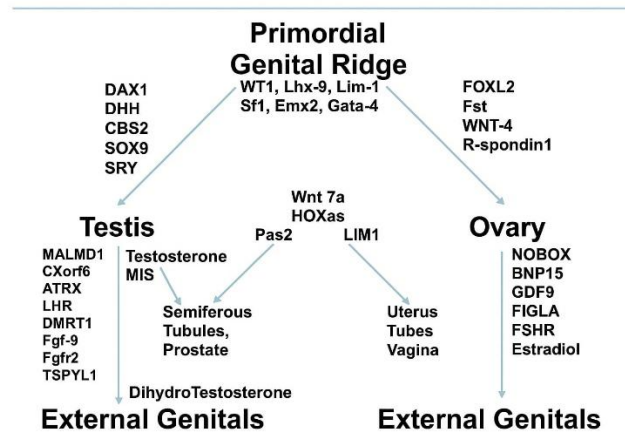
These processes could explain why individuals with identical genotypes or even monozygotic twins can develop different gender identities. In addition, prenatal stress and exposure to endocrine disruptors have been linked to persistent epigenetic changes affecting the hypothalamic axis and hormone regulation (57).

8.4 POLYGENIC AND MULTIFACTORIAL MODEL

The available evidence suggests that gender dysphoria responds to a polygenic and multifactorial model, in which multiple small-effect genes contribute to a particular neurobiological phenotype (58). Polymorphisms in *AR*, *ERα*, *ERβ*, *SULT2A1* and *STS* affect the conversion and action of sex steroids in the fetal brain, while epigenetics modulates the final expression of these genes. Thus, gender identity can be understood as a continuous biological trait, determined by the interaction of numerous genetic and environmental factors, rather than as a strict male/female dichotomy. Figure 8.

Figure 8

Sex determination and gonadal differentiation require a lot of protein and endocrine stimulants to father a fetus.1 1 MacLaughlin DT, Donahoe PK. Sexual determination and differentiation. N Engl J Med. 2004; 350 [4]:367–378



8.5 CLINICAL AND ETHICAL IMPLICATIONS

Recognizing the biological basis of gender dysphoria has profound implications for medical practice and clinical ethics.

First, it allows us to support a compassionate and depathologizing approach, where dysphoria is not conceived as a disease, but as a variation of human sexual development (59). Second, it reinforces the need for multidisciplinary management that integrates genetics, endocrinology, psychiatry, and clinical psychology, to offer respectful and evidence-based accompaniment.

Finally, understanding the genetic and epigenetic mechanisms involved can guide research towards **predictive biomarkers** that improve the early detection of gender incongruence, avoiding late diagnoses or inappropriate interventions.

8.6 CONSTRAINTS AND FUTURE PROSPECTS

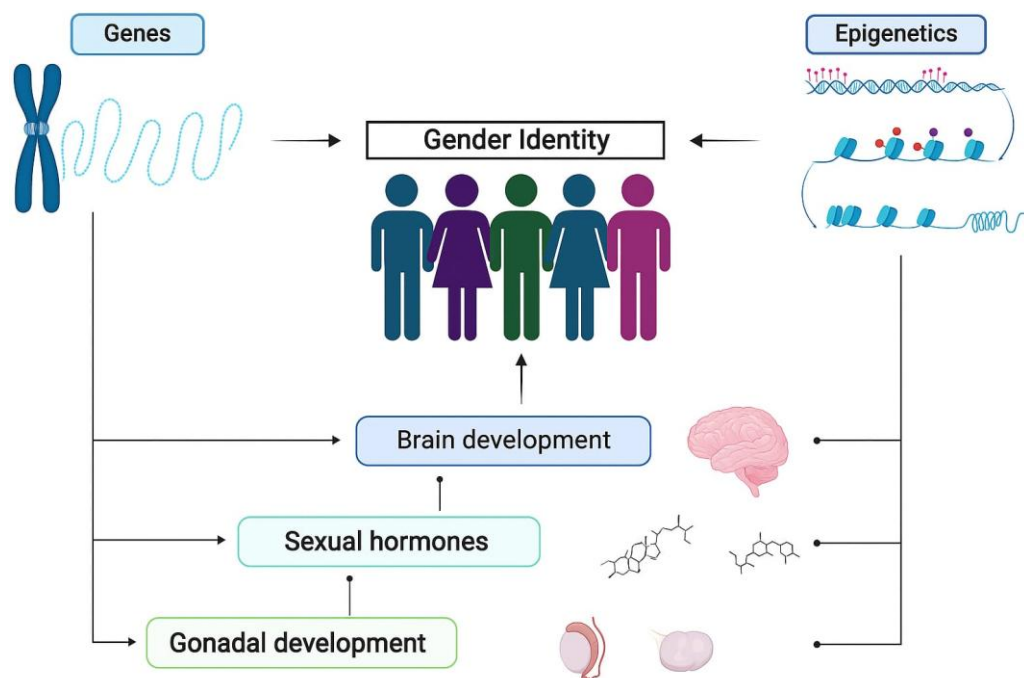
Despite the advances, most of the available studies have small samples, phenotypic heterogeneity and methodological limitations. The genetic and epigenetic complexity of sexual identity requires the application of next-generation sequencing techniques, epigenomic studies (EWAS), and advanced functional neuroimaging, with integrated data analysis (60).

Future research should combine genetic and epigenetic information with endocrine and neuroanatomical measurements, to build a comprehensive predictive model that explains the diversity of human identities and gender expressions.

In short, gender dysphoria emerges as a complex biological phenomenon in which genetics, epigenetics and neuroscience converge. Understanding its etiology from this approach not only expands medical knowledge, but also promotes more ethical, empathetic, and scientifically grounded care toward transgender people. (Figure 9).

Figure 9

The biological factors that influence gender identity



9 CONCLUSIONS

Gender dysphoria represents a complex expression of human diversity, where genetic, epigenetic, hormonal and neurobiological factors converge. Current evidence supports that gender identity originates largely during fetal development, when the brain undergoes processes of sexual differentiation influenced by the action of sex genes and hormones.

Genetic polymorphisms in genes such as *SRY*, *SOX9*, *AR*, *ERα*, *ERβ*, *SRD5A2*, *SULT2A1*, and *STS* can alter the sensitivity of the nervous system to sex steroids, generating variable brain patterns of masculinization or feminization. In turn, epigenetic

mechanisms—DNA methylation, histone and microRNA modifications—modulate the expression of these genes, mediating the interaction between the genome and the intrauterine environment.

The structural and functional differences observed in regions such as the BNSTc, INAH3, amygdala, and insula provide neuroanatomical evidence that gender identity has tangible biological correlates. These findings reinforce the need for a scientific, ethical and multidisciplinary approach that combines genetics, endocrinology, neuroscience and mental health in the clinical approach.

Finally, it is recommended to promote broad-spectrum genomic and epigenomic association research (GWAS and EWAS), combined with functional neuroimaging techniques, to clarify the molecular mechanisms involved and move towards a more precise, inclusive and humanistic understanding of gender diversity.

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WHEN TECHNOLOGY GETS IN THE WAY: INVISIBLE RISKS IN MODERN EDUCATION

QUANDO A TECNOLOGIA ATRAPALHA: RISCOS INVISÍVEIS NO ENSINO MODERNO

CUANDO LA TECNOLOGÍA SE INTERPONE EN EL CAMINO: RIESGOS INVISIBLES EN LA EDUCACIÓN MODERNA

 <https://doi.org/10.56238/sevened2025.036-139>

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ABSTRACT

This article addresses the invisible risks of the increasing use of technology in modern education, which, despite its evident benefits such as broadening access to knowledge and personalizing teaching, can generate negative impacts on student performance and well-

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being. Among the main risks discussed are distractions caused by digital devices, reduced face-to-face social interactions, and technological dependence, which compromise attention, socio-emotional development, and critical autonomy. The physical and psychological impacts of excessive screen use are also examined, such as eye strain, sleep disorders, and anxiety, which harm students' health. The article highlights the consequences for learning, such as superficial teaching and difficulty in developing critical thinking, based on studies that demonstrate inadequate pedagogical practices. To mitigate these effects, it proposes strategies for balanced and conscious use of technology, emphasizing responsible pedagogical approaches, harmonious integration with traditional methods, and school policies that guide the safe use of digital resources. The final reflection highlights the importance of balancing technology and in-person teaching, valuing human interaction and the critical thinking development of students, and points to the need for future research that delves deeper into the impacts and innovative pedagogical strategies for the effective use of technology.

Keywords: Educational Technology. Technological Dependence. Socio-emotional Development. Critical Autonomy. Conscious Use of Technologies.

RESUMO

O artigo aborda os riscos invisíveis do uso crescente da tecnologia na educação moderna, que, apesar de seus benefícios evidentes, como a ampliação do acesso ao conhecimento e a personalização do ensino, pode gerar impactos negativos no desempenho e bem-estar dos estudantes. Entre os principais riscos discutidos estão as distrações causadas por dispositivos digitais, a redução das interações sociais presenciais e a dependência tecnológica, que comprometem a atenção, o desenvolvimento socioemocional e a autonomia crítica. Também são examinados os impactos físicos e psicológicos do uso excessivo de telas, como a fadiga ocular, distúrbios do sono e ansiedade, que prejudicam a saúde dos alunos. O artigo destaca as consequências para a aprendizagem, como o ensino superficial e a dificuldade no desenvolvimento do pensamento crítico, embasadas em estudos que evidenciam práticas pedagógicas inadequadas. Para mitigar esses efeitos, propõe estratégias de uso equilibrado e consciente da tecnologia, enfatizando propostas pedagógicas responsáveis, integração harmoniosa com métodos tradicionais e políticas escolares que orientem o uso seguro dos recursos digitais. A reflexão final ressalta a importância do equilíbrio entre tecnologia e ensino presencial, valorizando a interação humana e a formação crítica dos estudantes, e aponta para a necessidade de futuras pesquisas que aprofundem os impactos e estratégias pedagógicas inovadoras para uso eficaz da tecnologia.

Palavras-chave: Tecnologia Educativa. Dependência Tecnológica. Desenvolvimento Socioemocional. Autonomia Crítica. Uso Consciente das Tecnologias.

RESUMEN

Este artículo aborda los riesgos invisibles del creciente uso de la tecnología en la educación moderna, que, a pesar de sus evidentes beneficios, como la ampliación del acceso al conocimiento y la personalización de la enseñanza, puede generar impactos negativos en el rendimiento y el bienestar estudiantil. Entre los principales riesgos que se discuten se encuentran las distracciones causadas por dispositivos digitales, la reducción de las interacciones sociales presenciales y la dependencia tecnológica, que comprometen la atención, el desarrollo socioemocional y la autonomía crítica. También se examinan los impactos físicos y psicológicos del uso excesivo de pantallas, como la fatiga visual, los

trastornos del sueño y la ansiedad, que perjudican la salud de los estudiantes. El artículo destaca las consecuencias para el aprendizaje, como la enseñanza superficial y la dificultad para desarrollar el pensamiento crítico, con base en estudios que demuestran prácticas pedagógicas inadecuadas. Para mitigar estos efectos, se proponen estrategias para un uso equilibrado y consciente de la tecnología, enfatizando enfoques pedagógicos responsables, la integración armoniosa con los métodos tradicionales y las políticas escolares que guían el uso seguro de los recursos digitales. La reflexión final destaca la importancia de equilibrar la tecnología y la enseñanza presencial, valorando la interacción humana y el desarrollo del pensamiento crítico de los estudiantes, y señala la necesidad de futuras investigaciones que profundicen en los impactos y las estrategias pedagógicas innovadoras para el uso efectivo de la tecnología.

Palabras clave: Tecnología Educativa. Dependencia Tecnológica. Desarrollo Socioemocional. Autonomía Crítica. Uso Consciente de las Tecnologías.

1 INTRODUCTION

Technology has become ubiquitous in the educational environment, transforming pedagogical practices and forms of interaction between teachers and students. While technological advances have introduced a number of benefits, such as easier access to information and the personalization of learning, they also bring risks that often remain invisible. These risks, ranging from distractions to impacts on students' health and cognitive development, deserve careful attention to ensure that technology does not become an impediment, but rather an enabler of education.

The purpose of this article is to critically review the existing literature on the risks associated with the use of technology in modern education, highlighting the invisible impacts that can compromise academic performance and student well-being. It is also intended to present strategies for the balanced and conscious use of technological resources, in order to promote an integration that values human interaction and effective pedagogical approaches.

In today's landscape, technology is widely used in education to expand the possibilities of teaching and learning. Digital tools facilitate access to diverse materials, promote collaboration, and offer interactive resources that enrich the educational process. The use of virtual platforms, educational applications and mobile devices is growing, which shows a movement towards the modernization of educational practices. The recognized benefits include the flexibility of learning time and space, encouragement of student protagonism and support for the personalization of teaching.

However, it is necessary to consider the side effects that accompany this technological expansion. The ease of access and the amount of digital stimuli can disperse students' attention, impairing concentration and the deepening of knowledge. In addition, the gradual replacement of face-to-face communication with screen-mediated interactions can negatively impact social and emotional aspects that are important for the integral development of students.

Another relevant point concerns the physical and mental health of students, often affected by the prolonged use of digital devices. Problems such as eye fatigue, changes in the sleep cycle, and increased anxiety are consequences that are increasingly documented in the literature. Such conditions, although not always apparent, directly interfere with the quality of learning and school performance.

Finally, it is essential that schools, educators, and families are aware of these challenges so that technology, although present, does not dominate or harm the educational process. The construction of pedagogical practices that consciously integrate digital resources, respecting human limits, is a promising way to ensure more effective and healthy teaching.

The methodology adopted in this article is the bibliographic review, through the critical analysis of academic publications, books and scientific articles related to the use of technology in education and its adverse effects. This approach allows the survey and synthesis of the main theoretical and empirical contributions on the subject, providing a broad and grounded view of the invisible risks and possibilities for a more balanced use of technology in teaching.

2 THEORETICAL FOUNDATION ON TECHNOLOGY AND EDUCATION

The use of technology in education has been widely discussed in various fields of knowledge, where different theories and pedagogical approaches seek to explain and guide this integration. This theoretical foundation seeks to present the main conceptions and developments that support the relationship between technology and teaching, providing a critical and historical understanding of the technological evolution applied to the educational process.

Theories related to technology in education include concepts of technological mediation and scientific paradigms that impact pedagogical practice. According to Adão *et al.* (2024), educational technology can be understood as a paradigm that involves shared beliefs, values, techniques, and theories, influenced by cultural, political, and social factors. For technological mediation to be effective, it is essential that educators recognize their limits and potential, promoting pedagogical innovation with responsibility and ethics. Other perspectives consider technologies as tools for inclusion and accessibility, highlighting universal design for learning (UDL) and assistive technology as complementary to ensure school inclusion (Melo *et al.*, 2024). In fact, it is important to emphasize that inclusion transcends the simple act of allowing everyone to participate; it is a commitment to equity, diversity, and respect for human dignity (Costa Júnior *et al.*, 2024).

Still, in learning theories, authors such as Dewey and Freire emphasize an active, democratic and critical education, which can be enhanced by the use of technology when it serves the emancipation of the student (Laurindo *et al.*, 2023).

Starting from the historical aspects, it is important to say that technological advancement in teaching has gone through different phases, from the initial use of audiovisual resources and personal computers to the adoption of digital technologies and distance education. The twentieth century saw the introduction of technologies such as radio, television, and video, which gradually took on an important role in pedagogical mediation. With the advent of the internet and mobile devices, teaching has gained new possibilities, including virtual learning environments and interactive resources. This technological evolution has brought profound transformations in the school structure and teaching methods, making technology an indispensable tool in the contemporary educational context.

The flexibility provided by the use of mobile devices, which offer communication and information anywhere and at any time, brings with it the idea of ubiquity, that is, being present everywhere at any time, being omnipresent:

[...] Technological development has led me to the conviction that the contemporary condition of our existence is ubiquitous. Because of hypermobility, we become ubiquitous beings. We are, at the same time, somewhere and outside of it. We intermittently become present-absent people. Mobile devices offer us the possibility of perpetual presence, near or far, always presence. We are approached for any purpose at any time and we can be in contact with other people regardless of their location and tasks at the time, which gives us a feeling of omnipresence. Ubiquitous body, mind and life. Undoubtedly, this brings side effects, a certain state of frenzy caused by the paradox of presence and at the same time of the constant upheaval in the various physical, psychological and computational conditions (Santaella, 2013, p.16).

As for the pedagogical approaches that use technology, the integration of active methodologies stands out, where the student assumes a leading role and technology works as a support for knowledge construction processes. Hybrid or blended learning models combine face-to-face classes with virtual activities, seeking a balance between human interaction and digital resources (Casagrande; Maieski; Alonso, 2023). In addition, virtual learning environments (VLE) and educational platforms facilitate the personalization of content and individualized monitoring, promoting more flexible learning.

Wrapped in this scenario full of connections, Gabriel (2013, p. 15) makes a very blunt statement about being and being connected:

Internet broadband enabled the important shift from "being connected" to "being connected." "Being" connected means that you eventually get in and out of the internet, [...] "Being" connected means that part of you is in the network – you live in symbiosis with it (p. 15).

These approaches show that technology, when aligned with well-founded pedagogical proposals, can enhance the critical, autonomous and collaborative training of students.

3 INVISIBLE RISKS OF TECHNOLOGY IN MODERN EDUCATION

The growing use of technology in the educational environment, despite its numerous advantages, presents a number of often hidden risks that negatively impact student learning and development. These invisible risks go beyond technical issues and involve cognitive, social and emotional aspects relevant to the educational process, requiring careful analysis so that their use is effectively beneficial.

Distractions caused by digital devices are one of the main concerns in contemporary education. The constant presence of notifications, messages, and multiple tabs open on computers and mobile devices tends to fragment students' attention, making it difficult to concentrate for the long time needed for deep learning. Although technologies offer tools that can enrich the classroom, inappropriate use can lead to dispersion and reduced ability to focus, leading to impairments in academic performance. The consequence is superficial learning, in which students are unable to fully absorb and process the content presented.

Another visible risk is the reduction of face-to-face social interactions between students and teachers due to the increase in digital mediation. This decrease in face-to-face coexistence compromises the socio-emotional development of students, which depends on direct interaction for the development of skills such as empathy, communication, and cooperation. The lack of personal exchange can cause a feeling of isolation and fragility in interpersonal relationships, affecting the school environment and the emotional well-being of students.

Lévy (1999, p. 7) points out his point of view in relation to this very complex theme:

In general, they consider me an optimist. They are right. My optimism, however, does not promise that the Internet will magically solve all the cultural and social problems of the planet. It consists only in recognizing two facts. Firstly, that the growth of cyberspace is the result of an international movement of young people eager to experiment, collectively, with forms of communication different from those that the

classical media propose to us. Secondly, that we are experiencing the opening of a new space of communication, and it is only up to us to explore the most positive potentialities of this space in the economic, political, cultural and human spheres (p. 7).

In addition, technological dependence can lead to the loss of critical autonomy and decreased problem-solving skills. Overuse of digital tools such as search engines and quick-response apps can reduce students' ability to think independently, reflect critically, and solve problems on their own. Such dependence harms cognitive development and weakens student protagonism, making teaching a mechanical and unreflective process.

4 PHYSICAL AND PSYCHOLOGICAL IMPACTS OF EXCESSIVE SCREEN USE

The intensive and prolonged use of digital devices has raised growing concerns regarding the physical and psychological impacts on students' health. Although these devices offer several facilities for teaching and learning, excessive exposure can cause adverse effects that compromise general well-being and academic performance. The main impacts identified in the literature are discussed below.

Digital eye strain, also known as computer vision syndrome, is a common problem associated with prolonged screen use and has been widely researched in recent years due to the growth in the use of electronic devices. CVS is characterized by a set of visual and ocular symptoms resulting from prolonged exposure to screens. These symptoms include eye strain, dryness, blurred vision, headaches, and visual discomfort. Constant exposure to blue light emitted by digital devices can impair the circadian cycle, affect sleep quality, and lead to progressive myopia, particularly in children and young people (Edem *et al.*, 2024). According to Binda *et al.* (2025), this condition includes symptoms such as irritation, dry eyes, feeling tired, blurred vision, and headache, resulting mainly from continuous exposure to the blue light emitted by devices and the lack of adequate breaks. The phenomenon is aggravated by poor posture and reduced blinking while using screens, culminating in visual discomfort and potential aggravation of eye problems such as myopia and dry eye syndrome. Preventive strategies such as regular breaks, correct ergonomics, and blue light filters are recommended to minimize these impacts.

Binda *et al.*, (2025), when they point out that the excessive use of electronic devices is directly linked to visual and systemic symptoms, such as eye strain, dryness, headache, and sleep problems. In addition, prolonged exposure to blue light, decreased blinking

frequency, and inadequate ergonomic factors contribute significantly to the worsening of these symptoms, making CVS an emerging public health issue.

As for sleep disorders, exposure to the lights emitted by screens, especially at night, interferes with the production of melatonin, a sleep-regulating hormone. According to Aquino and Fonseca (2025), this interference causes delays in sleep onset, lower quality of rest, and increased daytime sleepiness. The excessive use of digital devices in the hours close to bedtime has been associated with difficulties in falling asleep and a reduction in total rest time, which directly affects students' concentration and cognitive performance.

In addition to the physical effects, the psychological impacts of excessive use of technology are also evident. Excessive screen time is correlated with high levels of anxiety, stress, and depressive symptoms among children and adolescents. Continuous use, especially on social networks and virtual environments, can generate social pressures, harmful comparisons, and isolation, aggravating emotional distress. The lack of balance between online and offline time contributes to mental overload and decreased ability to manage emotions, compromising students' mental health and academic performance.

While the physical and psychological impacts of long-term use of digital devices are widely recognized, it is critical to go beyond diagnosing these issues to implement effective solutions in the educational context. The promotion of healthy habits, such as regular breaks during the use of screens, visual hygiene practices, and the encouragement of outdoor activities, should be systematically incorporated into the school routine. In addition, teacher training needs to include strategies to identify signs of digital fatigue and emotional discomfort, equipping them to act preventively. Clear school policies and the continuous awareness of students and families are also essential to control the time and quality of device use, avoiding the exacerbation of symptoms.

Another critical aspect is the challenge of balancing the use of technology with the development of students' socio-emotional and cognitive skills. Excessive use of screens and continuous exposure to virtual environments can impair the ability to concentrate, cause social isolation, and inhibit the development of important life skills, such as empathy, resilience, and communication. In this sense, technology should be a mediated resource, which complements face-to-face interactions and enriches pedagogical practices, without replacing them. The school should seek to provide learning contexts that integrate the digital with the human, valuing active participation, dialogue, and critical thinking.

Finally, the mental health of students requires special attention in the face of the

impacts of hyperconnectivity. The feelings of anxiety, stress and social pressures derived from the intensive use of networks and the digital environment reinforce the need for multidisciplinary interventions involving educators, psychologists and families. Emotional and digital education programs should be incorporated into school practices to strengthen students' autonomy in managing time online and offline, promoting balance between different aspects of life. The future of education depends on the ability of the educational system to promote a conscious and healthy use of technology, ensuring the integral well-being of students.

5 CONSEQUENCES FOR LEARNING AND TEACHING

The massive introduction of technologies in the educational environment has brought numerous changes, but it has also highlighted problems that affect the quality of teaching and learning. Among the main challenges, superficial teaching and the difficulty of developing complex cognitive skills, such as critical thinking, stand out. These negative impacts stem, in large part, from the inappropriate and decontextualized use of technology, which can reduce the depth of knowledge and autonomy of students.

Superficial teaching is a frequent consequence of the misuse of technology in education. As addressed by Corti and Silva (2022), many contents are treated quickly, in little depth, and with a bias very close to the popular language of social networks, focusing more on quantity than on the quality of learning. This happens, for example, when the use of technologies replaces reflective study with ready-made and superficial information, making it difficult to internalize concepts. Such an approach compromises the student's comprehensive education and preparation to face complex challenges.

Additionally, misused technology can hinder the development of critical thinking and other essential cognitive skills. The excessive dependence on digital resources that offer instant answers tends to reduce the capacity for analysis, synthesis and autonomous problem solving. The student, instead of building knowledge, starts to act passively, which limits his intellectual and critical growth. Encouraging the reflective and active use of technology is, therefore, essential to reverse this situation. If we go further and consider the skills relevant to the twenty-first century, according to Bray and McClaskey (2015, p. 7), they would be the set of essential skills for success in the digital age, including "critical thinking, creativity, collaboration, communication, and digital literacy".

It is known that, in certain schools, there is a predominance of activities mediated by

repetitive slides and videos, which do not stimulate the active participation of students. In addition, the superficiality of digital materials was associated with low content retention and demotivation in deeper investigations. This evidence indicates the need to rethink technological integration to promote more meaningful teaching.

The excessive use of technologies in the educational environment has created a scenario of transformations and challenges that require deep and critical reflection. It is essential to recognize that the introduction of technology cannot be seen as a magic solution that will automatically guarantee the improvement of teaching. The excessive emphasis on the use of digital resources, without the proper pedagogical contextualization, generates a superficial form of teaching, where the amount of information prevails over the significant construction of knowledge. Easy access to ready-made answers, widely available through digital tools, often limits the development of critical thinking, which is crucial for forming autonomous and reflective students.

It is also perceived that, in environments where technology is widely present (referring here to conditions where children and young people handle digital devices) the deep reading of books or even slightly more elaborate excerpts of texts, these same individuals do not present their totality in terms of learning and content retention. In this sense, Júnior *et al.*, (2023) highlights that reading plays a fundamental role in the development of cognitive areas, such as memory, attention, and language. Reading challenges us to store and retrieve information, which improves our ability to memorize and retain knowledge. This works as an exercise for the brain, activating neural functions (synapses). In this way, reading stimulates concentrated attention, since focus and concentration are necessary to understand the text.

In addition, the role of the teacher in this context gains even more relevance, as he needs to act in a mediating and creative way to prevent technology from transforming the classroom into a mechanical and repetitive environment. Teacher training is, therefore, essential for the educator to know how to combine the best of digital solutions with practices that encourage the active participation of students, dialogue and the deepening of the themes. Without continuous training and aligned pedagogical planning, technology can reinforce passive and demotivating methods, hindering effective learning.

It is necessary to be aware that "in the daily pedagogical practice of teachers, the way of using technology must be rethought in order to offer students tools that enable a more complete and current training. The contemporary teacher must break the paradigms

of traditional pedagogy and readapt to new trends" (Costa Júnior *et al.*, 2022, p. 58).

In fact, Allegretti and Jimena maintain that the challenges faced by teachers when integrating technologies are related to three fundamental issues:

[...] the need for the teacher to be aware that he should be the only source of information for the student; that the appropriation of a new technological resource requires knowledge of the technical and communicational potential of this resource, and to recognize to what extent the same applies to the pedagogical approach used (2007, p. 4).

Finally, it is essential to consider that access to technology is not uniform in all educational contexts, which widens inequalities and can compromise initiatives that seek innovation. School infrastructure, training and pedagogical support need to go hand in hand so that technology is an ally in building quality education. Rethinking technological integration with a focus on the depth of learning, critical formation, and student protagonism is an urgent and necessary path to face the contemporary challenges of education.

6 STRATEGIES FOR THE BALANCED AND CONSCIOUS USE OF TECHNOLOGY

To mitigate the invisible risks of technology in education, it is necessary to adopt strategies that promote the balanced and conscious use of digital resources. These strategies involve responsible pedagogical proposals, the harmonious integration of technology with traditional methods, and the implementation of school policies that guide and limit potential negative effects. The objective is to ensure that technology positively complements the teaching-learning process, without replacing human interaction and efficient pedagogical practices.

Pedagogical proposals for the responsible use of digital resources argue that technology should be incorporated into educational planning in an intentional and critical way. According to Fanti (2019), the role of the teacher is fundamental to mediate the use of technologies, promoting activities that stimulate reflection, creativity and active participation of students. Technology needs to serve as a means to achieve clear learning objectives, valuing student interaction and engagement, avoiding mechanical or merely substitutive use of traditional methods.

It should be said that technological resources should help to build "knowledge by making impossible or very discouraging operations or manipulations accessible" if reduced to pencil and paper (Perrenoud, 2000, p. 133).

Marins (2024) also highlights that it is necessary to reflect on this topic, because, although the connectivity offered by technology is considered a facilitator to overcome the physical and conventional barriers of classrooms and traditional teaching, the enormous amount of information available in the digital environment can have the opposite effect in relation to learning.

The integration of technology with traditional methods and human interaction is pointed out as an effective way to maximize educational benefits. Silva, Bilessimo and Machado (2021) highlight that hybrid models, which combine face-to-face teaching with digital resources, promote richer learning by favoring direct contact between teachers and students, expanded by technological tools that personalize teaching. This approach values the development of socio-emotional and cognitive skills, ensuring that technology does not become an impediment to building interpersonal relationships in the school environment.

Coll (2007) makes a very relevant point on the subject when he says that

[...] the incorporation of ICT into classroom activities is not necessarily, and not in itself, a factor of transformation and innovation in educational practices. On the contrary, ICT reveals itself rather as a reinforcing element of existing educational practices, which is to say that they only reinforce or promote innovation when they are inserted in a broader dynamic of educational change (Coll, 2007, p. 124).

Finally, school policies play a crucial role in limiting the risks of indiscriminate use of technology. It is necessary to implement regulations that guide the use of digital devices, such as rules for exposure time, moments of disconnection, and training of educators for the qualified pedagogical use of technologies. Such policies aim not only to protect the health and well-being of students, but also to ensure that technology is used ethically, responsibly, and in line with institutional educational objectives.

7 FINAL CONSIDERATIONS

We have witnessed a society that values the immediate and faces the acceleration of time. Despite this constant social movement, which has been experienced throughout the ages, with entries and exits marked by crises, we experience everything in a more cyclical and fast way. Bauman (2001) describes that we live in a time of "liquid modernity", in which relationships, values and institutions become progressively fluid and unsolid, and in which speed and instability predominate in everyday experiences. Exactly for this reason such a subject deserves and needs to be widely and constantly discussed, since education

is a field that needs depth, and this, unfortunately, is enemy number one of the most popular scenarios in which we find technology.

Therefore, and in the expectation of making relevant notes on the aspects surrounding technology, this article addressed the invisible risks associated with the growing use of technology in modern education, highlighting the cognitive, social, physical and psychological impacts that can harm the educational process. The problem of digital distractions, the reduction of face-to-face interactions and technological dependence that affect students' critical autonomy was analyzed.

In addition, the effects of excessive use of screens on eye health, sleep disorders and psychological disorders were discussed, showing the complexity of the consequences for students. There was also a reflection on the negative implications for learning, such as superficial teaching and the weakening of critical thinking, supported by studies that show insufficient pedagogical practices. Finally, strategies for the balanced and conscious use of technology were presented, including pedagogical guidelines, integration with traditional methods and school policies that limit risks.

Reflecting pragmatically, the balance between technology and face-to-face teaching is essential to enhance educational benefits without compromising essential aspects of human development. Technology should be perceived as a resource that complements, not replaces, the direct interaction between teachers and students, which is irreplaceable for social-emotional learning and the critical construction of knowledge. The adoption of hybrid models, which combine face-to-face teaching with digital resources, is a viable alternative to combine flexibility and quality, as long as there is adequate pedagogical planning, continuous teacher training and sufficient infrastructure. This balance also contributes to the promotion of digital inclusion, considering the different socioeconomic realities of students.

The healthy process of integrating technology in education depends on continuous and critical teacher training that provides skills for the effective and reflective use of digital resources. This training should go beyond technical learning and address the pedagogical, ethical, and social aspects involved in technological mediation. Training teachers for hybrid and flexible environments is not only about teaching the use of tools, but about developing the ability to rethink traditional methodologies, promoting teaching that values critical thinking, collaboration, and student autonomy.

Teacher training combined with clear school policies favors the construction of

pedagogical practices that avoid superficial teaching, stimulating the active participation of students and the critical appropriation of knowledge. In addition, schools that encourage student awareness of the risks of excessive use of screens contribute to comprehensive education, taking care of the student's physical and mental health. It is in this balance between technology and human care that the school can become a healthy learning space, where digital complements and does not replace personal interaction.

It is important to highlight that teacher training must consider the rapid technological and social transformations, offering permanent support for teachers to update their practices according to contemporary demands. Lack of preparation can result in inappropriate use of technology, reinforcing the passive and fragmented model of learning. Investing in critical training is, therefore, also investing in pedagogical innovation that enhances students' protagonism and reflection.

In addition, school policies need to establish clear guidelines for the balanced use of technologies, defining adequate times, advising on breaks, and promoting practices that minimize negative impacts on students' health and performance. This set of strategies forms an educational environment that promotes well-being and meaningful learning, aligning technology with well-defined pedagogical objectives.

Finally, raising awareness among the school community, including teachers, students, and families, is essential for technology to be used in a critical, ethical, and healthy way. From the collaboration and dialogue between these actors, it is possible to build a school culture that values the balance between the digital world and human needs, preparing students to act competently and responsibly in an increasingly connected society.

For future research, it is crucial to deepen empirical investigations on the impact of new educational technologies in different school contexts and age groups, evaluating their effects on student performance and well-being. Innovative strategies that enhance active, collaborative, and critical learning should also be explored, taking advantage of the best in digital tools. From the point of view of educational practices, inclusive policies are recommended that enable equitable access to technological resources, permanent teacher training and clear protocols to limit the negative effects of technology, ensuring an education that adapts to the challenges of the twenty-first century without losing its human character.

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**PSYCHOSOCIAL TRAFFIC AUTOPSY AS A STRATEGY FOR ASSESSING
INTENTIONALITY IN ROAD TRAFFIC INCIDENTS: A METHODOLOGICAL
STUDY**

**AUTÓPSIA PSICOSSOCIAL DE TRÂNSITO COMO ESTRATÉGIA PARA
AVALIAÇÃO DA INTENCIONALIDADE EM SINISTROS VIÁRIOS: UM ESTUDO
METODOLÓGICO**

**AUTOPSIA PSICOSOCIAL DE TRÁNSITO COMO ESTRATEGIA PARA LA
EVALUACIÓN DE LA INTENCIONALIDAD EN SINIESTROS VIALES: UN
ESTUDIO METODOLÓGICO**

 <https://doi.org/10.56238/sevened2025.036-140>

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ABSTRACT

Traffic accidents rank among the leading causes of death from external causes and constitute a major public health concern. Traditionally classified as unintentional events, these fatalities are often attributed to human error, environmental conditions, or deficiencies in road infrastructure. However, scientific evidence indicates that some of these deaths may involve signs of self-harm intentionality, which remain largely underreported and are frequently recorded as accidents of undetermined cause. In light of this gap, the present study aims to introduce traffic psychosocial autopsy as an innovative methodological strategy for assessing intentionality in fatal road accidents. This study is a methodological development, qualitative and applied in nature, which systematizes an integrated process

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for retrospective investigation of traffic-related deaths. The methodology adapts the principles of classical psychological and psychosocial autopsies, expanding them to incorporate technical-forensic, psychosocial, epidemiological, environmental, and institutional data. The process is organized into six sequential steps: case identification, integration of data sources, retrospective psychosocial investigation, technical and contextual road analysis, intersectoral integration and inference session, and preparation of a technical report with recommendations. It is concluded that the traffic psychosocial autopsy enhances the analytical capacity of traffic death investigations, contributes to improving epidemiological surveillance, and supports intersectoral public policies aimed at preventing avoidable fatalities.

Keywords: Psychosocial Autopsy. Road Safety. Traffic Accidents. Intentionality. Mortality from External Causes. Epidemiological Surveillance.

RESUMO

Os sinistros de trânsito figuram entre as principais causas de morte por causas externas e constituem um problema prioritário de saúde pública. Tradicionalmente classificados como eventos não intencionais, esses óbitos são frequentemente atribuídos a falhas humanas, condições ambientais ou deficiências da infraestrutura viária. Contudo, evidências científicas indicam que parte dessas mortes pode envolver indícios de intencionalidade auto lesiva, os quais permanecem amplamente subnotificados e registrados como acidentes de causa indeterminada. Diante dessa lacuna, o presente estudo tem como objetivo apresentar a autópsia psicossocial de trânsito como uma estratégia metodológica inovadora para a avaliação da intencionalidade em sinistros viários com óbito. Trata-se de um estudo de desenvolvimento metodológico, de natureza qualitativa e aplicada, que sistematiza um processo integrado de investigação retrospectiva de mortes no trânsito. A metodologia adapta os pressupostos da autópsia psicológica e psicossocial clássica, incorporando de forma ampliada dados técnico-periciais, psicossociais, epidemiológicos, ambientais e institucionais. O processo é organizado em seis etapas sequenciais: identificação do caso, integração de fontes de dados, investigação psicossocial retrospectiva, análise técnica e contextual da via, sessão intersectorial de integração e inferência, e elaboração de relatório técnico com recomendações. Conclui-se que a autópsia psicossocial de trânsito amplia a capacidade analítica da investigação de óbitos no trânsito, contribui para a qualificação da vigilância epidemiológica e subsidia políticas públicas intersectoriais voltadas à prevenção de mortes evitáveis.

Palavras-chave: Autópsia Psicossocial. Segurança Viária. Sinistros de Trânsito. Intencionalidade. Mortalidade por Causas Externas. Vigilância Epidemiológica.

RESUMEN

Los accidentes de tránsito se encuentran entre las principales causas de muerte por causas externas y constituyen un problema prioritario de salud pública. Tradicionalmente clasificados como eventos no intencionales, estas muertes suelen atribuirse a errores humanos, condiciones ambientales o deficiencias en la infraestructura vial. Sin embargo, la evidencia científica indica que una parte de estas muertes puede involucrar indicios de intencionalidad autolesiva, los cuales permanecen ampliamente subregistrados y suelen clasificarse como accidentes de causa indeterminada. Ante esta laguna, el presente estudio tiene como objetivo presentar la autopsia psicossocial de tránsito como una estrategia metodológica innovadora para la evaluación de la intencionalidad en accidentes

viales con resultado fatal. Se trata de un estudio de desarrollo metodológico, de naturaleza cualitativa y aplicada, que sistematiza un proceso integrado de investigación retrospectiva de muertes en el tránsito. La metodología adapta los supuestos de la autopsia psicológica y psicosocial clásica, incorporando de manera ampliada datos técnico-periciales, psicosociales, epidemiológicos, ambientales e institucionales. El proceso se organiza en seis etapas secuenciales: identificación del caso, integración de fuentes de datos, investigación psicosocial retrospectiva, análisis técnico y contextual de la vía, sesión intersectorial de integración e inferencia, y elaboración de informe técnico con recomendaciones. Se concluye que la autopsia psicosocial de tránsito amplía la capacidad analítica de la investigación de muertes en accidentes de tránsito, contribuye a la mejora de la vigilancia epidemiológica y respalda políticas públicas intersectoriales orientadas a la prevención de muertes evitables.

Palabras clave: Autopsia Psicosocial. Seguridad Vial. Accidentes de Tránsito. Intencionalidad. Mortalidad por Causas Externas. Vigilancia Epidemiológica.

1 INTRODUCTION

Traffic accidents are among the main causes of death from external causes in the world, configuring themselves as a priority public health problem. Traditionally, these events are interpreted as unintentional occurrences, resulting from human error, adverse environmental conditions, or deficiencies in road infrastructure. Although this framework has supported important advances in traffic engineering and enforcement, it is insufficient to explain the totality of deaths recorded in traffic, especially those classified as accidents of undetermined cause (WORLD HEALTH ORGANIZATION, 2023).

Since the mid-twentieth century, studies in psychiatry and forensic medicine have indicated that the vehicle can be used as a means of self-injury, especially in contexts characterized by high lethality and low possibility of external intervention. Selzer and Payne (1962) described suicide by vehicular collision at an early age, while Shneidman (1973) introduced the concept of *vehicular suicidal ideation*, highlighting the ambivalent, impulsive and socially concealable character of this behavior. Despite these pioneering contributions, self-injurious intentionality remains largely underreported in official traffic death registration systems.

Contemporary empirical evidence reinforces this interpretative gap. Observational and population-based studies have shown a consistent association between suicidal ideation and risky driving behaviors, such as speeding, driving under the influence of alcohol or other substances, and lower adherence to safety devices, substantially increasing the likelihood of fatal collisions (BRAMNESS et al., 2008; THOMPSON et al., 2011). Such findings suggest that certain road accidents cannot be understood exclusively as fortuitous accidents, but may involve subjective and emotional dimensions relevant to the occurrence of the event.

In addition, investigations carried out in transport infrastructures, such as railways, bridges and highways, indicate that improvements in the procedures for analyzing and classifying deaths significantly alter the proportion of events attributed to accidents or suicides (PIRKIS et al., 2013; RUNESON et al., 2025). These results highlight structural limitations of traditional research models, which often focus on the physical dynamics of the event and neglect psychosocial and contextual factors.

In this scenario, the psychosocial autopsy is consolidated as an interdisciplinary methodology capable of retrospectively investigating deaths from external causes, by integrating clinical, psychological, social and contextual data in the reconstruction of the

fatal event (WERLANG et al., 2003; ROZA et al., 2023). In Brazil, studies published in national scientific journals demonstrate the validity and applicability of this approach to qualify the investigation of suicides and ambiguous deaths, overcoming analyses restricted to the physical cause of death (WERLANG et al., 2003).

By adapting this methodological framework to the field of road safety, psychosocial traffic autopsy broadens the analytical scope by incorporating, in an integrated manner, expert reports of collision dynamics, road conditions, risk history of the site and interviews with key informants. This approach makes it possible to assess signs of self-injurious intent in traffic accidents with death, contributing to the reduction of underreporting, the improvement of epidemiological surveillance, and the strengthening of intersectoral public policies aimed at prevention (TRANSPORT FOR NSW, 2020; WORLD HEALTH ORGANIZATION, 2023).

In view of these evidences and methodological gaps, the present study aims to present the psychosocial traffic autopsy as an innovative and integrated methodology developed to evaluate signs of intentionality in traffic accidents with death, detailing its procedures, data sources, instruments, analytical strategies and implications for epidemiological surveillance and road safety policies.

2 METHODS

This is a methodological development study, of a qualitative and applied nature, whose objective was to structure, describe and systematize the Psychosocial Traffic Autopsy as an integrated process of evaluation of signs of intentionality in traffic accidents with death. The study does not propose to estimate prevalences, but to develop an operational methodological framework, capable of being incorporated into the institutional practice of traffic agencies, public health and technical expertise.

The methodology developed is inspired by the assumptions of psychological and psychosocial autopsy, widely used in the investigation of suicides and ambiguous deaths, but substantially expands its scope by incorporating road, forensic and environmental and institutional variables, as well as by involving multiple sectors of the public power in the investigative and analytical process.

The construction of the methodology was based on three main references: (i) the classic and contemporary literature on psychological and psychosocial autopsy; (ii) international evidence on suicide in transport systems and difficulties in classifying deaths;

(iii) road safety and public health guidelines, including the principles of Vision Zero and epidemiological surveillance of external causes.

These references guided the definition of the analytical categories, the collection instruments and the criteria for inferring intentionality, ensuring conceptual coherence and practical applicability.

The methodology was organized as a sequential and cumulative process, composed of six interdependent macro steps:

1. Case identification and selection
2. Survey and integration of data sources
3. Retrospective psychosocial investigation
4. Technical-forensic and contextual analysis of the road
5. Cross-sector integration and inference session

Accidents with death that present, alone or together: (a) high-lethality collisions (e.g., frontal impact, single vehicle, run-overs on high-speed highways) are eligible for the application of the psychosocial traffic autopsy; (b) absence or inconsistency of evidence of evasive maneuver; (c) previous history of psychosocial risk or known psychological distress; (d) initial classification as an accident of undetermined cause; (e) recurrence of deaths on the same road section (critical point). The selection of cases can be carried out prospectively (continuous flow) or retrospectively (review of deaths already registered).

The methodology presupposes the integration of multiple sources of information, organized into four axes:

- Technical-forensic sources that include official expert reports (collision dynamics, estimated speed, braking marks, vehicle deformations); Reports from PRF, DETRAN and DNIT; Photographic records, monitoring videos and telemetry data, when available; Autopsy reports and toxicological examinations.
- Psychosocial sources include semi-structured interviews with family members, cohabitants, co-workers, and friends; History of stressful life events; Family relationships and social support network; Recent behavioral changes and verbalizations of farewell or hopelessness.
- Public health sources such as Mortality Information System (SIM) records; Clinical and mental health records; Notifications of violence and previous attempts.

- Contextual and environmental sources involving the road conditions (geometry, signaling, lighting, accident history); Characterization of the site as a potential critical point; Weather conditions and visibility at the time of the event.

The psychosocial investigation follows the principles of the classic psychosocial autopsy, using a validated semi-structured script, adapted to the traffic context. The following axes are explored:

- Life trajectory and recent psychosocial context;
- Mental health and substance use history;
- Previous, explicit or veiled suicidal ideation;
- Repeated risk behaviors;
- Meanings attributed to traffic and displacement.

The interviews are conducted by trained professionals, with an ethical and empathetic approach, prioritizing the triangulation of independent informants.

Parallel to the psychosocial investigation, a detailed analysis of the dynamics of the accident is carried out, including: Compatibility between the narrative of the event and physical evidence; Existence of road alternatives and opportunities for evasion; Choice of the place and time of the claim; Degree of predictability of lethality. This analysis allows the identification of recurring patterns of structural and behavioral risk.

The data are discussed in an intersectoral session, involving representatives of forensics, mental health, traffic and epidemiological surveillance. An inference matrix of intentionality is used, with graduated classification: Strong indications of intentionality; Moderate indications; Event without evidence of intentionality; Indeterminate (inconclusive data). Decisions are reasoned, documented and consensual, avoiding isolated individual judgments.

The process culminates in a technical-synthetic report of the case; Recommendations for updating official records; Indication of local preventive measures (engineering, inspection, psychosocial support); Institutional feedback to the agencies involved.

The methodology observes ethical principles of confidentiality, respect for families and responsible use of information. As it is an investigation with secondary data and retrospective interviews, its institutional application requires its own regulations and informed consent.

The Psychosocial Traffic Autopsy is distinguished by: broadening the scope of the traditional psychosocial autopsy; integrate technical, human and environmental dimensions; operate in an intersectoral manner; directly guide public policies and preventive interventions.

3 RESULTS

The methodological process of the Psychosocial Traffic Autopsy is organized in six sequential and integrated stages, as described below:

1. Identification of the accident with death: selection of eligible cases based on risk criteria (high lethality, undetermined cause, atypical patterns, recurrence in a given location).
2. Technical-forensic survey: collection and analysis of collision reports, autopsy, toxicological examinations, photographic records, videos and road data.
3. Retrospective psychosocial investigation: semi-structured interviews with key informants; reconstruction of psychosocial trajectory, mental health history, and stressful events.
4. Contextual and environmental analysis of the road: evaluation of the physical conditions of the site, history of accidents, structural characteristics and potential risk factors.
5. Intersectoral integration and inference session: collegiate discussion of data by a multiprofessional team; application of the inference matrix of intentionality.
6. Classification, registration and feedback: preparation of technical report; recommendations for updating official records and proposing preventive actions. It is expected that the development and systematization of psychosocial traffic autopsy will produce conceptual, methodological and operational advances in the evaluation of traffic accidents with death, especially with regard to the identification of signs of self-injurious intentionality.

On the methodological level, the main expected result is the consolidation of a structured, replicable and intersectoral process for retrospective investigation of traffic deaths, overcoming fragmented approaches focused exclusively on the physical dynamics of the accident. The application of the methodology should allow the systematic integration of technical-forensic data, psychosocial, epidemiological and contextual, expanding the analytical capacity of the institutions involved.

In terms of diagnosis, a better qualification of the intentionality of fatal events is expected, with a reduction in the proportion of deaths classified as "accidents of undetermined cause". The use of graded inference criteria (strong, moderate, absent or inconclusive evidence) should enable a more realistic reading of road mortality, without imposing dichotomous or simplified classifications.

At the epidemiological level, the methodology tends to contribute to the improvement of health and traffic information systems, especially through the qualification of records from the Mortality Information System (SIM) and institutional databases of highway agencies. The generation of more accurate data will allow more consistent temporal, spatial and population analyses, favoring the identification of recurrent patterns of psychosocial and structural risk.

In the preventive plan, it is expected that the findings produced by the psychosocial traffic autopsy will support more effective and targeted interventions, such as the prioritization of critical points for engineering, monitoring and signaling actions, as well as the development of psychosocial care protocols for vulnerable groups. By identifying human and contextual factors associated with fatal claims, the methodology expands the potential for primary and secondary prevention.

At the institutional and intersectoral level, it is expected to strengthen the articulation between traffic agencies, technical expertise, mental health and epidemiological surveillance. Conducting cross-sectoral analysis and consensus sessions tends to promote institutional learning, standardization of investigative practices, and strengthening a life-centered road safety culture.

Finally, at the political and strategic level, the adoption of psychosocial traffic autopsy can support the formulation of evidence-based public policies, aligned with the guidelines of Vision Zero, PNATTRANS and the Sustainable Development Goals, contributing to the reduction of avoidable traffic deaths.

4 DISCUSSION

The results expected with the development of the Psychosocial Traffic Autopsy point to a substantial expansion of the analytical capacity of traffic death investigation systems, by incorporating traditionally neglected dimensions in models focused exclusively on the physical dynamics of the accident. The international literature has shown that the restricted interpretation of the event as an "accident" tends to hide subjective, emotional and

contextual factors that may be directly implicated in the occurrence of fatal collisions, especially those classified as having an undetermined cause (SELZER; PAYNE, 1962; SHNEIDMAN, 1973).

In this sense, the expectation of a reduction in the proportion of deaths classified as undetermined is supported by studies that have applied expanded investigation methodologies, such as psychological and psychosocial autopsy, in contexts of ambiguous deaths. Systematic reviews indicate that the inclusion of interviews with key informants and the retrospective reconstruction of the individual's life context significantly increase the identification of previously unrecognized indications of intentionality (ROZA et al., 2023; CRISĂN; BĂCILĂ; MORAR, 2022). By transposing this methodological framework to the field of traffic, the psychosocial autopsy of traffic tends to produce similar effects, qualifying the epidemiological reading of road mortality.

The integration between technical-forensic data and psychosocial information is one of the main advances expected from the methodology. Studies carried out in countries such as Australia and Sweden show that the isolated analysis of collision dynamics is insufficient to differentiate accidental events from potentially intentional occurrences, especially in scenarios of high lethality and absence of witnesses (TRANSPORT FOR NSW, 2020; PARACHUTE, 2023). The systematic incorporation of variables such as mental health history, stressful life events, and recurrent behavioral patterns broadens the understanding of the phenomenon and reduces interpretive biases.

On the epidemiological level, it is expected that the application of psychosocial traffic autopsy will contribute to the improvement of the surveillance of deaths from external causes, especially in the Mortality Information System. The World Health Organization highlights that the underreporting of intentionality compromises the formulation of effective public policies, by making specific segments of the population at risk invisible (WORLD HEALTH ORGANIZATION, 2023). By qualifying the records and reducing the overuse of the "undetermined cause" category, the methodology can generate more consistent and comparable databases over time.

Another relevant aspect of the expected results refers to the preventive potential of the methodology. International evidence indicates that structural and psychosocial interventions targeting critical points and vulnerable groups are more effective when based on integrated analyses of human behavior and the road environment (PIRKIS et al., 2013; RUNESON et al., 2025). By identifying recurrent patterns of risk — such as deliberate

choice of places of high lethality or absence of evasive maneuvers — the psychosocial traffic autopsy provides technical subsidies for engineering, signaling, inspection and psychosocial support actions.

From an institutional point of view, the expected results include the strengthening of intersectoral coordination between traffic, forensics, mental health and epidemiological surveillance agencies. The holding of collegiate integration and inference sessions promotes not only greater analytical rigor, but also organizational learning and standardization of practices, elements pointed out as essential for the sustainability of evidence-based road safety policies (WORLD HEALTH ORGANIZATION, 2023). This institutional arrangement contributes to overcoming the traditional fragmentation between sectors and to consolidating a systemic approach to the phenomenon.

Finally, the expectation that the methodology will contribute to the conceptual redefinition of traffic as a space of care and prevention is supported by the principles of Vision Zero, which recognizes that deaths in the transport system are neither acceptable nor inevitable. By revealing hidden dimensions of road mortality, psychosocial traffic autopsy challenges traditional paradigms and broadens the horizon of public policies, by integrating road safety and mental health in a perspective centered on the protection of life.

5 FINAL THOUGHTS

The development of the Psychosocial Traffic Autopsy, presented in this study, highlights the need to expand the traditional models of investigation of traffic deaths, incorporating psychosocial, contextual and institutional dimensions to the analysis of fatal accidents. By recognizing that part of these deaths may involve evidence of self-injurious intentionality, the proposed methodology contributes to overcoming the restrictive reading of the accident as an exclusively fortuitous event.

The expected results indicate that the application of this approach has the potential to qualify epidemiological surveillance, reduce underreporting of intentionality, and improve the classification of deaths from external causes. By integrating technical-forensic data, psychosocial interviews and analysis of the road environment, the psychosocial traffic autopsy offers a more comprehensive understanding of the factors that converge to the occurrence of fatal accidents, in line with international evidence and the recommendations of the World Health Organization.

In addition to its analytical value, the methodology has practical relevance in supporting more precise preventive interventions, either through engineering and signaling actions at critical points, or by identifying vulnerable groups that require psychosocial care strategies. The emphasis on intersectoral articulation strengthens institutional response capacity and promotes a road safety culture centered on the protection of life.

It is recognized, however, that the consolidation of the Psychosocial Traffic Autopsy requires investments in professional training, standardization of protocols and improvement of information systems. Future studies may empirically evaluate its application in different territorial contexts, contributing to the refinement of inference criteria and to the measurement of its impact on public policies. Even so, the methodology presents itself as a relevant conceptual and operational advance, by integrating road safety and mental health in a preventive, humanized and evidence-based perspective.

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**A TEACHING SEQUENCE BASED ON PROBLEM-BASED LEARNING AND
FLIPPED CLASSROOM FOR TEACHING ELECTROCHEMISTRY IN HIGH
SCHOOL**

**UMA SEQUÊNCIA DIDÁTICA BASEADA EM APRENDIZAGEM BASEADA EM
PROBLEMAS E SALA DE AULA INVERTIDA PARA O ENSINO DE
ELETROQUÍMICA NO ENSINO MÉDIO**

**UNA SECUENCIA DIDÁCTICA BASADA EN EL APRENDIZAJE BASADO EN
PROBLEMAS Y EL AULA INVERTIDA PARA LA ENSEÑANZA DE LA
ELECTROQUÍMICA EN LA EDUCACIÓN SECUNDARIA**

 <https://doi.org/10.56238/sevened2025.036-141>

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ABSTRACT

The teaching of Electrochemistry in High School presents challenges related to the abstraction of concepts, the difficulty in articulating theory and practice, and student demotivation, especially when approached through traditional methodologies. Given this scenario, this work aimed to investigate the contributions of Problem-Based Learning and the flipped classroom to the teaching of Electrochemistry in High School. The methodology adopted was characterized as qualitative and bibliographic research, developed from the analysis of academic productions published between 2019 and 2025, located in the SciELO and Google Scholar databases, related to Chemistry teaching, active methodologies, and Electrochemistry. As a result, the literature analysis showed that the integration between Problem-Based Learning and the flipped classroom favors the contextualization of content, student protagonism, and the progressive organization of teaching, aspects relevant to the learning of electrochemical concepts. Based on these results, a theoretical teaching sequence was developed, structured in articulated stages aligned with the learning objectives of secondary education. It was concluded that the proposed approach contributes to lesson planning and reflection on substantial pedagogical practices in the teaching of Electrochemistry.

Keywords: Chemistry Teaching. Electrochemistry. Active Methodologies. Problem-based Learning. Flipped Classroom.

RESUMO

O ensino de Eletroquímica no Ensino Médio apresenta desafios correlatos à abstração dos conceitos, à dificuldade de articulação entre teoria e prática e à desmotivação dos estudantes, sobretudo quando abordado por meio de metodologias tradicionais. Diante desse cenário, este trabalho teve como objetivo geral averiguar as contribuições da Aprendizagem Baseada em Problemas e da sala de aula invertida para o ensino de Eletroquímica no Ensino Médio. A metodologia adotada caracterizou-se como uma pesquisa qualitativa e bibliográfica, desenvolvida a partir da análise de produções acadêmicas publicadas entre 2019 e 2025, localizadas nas bases SciELO e Google

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Acadêmico, relacionadas ao ensino de Química, às metodologias ativas e à Eletroquímica. Como resultados, a análise da literatura evidenciou que a integração entre a Aprendizagem Baseada em Problemas e a sala de aula invertida favorece a contextualização dos conteúdos, o protagonismo discente e a organização progressiva do ensino, aspectos relevantes para a aprendizagem de conceitos eletroquímicos. Com base nesses resultados, foi elaborada uma sequência didática de caráter teórico, estruturada em etapas articuladas e alinhadas aos objetivos de aprendizagem do Ensino Médio. Concluiu-se que a proposta apresentada contribui para o planejamento docente e para a reflexão sobre práticas pedagógicas substanciais no ensino de Eletroquímica.

Palavras-chave: Ensino de Química. Eletroquímica. Metodologias Ativas. Aprendizagem Baseada em Problemas. Sala de Aula Invertida.

RESUMEN

Los accidentes de tránsito se encuentran entre las principales causas de muerte por causas externas y constituyen un problema prioritario de salud pública. Tradicionalmente clasificados como eventos no intencionales, estas muertes suelen atribuirse a errores humanos, condiciones ambientales o deficiencias en la infraestructura vial. Sin embargo, la evidencia científica indica que una parte de estas muertes puede involucrar indicios de intencionalidad autolesiva, los cuales permanecen ampliamente subregistrados y suelen clasificarse como accidentes de causa indeterminada. Ante esta laguna, el presente estudio tiene como objetivo presentar la autopsia psicosocial de tránsito como una estrategia metodológica innovadora para la evaluación de la intencionalidad en accidentes viales con resultado fatal. Se trata de un estudio de desarrollo metodológico, de naturaleza cualitativa y aplicada, que sistematiza un proceso integrado de investigación retrospectiva de muertes en el tránsito. La metodología adapta los supuestos de la autopsia psicológica y psicosocial clásica, incorporando de manera ampliada datos técnico-periciales, psicosociales, epidemiológicos, ambientales e institucionales. El proceso se organiza en seis etapas secuenciales: identificación del caso, integración de fuentes de datos, investigación psicosocial retrospectiva, análisis técnico y contextual de la vía, sesión intersectorial de integración e inferencia, y elaboración de informe técnico con recomendaciones. Se concluye que la autopsia psicosocial de tránsito amplía la capacidad analítica de la investigación de muertes en accidentes de tránsito, contribuye a la mejora de la vigilancia epidemiológica y respalda políticas públicas intersectoriales orientadas a la prevención de muertes evitables.

Palabras clave: Autopsia Psicosocial. Seguridad Vial. Accidentes de Tránsito. Intencionalidad. Mortalidad por Causas Externas. Vigilancia Epidemiológica.

1 INTRODUCTION

The teaching of Chemistry in High School is elementary in the scientific training of students, corroborating the development of critical thinking, the understanding of natural phenomena and the relationship between science, technology and society. However, the literature points out that, historically, the teaching of this discipline has been marked by traditional practices centered on the transmission of content, which makes it difficult to build meaningful and contextualized learning, especially when it comes to abstract concepts and high conceptual complexity (LINHARES, 2024).

In this context, Electrochemistry stands out as one of the contents that most present obstacles to the teaching and learning process in High School. It should be noted that the difficulties are mainly related to the abstraction of the microscopic processes involved in oxidation-reduction reactions, the need for articulation between chemical, physical and mathematical concepts, as well as the recurrent use of calculations, which can generate demotivation and low engagement of students (INOCÊNCIO et al., 2019). In fact, the dissociation between theoretical content and everyday situations contributes to the perception that Electrochemistry is a topic far from the students' reality (ARAUJO, 2021).

Given this scenario, it becomes evident the need to rethink the pedagogical strategies adopted in the teaching of Science, in order to favor the active participation of students in the learning process (LINHARES, 2024). Active methodologies emerge as alternatives capable of promoting greater student involvement, intellectual autonomy and significant construction of knowledge, by moving the student to the center of the educational process and redefining the role of the teacher as a mediator of learning (VIANA et al., 2020).

Among the active methodologies discussed in the literature, Problem-Based Learning (PBL) stands out for proposing contextualized problem-situations that stimulate investigation, reasoning and decision-making by students, favoring conceptual understanding and the development of cognitive and collaborative skills (INOCÊNCIO et al., 2019). In a complementary way, the flipped classroom proposes the reorganization of learning time and spaces, allowing the initial contact with the contents to occur outside the classroom, through previously available materials, while the face-to-face time is intended for discussion, problem solving and conceptual deepening (NACHTIGALL; ABRAHÃO, 2021).

In this context, the articulation between Problem-Based Learning and the flipped classroom presents itself as a promising pedagogical possibility for the teaching of

Electrochemistry in High School, since both approaches value the active participation of the student, the contextualization of the contents and the progressive construction of knowledge. Thus, the following research problem arises: how to make the teaching of Electrochemistry in High School more meaningful from the proposition of a didactic sequence based on Problem-Based Learning and the flipped classroom?

In view of this problem, this work has as its general objective to investigate the contributions of Problem-Based Learning and the flipped classroom to the teaching of Electrochemistry in High School. The specific objectives are: to discuss the main difficulties related to the teaching and learning of Electrochemistry in High School, to analyze the potentialities of Problem-Based Learning and the flipped classroom as pedagogical strategies for the teaching of Chemistry and to propose, based on the literature analyzed, a didactic sequence for the teaching of Electrochemistry in High School based on Problem-Based Learning and the flipped classroom.

2 PROBLEM-BASED LEARNING AND FLIPPED CLASSROOM IN ELECTROCHEMISTRY EDUCATION

2.1 TEACHING OF ELECTROCHEMISTRY IN THE SCHOOL CONTEXT

The teaching of Chemistry in High School plays a central role in the scientific training of students, as it contributes to the understanding of natural phenomena, technological processes and transformations that occur in everyday life, favoring the construction of a critical view of science and its relationship with society. By enabling the interpretation of physical and chemical phenomena present in real situations, the discipline helps in the development of scientific thinking, argumentation, and reasoned decision-making, essential aspects for the integral formation of the student in basic education (LINHARES, 2024).

Despite this relevance, the teaching of Chemistry still faces significant challenges when predominantly based on traditional methodologies. The centrality of oral exposition, the emphasis on memorizing concepts and formulas, and the dissociation between theory and context contribute to a teaching-learning process that is not very significant, in which the student assumes a passive posture. This scenario tends to hinder conceptual understanding and generate disinterest in the discipline, especially in content that requires a higher level of abstraction and articulation of knowledge, such as those covered in High School (SAMPAIO, 2022).

In view of these limitations, it is necessary to adopt pedagogical strategies that favor meaningful learning, promoting greater involvement of students in the educational process. Methodologies that value active participation, problematization and contextualization of content enable students to establish relationships between scientific knowledge and their reality, favoring the construction of meanings and intellectual autonomy. In the meantime, the literature points out that innovative pedagogical approaches in the teaching of Chemistry can contribute to overcoming the challenges of the traditional model, by stimulating student protagonism and critical reflection on the contents worked on in the classroom (LINHARES, 2024).

The content of Electrochemistry occupies a relevant position in the High School Chemistry curriculum because it articulates fundamental concepts related to chemical transformations, electron transfer and the conversion between chemical and electrical energy. Such knowledge is essential for the understanding of various technological and natural processes, such as the operation of batteries, the corrosion of metals and industrial applications, which reinforces its formative and contextualizing potential when properly worked in the school environment (INOCÊNCIO et al., 2019).

However, the way Electrochemistry is traditionally approached in the classroom does not always favor conceptual understanding by students. The fragmented presentation of content and the excessive emphasis on algorithmic procedures tend to hinder the construction of meanings, making this topic one of the most complex within the discipline of Chemistry in High School (ARAUJO, 2021).

In high school, the study of Electrochemistry generally begins with the concepts of oxidation and reduction, which describe the loss and gain of electrons during chemical reactions. Understanding these processes is fundamental for understanding oxidation-reduction reactions, but it requires the student to move between different levels of representation, such as the symbolic, the microscopic, and the macroscopic, which can generate difficulties when there is no adequate pedagogical mediation (RODRIGUES, 2023).

Electrochemical batteries constitute another central axis of this content, being used as an example of the conversion of chemical energy into electrical energy. In the school context, the study of batteries involves the identification of electrodes, electron flow, and the function of the salt bridge, in addition to the interpretation of the semi-reactions involved. Despite their potential for contextualization, these concepts are often presented in an

excessively theoretical way, which compromises students' understanding of the global functioning of the electrochemical system (INOCÊNCIO et al., 2019).

Electrolysis, in turn, introduces the idea of non-spontaneous processes, in which electrical energy is used to promote chemical reactions. This content demands from the student the ability to differentiate spontaneous and non-spontaneous electrochemical processes, in addition to understanding the inversion of the direction of reactions in relation to batteries. The literature points out that the lack of articulation between these concepts contributes to recurrent conceptual confusion in the teaching of this topic (ARAUJO, 2021; LINHARES, 2024).

Another relevant concept addressed in high school is the electrochemical potential, used to predict the spontaneity of reactions and compare the tendency of oxidation or reduction of chemical species. The interpretation of the standard potential tables and their application in problem solving require mathematical and conceptual skills that are not always consolidated in students, which reinforces the complexity of this content in the school context (INOCÊNCIO et al., 2019).

Several studies point out that one of the main difficulties in teaching and learning Electrochemistry is related to the abstraction of the concepts involved. Electrochemical processes occur at the microscopic level, requiring the student to be able to imagine phenomena that are not directly observable, such as the movement of electrons and ions, which can compromise understanding when teaching does not favor the construction of adequate mental models (RODRIGUES, 2023).

In addition to conceptual abstraction, the mathematical difficulties associated with electrochemical potential calculations and the interpretation of chemical equations also pose a significant obstacle. The need to integrate knowledge of Chemistry, Physics, and Mathematics makes the content challenging, especially when the student does not have previous mastery of these areas, which can result in low performance and demotivation in relation to the topic (LINHARES, 2024).

When concepts are presented in a decontextualized way, without explicit relationship with real situations or practical applications, students tend to perceive the content as abstract and not very relevant. The distance corroborates the loss of interest and hinders the construction of meaningful learning, reinforcing the need for pedagogical approaches that promote greater contextualization and student engagement (SAMPAIO, 2022).

2.2 FLIPPED CLASSROOM IN SCIENCE TEACHING

Active methodologies have gained prominence in the teaching of Chemistry because they propose a reorganization of the teaching-learning process, shifting the focus from the transmission of content to the effective participation of the student in the construction of knowledge. In the context of basic education, these approaches seek to overcome limitations of traditional teaching, promoting greater student involvement, intellectual autonomy, and the development of cognitive and socio-emotional skills, aspects widely discussed in recent academic production on the teaching of Science (LINHARES, 2024).

By considering the challenges inherent to the learning of abstract and complex contents, such as those addressed in Chemistry, the adoption of active methodologies presents itself as a strategy capable of favoring conceptual understanding and contextualization of knowledge. It is emphasized that these methodologies contribute to making the educational process more dynamic and meaningful, especially when articulated with problem situations and contexts close to the students' reality (VIANA et al., 2020).

Active methodologies can be understood as pedagogical approaches that place the student at the center of the learning process, attributing to him an active role in the construction of knowledge. Unlike traditional models, these methodologies value problematization, investigation, and reflection, encouraging the student to mobilize previous knowledge, formulate hypotheses, and seek solutions to proposed situations, as discussed in the literature on the teaching of Chemistry (LINHARES, 2024).

In this context, the role of the teacher is redefined, moving from a transmitter of content to a mediator and facilitator of learning. It is up to the teacher to organize the pedagogical environment, propose cognitive challenges and guide the students' research process, while they assume a more autonomous and responsible posture for their learning. This change in roles favors the construction of a collaborative environment, in which dialogue and the exchange of experiences become central elements of the educational process (SAMPAIO, 2022).

The relationship between active methodologies and meaningful learning is widely highlighted in the literature, since these approaches allow students to establish connections between new knowledge and their previous experiences. By promoting the contextualization of content and the active participation of students, active methodologies favor the attribution of meaning to scientific knowledge, contributing to a more lasting and integrated learning, especially in the teaching of Chemistry (LINHARES, 2024).

Problem-Based Learning (PBL) originates from educational proposals that seek to articulate theory and practice through the presentation of contextualized problem situations, capable of instigating students' curiosity and reasoning. This methodology is based on the idea that knowledge is built more effectively when the student is challenged to investigate, discuss and propose solutions to problems that make sense in their learning context (VIANA et al., 2020).

Among the central characteristics of PBL, the use of problems as a starting point for the study, collaborative work in groups, and the valorization of the investigative process stand out. In this approach, students are encouraged to identify what they already know, what they need to learn, and what strategies can be used to solve the proposed problem, promoting the development of cognitive, communicative, and social skills (INOCÊNCIO et al., 2019).

In the teaching of Chemistry, the literature points out that PBL contributes to the contextualization of contents and to the understanding of complex concepts, by allowing students to relate scientific knowledge to real or simulated situations. Studies indicate that this methodology favors student engagement, motivation for learning, and the development of critical thinking, and is especially relevant for teaching challenging topics, such as Electrochemistry (ARAUJO, 2021).

The flipped classroom has been consolidated as a relevant pedagogical approach in the teaching of Science by proposing the reorganization of the teaching-learning process, breaking with the traditional logic of centralization of the exposure of contents in the classroom space. From this perspective, the student's initial contact with the contents occurs previously, through guided materials, while the face-to-face time is intended for conceptual deepening, problem solving and interaction between teacher and students, favoring a more active and reflective learning (NACHTIGALL; ABRAHÃO, 2021).

In the teaching of Chemistry, this methodology has significant potential by allowing complex concepts to be explored in a more dynamic and contextualized way. It is noted that the flipped classroom contributes to the expansion of opportunities for pedagogical interaction and to the more efficient use of time in the classroom, aspects considered fundamental for working with content that requires greater teacher mediation, such as those present in science teaching (RODRIGUES, 2023).

The flipped classroom can be understood as a methodology that reorganizes the pedagogical process by transferring the initial exposure of the contents to moments prior to

the face-to-face class. In this approach, students access previously available materials, such as texts, videos and other digital resources, allowing them to arrive at the classroom with an initial contact with the content to be worked on. Thus, it is possible for the face-to-face space to be used for activities that promote interaction, problematization and the collective construction of knowledge (NACHTIGALL; ABRAHÃO, 2021).

The organization of the pedagogical process in the flipped classroom requires careful planning on the part of the teacher, who must select and produce materials appropriate to the students' level of understanding, as well as structure face-to-face activities consistent with the learning objectives. Such reorganization favors a more active posture of the student, who starts to assume greater responsibility for his learning process, while expanding the possibilities of monitoring and mediation by the teacher (SAMPAIO, 2022).

The use of digital resources is a central element in the implementation of the flipped classroom, since it enables access to content outside the school environment. Video classes, virtual platforms, and multimodal materials are widely used as support for this methodology, contributing to the diversification of teaching strategies and to the flexibility of the learning pace. Nevertheless, the use of these resources can favor the understanding of the contents and expand access to information, as long as it is accompanied by adequate pedagogical guidance (RODRIGUES, 2023).

In the teaching of Chemistry, the flipped classroom presents relevant contributions by favoring the development of student autonomy. With access to content in advance, students are encouraged to organize their study time, identify doubts, and take a more active stance in the learning process, which contributes to the construction of more meaningful and lasting knowledge (SAMPAIO, 2022).

In addition to autonomy, the literature points out that this methodology promotes greater engagement and protagonism of students during face-to-face classes. By reserving this moment for discussions, problem-solving, and collaborative activities, the flipped classroom favors active participation and dialogue, creating an environment conducive to the collective construction of knowledge and conceptual deepening in Chemistry (SCHUINA, 2024).

Despite the contributions pointed out, some studies also highlight limitations associated with the implementation of the flipped classroom. Among them, the dependence on access to technological resources, the differences in student engagement in extra-class

moments, and the need for greater teacher preparation for the planning and mediation of activities stand out (SAMPAIO, 2022). The limitations in question indicate that the effectiveness of the methodology is directly related to the institutional conditions and the pedagogical follow-up offered to students (NACHTIGALL; ABRAHÃO, 2021).

2.3 PBL AND FLIPPED CLASSROOM IN ELECTROCHEMISTRY TEACHING

The analysis of the literature shows that Problem-Based Learning and the flipped classroom present conceptual and methodological convergences relevant to the teaching of Electrochemistry in High School. Both approaches break with the traditional model centered on the exposure of contents, by prioritizing the active participation of the student, the problematization and the construction of knowledge based on contextualized situations (LINHARES, 2024). Such convergence favors the reorganization of the pedagogical process, allowing the student to assume a central role in learning, while the teacher acts as a mediator and advisor of the proposed activities (VIANA et al., 2020).

From a theoretical point of view, the literature points out that the integration between PBL and the flipped classroom enhances the learning of complex contents, such as those of Electrochemistry, by articulating investigation, previous study and conceptual deepening. PBL contributes by presenting contextualized problems that instigate scientific reasoning, while the flipped classroom reorganizes pedagogical time, allowing the face-to-face space to be used for discussions, clarification of doubts and consolidation of concepts. This articulation favors meaningful learning, by allowing students to relate electrochemical content to real situations and build more consistent conceptual models (ARAUJO, 2021; RODRIGUES, 2023).

Despite the contributions evidenced, the literature also points out gaps related to the integrated approach of these methodologies in the teaching of Electrochemistry. It is observed that many studies analyze PBL and the flipped classroom in isolation or applied to other Science contents, with a smaller number of productions that discuss, in a systematized way, the combination of these strategies specifically for the teaching of Electrochemistry in High School. In addition, limitations are identified regarding the detailed description of the pedagogical proposals and the reflection on the challenges faced in the implementation of these methodologies in different school contexts (LINHARES, 2024; SCHUINA, 2024).

In the meantime, the literature indicates future pedagogical possibilities that involve the elaboration of didactic sequences that integrate, in a planned way, Problem-Based Learning and the flipped classroom for the teaching of Electrochemistry. These proposals can contribute to overcoming conceptual difficulties, promoting greater student engagement and favoring the contextualization of contents, as long as they consider institutional conditions, access to technological resources and the pedagogical training of teachers. Thus, the articulation between these methodologies presents itself as a promising field for the development of innovative pedagogical practices and for the expansion of theoretical discussions in the teaching of Chemistry (ROSA, 2025).

2.4 DIDACTIC SEQUENCE PROPOSED FOR THE TEACHING OF ELECTROCHEMISTRY

The proposition of a didactic sequence based on Problem-Based Learning and the flipped classroom emerges as a pedagogical strategy coherent with contemporary discussions on the teaching of Chemistry, especially with regard to overcoming the difficulties associated with learning Electrochemistry. It is noteworthy that the sequence presented in this research has an exclusively theoretical character, being elaborated from the analysis of the literature, without practical application in a school context, with the objective of contributing to teacher planning and pedagogical reflection in High School.

The didactic sequence can be defined as an organized and progressive set of teaching activities, planned with the aim of favoring the gradual construction of knowledge by students. This organization presupposes the articulation between learning objectives, contents, pedagogical strategies and forms of monitoring the educational process, allowing teaching to occur in a systematic and coherent way (ROSA, 2025).

The progressive organization of teaching is one of the central elements of the didactic sequence, since it enables the resumption of previous knowledge, conceptual deepening and consolidation of contents throughout the proposed stages. In the teaching of Electrochemistry, this progression is especially relevant, considering the complexity and level of abstraction of the concepts involved, which require careful and articulated planning (ARAUJO, 2021).

From the point of view of teacher planning, the didactic sequence corroborates the organization of pedagogical work by guiding the selection of contents, methodologies and didactic resources in an integrated way. The literature points out that the elaboration of

theoretically based didactic sequences favors pedagogical intentionality and expands the possibilities of teacher mediation, especially when associated with active methodologies in the teaching of Chemistry (SCHUINA, 2024).

The proposed didactic sequence is based on the articulation between Problem-Based Learning and the flipped classroom, integrating principles common to these methodologies, such as the centrality of the student, the problematization of the contents and the valorization of the investigative process. This articulation seeks to enhance the learning of Electrochemistry by promoting study situations that stimulate scientific reasoning and the active construction of knowledge (INOCÊNCIO et al., 2019).

The alignment with the learning objectives is another guiding principle of the proposal, ensuring that the suggested activities are in line with the Electrochemistry contents planned for High School. The clear definition of these objectives allows us to guide the progression of the stages of the didactic sequence, favoring conceptual understanding and integration between the different topics addressed, as indicated by the literature on pedagogical planning in science teaching (LINHARES, 2024).

Regarding the roles of the subjects involved, the proposal attributes to the student an active and investigative posture, stimulating autonomy, reflection and collaborative work. The teacher has the role of mediator of the learning process, responsible for guiding activities, proposing cognitive challenges and promoting the articulation between previous knowledge and new concepts. This redefinition of roles is in line with the principles of active methodologies discussed in the literature on the teaching of Chemistry (SAMPAIO, 2022).

Coherence with the curricular guidelines also guides the elaboration of the proposed didactic sequence, ensuring that the contents and suggested strategies are aligned with the guidelines for High School. This concern reinforces the pedagogical character of the proposal, which seeks to contribute to teaching practice without detaching itself from the curricular and formative requirements of basic education (LINHARES, 2024).

The proposed didactic sequence has as its central theme Electrochemistry in High School, with emphasis on oxidation and reduction processes, the operation of electrochemical batteries, electrolysis and electrochemical potential. These contents are organized in an articulated way, considering their conceptual interdependence and the need for progression in teaching, as indicated by the specialized literature (INOCÊNCIO et al., 2019).

The guiding problem-situation is the initial element of the sequence, being elaborated in order to contextualize the electrochemical contents from situations close to the students' reality, such as the use of batteries and corrosion processes. This initial problematization has a theoretical character and seeks to stimulate the raising of hypotheses and conceptual investigation, in line with the principles of Problem-Based Learning discussed in the literature (VIANA et al., 2020).

The contents covered throughout the sequence include fundamental concepts of Electrochemistry, articulated from the proposed problem-situation. As suggested didactic resources, digital materials, guiding texts and video classes stand out, used mainly in moments of previous study, according to the assumptions of the flipped classroom. It should be noted that these resources are indicated in a theoretical way, without description of practical application (NACHTIGALL; ABRAHÃO, 2021).

As for the temporal organization, the didactic sequence is structured in stages, distributed throughout classes or pedagogical moments, respecting the conceptual progression of the contents. This temporal organization has a flexible and adaptable character, being presented as a theoretical proposal that can be adjusted by the teacher according to the school context and the needs of the students (SCHUINA, 2024).

The initial stage of the didactic sequence corresponds to the problematization and activation of the students' previous knowledge, based on the presentation of the guiding problem-situation. In this phase, it seeks to stimulate the initial reflection on electrochemical phenomena, promoting the raising of ideas, questions and hypotheses, according to the assumptions of Problem-Based Learning discussed in the literature (VIANA et al., 2020).

The investigative stage encompasses the guided study of the contents of Electrochemistry, based on previously available materials, in line with the logic of the flipped classroom. In this phase, students are encouraged to deepen their conceptual understanding, identify relationships between contents, and review their initial hypotheses, always under the theoretical mediation of the teacher (RODRIGUES, 2023).

In the systematization stage, the conceptual organization of the Electrochemistry contents occurs, seeking to integrate the knowledge built throughout the investigative process. The phase in question aims to consolidate concepts such as oxidation, reduction, batteries, electrolysis and electrochemical potential, promoting an integrated view of the content, as suggested in studies on didactic sequences in science teaching (ARAUJO, 2021).

Therefore, the synthesis and reflection stage proposes the consolidation of the acquired knowledge, encouraging students to reflect on the learning process and on the application of electrochemical concepts in different contexts. This final stage reinforces the formative character of the proposed didactic sequence, highlighting again that it is a theoretical construction based on the literature, with the potential to support future practical applications in the teaching of Chemistry (SCHUINA, 2024).

3 METHODOLOGY

This research is characterized as a qualitative and bibliographic study, focusing on the proposition of a didactic sequence based on active methodologies for the teaching of Electrochemistry in High School. The qualitative approach is justified by the intention to understand and analyze, in an interpretative way, the theoretical contributions presented in the literature about the teaching of Chemistry, active methodologies and, specifically, Problem-Based Learning and the flipped classroom, without the use of statistical procedures or quantification of data.

As for the type of research, it is a bibliographic review, carried out from the survey, selection and analysis of relevant academic productions on the subject. Works published in the period from 2019 to 2025 were considered, with the objective of ensuring the theoretical and methodological updating of the study. The searches were carried out in the SciELO and Google Scholar databases, as they are widely recognized as reliable sources of scientific production in the area of Science Education and Teaching. The keywords used in the searches were related to the teaching of Chemistry, Electrochemistry, active methodologies, Problem-Based Learning, flipped classroom and didactic sequence.

The nature of the study is classified as a pedagogical proposal, since, from the analysis of the selected literature, a theoretical didactic sequence is elaborated focused on the teaching of Electrochemistry in High School, without practical application in the classroom. This type of approach allows the articulation of theoretical and methodological foundations discussed by different authors, aiming to contribute to teacher planning and to the reflection on innovative pedagogical practices in the teaching of Chemistry.

The methodological procedures initially involved the exploratory reading of the selected works, followed by an analytical reading, focusing on the identification of concepts, pedagogical strategies and results discussed by the authors. Subsequently, the information was systematized, seeking to establish relationships between the studies analyzed and the

research objectives. This process enabled the construction of a consistent theoretical basis for the proposition of the didactic sequence, aligned with contemporary discussions on active methodologies in the teaching of Science.

The criteria used for the elaboration of the didactic sequence included the coherence with the contents of Electrochemistry planned for High School, the articulation between theory and context, the centrality of the student in the learning process and the integration between Problem-Based Learning and the flipped classroom. In fact, the progressive organization of the teaching stages was considered, in order to favor the understanding of electrochemical concepts and the development of scientific reasoning, as pointed out in studies that discuss the elaboration of didactic sequences within the scope of active methodologies.

The choice of active methodologies as the structuring axis of the didactic proposal is based on the literature that shows its potential to promote greater engagement, autonomy and participation of students in the learning process. Problem-Based Learning benefits the contextualization of content and the development of investigative skills, while the flipped classroom favors the reorganization of pedagogical time and conceptual deepening during face-to-face moments, aspects widely discussed in recent research in the teaching of Chemistry and Science.

4 FINAL CONSIDERATIONS

From the analysis of the literature, it was understood the recurrent challenges associated with the learning of this content and to reflect on pedagogical alternatives that favor a more meaningful and contextualized approach in the teaching of Chemistry.

The proposed didactic sequence, of a theoretical nature, presents itself as a relevant instrument for teacher planning, by progressively organizing the contents of Electrochemistry and articulating pedagogical strategies that value the active participation of the student. Its structure highlights the importance of intentional planning, capable of integrating learning objectives, contents and methodologies, contributing to the overcoming of fragmented and excessively transmissive practices in the teaching of this theme.

Regarding the contributions to the teaching of Electrochemistry, the potential of the proposal to favor the understanding of abstract concepts is highlighted, by promoting the problematization, investigation and systematization of knowledge. The articulation between problem-situations and moments of guided study enables a more integrated approach to

the contents, bringing scientific knowledge closer to the students' reality and expanding the possibilities of constructing meanings in the learning process.

Active methodologies, especially Problem-Based Learning and the flipped classroom, demonstrate significant potential for the scientific training of students, by stimulating autonomy, critical thinking and student protagonism. By repositioning the student as an active agent of learning and the teacher as a mediator of the educational process, these approaches contribute to the development of cognitive and socio-emotional skills that are fundamental for comprehensive education in high school.

Among the limitations of the work, the lack of practical application of the proposed didactic sequence stands out, which prevents the empirical analysis of its impacts on the teaching-learning process. In addition, the study is based exclusively on a literature review, which restricts the conclusions to the theoretical discussions presented in the literature analyzed.

In view of this, it is suggested that future research can apply and empirically evaluate the proposed didactic sequence in real school contexts, investigating its effects on student learning and teaching practice. It is also recommended to carry out studies that explore the integration of active methodologies in other Chemistry contents, expanding reflections on innovative pedagogical practices in basic education.

It is concluded that the proposition of a didactic sequence based on Problem-Based Learning and the flipped classroom constitutes a relevant contribution to the teaching of Electrochemistry in High School, by offering theoretical and methodological subsidies for teacher planning and for reflection on more significant pedagogical practices, aligned with the contemporary demands of Science education.

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**IMPACT OF THE PUBLIC-PRIVATE PARTNERSHIP FOR PHOTOVOLTAIC
SOLAR MINI-POWER PLANTS IN THE STATE OF PIAUÍ ON THE
DEPARTMENT OF EDUCATION**

**IMPACTO DA PPP DAS MINIUSINAS DE ENERGIA SOLAR FOTOVOLTAICA
DO ESTADO DO PIAUÍ NA SEDUC**

**IMPACTO DE LA ASOCIACIÓN PÚBLICO-PRIVADA PARA MINICENTRALES
SOLARES FOTOVOLTAICAS EN EL ESTADO DE PIAUÍ EN EL
DEPARTAMENTO DE EDUCACIÓN**

 <https://doi.org/10.56238/sevened2025.036-142>

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ABSTRACT

The growth in global energy demand, coupled with the environmental impacts caused by non-renewable sources, requires the adoption of public policies aimed at transitioning to renewable sources. In this context, photovoltaic solar energy has stood out as a strategic alternative, especially in regions with high solar incidence, such as the state of Piauí. This study aimed to quantify the economic impact of implementing mini photovoltaic solar power plants within the scope of public-private partnerships (PPPs) in the State of Piauí's Department of Education (SEDUC). The results demonstrated savings in electricity costs (R\$ 1,482,184.04 from March 2024 to February 2025). However, important challenges were identified: inadequate initial planning for the allocation of generation credits and delays in the project schedule. It is concluded that the adopted PPP model presents technical and economic viability, but needs adjustments to maximize its social and environmental impacts.

Keywords: Renewable Energy. Sustainability. Energy Demand. Socioeconomic Development. Economic Impact.

RESUMO

O crescimento da demanda energética global, aliado aos impactos ambientais causados pelas fontes não renováveis, exige a adoção de políticas públicas voltadas à transição para fontes renováveis. Nesse contexto, a energia solar fotovoltaica tem se destacado como uma alternativa estratégica, especialmente em regiões com alta incidência solar, como o Estado do Piauí. Esse estudo teve como objetivo quantificar o impacto econômico da implementação das miniusinas de energia solar fotovoltaica no âmbito das parcerias público-privadas (PPP) do Estado do Piauí na Secretaria de Educação (SEDUC). Os resultados demonstraram economia nos gastos com energia elétrica (R\$ 1.482.184,04 no

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período de março de 2024 à fevereiro de 2025). No entanto, foram identificados desafios importantes: planejamento inicial inadequado da alocação dos créditos de geração e atrasos no cronograma do projeto. Conclui-se que o modelo de PPP adotado apresenta viabilidade técnica e econômica, mas precisa de ajustes para maximizar seus impactos sociais e ambientais.

Palavras-chave: Energia Renovável. Sustentabilidade. Demanda Energética. Desenvolvimento Socioeconômico. Impacto Econômico.

RESUMEN

El crecimiento de la demanda mundial de energía, sumado a los impactos ambientales causados por las fuentes no renovables, exige la adopción de políticas públicas orientadas a la transición hacia fuentes renovables. En este contexto, la energía solar fotovoltaica se ha consolidado como una alternativa estratégica, especialmente en regiones con alta incidencia solar, como el estado de Piauí. Este estudio tuvo como objetivo cuantificar el impacto económico de la implementación de minicentrales solares fotovoltaicas en el marco de asociaciones público-privadas (APP) en la Secretaría de Educación del Estado de Piauí (SEDUC). Los resultados demostraron un ahorro en costos de electricidad (R\$ 1.482.184,04 entre marzo de 2024 y febrero de 2025). Sin embargo, se identificaron importantes desafíos: una planificación inicial inadecuada para la asignación de créditos de generación y retrasos en el cronograma del proyecto. Se concluye que el modelo de APP adoptado presenta viabilidad técnica y económica, pero requiere ajustes para maximizar sus impactos sociales y ambientales.

Palabras clave: Energía Renovable. Sostenibilidad. Demanda de Energía. Desarrollo Socioeconómico. Impacto Económico.

1 INTRODUCTION

The world's energy demand is largely met with the use of energy resources of fossil origin, such as oil, coal, and natural gas, which contribute significantly to the emission of greenhouse gases (GHG). The intensive and uncontrolled use of fossil sources (non-renewable) has caused environmental and social impacts of great proportions. Among these impacts, the intensification of global warming, the degradation of air, water and soil quality and health problems in the population stand out. The combustion of fossil fuels is responsible for the massive emission of GHGs, especially carbon dioxide (CO₂), resulting in global climate change. These environmental impacts are of great concern as they compromise the sustainability and well-being of current and future populations (Kibaara and Karweru, 2022).

In view of this alarming context, it is necessary to promote an energy transition, which consists of the gradual replacement of non-renewable sources with renewable energy sources, sustainable and with low environmental impact (Rana et al., 2020).

In this sense, the movement for energy transition is highlighted in multilateral agreements, such as the Paris Agreement, approved in 2015 by 195 countries and the European Union, within the scope of the 21st Conference of the Parties (COP 21). This treaty set ambitious targets for the reduction of global GHG emissions, with the aim of limiting the increase in the Earth's average temperature to less than 2 °C compared to pre-industrial levels (Meinshausen et al., 2022).

In parallel, also in 2015, the United Nations (UN) instituted the Sustainable Development Goals (SDGs), as part of the 2030 Agenda. This global agenda aims to guide actions by governments, companies, and civil society towards sustainable development by the year 2030 (UN, 2025).

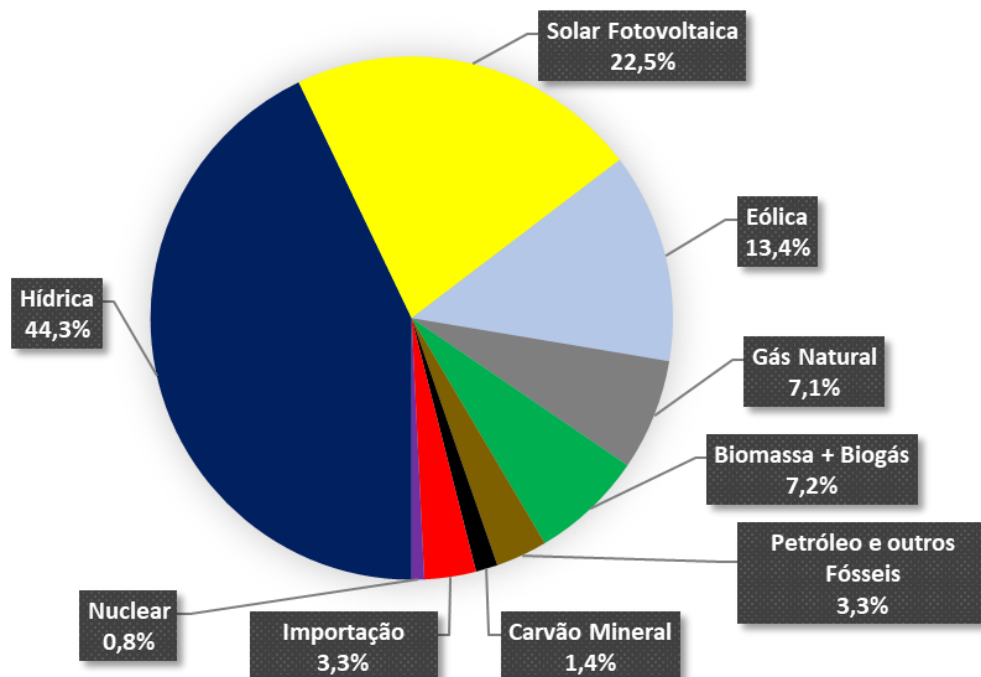
In line with this perspective, several scholars point out that the current energy model, based predominantly on non-renewable sources, has become incompatible with the sustainable development goals established by the 2030 Agenda, especially with regard to SDG 7, which seeks to ensure reliable, sustainable, modern, and affordable access to energy for all (Saccardo et al., 2023).

In Brazil, the growing consumption and socio-environmental impact caused by traditional energy sources (hydroelectric plants, which flood a large area to store water, and thermoelectric plants that produce GHGs by burning fossil fuels) have led the government and society to think of new alternatives for generating electricity (Sousa et al., 2023). The

Brazilian electricity matrix (Figure 1) is mostly dependent on hydroelectric generation, which corresponds to 44.3% of the total (EPE, 2025). However, due to the irregular rainfall regime, the country faces recurrent water crises, which are also reflected in energy crises.

Figure 1

Brazilian Electricity Matrix



Source: Prepared by the author with data from (EPE, 2025).

The search for sustainable and low-GHG energy alternatives is necessary to promote sustainable development (Mele et al., 2021; Dai et al., 2024). Corroborating this perspective, Lira et al. (2019) highlight that photovoltaic solar energy also has additional advantages, such as the absence of direct GHG emissions in the generation process, the reduction of electrical losses, given the proximity of generation to consumer centers, and the reduction of dependence on thermal plants.

In view of the intensification of the problems resulting from the climate crisis, there is an expansion of debates and initiatives aimed at the development and adoption of new energy matrices, among which solar energy stands out (Hecksher, 2024). In Brazil, there is a significant expansion of energy generation through photovoltaic solar sources. This advance was driven by the publication of Normative Resolution No. 482, of April 17, 2012, of the National Electric Energy Agency (ANEEL), which established rules for the insertion of distributed generation in the country and by the favorable scenario of solar irradiation,

especially in the northeast region, with emphasis on the State of Piauí (Rocha & Barra Neto, 2024; Pereira et al., 2017).

The State of Piauí has high potential for generating electricity from photovoltaic solar sources, due to its geographical location in one of the regions with the highest levels of solar radiation in Brazil (Morais et al., 2025). The sectors that most use the photovoltaic solar source for electricity generation are the residential and commercial sectors. On the other hand, the public sector is the one with the lowest percentage of energy generation through solar energy, evidencing the need for more investments aimed at expanding the use of renewable sources (EPE, 2025).

In this context, public-private partnerships (PPPs) emerge as a strategic model of cooperation between the public sector and the private sector, in which both assume responsibilities, risks, and investments in the implementation of projects of collective interest. PPPs have the ability to attract private investments to the sector, so the government is able to dilute the payment of the counterpart over time, without having to invest a high amount. This type of partnership enables the mobilization of private capital for the development of energy projects, while promoting the optimization of public resources. In the electricity sector, PPPs have the potential to accelerate the adoption of photovoltaic technology, contributing to the diversification of the energy matrix, the expansion of installed renewable generation capacity, and the reduction of government spending on the payment of electricity bills (Awuku et al., 2022).

Cooperation between the public and private sectors is essential for strengthening the capacity to generate photovoltaic solar energy. Such initiatives contribute not only to the expansion of installed capacity, through the implementation of photovoltaic systems of different sizes, but also to the promotion of sustainable growth, in line with global guidelines for energy transition and decarbonization of the electricity matrix. International organizations, such as the World Bank, highlight that PPPs are effective instruments to accelerate technological development, reduce investment costs, and mitigate risks associated with the expansion of generation from renewable sources (World Bank, 2023).

Based on this model, the Government of the State of Piauí instituted, in 2018, the Piauí Clean Energy Development Program – PROPIDEL to prepare the project "Public-Private Partnership for the implementation, operation and maintenance of Solar Energy Mini-Plants".

The project was divided into 4 lots, in the form of an administrative concession for the construction, operation, maintenance and management of photovoltaic solar energy generation mini-plants, with management and operation of electricity credit compensation services, and the construction of two mini-plants per lot was planned (SUPARC, 2024).

Mini-plants help promote the energy transition and reduce dependence on non-renewable sources. This project is a pioneering example of PPP in this area. The main objective of the mini-plants is to meet the energy demand of the Government of the State of Piauí (SUPARC, 2024). The generation of electricity through photovoltaic solar sources increases the availability of power in the SIN, reduces electricity expenses and reduces the environmental impacts caused by non-renewable sources. This use directly contributes to the achievement of the Sustainable Development Goals (Soares et al., 2023).

To contribute to the energy transition process and to the strengthening of sustainable development, this work carries out a study of the impacts caused by the implementation of photovoltaic solar energy mini-plants built through PPPs to meet the energy demand of SEDUC in Piauí. The research seeks to answer the following scientific problem: how these mini-plants can contribute to the reduction of SEDUC's electricity costs, promote local socioeconomic development and what are the best guidelines to improve and expand the use of this technology in the context of PPPs.

Understanding these impacts is crucial to justify and optimize investments in renewable energy, aiming at sustainable development and more efficient energy management in the State. The main hypothesis raised was that the implementation of mini-plants can reduce electricity costs and the amount saved can be applied in actions that promote environmental conservation and local social development.

2 METHODOLOGY

The methodological steps include bibliographic review, survey and analysis of public data, development and application of interviews and questionnaires, as well as technical visits.

To obtain a solid theoretical basis on PPPs, renewable energies and mini solar photovoltaic plants, a literature review was carried out. The research was conducted in the academic databases: Brazilian Digital Library of Theses and Dissertations (BDTD), Capes Journal, Scopus, Web of Science and Google Scholar, using combined keywords (solar energy, PPP, socio-environmental impact, economic impact, mini-plants, renewable energy,

sustainability and infrastructure) with the connectors "AND" and "OR". The same keywords were used in English to broaden the search following the methodology used by Xue et al. (2021). After the initial filtering, a critical analysis was carried out on the scientific articles and technical reports found.

To obtain the data related to the mini-plants and the SEDUC of Piauí, which receives the generation credits, those responsible for them were contacted. The requests were made by different means of communication (e-mail, telephone contact, WhatsApp and request protocol directly in the SEDUC protocol sector). The electricity bills (covering the period of 12 months), the list of consumer units that receive the credits with the percentages allocated to each one and the monthly amount paid for the generation of the mini-plant were requested.

With the data from electricity bills, it is possible to compare energy costs, comparing the amounts that would be paid without generation with the amounts paid with the compensation of credits to calculate and evaluate the economic impact.

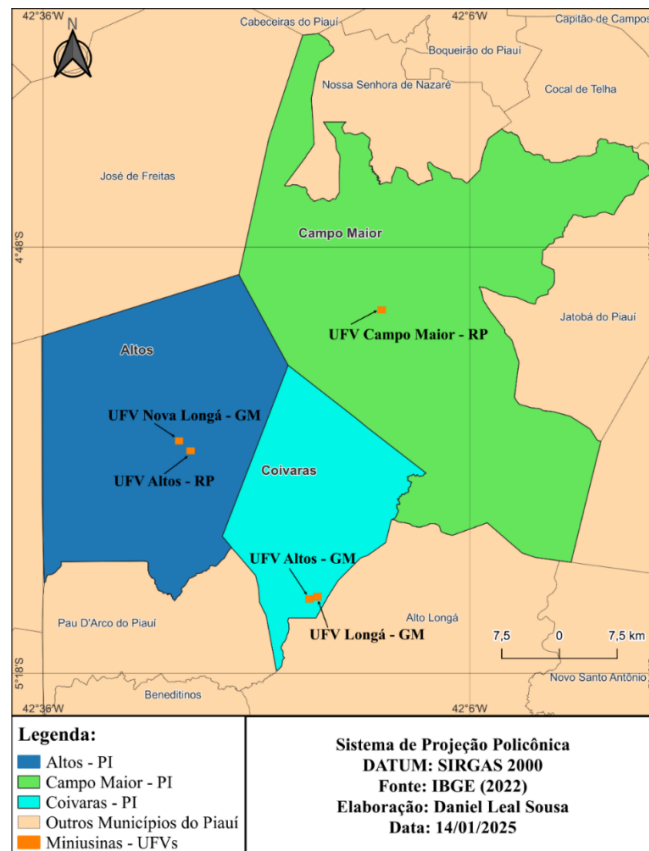
The combination of these methodological steps allowed a comprehensive and interdisciplinary analysis of the impacts of photovoltaic solar power plants in the scope of PPPs in the State of Piauí. The results obtained contribute to the development of guidelines aimed at improving the implementation of these projects, maximizing the benefits.

2.1 DELIMITATION AND CHARACTERIZATION OF THE STUDY AREA

The area delimited for the study comprises the locations where the mini photovoltaic solar energy plants are installed in the State of Piauí through PPPs of the State Government. These mini-plants represent an important milestone in the development of renewable energy generation in the region (SUPARC, 2024). A total of five photovoltaic solar generation mini-plants were built in three municipalities in the State of Piauí: Altos, Coivaras and Campo Maior (Figure 2).

Figure 2

Location map of the five mini-plants built

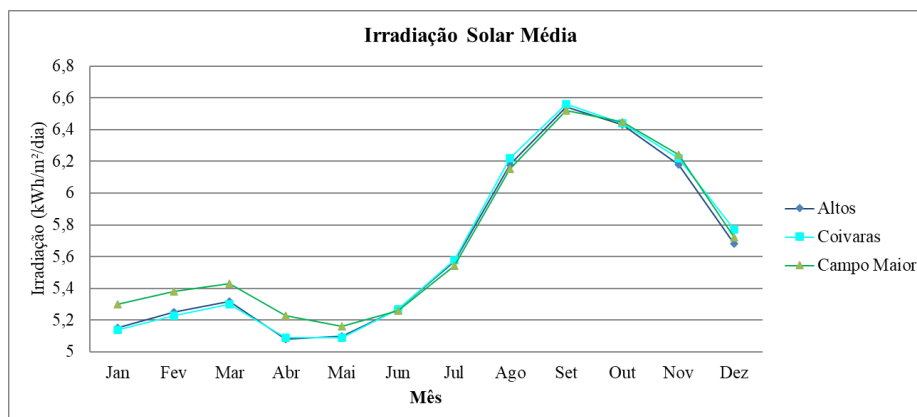


Source: Prepared by the Author

The choice of these three municipalities was justified by the high level of solar radiation in these locations, which are among the municipalities with the highest rates of solar irradiation in the State of Piauí (Pereira et al., 2017). Such a climatic condition significantly favors the performance of photovoltaic plants, maximizing their generation and reducing the payback time of investments. Figure 3 shows the graph with the average solar irradiation indices in the municipalities of Altos, Coivaras and Campo Maior in (kWh/m².day).

Figure 3

Average solar irradiation in the municipalities of Altos, Coivaras and Campo Maior in Piauí



Source: Prepared by the Author with data from EPE (2025)

3 RESULTS AND DISCUSSIONS

In this section, the main results and the respective discussions will be presented.

3.1 MINI-PLANTS CONTRACTED BY SEDUC

One of the mini-plants was installed in the municipality of Altos – PI (UFV Nova Longá), with the following coordinates of the installation site: latitude: -5.028271; longitude: -42.439764. UFV Nova Longá, has an installed capacity of 1,350 kW and was connected to Equatorial Piauí's distribution network in April 2023. The plant's infrastructure consists of 2,673 bifacial photovoltaic modules of the TSM-650DEG21C.20 model, with a unit power of 650 Wp, totaling a peak power of 1,737.45 kWp. To convert the energy generated, six TBEA – TS228KTL-HV inverters were installed, with a power of 225 kW each. It uses a support structure with a solar tracking system (*tracker*), which makes it possible to monitor the movement of the sun throughout the day, increasing efficiency in capturing solar radiation. The company responsible for the execution of the project and installation of the system was NETLUX Solar.

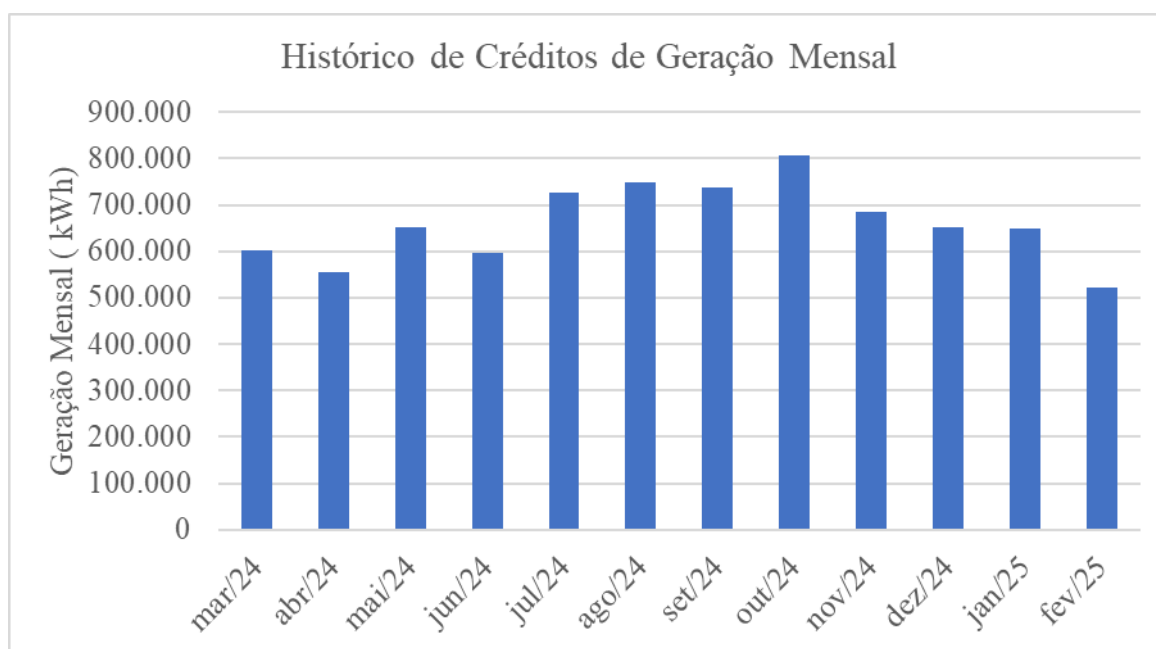
The other unit was installed in Coivaras - PI (UFV Longá), with the following coordinates of the installation site: latitude: -5.213587; longitude: -42.284163. The Longá UFV also has the same characteristics as the Nova Longá UFV with different amounts of modules and inverters. It has an installed power of 1,800 kW, consisting of 3,663 photovoltaic modules of 650 Wp, resulting in a total peak power of 2,380.95 kWp. The system has eight TBEA – TS228KTL-HV inverters, with a capacity of 225 kW per unit and

also uses *trackers*. The connection of the plant to the grid of the concessionaire Equatorial Piauí was carried out in May 2023, installed by NETLUX Solar.

The history of electricity generation of the two mini-plants in the period between March 2024 and February 2025 is outlined in Figure 4. It is observed that the months of July 2024 to November 2024 are the months in which we have the highest generation of electricity. This is due to the solar irradiation being higher in these months of the year, as we can see in the solar irradiation graph in Figure 3.

Figure 4

History of electricity generation in kWh of the mini-plants, UFV Nova Longá and UFV Longá, which serves SEDUC built from contract 04/2020



Source: Prepared by the author with data from . (SUPARC, 2024)

The contract signed between SEDUC and GM ENERGIA foresees that these two mini-plants should generate an average of 650,000 kWh per month. The contract also specifies a minimum monthly generation value that is 5% below the contracted average, that is, 617,500 kWh at least.

If the generation supplied does not reach the amount contacted, the company must pay a fine, in addition to the reduction of the amount paid in the month for the generation of the mini-plant. The amount contracted for the monthly purchase of the mini-mill's production was set at R\$ 387,000.00 (three hundred and eighty-seven thousand reais) in 2020, the year the contracts were signed, and this amount is readjusted by the IPCA each

year. In this way, the secretariat increases the predictability of electricity expenses. In 2025, this amount was corrected by the IPCA, as provided for in the contract and was set at R\$ 514,427.06 (five hundred and fourteen thousand, four hundred and twenty-seven reais and six cents).

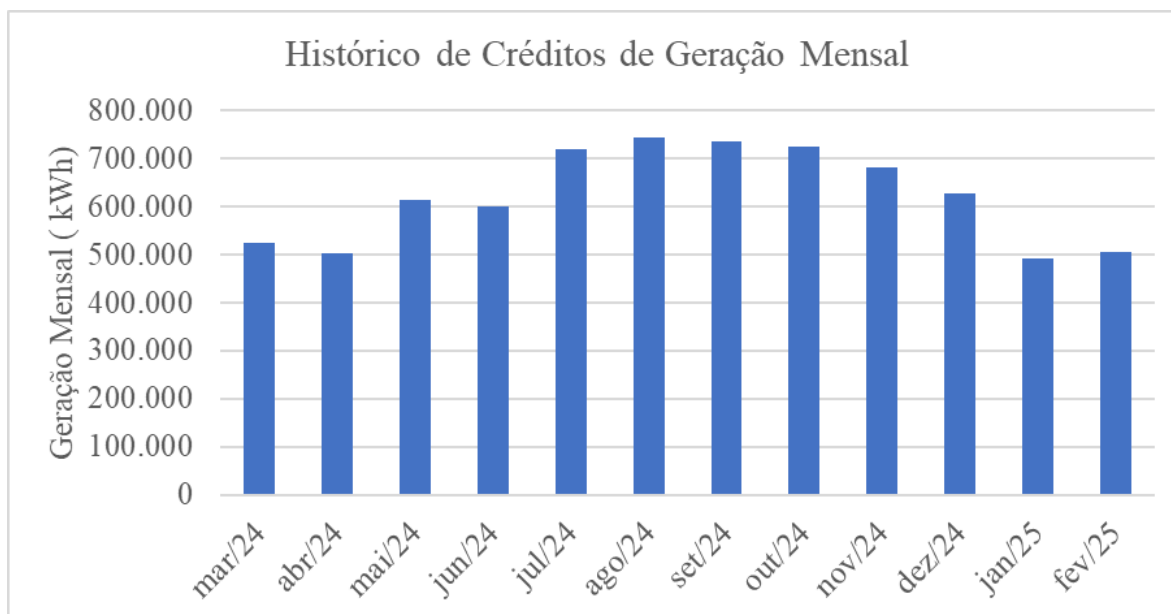
In the municipality of Altos – PI, we have another mini-plant installed (UFV Altos) built by RIO POTI ENERGIA, to meet the energy demand of SEFAZ. After the start of operation, it was found that the generation of electricity by the mini-plant was much higher than SEFAZ's electricity demand, for this reason this unit was ceded to SEDUC in March 2024.

This photovoltaic minigeneration installation has a nominal capacity of 2,895 kW, and is located in the municipality of Altos – PI. The coordinates of the mini-plant installation site are: latitude: -5.040073; Longitude: -42.427166. It has an installed power of 2,895 kW, and is composed of 7,068 bifacial photovoltaic modules of the RSM110-8-540BMDG model, manufactured by RISEN SOLAR, each with a power of 540 Wp, totaling a peak power of 3,816.72 kWp. It has 13 215 kW inverters and one 100 kW inverter, all from the manufacturer HUAWEI, models SUN2000-215KTL and SUN2000-100KTL, respectively and also has a *tracker*. The connection to the grid of the concessionaire Equatorial Piauí was completed in May 2023. The estimated energy production for this mini-plant is approximately 7,800,000 kWh per year or 650,000 kWh per month.

The history of electricity generation of this mini-plant in the period between March 2024 and February 2025 is outlined in Figure 5.

Figure 5

History of electricity generation in kWh of the mini-plants built from contract 08/2020



Source: Prepared by the author with data from . (SUPARC, 2024)

The contract signed between SEDUC and RIO POTI ENERGIA provides that this mini-plant should generate an average of 650,000 kWh per month and has the same specifications as the contract with GM Energia. In the year 2024, the amount paid per month by SEDUC for the monthly consideration of contract 08/2020 is R\$ 484,858.52 (four hundred and eighty-four thousand, eight hundred and fifty-eight reais and fifty-two cents). In 2025, this amount was corrected by the IPCA, as provided for in the contract and was set at R\$ 511,129.44 (five hundred and eleven thousand, one hundred and twenty-nine reais and forty-four cents).

Until 2023, SEDUC had 35 collective electricity invoices and currently these invoices have been regrouped into 3 collective invoices:

- ✓ Invoice for units served at low voltage, group B.
- ✓ Invoice for units served in medium voltage, group A.
- ✓ Invoice of the administrative center unit in Teresina – PI, group A.

The units of GROUP A pay cheaper for the kWh consumed during off-peak hours (from 8:30 pm to 5:29 pm), so it is not so feasible to offset the consumption of these units with the generation credits of the mini-plants.

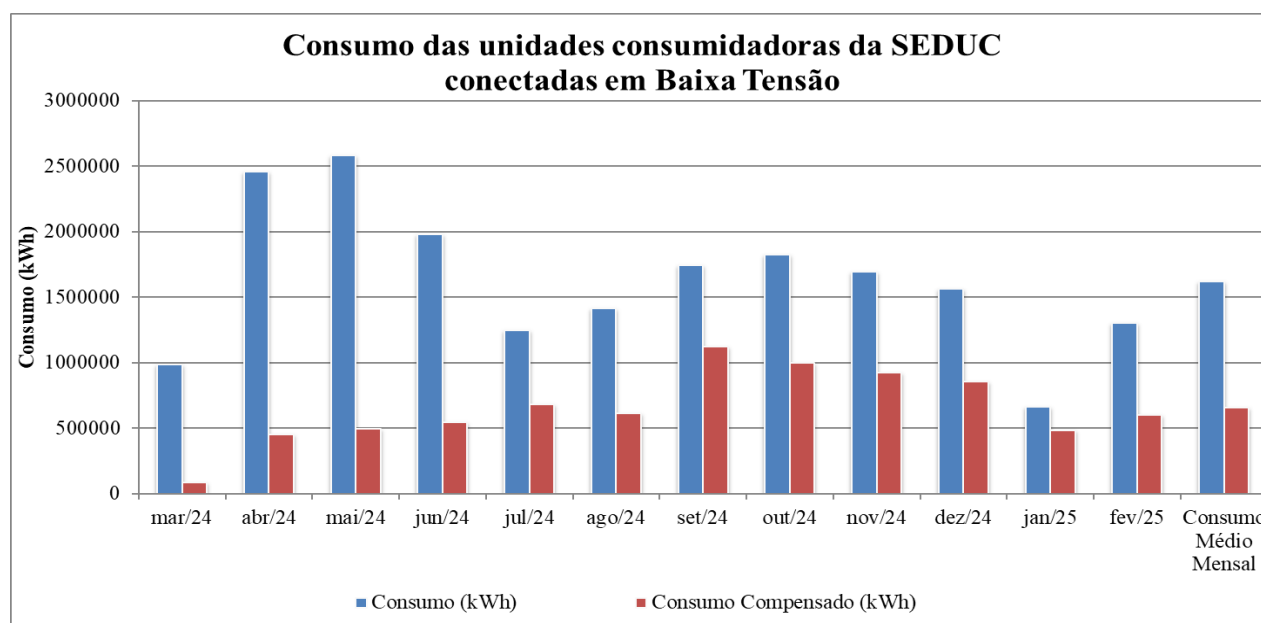
Analyzing the consumer units belonging to SEDUC, we obtain a total of 1,046 consumer units. Of this total, 124 are classified in group A and 922 are in group B. The

demand contracted by SEDUC at the headquarters in the administrative center is 700 kW and in the other 123 units of group A it is 9,944 kW.

The average monthly consumption of SEDUC units connected to low voltage (Group B) considering the period from March 2024 to February 2025 is 1,623,045 kWh per month. Regarding the average consumption compensated per month, there is a value of 656,268 kWh/month. This indicates that approximately 40.4% of the total consumption of these units was compensated. The history of energy consumption in kWh and compensated consumption can be seen in Figure 6.

Figure 6

Consumption history of SEDUC consumer units connected to Low Voltage



Source: Prepared by the author with data from SEDUC

The total electricity consumption recorded by SEDUC's low voltage units was approximately 19,476,542 kWh, resulting in an average monthly consumption of 1,623,045 kWh. This consumption value represents an expressive and continuous demand for electricity, compatible with the decentralized functioning structure of the state school network, which covers 922 consumer units distributed throughout the territory of Piauí.

The variability observed between the months reinforces the need for a dynamic strategy for the allocation of distributed generation credits, which takes into account the cycles of higher and lower demand. Even without the variation in allocation, the compensation is benefited because the excess credits in a month have up to 5 years to be

used. The maintenance of a monthly average of more than 1.6 GWh reinforces the potential for economic gains arising from an efficient energy compensation, especially considering the high tariffs applied to low-voltage consumer units.

In this context, the generation from photovoltaic mini-plants represents a strategic instrument to reduce electricity costs, and it is essential that credits are allocated preferentially to this group, which has high consumption and high higher cost per kilowatt-hour, compared to units connected to medium voltage. The prioritization of low-voltage units in SEDUC's energy compensation policy allows maximizing the financial benefits of the PPP, contributing to the fiscal sustainability of the public administration and to the fulfillment of the SDG targets, in particular SDG 7 and SDG 12.

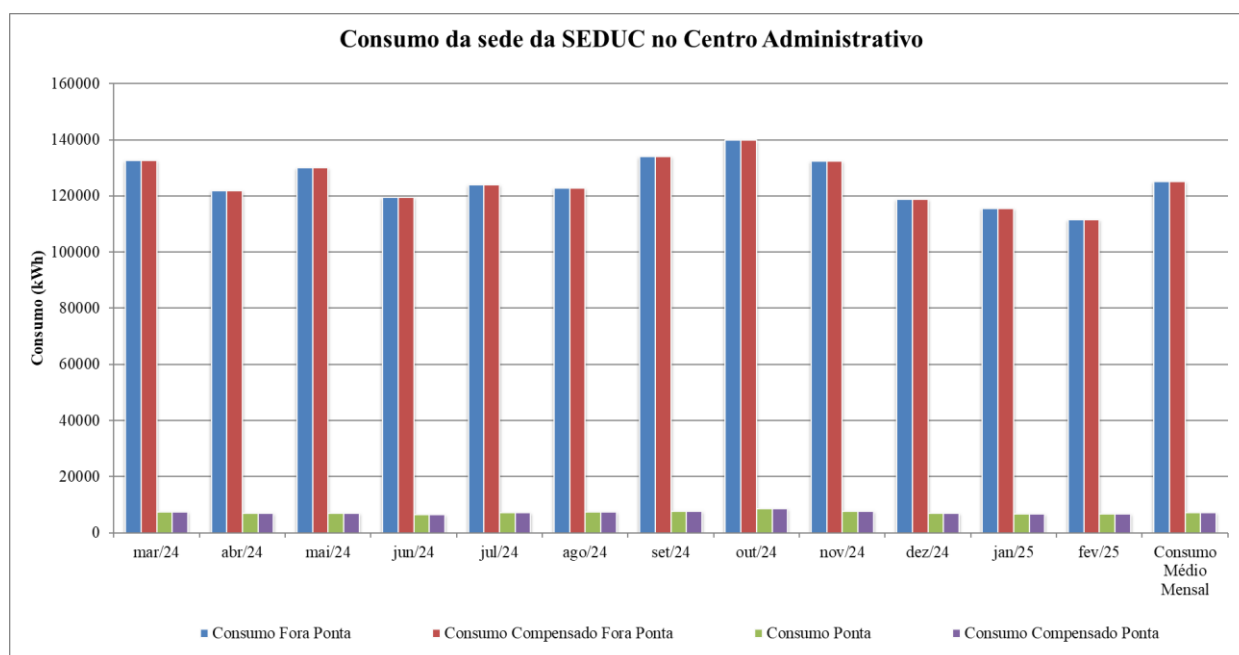
The consumption pattern verified in the low voltage units of SEDUC shows both the high demand and the opportunity to increase the economic efficiency of the distributed generation project, through energy planning that considers the seasonal specificities of the state school network and optimizes the allocation of available electricity credits.

The analysis of the energy consumption of the Headquarters Unit of the State Department of Education (SEDUC), located at the Administrative Center in Teresina – PI, from March 2024 to February 2025, reveals that the unit had a total consumption of 1.59 GWh, with a monthly average of 132,403 kWh. Most of this consumption occurred during off-peak hours, totaling 1.50 GWh, while 86,349 kWh were recorded during peak hours. It is observed that consumption was fully compensated with generation credits over the twelve months (Figure 7), resulting in a compensation percentage of 100%.

Although this result of offsetting all consumption may seem to be the ideal scenario, a critical evaluation is necessary from the perspective of economic optimization of credit allocation. The Headquarters Unit is connected to medium voltage, which implies lower energy tariffs than those applied to low-voltage consumer units. In practical terms, the cost avoided by offsetting thirst consumption is significantly lower than the cost avoided by offsetting the same volume of power in low-voltage units.

Figure 7

Consumption history of the SEDUC Headquarters in the Administrative Center



Source: Prepared by the author with data from SEDUC

Thus, the full allocation of generation credits to the Headquarters Unit, although technically effective, is not the best strategy from a financial point of view. The ideal model, in terms of maximizing the tax savings generated by the PPP, consists of prioritizing the compensation of low voltage units, whose energy is priced at higher values, thus ensuring a more significant financial return for each kWh compensated. The Headquarters Unit, in turn, must be compensated only when there is a surplus of generation credits after all units of the grid connect to low voltage.

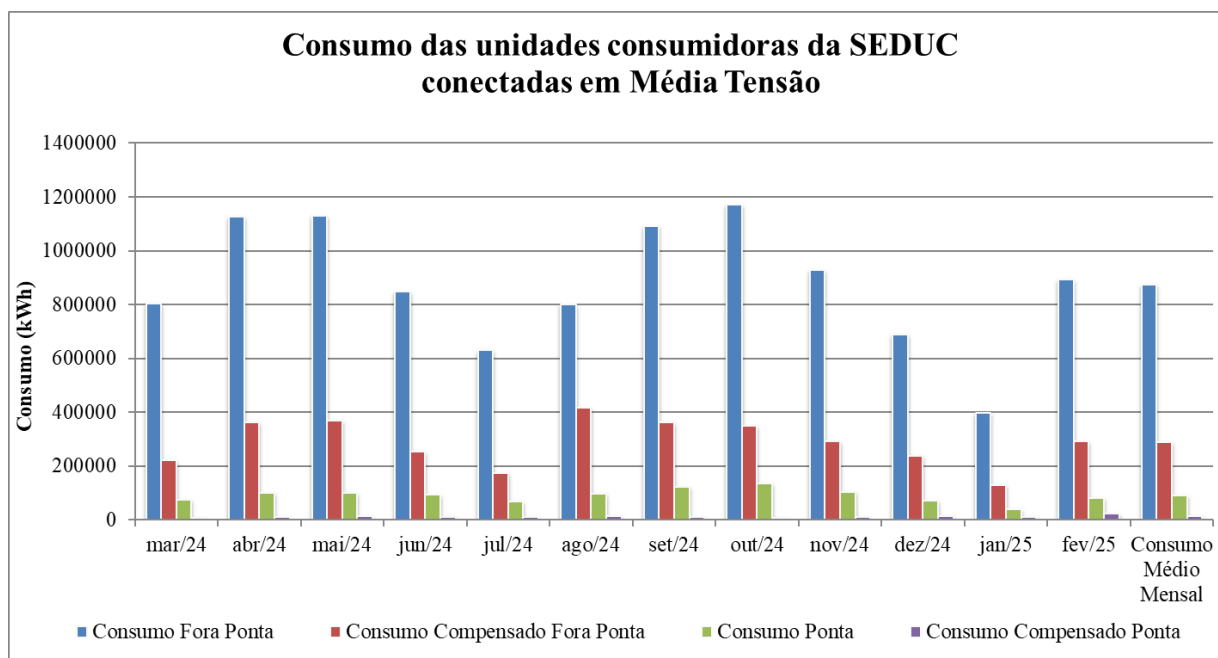
Adopting this strategy of hierarchical allocation of credits (with prioritization based on the cost of energy) would maximize the economic impact of the distributed generation project, enhancing the savings provided by the PPP and reinforcing the financial sustainability of the public policy.

It is observed, therefore, that the decision to fully compensate the consumption of the Headquarters Unit, although operationally viable, does not represent the best practice in terms of public energy policy, given the current tariff structure. The analysis recommends reviewing the strategy for allocating generation credits, based on economic and tariff criteria, in order to ensure the maximum effectiveness of the PPP in meeting the principles of economy, efficiency and sustainability, as recommended by the SDGs.

The evaluation of the energy consumption of the SEDUC units connected to medium voltage during the period analyzed, shows that the medium voltage units recorded a total consumption of 11,599,502 kWh, with a monthly average of 966,625 kWh. Of this total, 3,617,887 kWh were effectively compensated, resulting in an average compensation index of 31.36%. Although this percentage can be considered modest, it should be interpreted with caution: medium voltage units, despite their high absolute consumption, as already mentioned in the consumption analysis of the SEDUC headquarters unit, have a lower value charged per kWh than low voltage units. Thus, each kWh compensated in this group generates a lower financial return for the public administration. Figure 8 shows the monthly consumption in the period analyzed.

Figure 8

Consumption history of SEDUC consumer units connected to Medium Voltage



Source: Prepared by the author with data from SEDUC

In this context, maintaining or expanding the compensation of these units, while there is still a significant deficit of compensation in low-voltage units (which pay higher tariffs), does not represent the most efficient allocation of available generation credits. The analysis of the data shows that low voltage units, despite representing a relevant portion of consumption, have been partially compensated (on average 43%), maintaining monthly deficits above 960,000 kWh.

Therefore, from the perspective of maximizing the economic benefit of the PPP, the ideal would be that all generation credits from mini-plants should be allocated primarily to low-voltage units. Only after the full compensation of this group should the eventual surplus be directed to medium voltage units. This allocation logic respects the principle of economy and seeks the highest possible financial return per unit of energy compensated.

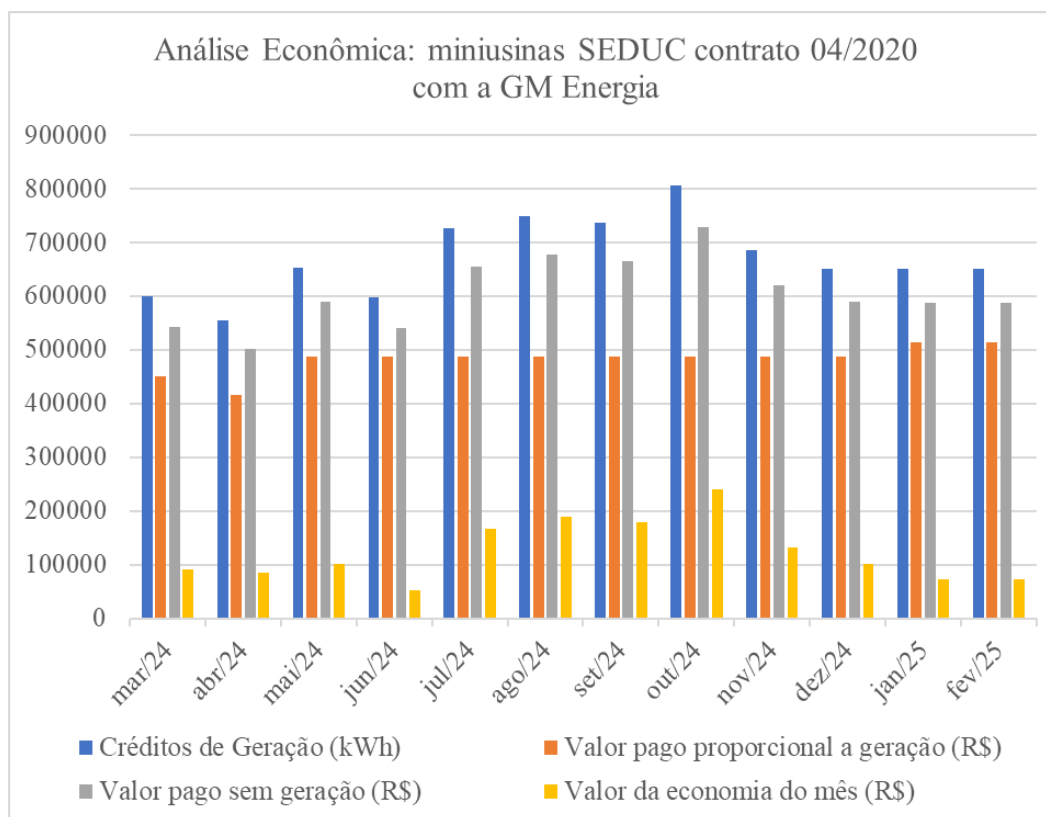
To analyze the economic impact, the amount paid monthly to the companies of the mini-plants was compared and the amount that would be paid without generation credits was calculated. The analysis was made for the credits of each contract. Figure 9 shows the history of offset credits for the mini-plant of contract 04/2020 and the amounts paid to the company proportional to the generation received and the amount that would be paid to Equatorial Piauí without considering the generation credits.

Based on the data presented in Figure 9, it is possible to identify savings in electricity expenses, directly reflecting the positive effects of distributed generation.

In the period from March 2024 to February 2025, the energy compensation resulted in a total saving of R\$ 1,482,184.04, which is equivalent to an average monthly saving of approximately R\$ 123,515.34. This amount represents the difference between what would be paid by SEDUC in a scenario without its own generation and the amount actually paid proportional to the volume of energy compensated with credits from the mini-plants.

Figure 9

History of offset generation credits and amounts paid for generation credits related to contract 04/2020



Source: Prepared by the author with data from SEDUC

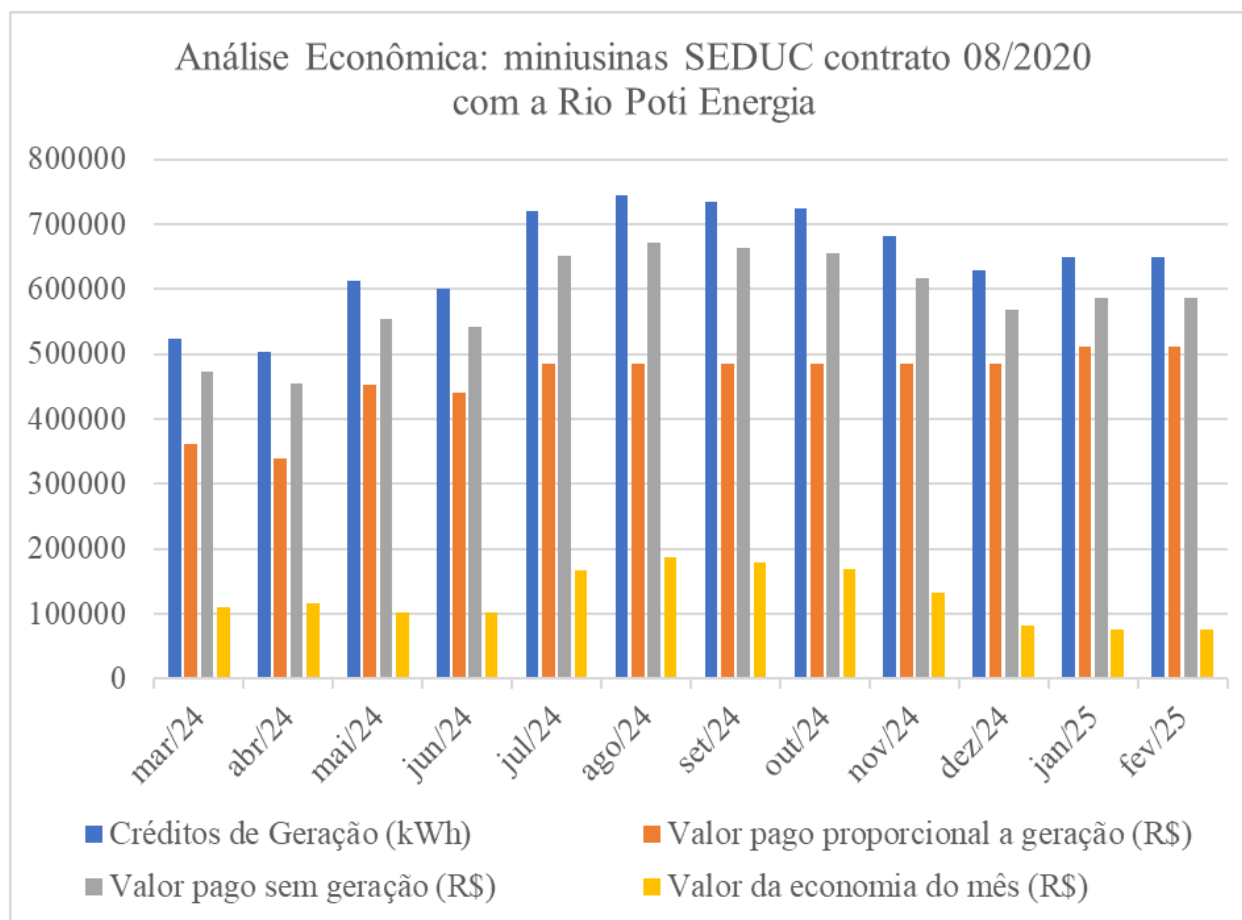
The month with the highest savings was October 2024, with an amount saved of R\$ 239,671.61. It is observed that the months with the lowest savings were the months of January and February 2025. This reduction in savings occurred due to the reduction in the value of the energy tariff by Equatorial and the increase in the amount to be paid for the monthly consideration to the company, which is corrected by the IPCA every year.

The savings generated are particularly relevant considering the context of growing operating expenses of the public administration with electricity. In addition, it is a recurring saving, which is renewed with each billing cycle and contributes to the relief of the public budget, without compromising the quality of the services provided by the school units.

The same analysis was also carried out for the mini-plant of contract 08/2020, as can be seen in Figure 10.

Figure 10

History of offset generation credits and amounts paid for generation credits related to contract 08/2020



Source: Prepared by the author with data from SEDUC

In the period analyzed, the energy compensated by the plants linked to contract 08/2020 enabled a total saving of R\$ 1,499,163.08, which corresponds to an average monthly saving of R\$ 124,930.26. This saving is calculated as the difference between what would be disbursed without the use of generation credits and the amount actually paid proportional to the compensated consumption.

The month with the greatest savings was August 2024, when the amount saved reached R\$ 187,234.30, possibly due to higher photovoltaic generation associated with the peak of solar irradiance and the good allocation of credits to units with higher tariff costs.

These results confirm the effectiveness of Contract No. 08/2020 as a public policy tool for reducing current expenses with electricity. The recurring monthly savings obtained over a budget year provides not only tax relief, but also the opportunity to redirect resources

to other areas of education, such as school infrastructure, food, transportation, or teacher training.

4 CONCLUSION

The energy transition to renewable sources, especially solar photovoltaics, is an urgent need in the face of the climate and environmental challenges that the world is facing. In Brazil, and particularly in the State of Piauí, the potential for solar energy generation is great, as it has high levels of solar radiation all year round, but it is still underutilized.

The government must lead this energy transition policy for the use of renewable sources. PPPs are vital instruments to assist this transition, significantly increasing the contribution of generation through renewable sources by the government, offering a collaborative model that can help overcome the financial and technical obstacles that limit the expansion of renewable energy energy.

From a technical point of view, it can be proven that the performance of the mini-plants was satisfactory, with all units managing to reach the contracted value of average monthly generation of 650,000 kWh. All installations have *tracker technology*, which allows the photovoltaic modules to be directed according to the position of the sun to increase the facility's generation capacity. These mini-plants were the first to be installed in the state of Piauí with this type of mechanism.

Regarding the economic analysis, the implementation of the mini-plants resulted in significant savings in the energy bills of the secretariat. The savings generated between March 2024 and February 2025 (12 months) totaled R\$ 1,482,184.04, with a monthly average of R\$ 123,515.34. The peak of savings was observed in October 2024, with R\$ 239,671.61 saved, while the lowest amount occurred in February 2025, reflecting tariff adjustments by the distributor and contractual correction of the consideration.

The analysis of consumption at the SEDUC Headquarters Unit, located in the administrative center in Teresina, revealed a total of 1,588,830 kWh consumed in the 12-month period, of which 1,502,481 kWh occurred during off-peak hours and 86,349 kWh during off-peak hours. All consumption was offset with generation credits, reaching 100% offset. However, the total compensation of the Headquarters unit, connected to medium voltage, proved to be financially less advantageous than the compensation of the units in low voltage, whose tariff is higher. Thus, it was found that the strategy of compensating all with consumption of the headquarters unit, from an economic point of view, is not the best

option. Initially, all units connected to low voltage must be compensated and only compensate the consumption of units served at medium voltage if there are still generation credits left.

However, the project also highlighted structural problems and challenges that compromise its efficiency. The main one was the lack of planning taking into account the energy demand of each government agency that benefited. The inadequate initial allocation of generation from the mini-plant contracted to the Department of Finance (SEFAZ), for example, whose monthly demand was lower than the contracted generation capacity, was one of the main problems found. This distortion was corrected with the transfer of the generating unit to SEDUC, with compatible demand, but the episode revealed flaws in prior planning and in the estimation of the real demand of public agencies.

Piauí's experience in implementing solar mini-plants via PPP is successful in terms of technical feasibility and contribution to the energy transition. However, maximizing its benefits requires greater integration between technical planning, local public policies, and social engagement. The replication and expansion of this model depends on strengthening governance, improving demand diagnostics, and adopting inclusive strategies that consolidate environmental and social gains with affected communities. Such measures can amplify the positive effects of PPPs, consolidating mini-plants as effective instruments of energy, environmental and social public policy.

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FENTANYL: THE CRIME ENTERPRISE

FENTANIL: A EMPRESA DO CRIME

FENTANILO: LA EMPRESA DEL CRIMEN

 <https://doi.org/10.56238/sevened2025.036-143>

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ABSTRACT

Fentanyl is a powerful synthetic opioid (manufactured in laboratories), 50 times more potent than heroin and 100 times stronger than morphine. In Mexico, it is classified under the General Health Law as a narcotic whose medical use is legal and regulated and supervised by the Federal Commission for the Protection against Sanitary Risks (COFEPRIS). “Fentanyl is a chemical substance that began to be used for medical purposes, indeed as an anesthetic, replacing morphine. However, parallel to this use, an entire black market emerged to use it in the production of drugs sold on the streets of the United States, which has caused this public health crisis” (Ágreda, 2025). Initially, its use was restricted to cardiac surgeries, as it could assist both the required sedative effect and postoperative pain management. Currently, it is used in combination with anesthetics during surgeries or for very intense pain, such as in the terminal stages of cancer. After the original injectable medical formulation, several other forms were developed, including transdermal patches, tablets, sprays, and lozenges, with the aim of providing broader administration options. The Sinaloa Cartel (SC) was the first to identify the business potential represented by fentanyl, followed by the Jalisco New Generation Cartel (CJNG) and other criminal groups. “One kilogram of fentanyl earns the cartel approximately USD 200,000 in the United States” (Grant, 2024). The leading cause of death from overdoses involving synthetic opioids in the United States is fentanyl, triggering a severe public health crisis; according to the Centers for Disease Control and Prevention (CDC), from 2021 to 2023 overdose deaths exceeded 100,000 annually. The reduction in fentanyl overdose deaths is largely attributed to the use of naloxone, known as Narcan, which rapidly restores normal breathing in overdose cases; however, its effects last only 30 to 90 minutes and require immediate medical attention. In Mexico, naloxone is classified as a psychotropic medication and is highly controlled, intended mainly for hospital use and requiring a prescription. In the United States, organized crime groups based in Mexico control the fentanyl supply to the U.S. drug market, particularly the Sinaloa Cartel (SC) and the Jalisco New Generation Cartel (CJNG), and in several cases local and regional U.S. criminal groups have mixed fentanyl with heroin to maximize profitability.

Keywords: Fentanyl. Synthetic Opioid. Cartels. Business. Profitability. Naloxone.

RESUMO

O fentanilo é um potente opioide sintético (fabricado em laboratório), 50 vezes mais potente que a heroína e 100 vezes mais forte que a morfina. No México, é classificado na Lei Geral de Saúde como um entorpecente cujo uso médico é legal, sendo regulado e fiscalizado pela

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Comissão Federal para a Proteção contra Riscos Sanitários (COFEPRIS). “O fentanilo é uma substância química que começou a ser utilizada para fins médicos, de fato como anestésico, substituindo a morfina. No entanto, paralelamente a esse uso, abriu-se um amplo mercado negro para sua utilização na produção de drogas vendidas nas ruas dos Estados Unidos, o que causou esta crise de saúde pública” (Ágreda, 2025). Inicialmente, seu uso era restrito a cirurgias cardíacas, pois auxiliava tanto no efeito sedativo necessário quanto no controle da dor pós-operatória. Atualmente, é utilizado em conjunto com anestésicos durante cirurgias ou para o tratamento de dores muito intensas, como nas fases terminais do câncer. Após a apresentação médica original injetável, foram desenvolvidas diversas formulações, como adesivos transdérmicos, comprimidos, sprays e pastilhas, com o objetivo de ampliar as opções de administração. O Cartel de Sinaloa (CS) foi o primeiro a identificar o potencial de negócio representado pelo fentanilo, seguido pelo Cartel Jalisco Nova Geração (CJNG) e outros grupos criminosos. “Um quilo de fentanilo gera ao cartel cerca de US\$ 200.000 nos Estados Unidos” (Grant, 2024). A principal causa de morte por overdose de opioides sintéticos nos Estados Unidos é o fentanilo, desencadeando uma grave crise de saúde pública; segundo dados dos Centros de Controle e Prevenção de Doenças (CDC), de 2021 a 2023 as mortes por overdose superaram 100.000 por ano. A redução das mortes por overdose de fentanilo deve-se em grande parte ao uso da naloxona, conhecida como Narcan, que restaura rapidamente a respiração normal em casos de overdose; entretanto, seus efeitos duram apenas de 30 a 90 minutos, sendo necessária atenção médica imediata. No México, a naloxona é classificada como medicamento psicotrópico e altamente controlado, com uso predominantemente hospitalar e exigência de prescrição médica. Nos Estados Unidos, grupos de criminalidade organizada com base no México controlam o fornecimento de fentanilo ao mercado norte-americano, especialmente o Cartel de Sinaloa (CS) e o Cartel Jalisco Nova Geração (CJNG), e em diversos casos grupos criminosos regionais e locais dos Estados Unidos misturaram fentanilo com heroína para maximizar a rentabilidade.

Palavras-chave: Fentanilo. Opióide Sintético. Cartéis. Negócio. Rentabilidade. Naloxona.

RESUMEN

El fentanilo es un fuerte opióide sintético (fabricado en laboratorio), 50 veces más potente que la heroína y 100 veces más que la morfina. En México está clasificado en la Ley General de Salud como un estupefaciente cuyo uso médico es legal y está regulado y vigilado por la Comisión Federal para la Protección contra Riesgos Sanitarios (COFEPRIS). “El fentanilo es una sustancia química que se empezó a utilizar para uso médico, en efecto, como anestesia, sustituyó a la morfina. Pero, paralelamente a este uso, se abrió todo un mercado negro para utilizarlo en la producción de drogas que se venden en las calles en Estados Unidos, y que ha causado esta crisis de salud pública”. (Ágreda, 2025) Inicialmente su uso estaba restringido a cirugías de tipo cardíaco, porque podía ayudar tanto al efecto de sedación requerido como al dolor asociado postoperatorio. Actualmente, se le utiliza junto a anestésicos durante cirugías o para dolores muy intensos como son las etapas terminales de cáncer. Posterior a la presentación original inyectable para uso médico, se desarrollaron diversas formulaciones como parches transdérmicos, tabletas, spray y paletas comestibles, con el objetivo de proporcionar opciones de administración más amplias. El Cártel de Sinaloa (CS) fue el primero en detectar el potencial de negocio que representaba el fentanilo. Posteriormente, el Cártel Jalisco Nueva Generación (CJNG) y otros grupos criminales se sumaron al tráfico de esta droga. “Un kilo de fentanilo le hace ganar al cártel unos 200,000 USD en EE.UU.”. (Grant, 2024) La causa principal de muerte por sobredosis con opioides sintéticos en Estados Unidos es por fentanilo lo que ha provocado una grave crisis de salud pública, que según datos de los Centros para el Control y la Prevención de Enfermedades (CDC, por sus siglas en inglés), durante tres años consecutivos del 2021 al 2023 las muertes por sobredosis superaron las 100,000. La disminución de muertes por sobredosis de

fentanilo se debe en gran parte al uso del medicamento naloxona, conocido como narkan, ya que restablece con rapidez la respiración normal de una persona que respira lentamente o ha dejado de respirar a causa de una sobredosis de drogas. Aunque la naloxona revierta la sobredosis por opioides como el fentanilo, la heroína, la oxicodona (OxyContin), la hidrocodona (Vicodin), la codeína y la morfina, los efectos son temporales de 30 a 90 minutos, la cual requiere atención médica inmediata. En México, la naloxona está clasificada como un medicamento psicotrópico y, por lo tanto, es una sustancia altamente controlada. Su uso está destinado principalmente para el ámbito hospitalario y requiere receta médica para su adquisición. En Estados Unidos, los grupos de delincuencia organizada con base en México actualmente controlan el suministro de fentanilo al mercado de drogas estadounidense. Entre ellos se encuentran grupos bien establecidos como el Cártel de Sinaloa (CS) y el Cártel Jalisco Nueva Generación (CJNG). En varios casos, grupos delictivos regionales y locales de Estados Unidos han mezclado fentanilo con heroína para maximizar la rentabilidad.

Palabras clave: Fentanilo. Opioide Sintético. Cáteles. Negocio. Rentabilidad. Naloxona.

1 INTRODUCTION

"Fentanyl is a synthetic drug, which was introduced in 1960, for clinical use (as an anesthetic and for the treatment of chronic and intense pain) in order to replace morphine and other opioids (derived from opium, which is a mixture of substances generated by the poppy flower or opium poppy (*Papaver somniferum*)). It was first synthesized by Dr. Paul Janssen and approved by the Janssen Company of Beerse in Belgium in December 1960 and by the Food and Drug Administration (FDA) of the United States of America in 1968." (Rosas Carrasco, 2023)

The drug epidemic in the United States known as the "fentanyl crisis" was due to medical malpractice in the 80s. Although opioids have always been used to treat very severe pain, 45 years ago the pharmaceutical company Purdue Pharma synthesized oxycodone, a semi-synthetic opioid, which it marketed under the name OxyContin.

"A letter published in the New England Journal of Medicine (NEJM), with a single paragraph of about 100 words, argued that prescription opioids, such as oxycodone, did not cause addiction, so it began to be cited by Purdue Pharma as evidence that opioid use posed no risk.

The letter written by Jane Porter and Dr. Hershel Jick, in 1980, described the analysis that was made of more than 11 thousand patients at Boston University Medical Center, who received opioids for pain, of which, the letter stated, only 3 developed dependence, but it referred to hospitalized patients under medical treatment.

From the 90s onwards, an aggressive marketing campaign was carried out, which argued that the drug was not addictive, this, coupled with the prestige of the medical journal, helped to flood pharmacies and doctor's offices throughout the country with oxycodone and to cement the idea that opioids prescribed for pain were safe.

The commercialization of oxycodone unleashed a great demand among addicts and became the breeding ground for the arrival of fentanyl illegally in the United States, which along with other opioids, has become the cause of the worst public health crisis in that country." (Avendaño, 2025)

It can be found mixed with other drugs such as heroin, cocaine, methamphetamine and ecstasy, which makes the use of any of these substances even more dangerous.

Illicitly manufactured fentanyl has a process similar to pills and with a presentation similar to candy. It can be given as an injection, in a patch that you put on your skin, or as a lozenge that dissolves in your mouth.

It is a drug that is commonly used in surgical interventions as an anesthetic and as an analgesic to treat intense pain in multiple health conditions, including cancer or chronic pain that is resistant to other types of medications.

"Fentanyl acts on the central nervous system (CNS) to relieve pain, but in doses close to two milligrams it causes overdose. The production of fentanyl in Mexican territory, which is destined for the United States, is carried out in clandestine laboratories with the presence of criminal groups, while the precursors used are imported from China, Taiwan or India. It is worth mentioning that, in Mexico, the medical use of fentanyl is well regulated and penalized under the current General Health Law." (González Lozano, 2023)

In Mexico, fentanyl is classified as a controlled narcotic by the General Health Law (Article 234), as it represents a public health risk due to its potential for dependence or addiction.

At first, the fentanyl trafficked to the United States came from China, but according to reports from the Drug Enforcement Administration (DEA), the Attorney General's Office (FGR) and the Ministry of Finance and Public Credit (SHCP), the procedure changed in 2017, as Mexican cartels began importing chemical precursors to make fentanyl in their own laboratories.

In Mexico, criminal organizations carry out the production of fentanyl in clandestine laboratories, which according to data from the Ministry of National Defense (SEDENA) these narco-laboratories are located in towns in Michoacán, Jalisco, Sinaloa, Durango or Baja California with the presence of the Jalisco New Generation Cartel (CJNG) and the Sinaloa Cartel (CS); and where other drugs, such as cocaine and heroin, and chemical precursors are also introduced from China, Taiwan and Hong Kong.

Various Mexican public security institutions "point out that the states of Sinaloa, Sonora, Baja California Sur, Durango, State of Mexico and Mexico City, is where they have located and destroyed the largest number of clandestine laboratories for the manufacture of fentanyl." (Flores Martínez, 2022)

"The production of fentanyl goes directly to the city of Tijuana in Baja California, facilitating its entry into the United States through San Diego, an area with the highest number of fentanyl seizures according to the DEA and Customs and Border Protection." (González Lozano, 2023)

The U.S. Department of Justice The U.S. indicates that there are 5,000 places in China that produce fentanyl or chemical precursors for the manufacture of this synthetic drug.

The precursor chemicals are transported from China to Mexico across the Pacific Ocean in containers from ships that arrive at the ports of Manzanillo, Colima and Lázaro Cárdenas, Michoacán. The main international airports to which these precursors arrive are Culiacán, Manzanillo and Mexico City.

This synthetic drug has acquired various names on the streets of cities in the United States: Apache, China Girl, China Town, Dance Fever, Friend, Goodfellas, Great Bear, He-Man, Jackpot, Kink Ivory, Murder 8, Poison, Tango and Cash. In Latin America, it is known as White or Synthetic Heroin, N-30, Fenta, Tango, China White or OxyContin. These terms are frequently used on the streets because fentanyl is sold alone or mixed with other substances, such as heroin, cocaine or methamphetamine, often without the consumer's knowledge and alludes to its potency or the effects that traffickers claim it produces.

Fentanyl can be consumed in different ways: powdered or smoked; in pill form it is ingested; There are also liquid presentations applied in patches or on blotting paper.

It is marketed alone or mixed with heroin, cocaine or crack. The tablets, known as rainbow fentanyl, usually have bright colors that, according to the DEA, only serve to identify the cartel responsible for distribution in each market.

In the case of patches, there are 12, 25, 50, 75 and 100 micrograms/hour. Illegal fentanyl in liquid form also circulates on the black market as a nasal spray, eye drops, applied on paper or in small treats.

"U.S. law enforcement authorities have documented the numerous ways Mexican criminal groups are trying to increase their ability to supply this market: Smuggling chemicals in legitimate commercial shipments; mislabeling shipments to avoid investigation by law enforcement authorities; diverting supplies from lawful purchases to the chemical or pharmaceutical sectors; and making open purchases of supplies on the web." (FATF, 2022)

2 OBJECTIVES AND GOALS

The main objective of this research is to analyze the diversification of the illicit activities of drug cartels, with special emphasis on the production and commercialization of fentanyl in its different presentations, due to the high profitability that this illicit market represents.

3 MATERIALS AND METHODS

The main sources of this research are documents such as laws in force in Mexico, reports, bulletins, interviews, executive summaries, books and magazines that talk about the fentanyl crisis, national and local newspapers that on numerous occasions and very frequently present articles denouncing this type of crime, as well as official websites and studies that experts have carried out on the subject.

Therefore, it is considered that this work is of a documentary and descriptive nature.

4 RESULTS

The public health crisis facing the United States has its origin when the FDA authorized through its pharmaceutical companies the sale of synthetic opioids such as oxycodone, which is a medication used for pain, which can eventually generate dependence.

The DEA began detecting the problem in 2014, when some addicts of pain medications in the U.S., such as oxycodone, began using fentanyl in pills that looked like prescription drugs.

Mexican cartels visualized the profits from the big fentanyl business and, as they did with methamphetamines, they already dominate the U.S. market.

The current extensive clientele of Mexican criminal organizations was created by U.S. laboratories, by prescribing the indiscriminate use of highly addictive opioid painkillers.

Doctors were writing opioid prescriptions to patients who didn't need them, knowing they were maintaining their dependence and increasing the labs' revenue.

"The place that fentanyl now occupies in the position of demand for opioids and opioids in the United States is because of the restriction that has been given in North America to the liberal prescription of medicines, such as Vicodin, tramadol and oxycontin." (Reyes, 2020)

"Due to its high addictive potential, low cost and the relative ease of its illicit production, small amounts of the psychoactive substance can produce large economic gains for organized crime groups, which stimulates the growth of illicit markets." (CONASAMA, 2024)

There are already other synthetic drugs more potent than fentanyl on the consumer market, but this is still the most widely consumed in the U.S. and is present in most of the substances circulating in that country, such as cocaine, heroin and marijuana, with one kilo

of fentanyl a million doses are produced and on the black market it is usually mixed with these substances to obtain a more potent product.

According to DEA reports, "cooks" produce over-the-counter tablets with very low doses of fentanyl, and at other times increase them, to such an extent that a single pill can kill three people by overdose. This explains the high number of deaths due to excessive consumption of this synthetic drug.

"In Mexico, fake tablets are manufactured that look very similar to any other drug produced, apparently, legally in the United States, with very exact dosage information, but in reality they are adulterated pills that contain 1 or 2 milligrams of fentanyl, which makes them extremely dangerous. The data that confirms the above is based on seizures made by the Border Patrol, the DEA and the Federal Bureau of Investigation (FBI), agencies that have analyzed the percentages of fentanyl in them and have discovered that the doses vary. Some are very low and others are fatal at the first consumption, as they are overrun." (Ravelo, 2025, p. 9)

Criminal organizations recruit children to help them traffic fentanyl. e.g. a 17-year-old drug trafficker and cartel hitman is paid about \$1,000 to take him north.

"One kilo of fentanyl generates half a million fatal doses, but criminal groups can obtain many more, up to twice as many." (Gómez Mena, 2024)

Traffickers often illegally mix fentanyl with other drugs such as heroin, cocaine, or methamphetamine, or press it into counterfeit pills, increasing the risk of accidental overdose for consumers who don't know they are ingesting this potent substance.

Someone can take a pill without knowing it contains fentanyl, it is also possible for them to take a pill knowing it contains fentanyl with no way of knowing if it contains a lethal dose.

The leading cause of death from fentanyl overdose is primarily due to illicitly manufactured fentanyl.

You can't tell if a drug is fake or legitimate unless it's prescribed by a licensed medical professional and distributed by a legitimate pharmacy. Without lab testing, there's no way to know how much fentanyl is in an individual pill or how much may have been added to another medication.

In the medical field, fentanyl requires exact doses so as not to cause respiratory arrest. However, the drug addict ends up consuming disproportionate amounts that cause death.

For the Sinaloa Cartel (CS), the cost of setting up the infrastructure of a laboratory ranges between 150,000 and 200,000 pesos per month, while accessing the recipe to manufacture fentanyl can be easily consulted on the Internet.

"The cost to produce fentanyl is also low, since it takes about 3,500 dollars to acquire a kilo of pure fentanyl, with which millions of doses can be generated without requiring large quantities of chemical precursors.

In addition, the payment for security can reach the sum of 20 thousand pesos and only between two and six people are needed to set up an industrial-sized operation. Profits reach up to 3 thousand dollars for each kilogram. Other reports indicate that producing 4.5 tons of fentanyl - enough to cover a year's demand - requires an investment of approximately 22.5 million dollars. However, the profits double that figure, as they exceed 41 million dollars." (Ravelo, 2025, p. 12)

"The FDA approved naloxone as a prescription drug decades ago, but access increased exponentially in 2023, when the agency approved an over-the-counter nasal spray version of the drug. And medications prescribed to treat opioid use disorder — specifically, buprenorphine and methadone — also save lives." (Mogg, 2025)

Fentanyl test strips, which identify whether another drug contains the opioid, are available over-the-counter, are inexpensive and typically deliver results in 5 minutes or less, which can mean the difference between life and death. Even if a negative result is obtained, the user should exercise caution: reactive tests do not always identify drugs similar to fentanyl, some of them much more potent.

The only way to avoid an overdose is to never use fentanyl without medical advice. "Any use of fentanyl without a prescription is life-threatening." (Mogg, 2025)

5 DISCUSSION

The public discussion about fentanyl in Mexico often mixes two different phenomena: medicinal fentanyl, legal and necessary in the health sector, and illicit fentanyl, produced in clandestine laboratories and linked to the overdose crisis in the United States. This confusion has generated misinformation, ambiguous policies, and reforms that make it difficult to access medical fentanyl, causing shortages and direct impacts on the work of the medical community.

While in the United States there is a crisis due to illegal fentanyl consumption, in Mexico there is no official evidence of a similar problem; however, the existence of

production and transit of illicit fentanyl is recognized. Even so, the Mexican government has adopted a war narrative focused on the "combat" of the substance, privileging security strategies and the participation of the armed forces, without distinguishing between medical and illegal uses.

Illicit fentanyl is presented in powder or pills without sanitary control, while medicinal fentanyl is manufactured by pharmaceutical companies under strict regulation and is used in anesthesia, intensive care and severe pain management. Despite this difference, official proposals such as the prohibition of medical fentanyl show the lack of clarity in public discourse.

In addition to the military approach, Congress has approved reforms that increase penalties for crimes related to fentanyl and its precursors, including automatic imprisonment, which violates human rights principles. At the same time, between 2017 and 2024, decrees were issued that further tighten the control of licit fentanyl, generating excessive procedures, new bureaucracies and restrictions that have affected the availability of the drug.

Interviews with anesthesiologists show that the shortage of the drug has led to cancellations of surgeries, the use of less effective alternatives and an environment of uncertainty and stigma towards doctors. "Between 2021 and 2024, the press reported the arrest of at least four anesthesiologists, whose accusations are related to medicinal fentanyl." (Treviño Rangel & Velázquez Moreno, 2025)

Taken together, these policies do not seem to curb illicit fentanyl trafficking, but they have negatively impacted medical work and patients' access to safe treatments, evidencing a more moral and punitive approach than public health.

In addition, the blows to the drug cartels have not been enough, despite the fact that many seizures have occurred in both the U.S. and Mexico. It is a crisis that keeps the U.S. government and now the Mexican government on alert. Seizures of the drug and its chemical precursors in ports, air terminals and highways are becoming more and more frequent.

One of the strongest blows dealt by the authorities to the Sinaloa cartel occurred in December 2024 when they seized 20 million pills in the Sinaloa demarcations of Ahome and Guasave. "With this seizure, it is estimated that 8 billion pesos or 400 million dollars will have an economic impact on organized crime. There is no precedent for a seizure of this magnitude." (Muñoz et al., 2024)

The expansion of fentanyl cannot be understood without looking at the pharmaceutical precedent in the United States. Firms such as Purdue Pharma created a market "based on corruption", where doctors were pressured and financially rewarded to prescribe opioids on a massive scale.

Mexican criminal groups cannot be exonerated for having expanded addictions, but there is a precedent. Pharmaceutical companies in the United States created a very large market based on corruption, corrupted many doctors with financial support to prescribe fentanyl for everything.

This network of complicities resulted in an entire population hooked on opioids, a scenario that was later exploited by Mexican cartels.

6 CONCLUSION

The United States is facing a serious public health crisis due to the ongoing epidemic of synthetic drug addiction, where fentanyl continues to be the leading cause of overdose deaths.

According to the Centers for Disease Control and Prevention (CDC), for three consecutive years from 2021 to 2023, overdose deaths exceeded 100,000, above the number of deaths from traffic accidents and firearms.

The "anti-narco-terrorist" approach, which includes unilateral U.S. military action against drug cartels and other Latin American gangs or criminal groups now called foreign terrorist organizations, will not reduce drug use in the United States.

"U.S. supply-side drug policies, such as the so-called kingpin strategy (or the focus on the heads of criminal organizations), have proven ineffective in addressing the nation's drug epidemic. A focus on the demand and distribution of synthetic drugs within the United States is needed, which must be considered in order to implement a successful comprehensive anti-drug strategy, since the demand for drugs generates its own demand." (Correa Cabrera, 2025)

Fentanyl has established itself as the most profitable business of Mexican drug trafficking. Its low production cost, ease of transport, and high demand in the United States make it an ideal product for cartels. The multimillion-dollar profits have strengthened the operational capacity of groups such as the Sinaloa Cartel (CS) and the Jalisco New Generation Cartel (CJNG), which control the entire value chain, from the import of precursors to international distribution.

Combating this phenomenon requires more than military operations: it requires international cooperation, financial control, preventive education, and public health policies that reduce demand. Only a comprehensive approach will mitigate the health and economic crisis that fentanyl represents for North America and the world.

In Mexico, injectable naloxone is classified as a psychotropic medication and, therefore, its sale and use are strictly regulated, requiring a prescription for its acquisition in pharmacies.

Currently, it is not available for over-the-counter sale in the country. The official position of the Mexican government has been to maintain the regulation and not allow its commercialization without a prescription, unlike other countries such as the United States, where the nasal spray naloxone (Narcan) has been approved for over-the-counter.

Naloxone is listed in section IV of article 245 of the General Health Law as a psychotropic substance. It can only be purchased with a doctor's prescription. It is available in the health system and specialized pharmacies, but its access is limited to the general public due to the need for a prescription. There have been initiatives in the Senate to remove naloxone from the list of psychotropic substances and thus allow wider access, but so far, the regulation is maintained.

Because of these restrictions, there have been reports of people smuggling small amounts of naloxone from the United States for harm reduction programs, given the risk of fentanyl overdose.

In Mexico, naloxone should be declassified as a dangerous substance because it reverses opioid overdoses. This medication does not cause addiction; It allows the person to breathe and not die in a short time. In the United States the version is unassailable; with heroin you need one dose and with fentanyl two. The World Health Organization (WHO) has expressed that it should not be restricted, but in Mexico the drug is in injected form. A person with an overdose has to get a doctor who has prescriptions for controlled drugs, then go to the pharmacy to buy it and then have someone inject it, while this is happening he has already died.

"José Manuel Castrejón, director of the Monte Fénix Center for Higher Studies (CESMF), said that if naloxone were more available, first responders could use this resource. " In the United States, the police bring it and when they find someone with an overdose they administer it and save their life; the time it takes to get to a hospital is deadly, but in Mexico it is still in the category of controlled substance." (Gómez Mena, 2024)

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LEISHMANICIDAL INSIGHTS FROM PINE RESINE DERIVATIVES

PERCEPÇÕES LEISHMANICIDAS A PARTIR DE DERIVADOS DA RESINA DE PINHEIRO

PERSPECTIVAS LEISHMANICIDAS A PARTIR DE DERIVADOS DE LA RESINA DE PINO

 <https://doi.org/10.56238/sevened2025.036-144>

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ABSTRACT

Due to the known potential of diterpenes to display biological activities, the aim of this work was to produce amide derivatives from dehydroabietic acid, naturally occurring in pine resins and evaluate them against *Leishmania amazonensis*. Our venture into the derivatives production led us to eight different amides which were properly identified and characterized by Nuclear Magnetic Resonance spectroscopy. Biological assays were carried out with all derivatives and the natural precursor against promastigote forms of *L. amazonensis*. Results show that two derivatives can be considered of better activity than the precursor against this parasite. This opens future perspectives to further explore that kind of diterpenes against *Leishmania* species.

Keywords: Abietanes. Dehydroabietic Acid. Structural Modification. Biological Assays. *Leishmania Amazonensis*.

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RESUMO

Devido ao conhecido potencial dos diterpenos em apresentar atividades biológicas, o objetivo deste trabalho foi produzir derivados amídicos a partir do ácido desidroabiético, naturalmente presente em resinas de pinheiro, e avaliá-los contra *Leishmania amazonensis*. O desenvolvimento desses derivados resultou na obtenção de oito amidas diferentes, devidamente identificadas e caracterizadas por espectroscopia de Ressonância Magnética Nuclear. Ensaios biológicos foram realizados com todos os derivados e com o precursor natural frente às formas promastigotas de *L. amazonensis*. Os resultados demonstram que dois derivados apresentam atividade superior à do precursor contra esse parasito, o que abre perspectivas futuras para a exploração adicional desse tipo de diterpeno contra espécies de *Leishmania*.

Palavras-chave: Abietanos. Ácido Desidroabiético. Modificação Estrutural. Ensaios Biológicos. *Leishmania amazonensis*.

RESUMEN

Debido al conocido potencial de los diterpenos para presentar actividades biológicas, el objetivo de este trabajo fue producir derivados amídicos a partir del ácido deshidroabiético, presente de forma natural en las resinas de pino, y evaluarlos frente a *Leishmania amazonensis*. El desarrollo de estos derivados dio lugar a la obtención de ocho amidas diferentes, debidamente identificadas y caracterizadas mediante espectroscopía de Resonancia Magnética Nuclear. Se realizaron ensayos biológicos con todos los derivados y con el precursor natural frente a las formas promastigotas de *L. amazonensis*. Los resultados muestran que dos derivados presentan una actividad superior a la del precursor frente a este parásito, lo que abre perspectivas futuras para una mayor exploración de este tipo de diterpenos contra especies de *Leishmania*.

Palabras clave: Abietanos. Ácido Deshidroabiético. Modificación Estructural. Ensayos Biológicos. *Leishmania amazonensis*.

1 ABOUT NATURAL PRODUCTS AND DITERPENES

Substances originating from living organisms, including plants, animals, and microorganisms, are classified as natural products (NPs). Natural products exhibit a wide diversity of chemical structures and encompass several distinct structural classes, which often confer various biological activities, such as antiparasitic, antiproliferative, and antimicrobial effects (Pertino *et al.*, 2014; Soares *et al.*, 2018). This diversity is of considerable scientific interest, as it contributes to the discovery and development of new drugs, supports the treatment of diseases, and enhances the therapeutic potential of existing medicines (Brusotti *et al.*, 2014).

In medicine, many drugs are direct or indirect derivatives of natural products, and they are widely used in the treatment of cancer and infectious diseases. To ensure the efficacy of these medicines in clinical use, multiple regulatory and quality control measures are implemented to demonstrate their safety and effectiveness before they reach the market (Xie *et al.*, 2018).

Studies on natural products can provide important insights into their biological potential and support the production of active substances from the vast diversity of plant species. Such investigations allow these compounds to be applied for the benefit of humanity by elucidating their mechanisms of action in specific living organisms. Given this remarkable potential, natural products are widely regarded as a promising source of new drugs (Soares *et al.*, 2018).

Terpenoids are a large and important class of natural products widely distributed in nature. They can be subdivided into several groups, including monoterpenes, sesquiterpenes, diterpenes, and others (Reveglia *et al.*, 2018). Among these subgroups, diterpenes are particularly prominent and are found in plants, fungi, bacteria, and animals, occurring in both marine and terrestrial environments (Garcia *et al.*, 2007). They exhibit a wide range of biological activities, including antimicrobial, antiparasitic, anti-inflammatory, and antiviral effects, among others (Porto *et al.*, 2009; Sebisubi *et al.*, 2010; Jiang *et al.*, 2015 [a]; Jiang *et al.*, 2015 [b]).

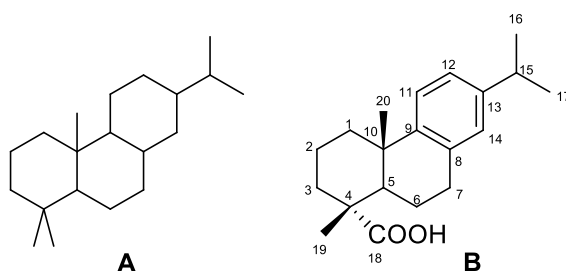
Pinus species represent an important plant group with high potential as a source of natural products. These trees are widely distributed and commonly found in countries such as China, the United States, India, and Brazil. A distinctive characteristic of *Pinus* species is the production of resin, a viscous yellow to brown liquid with a strong odor. This resin consists of a volatile fraction, known as turpentine, which contains monoterpenes and

sesquiterpenes, and a non-volatile fraction, known as pitch, which is rich in diterpenes (Sousa *et al.*, 2018).

Diterpenes exhibit a wide range of chemical structures and are subdivided into several classes, including abietanes, kauranes, pimaranes, clerodanes, and labdanes, among others. The abietane class is particularly notable, as its members are commonly found in conifers of the genus *Pinus*. Abietanes possess a characteristic tricyclic skeleton and occur largely in the form of resin acids, which can account for up to 21% of the resin (Guo *et al.*, 2019) (Figure 1 A).

Figure 1

A. Tricyclic skeleton of the abietan diterpenes. B. Chemical structure of dehydroabietic acid



Within this class of diterpenes, numerous resin-derived compounds have been reported, including abietic acid, isopimaric acid, dehydroabietic acid, among others (Fallarelo *et al.*, 2013). One of the major components of *Pinus* resin is dehydroabietic acid (DI) (Figure 1B), a tricyclic abietane-type diterpene that exhibits several biological activities, including antiulcer, anti-inflammatory, and antimicrobial effects, among others. These properties indicate that dehydroabietic acid is a highly valuable starting material for the synthesis of new compounds with relevant industrial and pharmacological applications (Gouiric *et al.*, 2004; Boeck *et al.*, 2005; Tanaka *et al.*, 2008).

Despite these findings, the antiparasitic activity of abietane diterpenes remains relatively underexplored in literature. In this context, this chapter focuses on recent advances achieved by our research group in the development of abietane-based molecules, with particular emphasis on their leishmanicidal activity. For this purpose, semi-synthetic methods have been established to obtain a series of derivatives from this class of compounds, which will be discussed below.

2 EXPERIMENTAL PROCEDURES

Several methods for the isolation of metabolites from *Pinus* resins have been reported in the literature. In the following sections of this chapter, the methodological sequence and corresponding results obtained by our research group in studies on *Pinus* oleoresins will be presented. Some *Pinus* resin sources are available from commercial suppliers. In Brazil, these resins can be obtained from the company Tecflora, which provides material from different *Pinus* species, such as *Pinus elliotti* from Buri, São Paulo-SP.

2.1 SEPARATION AND PURIFICATION OF OLEORESINS

The separation procedures were performed by vacuum liquid chromatography (VLC) and classical column chromatography (CCC) in glass columns, using silica gel 60 (70–230 mesh, 0.063–0.200 mm) and silica gel 60H (70–230 mesh, 0.040–0.063 mm), both Merck®, as the stationary phase. The choice of technique and column dimensions was adjusted according to the amount of sample available.

¹H nuclear magnetic resonance (NMR) spectra were recorded on a Bruker® AVANCE DRX400 spectrometer operating at 400 MHz. The experiments were carried out at Department of Chemistry of the University of São Paulo - USP de Ribeirão Preto. Compound identification was supported by ultraviolet (UV) irradiation and comparative thin-layer chromatography (TLC) on Merck® aluminum plates coated with silica gel 60 GF254 (0.25 mm thick), with visualization using vanillin sulfuric acid reagent followed by heating.

High-performance liquid chromatography (HPLC) analyses were performed on a Shimadzu Prominence system (CBM-20A, LC-6AD) equipped with a manual injector, DGU-20A5 degasser, SPD-20A diode array detector (DAD), and a microcomputer running LCsolution software for data acquisition and processing. A reversed-phase C18 Shimadzu column (4.6 mm × 250 mm, 5 μm) with a 20 μL injection loop was used, with acetonitrile/water (9:1) as the mobile phase at a flow rate of 1.0 mL/min. HPLC-grade reagents from J. T. Baker® and ultrapure water from a Milli-Q® system were employed. The solvents used for isolation, purification, and as reaction media were ethyl acetate (AcOEt), hexane (Hex), dichloromethane (DCM), methanol (MeOH), and ethanol (EtOH), all of analytical grade (P.A.).

The resin was coded as RP-1. These resins consist of a white solid mass impregnated with a light-yellow oily fraction. Samples from the three *Pinus* resins were

analyzed by HPLC to identify and compare their major constituents in both the oily fraction and the solid mass. Thus, the solid masses and oily fractions are described as Resin 1 (mass): RP-1M; Resin 1 (oil): RP-1O.

The fractionation of RP-1O was done by VLC. In this case, it was carried out only with the "oil" part and the following fractions were generated, which were thus coded.

- Fraction 1 - Hex: RP-1O.
- Fraction 2 - 9:1 (Hex/EtOAc): RP-1O.
- Fraction 3 - 8:2 (Hex/EtOAc): RP-1O.
- Fraction 4 - 7:3 (Hex/EtOAc): RP-1O.
- Fraction 5 - 6:4 (Hex/EtOAc): RP-1O.
- Fraction 6 - 1:1 (Hex/EtOAc): RP-1O.CLV-6.
- Fraction 7 - 4:6 (Hex/EtOAc): RP-1O.
- Fraction 8 - 3:7 (Hex/EtOAc): RP-1O.
- Fraction 9 - EtOAc: RP-1. LVC -9.
- Fraction 10 - EtOH: RP-1O. LVC -10.

The isolation and purification of the chemical constituents from *Pinus elliottii* resin were performed starting from 50.0 g of crude material. The procedure began with a VLC separation (Pelletier *et al.*, 1986), using 240.0 g of silica gel 60 and 240.0 g of silica gel 60H as stationary phases. The column was packed under vacuum with hexane as the initial solvent, and the sample was adsorbed onto 77.6 g of silica gel 60 prior to loading. During the chromatographic run, ten fractions were collected, using an elution gradient of increasing polarity as summarized in Table 1.

Table 1

Elution scheme used in RP-1O fractionation

Solvent used	Volume collected (mL)	Fraction	Mass obtained (g)
Hex	500	RP-1O.VLC-10.018	
Hex/EtOAc 9:1	500	RP-1O.VLC-20.720	
Hex/EtOAc 8:2	500	RP-1O.VLC-30.960	
Hex/EtOAc 7:3	500	RP-1O.VLC-441.450	
Hex/EtOAc 6:4	500	RP-1O.VLC-50.550	

Hex/EtOAc 1:1	500	RP-1O.VLC-61.430
Hex/EtOAc 4:6	500	RP-1O.VLC-72.000
Hex/EtOAc 3:7	500	RP-1O.VLC-80.990
EtOAc	500	RP-1O.VLC-90.460
EtOH	500	RP-1O.VLC-100.340

Hex: hexane; EtOAc: ethyl acetate; EtOH: ethanol

All fractions obtained from this procedure were analyzed through CTLC using as mobile phase a mixture of Hex/EtOAc (8:2). In this analysis, it was possible to observe that the fractions RP-1O.CLV-3 and RP-1O.CLV-4 had a similar chemical profile and therefore were selected to continue the isolation. The portions designated as “oils” afforded higher yields than the corresponding “mass” portions. RP-1M provided approximately 12% essential oil, whereas RP-1O gave yield of 17%.

2.2 STRUCTURAL MODIFICATIONS

2.2.1 General procedure for obtaining amides from dehydroabiatic acid (DI)

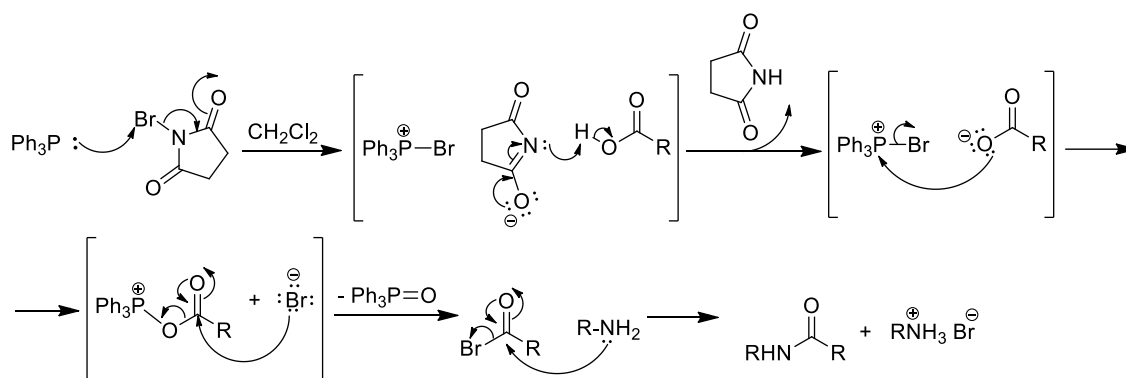
The fractionation of *Pinus* oleoresin affords dehydroabiatic acid (DI) as a purified product, which is subsequently used as a substrate for the semi-synthesis of amide derivatives. A general procedure was adopted for all DI amide-forming reactions. First, dichloromethane (DCM) was predried with calcium sulfate (CaSO_4) using 2.0 g of CaSO_4 per 100 mL of DCM under reflux for 3 h. The DCM was then collected and transferred to a second drying system containing phosphorus pentoxide (P_2O_5) added in an amount sufficient for complete drying, and the mixture was further refluxed for 3 h.

Recrystallization of N-bromosuccinimide (NBS) was carried out as follows. NBS (20.0 g) and deionized water were added to a 0.5 L Erlenmeyer flask to a final volume of 290 mL, and the mixture was heated in a water bath at 70-80 °C until complete dissolution. The resulting orange solution was allowed to stand at room temperature for 24 h, during which a crystalline solid precipitated. The solid was collected by vacuum filtration, washed several times with deionized water, and dried in an oven at 120 °C for 3 h. The dry material was then transferred to a light-protected bottle and stored in a desiccator.

According to the procedure described by Bandgar and co-workers (2004), and as outlined in the reaction mechanism shown in Figure 1, amidation reactions were carried out as follows. One equivalent of DI (40.0 mg) and two equivalents of triphenylphosphine (Ph_3P , 69.9 mg) were dissolved in 2 mL of DCM, and the mixture was cooled to 0-5 °C under stirring. Subsequently, 2.5 equivalents of N-bromosuccinimide (NBS, 59.3 mg) were added, and the reaction was stirred for 15 min. After this period, 4-5 equivalents of the corresponding amine were added, while maintaining the same temperature and continuous stirring.

Figure 2

Proposed scheme for amidation reaction using dehydroabietic acid, amine, triphenylphosphine and N-bromosuccinimide (Bandgar et al., 2004).



In all cases where a greater amount of product was required, the procedures for its preparation and purification were repeated as originally described. After each reaction, the mixture was concentrated by solvent evaporation, and the crude product was stored in a freezer prior to purification by classical column chromatography. Our research group proposed in this sense a synthesis of eight DI-amide-derivatives, follow the reactions performed are described in according to Figure 3 and Table 2

Figure 3

Scheme of the amidation reaction of dehydroabietic acid

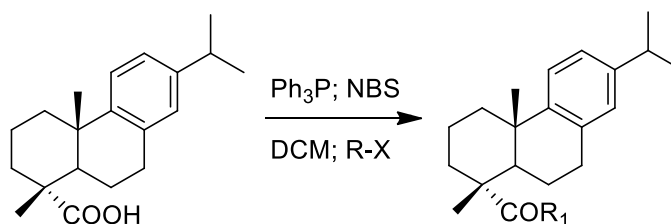


Table 2

Amidation reactions carried out with dehydroabietic acid

Reaction	Reagent (R-X)	Ramification (R ₁)	Reaction time (min)
1	Cyclohexylamine	C ₆ H ₁₁ N	11
2	3-amino-1-propanol	C ₃ H ₈ NO	45
3	<i>p</i> -anisidine	C ₇ H ₈ NO	9
4	Terc-butylamine	C ₄ H ₁₀ N	25
5	Isopropylamine	C ₃ H ₈ N	8
6	Aniline	C ₆ H ₆ N	9
7	Methyl piperazine	C ₅ H ₁₁ N ₂	9
8	Pyrrolidine	C ₄ H ₈ N	8

3 RESULTS

3.1 PRODUCTS OBTAINED FROM DEHYDROABIETIC ACID.

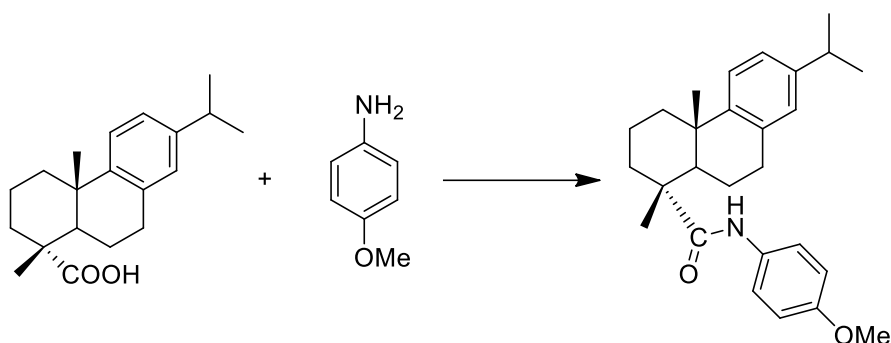
The dehydroabietic acid (DI) isolated from *Pinus elliottii* resin was subjected to structural modification at the hydroxyl region of the carboxylic acid group through reactions with different amines, leading to amidation. This process afforded four new amide derivatives, enabling comparative evaluation of their structural features relative to DI, which served as the starting material in each reaction. The ¹H NMR spectra of the products were recorded, and the signals were assigned and compared with those of the parent DI spectrum to confirm the proposed structural changes. Data for three of the obtained derivatives are presented below, with selected signals highlighted to illustrate the modifications introduced in each structure.

3.1.1 Identification of reaction product 3 (D1)

The identification of the product obtained was confirmed by ^1H NMR spectrum of the reaction 3 (Figure 4). Product data obtained: F.M. = $\text{C}_{27}\text{H}_{35}\text{NO}_2$ and M.M. = $405.27 \text{ g mol}^{-1}$.

Figure 4

Reaction of dehydroabietic acid with p-anisidine



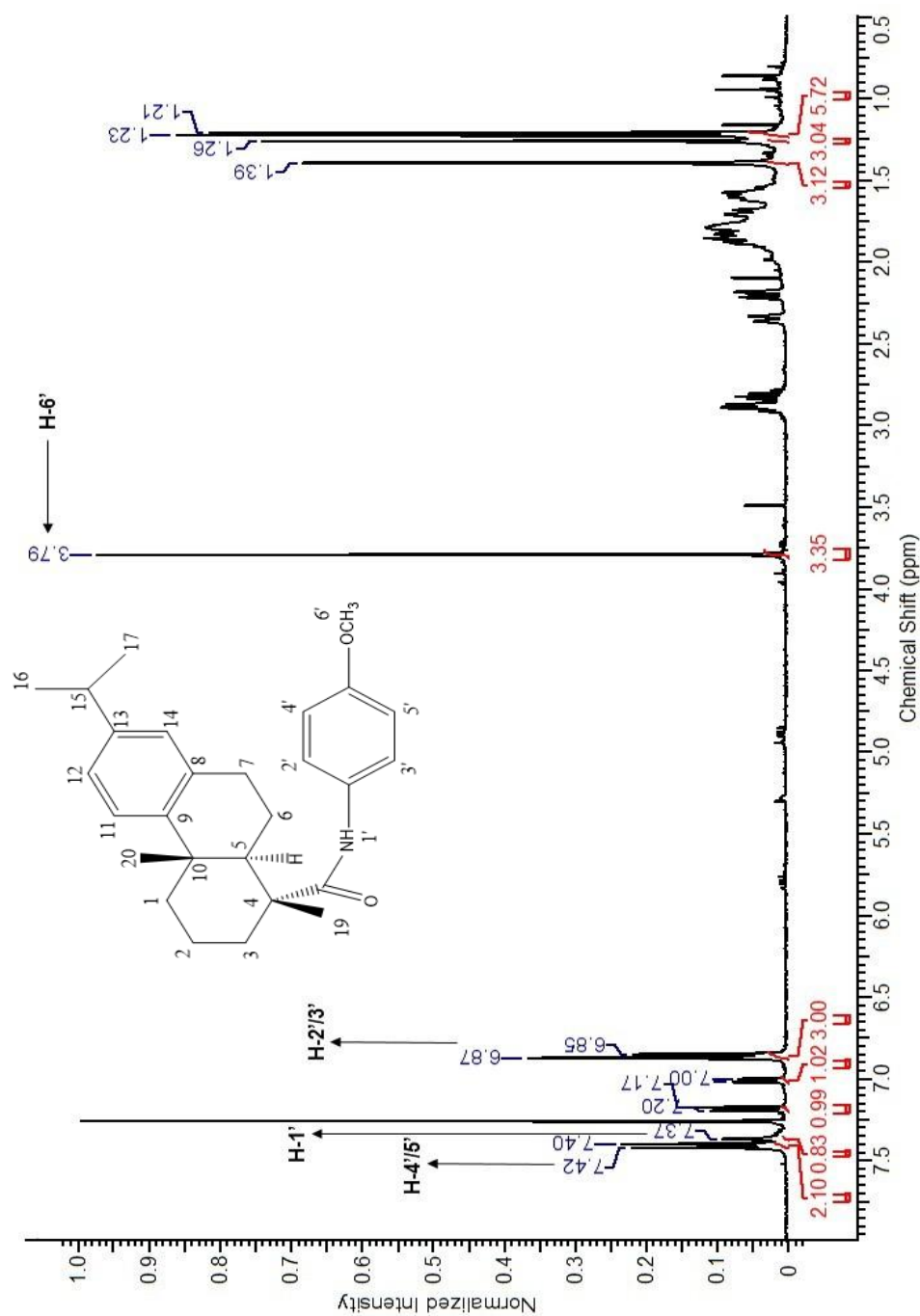
The ^1H NMR spectrum shown in Figure 5, in addition to the characteristic signals of DI, displays a new singlet at δ 3.79 ppm with an integral corresponding to 3H, attributable to the hydrogens of a methoxy group. This signal is consistent with the expected chemical shift for a methyl group bound to an ether oxygen, typically observed between δ 3.00 and 4.00 ppm. The signals obtained in the spectrum of Figure 4, in addition to the characteristic signs of DI, clearly show us the presence of a signal that differentiates it from the starting material, corresponding to a singlet with δ of 3.79 ppm and relative integral for 3H, referring to the hydrogens of the methoxy group. This signal is expected for this structure, since the methyl group bound to the ether group has its region found between δ 3.00 and 4.00 ppm.

A further diagnostic signal appears at δ 7.37 ppm with an integral for 1H, corresponding to a proton directly attached to nitrogen. This resonance agrees with the chemical shift range reported for amide NH hydrogens, usually found between δ 5.00 and 8.00 ppm. In addition, aromatic hydrogens in positions closer to the oxygen atom appear more deshielded, giving a signal at δ 7.41 ppm with an integral 2H.

A second set of aromatic protons, less deshielded and located nearer to the nitrogen atom, is observed at δ 6.86 ppm with an apparent integral for 3H. This higher integral value results from overlap with the H-14 signal of the parent DI, which contributes 1H to this resonance. Comparison with the spectrum of DI and the assignment of these new or shifted signals support that the amidation proceeded as expected.

Figure 5

^1H NMR spectrum of the product obtained from reaction 3, 400 MHz, CDCl_3

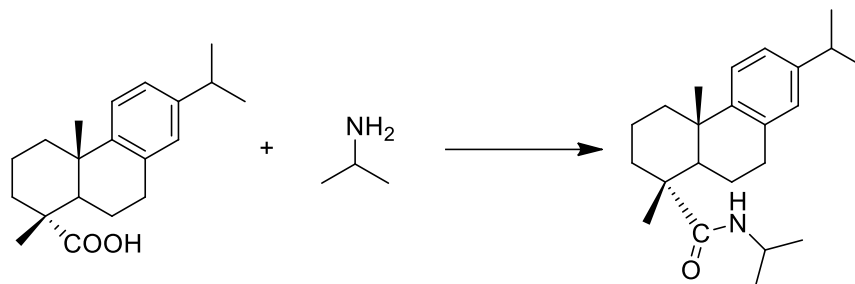


3.1.2 Identification of reaction product 5 (D3)

The identification of the product obtained was confirmed by NMR spectrum of ^1H , shown in Figure 6. Product data obtained: F.M. = $\text{C}_{23}\text{H}_{35}\text{NO}$ and M.M. = $341.27 \text{ g mol}^{-1}$.

Figure 5

Reaction of dehydroabietic acid with isopropyl amine

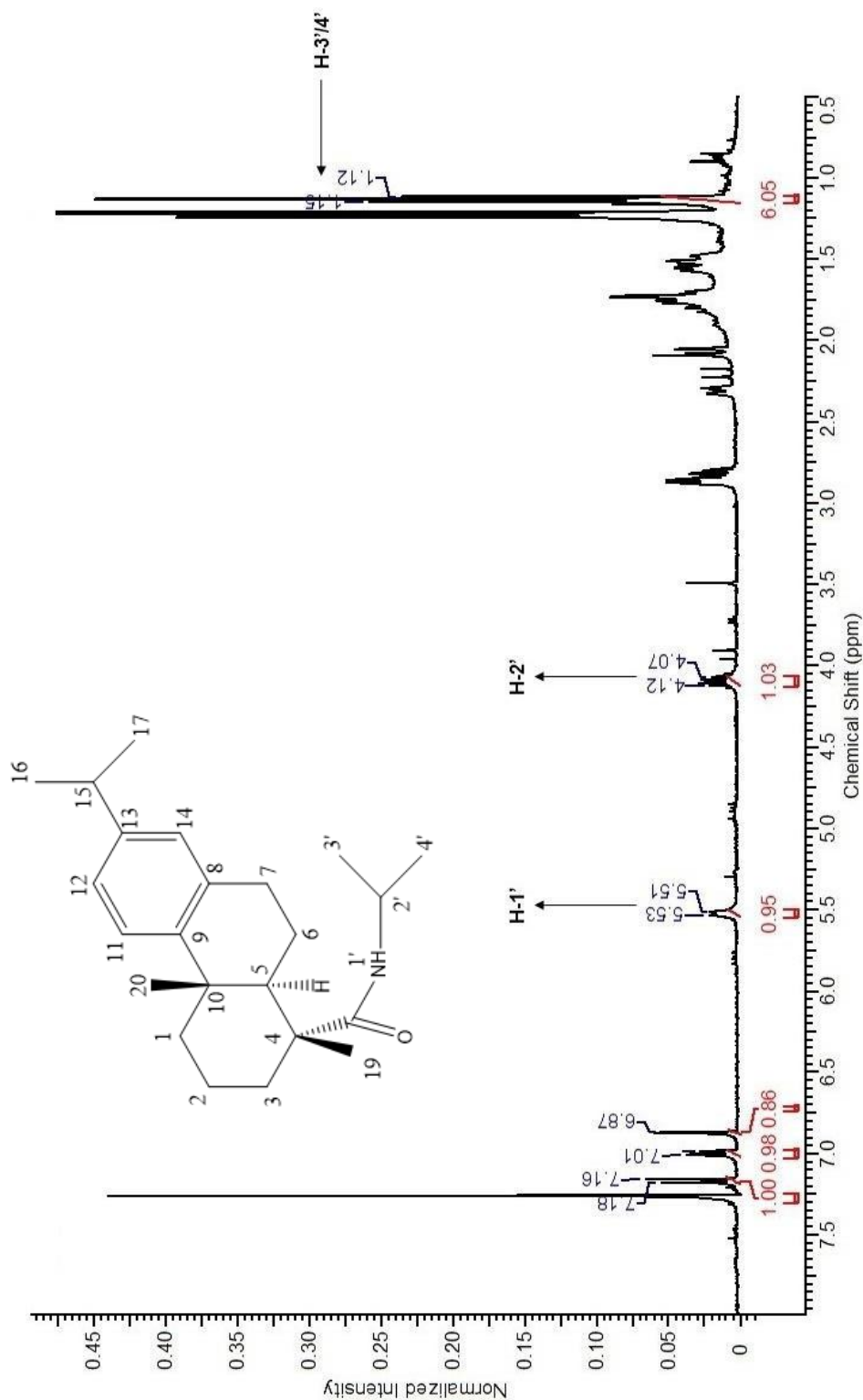


In Figure 7, the signals corresponding to the starting material DI are still observed, including H-11, H-12, and H-14, which appear more downfield due to their aromatic nature. In contrast, a new diagnostic signal (*d*) at δ 5.52 ppm with an integral for 1H is observed, assigned to the proton directly attached to the amide functional group. This resonance is consistent with the expected chemical shift range for amide NH protons and thus confirms the introduction of the amide function in the product

In addition to these signals, the spectrum in Figure 7 also shows a set of upfield resonances in an overlapping region at δ 1.13 ppm with an integral corresponding to 6H, which are attributed to the methyl protons of the product. A further signal at δ 4.10 ppm with an integral for 1H is assigned to the proton attached to the methine carbon of the newly formed fragment. Taken together, the presence of both the characteristic signals of the starting material and the new resonances assigned to the product confirms that the reaction proceeded satisfactorily.

Figure 7

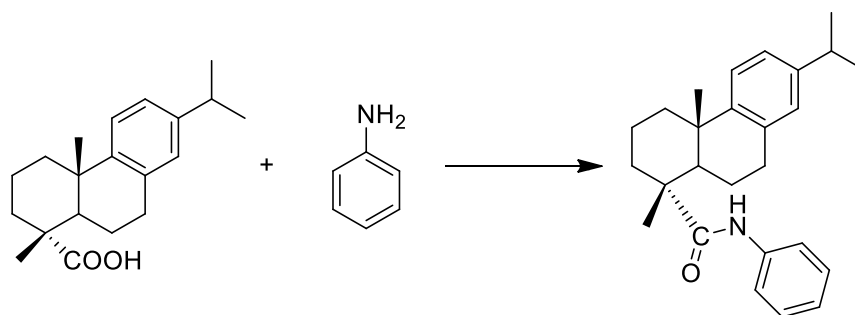
^1H NMR spectrum of the product obtained from reaction 5, 400 MHz, CDCl_3



The identification of product 6 obtained was confirmed by NMR spectrum of ^1H , shown in figure 9. Product data obtained: F.M. = $\text{C}_{26}\text{H}_{33}\text{NO}$ and M.M. = $375.26 \text{ g mol}^{-1}$.

Figure 8

Diagram of the reaction of dehydroabietic acid with aniline



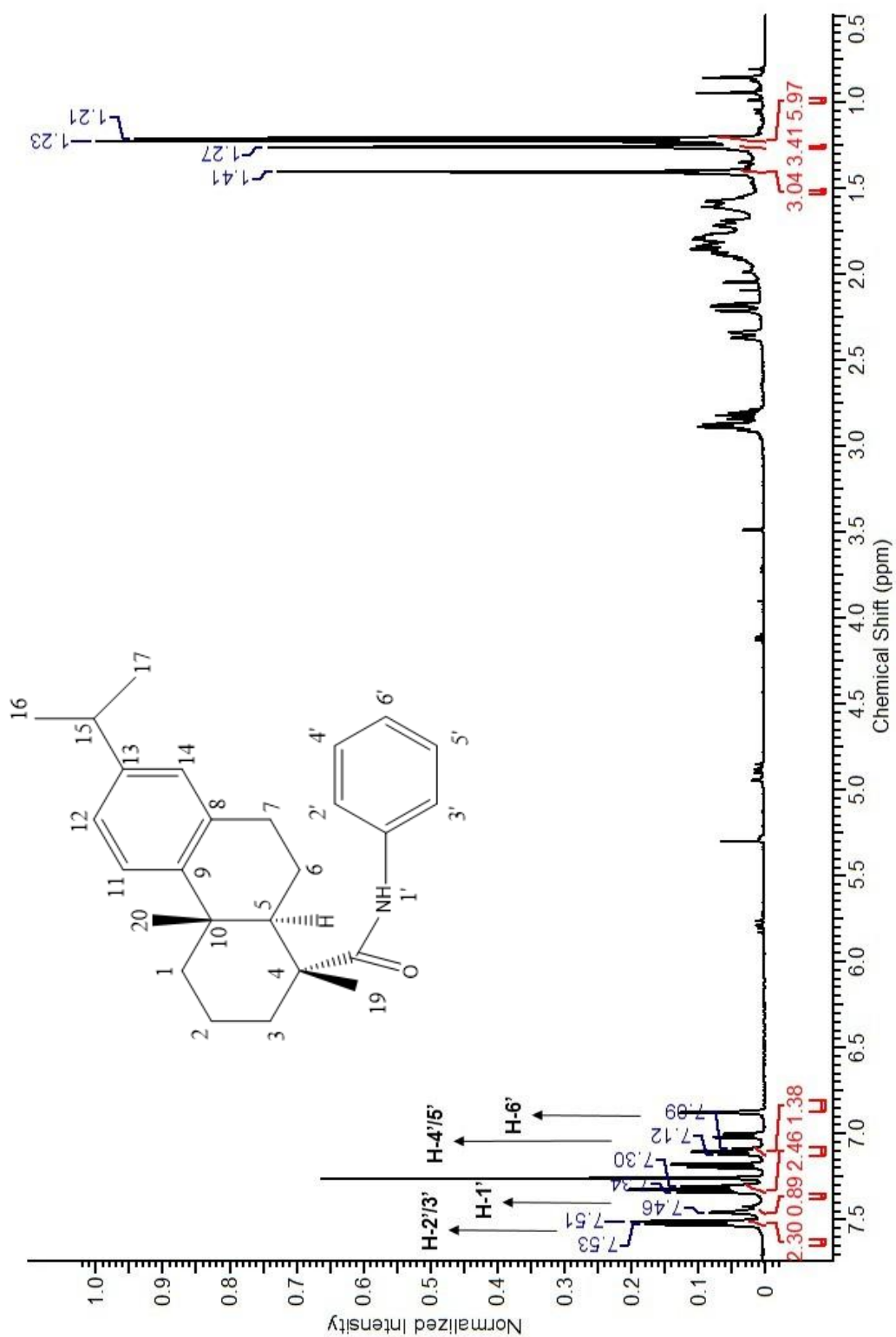
According to the spectrum shown in Figure 9, in addition to the most shielded methyl signals attributable to the starting material, several resonances distinct from those of DI are observed. A double doublet at δ 7.52 ppm with an integral for 2H is assigned to aromatic protons that are more deshielded and located closer to the amide functional group. These hydrogens experience a similar electronic environment and therefore appear as a single signal in the spectrum.

Another signal is observed at δ 7.33 ppm with an integral for 2H, corresponding to aromatic protons that are relatively less deshielded and appear as a single resonance due to their similar chemical environment. In addition, a signal at δ 7.11 ppm with an integral for 1H is attributed to the most shielded aromatic proton in the structure. All these aromatic proton signals fall within the expected chemical shift range for aromatic hydrogens, typically between δ 6.50 and 8.00 ppm, and are fully consistent with the proposed structure.

A singlet at δ 7.46 ppm with an integral corresponding to 1H was also observed and assigned to the proton directly bonded to nitrogen. This signal is consistent with the expected chemical shift range for amide NH protons, typically found between δ 5.00 and 8.00 ppm. Therefore, comparison with the spectrum of the starting material and the presence of these new diagnostic resonances indicate that the reaction proceeded as expected and that the product is distinct from DI.

Figure 9

^1H NMR spectrum of the product obtained from reaction 6, 400 MHz, CDCl_3



3.1.3 Evaluation of Leishmanicidal Activity

The biological activity investigated in this study was the leishmanicidal effect against promastigote forms of *Leishmania (L.) amazonensis*. The assays were carried out in collaboration with the Parasitology Laboratory of the University of Franca, Franca, São Paulo, Brazil. Initially, samples of the crude resin (RP-1), its essential oil (RP-1-EO), and the fixed fraction (RP-1-PF) obtained after essential oil extraction were evaluated. Under the experimental conditions employed, none of these samples exhibited significant leishmanicidal activity, as shown in Table 3.

Table 3

Leishmanicidal activity against promastigote forms of L. (L.) amazonensis and determination of inhibitory concentration values 50% (IC₅₀) in the 24-hour incubation period

% of inhibition of flagellar motility ± D.P.						
Substances	50	25	12.5	6.25	3.12	IC ₅₀ (µg/mL)
RP-1	54.59±0.59	22.97±16.81	28.91±1.52	19.05±0.95	11.62±1.14	>50
RP-1-PF	34.45±0.95	28.51±1.33	17.43±0.57	10.54±0.00	5.81±1.72	>50
RP-1-OE	21.89±0.76	15.54±2.10	8.91±1.47	0.00±0.00	0.00±0.00	>50
RP-1-FR (7:3)	88.78±0.95	84.05±0.00	69.18±1.91	58.51±1.33	50.67±1.33	3.43±0.73
Dehydroabietic acid	88.67±0.66	83.49±0.33	75.94±1.66	57.07±2.01	49.76±1.33	1.05±0.79
Other component	48.10±3.05	35.54±3.24	20.67±3.63	11.89±0.38	0.00±0.00	49.73±1.02
	0.19	0.095	0.047	0.023	0.011	
Amphotericin B	99.88±0.60	78.33±24.43	68.74±21.9	54.67±17.77	42.44±20.9	0.011±0.54
			7		7	

Positive Control: Amphotericin B 1 µg/mL Negative Control: Medium RPMI + 0.1% DMSO

However, after VLC of the resin, several fractions were obtained, and one of them contained the most abundant diterpenes in its composition. This fraction (RP-1-FR 7:3) was therefore considered rich in major diterpenic constituents. Evaluation of the leishmanicidal activity of this fraction yielded a notable result, revealing significant activity of the mixture against promastigote forms of the parasite (IC₅₀ = 3.43 µg/mL). The activity-guided assessment then focused on identifying the component responsible for this effect by testing dehydroabietic acid (DI) and the other, not yet fully identified, constituent of the fraction. Dehydroabietic acid showed a much stronger leishmanicidal effect (IC₅₀ = 1.05 µg/mL) than

the other component ($IC_{50} = 49.73 \mu\text{g/mL}$), supporting the conclusion that dehydroabietic acid is the main compound responsible for the observed activity.

These results reinforce the relevance of pursuing structural modifications of DI with the aim of obtaining derivatives that may display even more pronounced leishmanicidal activity. In this context, derivatives D1 to D4 were evaluated, and their IC_{50} values, expressed in micromolar units as appropriate for pure substances, are presented in Table 4.

Table 4

Leishmanicidal activity against promastigote forms of L. (L.) amazonensis and determination of inhibitory concentration values 50% (IC_{50}) in the 24-hour incubation period

% of inhibition of flagellar motility $\pm$ D.P.						
Substances	50	25	12.5	6.25	3.12	IC_{50} (μM)
Dehydroabietic acid	88.67 $\pm$ 0.66	83.49 $\pm$ 0.33	75.94 $\pm$ 1.66	57.07 $\pm$ 2.01	49.76 $\pm$ 1.33	3.49 $\pm$ 0.79
D1	76.35 $\pm$ 0.19	71.35 $\pm$ 1.52	65.13 $\pm$ 0.38	59.45 $\pm$ 1.14	50.40 $\pm$ 1.72	2.76 $\pm$ 0.41
D2	75.67 $\pm$ 0.76	74.45 $\pm$ 1.72	70.67 $\pm$ 0.57	60.13 $\pm$ 1.33	47.70 $\pm$ 2.10	2.97 $\pm$ 0.48
D3	72.43 $\pm$ 0.76	63.10 $\pm$ 1.33	55.40 $\pm$ 1.14	48.51 $\pm$ 1.33	45.40 $\pm$ 0.76	6.16 $\pm$ 0.40
D4	70.94 $\pm$ 4.01	62.29 $\pm$ 2.10	51.62 $\pm$ 0.77	40.67 $\pm$ 0.57	36.75 $\pm$ 0.38	10.35 $\pm$ 0.54
	0.19	0.095	0.047	0.023	0.011	
Amphotericin B	99.88 $\pm$ 0.60	78.33 $\pm$ 24.43	68.74 $\pm$ 21.97	54.67 $\pm$ 17.77	42.44 $\pm$ 20.97	0.011 $\pm$ 0.54

Positive Control: Amphotericin B 1 $\mu\text{g/mL}$ Negative Control: RPMI medium + 0.1% DMSO

The results obtained were promising, as all derivatives exhibited activity against the promastigote forms of the parasite. In addition, two of these derivatives were even more active than the precursor, dehydroabietic acid, which was the most active component of the resin. The next step in the search for bioactive compounds will be to evaluate the cytotoxicity of the natural products and the semi-synthetic derivatives.

4 CONCLUSION AND PERSPECTIVES

This chapter provides evidence that *Pinus* oleoresin is a valuable source of abietane-type diterpenes with leishmanicidal potential, particularly dehydroabietic acid and its semi-synthetic amide derivatives. Fractionation of the crude resin enabled the identification of a diterpene-enriched fraction (RP-1-FR 7:3) with significant activity against promastigote forms of *Leishmania* (*L.*) *amazonensis*, and subsequent assays identified dehydroabietic

acid as the principal bioactive component of this mixture. These findings align with the growing body of literature indicating that terpenoids and other plant-derived metabolites represent promising scaffolds for the discovery of new antileishmanial agents, particularly in the context of neglected tropical diseases. In addition, the successful application of a simple amidation protocol underscores the value of dehydroabietic acid as a synthetic platform for structural diversification and increasing antiparasitic activity.

Leishmanicidal profile observed for DI and derivatives D1–D4 underscores the importance of continued structure–activity relationship studies aimed at improving potency and selectivity, especially through rational modifications of the abietane skeleton and systematic evaluation against both promastigote and amastigote forms. Future investigations should prioritize cytotoxicity assays, determination of selectivity index, and mechanistic studies to elucidate cellular targets and pathways involved in parasite death, thereby meeting current criteria for early-stage drug discovery in leishmaniasis. Moreover, *in vivo* assessments, exploration of alternative formulations, and integration with contemporary approaches such as *in silico* modeling may facilitate the progression of these derivatives from promising hits to preclinical candidates, contributing to the development of safer and more effective therapies derived from natural products.

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UNVEILING PINE RESIN CHEMISTRY
DESVENDANDO A QUÍMICA DA RESINA DE PINHEIRO
REVELANDO LA QUÍMICA DE LA RESINA DE PINO

 <https://doi.org/10.56238/sevened2025.036-145>

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ABSTRACT

Pine resins, mostly the ones provided by *Pinus elliottii*, are known to present interesting activities in biological systems and are commonly treated as promising source of active compounds. Due to our interest in Natural Product chemistry and in diterpenes, also known to be pine resins components, we developed this work about the chemical composition of those resins. The essential oil composition showed the presence mostly of α - and β -pinene, α -phelandrene and α -cimene. The non-volatile fractions showed dehydroabietic acid as the primary component and revealed other abietane diterpenes were less abundant. This study revealed that these resins are surely good sources of dehydroabietic acid for further chemical studies with this natural product.

Keywords: *Pinus elliottii*. Pine Resins. Diterpenes. Chemical Composition. Monoterpenes.

RESUMO

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As resinas de pinheiro, principalmente aquelas provenientes de *Pinus elliottii*, são conhecidas por apresentar atividades interessantes em sistemas biológicos e são comumente tratadas como fontes promissoras de compostos ativos. Em função do nosso interesse na Química de Produtos Naturais e nos diterpenos, também conhecidos como componentes das resinas de pinheiro, desenvolvemos este trabalho sobre a composição química dessas resinas. A composição do óleo essencial mostrou predominantemente a presença de α - e β -pineno, β -felandreno e p-cimeno. As frações não voláteis apresentaram o ácido desidroabiético como componente principal e revelaram que outros diterpenos do tipo abietano estão presentes em menor abundância. Este estudo demonstrou que essas resinas são, de fato, boas fontes de ácido desidroabiético para futuros estudos químicos com esse produto natural.

Palavras-chave: *Pinus elliottii*. Resinas de Pinheiro. Diterpenos. Composição Química. Monoterpenos.

RESUMEN

Las resinas de pino, principalmente las provenientes de *Pinus elliottii*, son conocidas por presentar actividades interesantes en sistemas biológicos y son comúnmente consideradas como fuentes prometedoras de compuestos activos. Debido a nuestro interés en la Química de Productos Naturales y en los diterpenos, también conocidos como componentes de las resinas de pino, desarrollamos este trabajo sobre la composición química de dichas resinas. La composición del aceite esencial mostró predominantemente la presencia de α - y β -pineno, β -felandreno y p-cimeno. Las fracciones no volátiles presentaron al ácido deshidroabiético como componente principal y revelaron que otros diterpenos del tipo abietano se encuentran en menor abundancia. Este estudio demostró que estas resinas son, sin duda, buenas fuentes de ácido deshidroabiético para futuros estudios químicos con este producto natural.

Palabras clave: *Pinus elliottii*. Resinas de Pino. Diterpenos. Composición Química. Monoterpenos.

1 ABOUT PINE RESINS

Pinus is a coniferous genus in the family Pinaceae, characterized by rapid growth, tolerance to low temperatures, and the ability to develop in nutrient-poor soils (Figure 1) (Correa *et al.*, 2018). In general, species of this genus are widely distributed and occur in several countries, including China, the United States, and India, while in Brazil they are predominantly found in subtropical regions (Gonçalves *et al.*, 2018).

Figure 1

Conifer of the genus Pinus



Source: <http://www.mundoreal.xyz/arvores-brasileira-o-pinus-elliottii/grande-pinus-elliottii/>

A notable feature of *Pinus* species is the production of a resin, a viscous yellow to brown liquid with a strong odor (Figure 2). This exudate comprises a volatile fraction, known as turpentine, which contains monoterpenes and sesquiterpenes, and a non-volatile fraction, commonly referred to as resin or pitch, in which diterpenes are predominant. Upon attack by pathogens or herbivores, these trees activate a chemical defense mechanism based on the secretion of this resin, which contributes to inhibiting or limiting the action of invaders through a diverse repertoire of specialized metabolites (Keeling; Bohmann, 2006).

Figure 2

Pinus resin collection

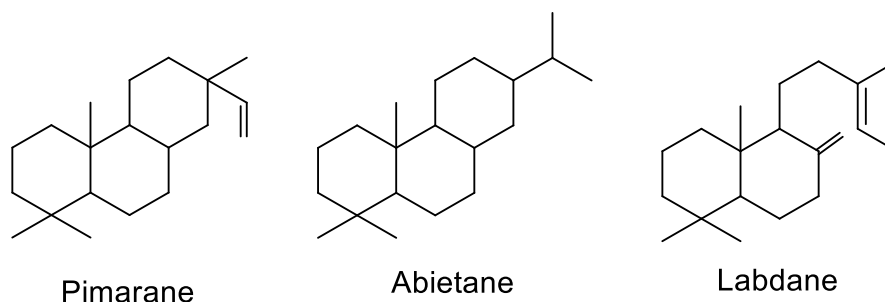


Source: <https://tecflora.com.br/2018/03/23/resinagem-revista-campo-e-negocios/>

Several phytochemical studies have reported that *Pinus* resins contain a mixture of monoterpenes, tricyclic diterpenic acids, mainly from the abietane and pimarane classes, and bicyclic diterpenes from related structural classes, as illustrated in Figure 3. In some cases, sesquiterpenes are also detected among the resin constituents (Rezzi *et al.*, 2002; Silva *et al.*, 2014). Among the diterpenes obtained from *Pinus* genus, dehydroabietic acid is one of main substances due to its promising antibacterial, insecticidal, antifungal, anti-aging, antiprotozoal, and anti-inflammatory properties (Soares *et al.*, 2019; Berger *et al.*, 2017; Fonseca *et al.*, 2004; Gao *et al.*, 2015; Kim *et al.*, 2015; Dembitsky *et al.*, 2021). It is a tricyclic aromatic diterpenoid characterized by three fused rings, three chiral carbon centers, and a reactive carboxylic acid functional group (Lv *et al.*, 2025).

Figure 3

Main chemical skeletons found in isolated diterpenes of the genus Pinus



Pinus resins constitute a valuable source of natural products with diverse applications and significant economic relevance. They are employed in cosmetic fragrances, as flavoring additives in foods, and as intermediates in the synthesis of fragrance chemicals, among other industrial uses (Leandro *et al.*, 2014).

In addition, *Pinus* resins exhibit a broad spectrum of biological activities, including anti-inflammatory and antifungal effects (Boeck *et al.*, 2005), as well as antimicrobial (Tanaka *et al.*, 2008; Fallarelo *et al.*, 2013) and anti-allergic properties (Gonçalves *et al.*, 2018). Considering the structural diversity of diterpenes present in these resins and this documented bioactivity profile, *Pinus* resins represent a promising source of potentially active compounds that may play an important role in this study, particularly in the search for molecules with relevant biological properties.

3 EXTRACTION AND PURIFICATION OF *Pinus* RESIN CHEMICALS

3.1 PLANT MATERIAL AND EXPERIMENTAL ANALYSES

Several methods have been described in the literature for the isolation of metabolites from *Pinus* resins. In the following sections of this chapter, the logical sequence and the results obtained by our research group in studies of *Pinus* oleoresins will be presented. Some *Pinus* resin sources are available from commercial suppliers. In Brazil, these resins can be obtained from the company Tecflora, which provides material from different *Pinus* species, such as:

1. *Pinus elliotti* from Buri, São Paulo-SP;
2. *Pinus caribaea* x *Pinus elliotti*, from Buri, São Paulo-SP;
3. *Pinus caribaeai*, from Cajuri, Minas Gerais-MG.

The metabolites were separated using vacuum liquid chromatography (VLC) and classical column chromatography (CCC) in glass columns, depending on the amount of sample available, employing silica gel 60, 70–230 mesh (0.063–0.200 mm), and silica gel 60H, 70–230 mesh (0.040–0.063 mm) (Merck®) as stationary phases. The ^1H nuclear magnetic resonance (NMR) spectra were acquired on a Bruker® AVANCE DRX 400 spectrometer operating at 400 MHz. All experiments were conducted in the Department of Chemistry of the Faculty of Sciences, Philosophy and Letters of Ribeirão Preto, at University of São Paulo (USP).

The identification methods included irradiation under ultraviolet (UV) light and comparative thin-layer chromatography (TLC) on Merck® aluminum plates coated with silica gel 60 GF254 (0.25 mm), with visualization using vanillin sulfuric acid reagent followed by heating. High-performance liquid chromatography (HPLC) analyses were performed on a Shimadzu Prominence system (CBM-20A/LC-6AD) equipped with a manual injector, DGU-20A5 degasser, SPD-20A diode array detector (DAD), and a microcomputer running LCsolution software for data acquisition and processing. The chromatographic separations were carried out on a Shimadzu C18 reversed-phase column (4.6 mm $\times$ 250 mm, 5 μm) with a 20 μL injection loop, using acetonitrile/water (ACN/ H_2O , 9:1) as the mobile phase at a flow rate of 1.0 mL min^{-1} . HPLC analyses employed HPLC-grade reagents from J. T. Baker® and ultrapure water obtained from a Milli-Q® system. The solvents used for isolation, purification, and as reaction media were ethyl acetate (EtOAc), hexane (Hex), dichloromethane (DCM), methanol (MeOH), and ethanol (EtOH), all analytical grade (P.A.).

3.2 COMPARATIVE STUDY OF *PINUS* RESINS BY HPLC

The resins were coded as follows: RP-1 (resin from sample 1), RP-2 (resin from sample 2), and RP-3 (resin from sample 3). These resins consist of a white solid mass impregnated with a light-yellow oily fraction. Samples from the three *Pinus* resins were analyzed by HPLC to identify and compare their major constituents in both the oily fraction and the solid mass; notably, RP-3, being a highly dry resin, lacked the oily fraction. Thus, the solid masses and oily fractions described below were evaluated.

- Resin 1 (mass): RP-1M; Resin 1 (oil): RP-1O.
- Resin 2 (mass): RP-2M; Resin 2 (oil): RP-2O.
- Resin 3 (mass): RP-3M; (does not contain the "oil" part).

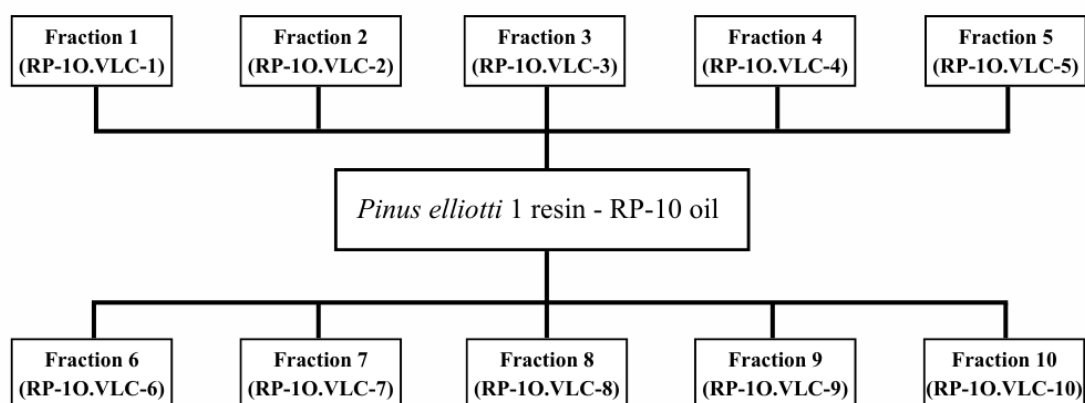
3.3 ISOLATION AND PURIFICATION OF DEHYDROABIETIC ACID (DI) FROM *PINUS ELLIOTTII* RESIN

The fractionation of RP-10 was done by VLC. In this case, it was carried out only with the "oil" part and the following fractions were generated, which were thus coded, as shown in figure 4.

- Fraction 1 - Hex: RP-10.
- Fraction 2 - 9:1 (Hex/EtOAc): RP-10.
- Fraction 3 - 8:2 (Hex/EtOAc): RP-10.
- Fraction 4 - 7:3 (Hex/EtOAc): RP-10.
- Fraction 5 - 6:4 (Hex/EtOAc): RP-10.
- Fraction 6 - 1:1 (Hex/EtOAc): RP-10.CLV-6.
- Fraction 7 - 4:6 (Hex/EtOAc): RP-10.
- Fraction 8 - 3:7 (Hex/EtOAc): RP-10.
- Fraction 9 - EtOAc: RP-1. LVC -9.
- Fraction 10 - EtOH: RP-10. LVC -10.

Figure 4

Flowchart of the coding of fractions obtained by VLC from Pinus elliottii resin



The isolation and purification of the chemical constituents from *Pinus elliottii* resin were performed starting from 50.0 g of crude material. The procedure began with a VLC separation (Pelletier *et al.*, 1986), using 240.0 g of silica gel 60 and 240.0 g of silica gel 60H as stationary phases. The column was packed under vacuum with hexane as the initial solvent, and the sample was adsorbed onto 77.6 g of silica gel 60 prior to loading. During

the chromatographic run, ten fractions were collected, using an elution gradient of increasing polarity as summarized in Table 1.

Table 1

Elution scheme used in RP-10 fractionation

Solvent used	Volume collected (mL)	Fraction	Mass obtained (g)
Hex	500	RP-10.VLC-10.018	
Hex/EtOAc 9:1	500	RP-10.VLC-20.720	
Hex/EtOAc 8:2	500	RP-10.VLC-30.960	
Hex/EtOAc 7:3	500	RP-10.VLC-441.450	
Hex/EtOAc 6:4	500	RP-10.VLC-50.550	
Hex/EtOAc 1:1	500	RP-10.VLC-61.430	
Hex/EtOAc 4:6	500	RP-10.VLC-72.000	
Hex/EtOAc 3:7	500	RP-10.VLC-80.990	
EtOAc	500	RP-10.VLC-90.460	
EtOH	500	RP-10.VLC-100.340	

Hex: hexane; EtOAc: ethyl acetate; EtOH: ethanol

All fractions obtained from this procedure were analyzed through CTLC using as mobile phase a mixture of Hex/EtOAc (8:2). In this analysis, it was possible to observe that the fractions RP-10.CLV-3 and RP-10.CLV-4 had a similar chemical profile and therefore were selected to continue the isolation.

3.4 FRACTION RP-10.VLC-3

With a portion of this fraction (0.96 g), a CCC separation was carried out using 25.0 g of silica gel 60 and 1.0 g of silica gel 60H, with a mixture of hexane/ethyl acetate (8.5:1.5) as the mobile phase. A total of 64 subfractions were collected, and the elution scheme followed that shown in Table 2.

Table 2

Elution scheme used in the fractionation RP-1O.VLC-3

Fraction	Mass obtained (mg)
RP-1O.VLC-3 (6-11)	41.4
RP-1O.VLC-3 (12)	6.6
RP-1O.VLC-3 (13-14)	190.4
RP-1O.VLC-3 (15-18)	207.0
RP-1O.VLC-3 (19-25)	111.1
RP-1O.VLC-3 (26-40)	5.1
RP-1O.VLC-3 (41-63)	17.9
MeOH	375.2

MeOH: methanol

All subfractions were pooled and analyzed by CTLC using a mixture of hexane/ethyl acetate (8:2) as the mobile phase. Analysis of the chromatographic profile indicated that subfraction RP-1O.VLC-3 (19–25) contained a major spot. This substance was labeled DI (111.1 mg) (Figure 5), and its chemical structure was elucidated by ¹H NMR spectroscopy and compared with data reported in the literature.

3.5 Fraction RP-1.VLC-4

With a part of this fraction (5.0 g), a VLC was performed again using 150.0 g of silica gel 60H as the stationary phase, and the column was packed under vacuum with hexane, with the sample adsorbed onto 11.0 g of silica gel 60. A total of ten fractions were collected, and the elution scheme with an increasing polarity gradient followed that shown in Table 3.

Table 3

Elution scheme used in the fractionation RP-1O.VLC-4

Solvent used	Volume collected (mL)	Fraction	Mass obtained (g)
Hex	250	RP-1O.VLC-4 (1)	0.0028
Hex/EtOAc (97:3)	250	RP-1O.VLC-4 (2)	0.0044
Hex/EtOAc (47:3)	250	RP-1O.VLC-4 (3)	0.0013

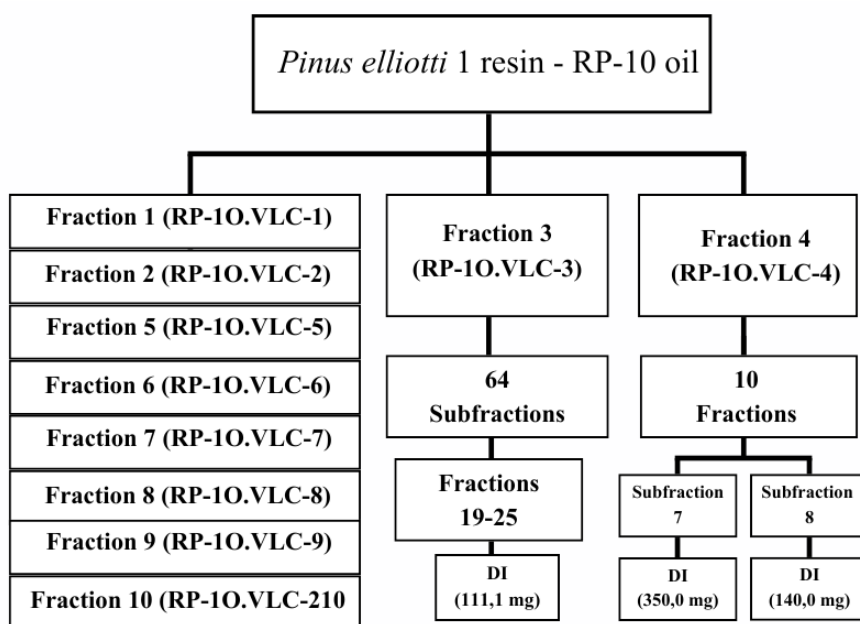
Hex/EtOAc (91:9)	250	RP-10.VLC-4 (4)	1.1900
Hex/EtOAc (22:3)	250	RP-10.VLC-4 (5)	1.9300
Hex/EtOAc (17:3)	250	RP-10.VLC-4 (6)	0.9200
Hex/EtOAc (41:9)	250	RP-10.VLC-4 (7)	0.3500
Hex/EtOAc (4:1)	250	RP-10.VLC-4 (8)	0.1400
EtOAc	250	RP-10.VLC-4 (9)	0.6800
MeOH	250	RP-10.VLC-4 (10)	0.4600

Hex: hexane; EtOAc: ethyl acetate; MeOH: ethanol

All fractions were analyzed by CTLC using a mixture of hexane/ethyl acetate (8.5:1.5) as the mobile phase. Analysis of the chromatographic profiles showed that subfractions RP-10.VLC-4 (7) and RP-10.VLC-4 (8) exhibited a major spot with a similar chemical profile. This substance was designated DI (490.0 mg) (Figure 5), and its chemical structure was elucidated by ^1H NMR spectroscopy and compared with data reported in the literature.

Figure 5

Flowchart of the isolation and purification of dehydroabietic acid from *Pinus elliottii* resin



4 RESULTS

4.1 COMPARATIVE STUDY OF *PINUS* RESINS

4.1.1 Comparison of chromatograms obtained by HPLC

Samples from the three *Pinus* resins were subjected to HPLC analysis (Figures 6–10) to compare their main constituents in both the more solid portion of the resin (“mass”, M) and the more liquid portion (“oil”, O). Resin 3 (RP-3) did not exhibit a significant liquid fraction.

Figure 6

Chromatogram obtained by HPLC at $\lambda = 201\text{nm}$ of the fraction RP-1M

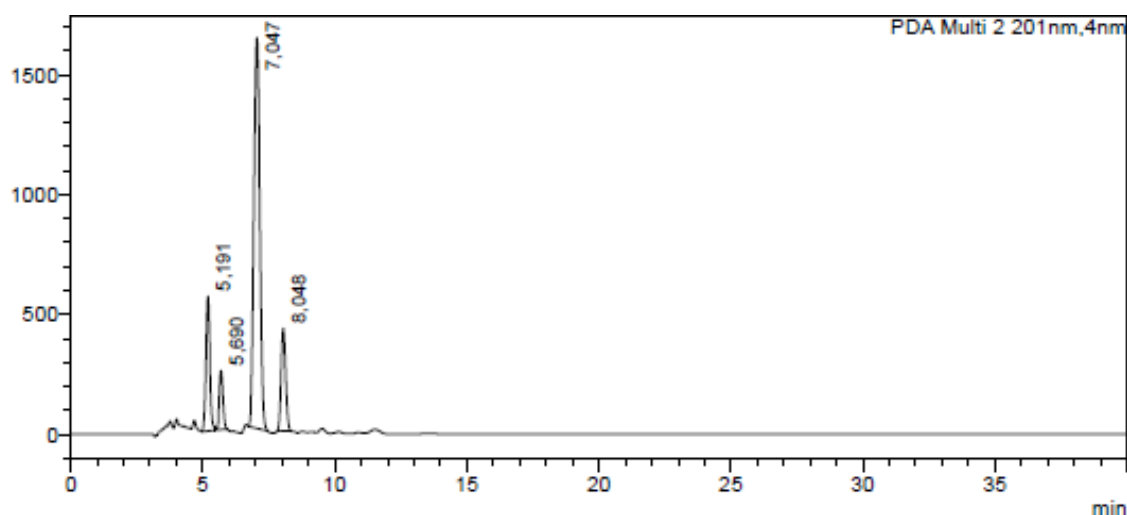


Figure 7

Chromatogram obtained by HPLC at $\lambda = 201\text{nm}$ of the RP-1O fraction

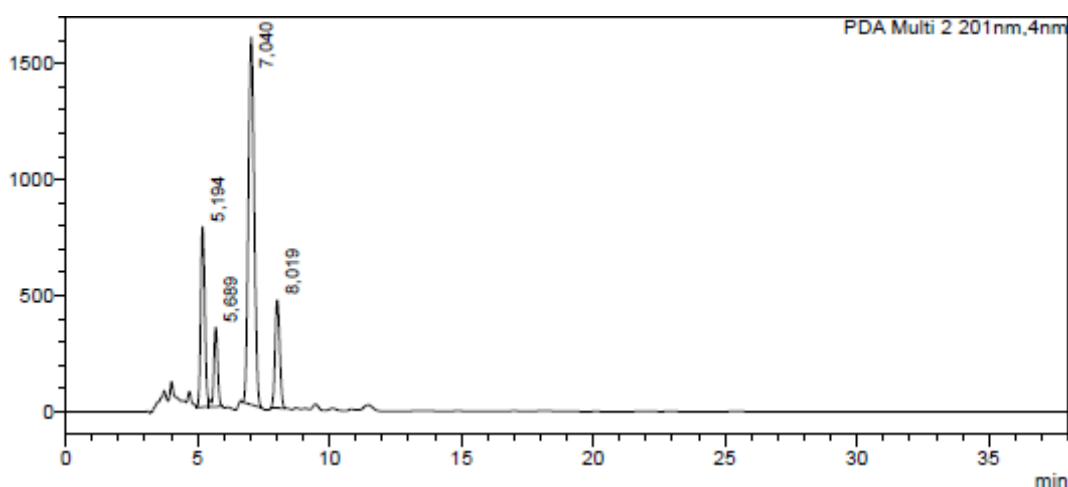


Figure 8

Chromatogram obtained by HPLC at $\lambda = 201\text{nm}$ of the fraction RP-2M

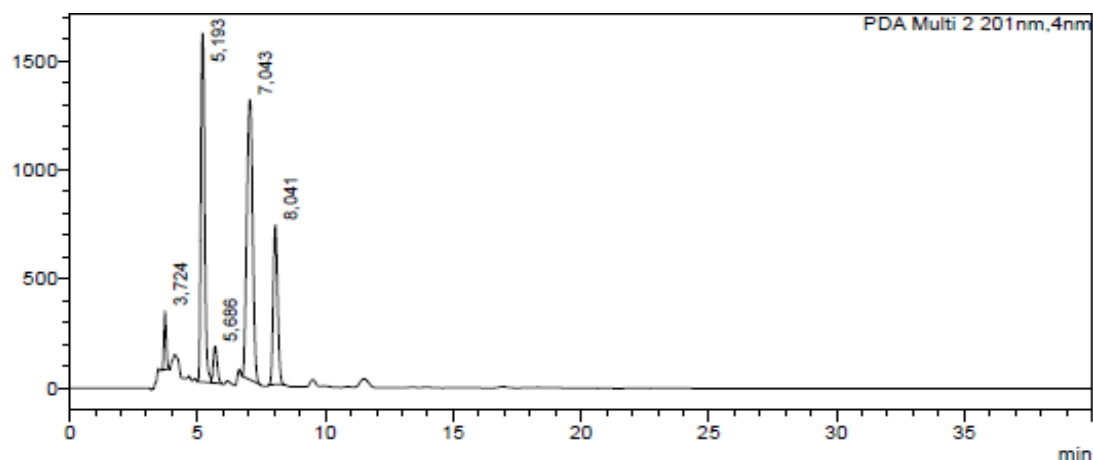


Figure 9

Chromatogram obtained by HPLC at $\lambda = 201\text{nm}$ of the RP-2O fraction

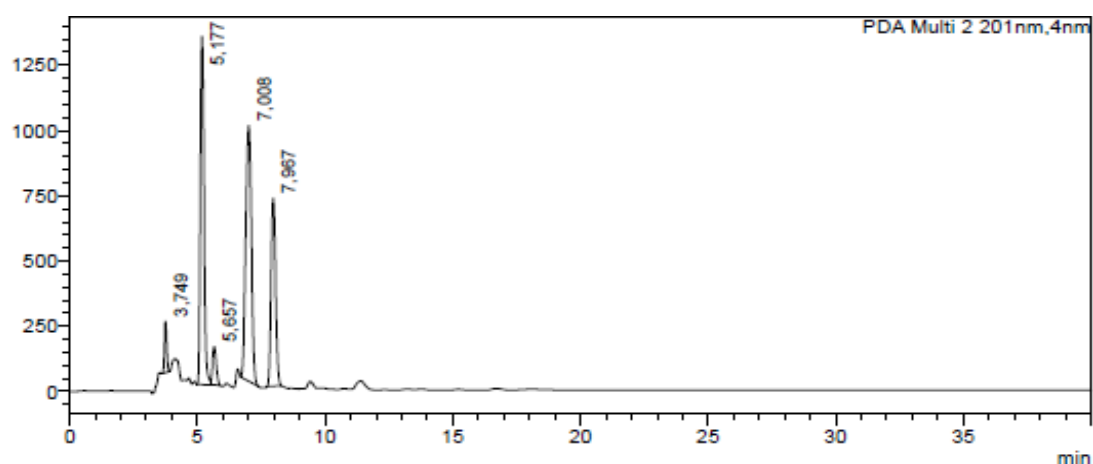
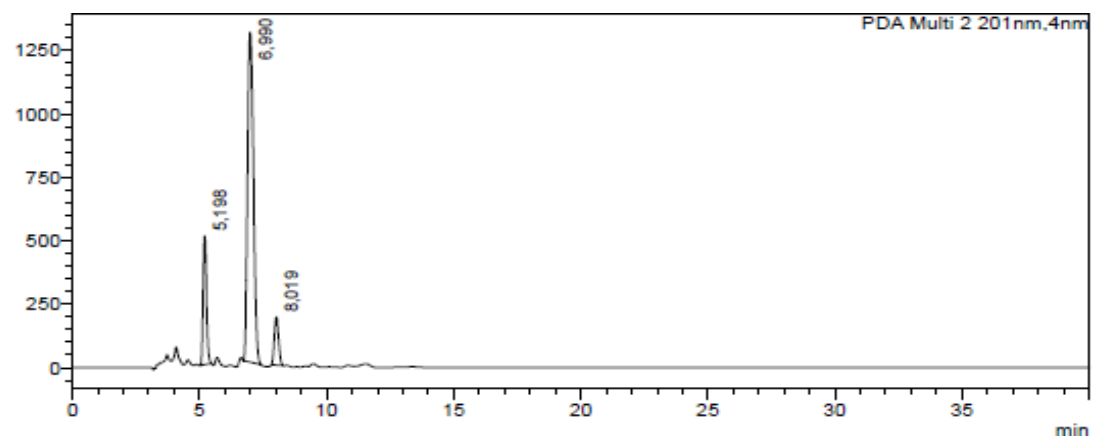


Figure 10

Chromatogram obtained by HPLC at $\lambda = 201\text{nm}$ of the fraction RP-3M



The first conclusion that can be drawn from this analysis is that there is no significant difference between the “mass” and “oil” portions of the same resin. The chromatographic profiles of RP-1M and RP-1O are practically identical, as are those of RP-2M and RP-2O. Therefore, separating and using the “mass” and “oil” portions independently does not provide any analytical advantage.

Notable differences were observed among resins 1, 2, and 3. Although peaks at retention times of 5.2 min, 7.0 min, and 8.0 min were present in all chromatograms, their relative intensities varied across the resins, indicating compositional differences. For example, the peak at 5.2 min predominated in resin 2 but not in resins 1 and 3, which featured the 7.0 min peak as their major component; resin 3 exhibited an even simpler profile, with only two additional minor components.

4.1.2 Comparison of the essential oils of each resin

Essential oils were also obtained from the same samples analyzed by HPLC in the previous section, namely RP-1M, RP-1O, RP-2M, RP-2O, and RP-3M. The first parameter evaluated was the yield of each extraction process, as summarized in Table 4.

Table 4

Yields of the processes for obtaining essential oils

Sample of <i>Pinus</i>	Mass used (g)	Mass of essential oil (g)	Yield (%)
RP-1M	34.519	4.0989	11.9
RP-1O	21.7038	3.7303	17.2
RP-2M	34.4530	4.1226	12.0
RP-2O	23.5235	4.9997	21.3
RP-3M	24.5657	1.6279	6.6

The portions designated as “oils” afforded higher yields than the corresponding “mass” portions. Both RP-1M and RP-2M provided approximately 12% essential oil, whereas RP-1O and RP-2O gave yields between 17% and 21%, and RP-3M, which was much drier than the others, afforded a lower yield of 6.6% essential oil.

The oils were subsequently analyzed by gas chromatography coupled to mass spectrometry (GC–MS). In this technique, the oil components are first separated by gas chromatography and then introduced into the mass spectrometer, where they are fragmented; the resulting mass spectra are compared with an instrument library that assigns the identity of each component based on similarity of fragmentation patterns, which is well established for many monoterpenes commonly found in essential oils.

For each oil, a table of identified components was constructed, including the percentage peak area of each signal in the chromatogram. The peak area is proportional to the relative amount of each constituent and can be used for comparative evaluation of the compositions, which are complex; therefore, the discussion focuses on the major components listed in Table 5. The main components tabulated have their structures depicted on Figure 11.

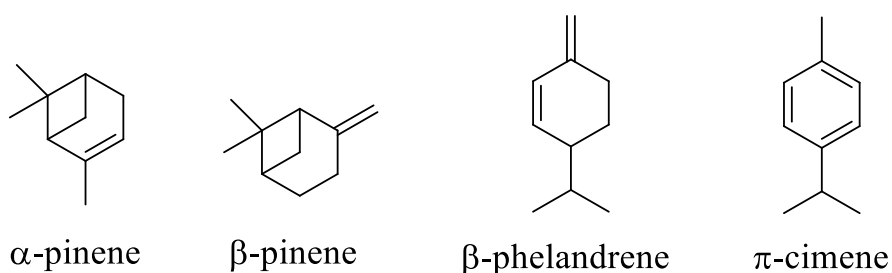
Table 5

Simplified composition of essential oils - percentage of comparison of peak areas in CG-MS analysis

Sample	α -pinene	β -pinene	β -phellandrene	p -cimene
RP-1M	51.2	30.2	5.8	6.2
RP-1O	46.7	30.0	6.3	7.1
RP-2M	66.5	20.2	9.3	----
RP-2O	50.4	28.8	12.6	----
RP-3M	73.9	4.9	16.5	----

Figure 11

Structures of the main components of essential oils



As expected for *Pinus* resins, the main component in all samples is α -pinene, with β -pinene occurring as the second most abundant constituent in all cases except resin 3. β -phellandrene, which is generally the third most abundant component, becomes the second major constituent in resin 3, representing the main distinguishing feature of this species (*caribaeae*). The distinguishing characteristic of *P. elliotii* is the presence of *p*-cymene, which was not identified in any of the other samples, whereas the hybrid (*elliotii* $\times$ *caribaeae*) exhibits feature of both parents: it lacks *p*-cymene, as in *caribaeae*, but shows an α and β -pinene ratio like that of *elliotii*.

These compositional differences suggest that there may be meaningful variation in the biological activity of both the resins and their essential oils, and that such variation can be exploited to obtain different major constituents for studies on natural diterpene derivatives. Consequently, resin 1 was selected for further investigation, as its composition has already been partially described in the literature.

4.2 ^1H NMR ANALYSIS OF THE ISOLATED SUBSTANCE

According to the literature, dehydroabietic acid (DI), a diterpene of the abietane class, is the major component of resins from *P. elliotii*. The research group, which focuses on structural modification of diterpenes, is particularly interested in developing methodologies to obtain this skeleton in high yield from a commercial source; therefore, fractionation of the resin was undertaken, although the absence of authentic standards for the isolation of individual constituents made this task more challenging.

To confirm the identity of DI, the ^1H NMR spectrum of the isolated substance was recorded in CDCl_3 and compared with data reported in the literature (Van Beek *et al.*, 2007). Based on this comparison, the isolated compound was unambiguously identified as dehydroabietic acid obtained from *Pinus elliotii* resin.

4.2.1 Identification of Dehydroabietic Acid (DI)

The signals observed in the spectrum shown in Figure 12 and their chemical shifts are consistent with those expected for the target compound. In the ^1H NMR spectrum, a singlet at 1.17 ppm, integrating for three protons, can be assigned to the methyl hydrogen at C-20 (H-20), which is characteristic of this structure.

Additional characteristic resonances of this diterpene include the aromatic protons H-11, H-12, and H-14: H-11 appears as a doublet (*d*) at δ 6.94 ppm (1H), H-12 as a doublet

of doublets (*dd*) at δ 6.77 ppm (1H), and H-14 at δ 6.67 ppm (1H). These downfield signals, located in the δ 6.50–8.00 ppm region, are consistent with aromatic hydrogens and are in excellent agreement with the proposed structure.

In the ^1H NMR spectrum of this compound, less downfield signals corresponding to the methyl group at C-19 (H-19) were also observed, appearing as a singlet (*s*) at δ 1.38 ppm and integrating for three protons, together with a doublet (*d*) at δ 1.18 ppm integrating for six protons, attributable to the methyl groups at C-16 and C-17 (H-16 and H-17).

In addition to the methyl resonances of H-16, H-17, H-19, and H-20, broad, unresolved signals were detected between δ 0.70 and 2.00 ppm, corresponding to the methylene protons present in the DI skeleton; these resonances appear in an overlapping region of the ^1H NMR spectrum, which hinders more detailed analysis.

Some other signals, such as H-5 and H-15 are also shown in Table 6, and because they are methylene carbon hydrogen, they are in a position that differentiates them from the others. Therefore, using the data of this work and compared with the data already obtained in the literature, it was possible to verify through these commented signals the attribution performed for the substance of interest (Van Beek *et al.*, 2007) (Table 6). Will also be shown below some data of the DI isolated from *Pinus elliottii* resin, such as: Data from DI: M.F. = $\text{C}_{20}\text{H}_{28}\text{O}_2$ e M.W. = $300.43 \text{ g mol}^{-1}$.

Table 6

^1H NMR data of the substance DI and chemical displacement

Attribution	DI (δ - literature)	DI (δ - experimental)
H-5	2.24	2.24
H-11	7.18	6.94
H-12	7.00	6.77
H-14	6.89	6.67
H-15	2.83	2.84
H-16	1.23	1.18
H-17	1.23	1.18
H-19	1.29	1.38

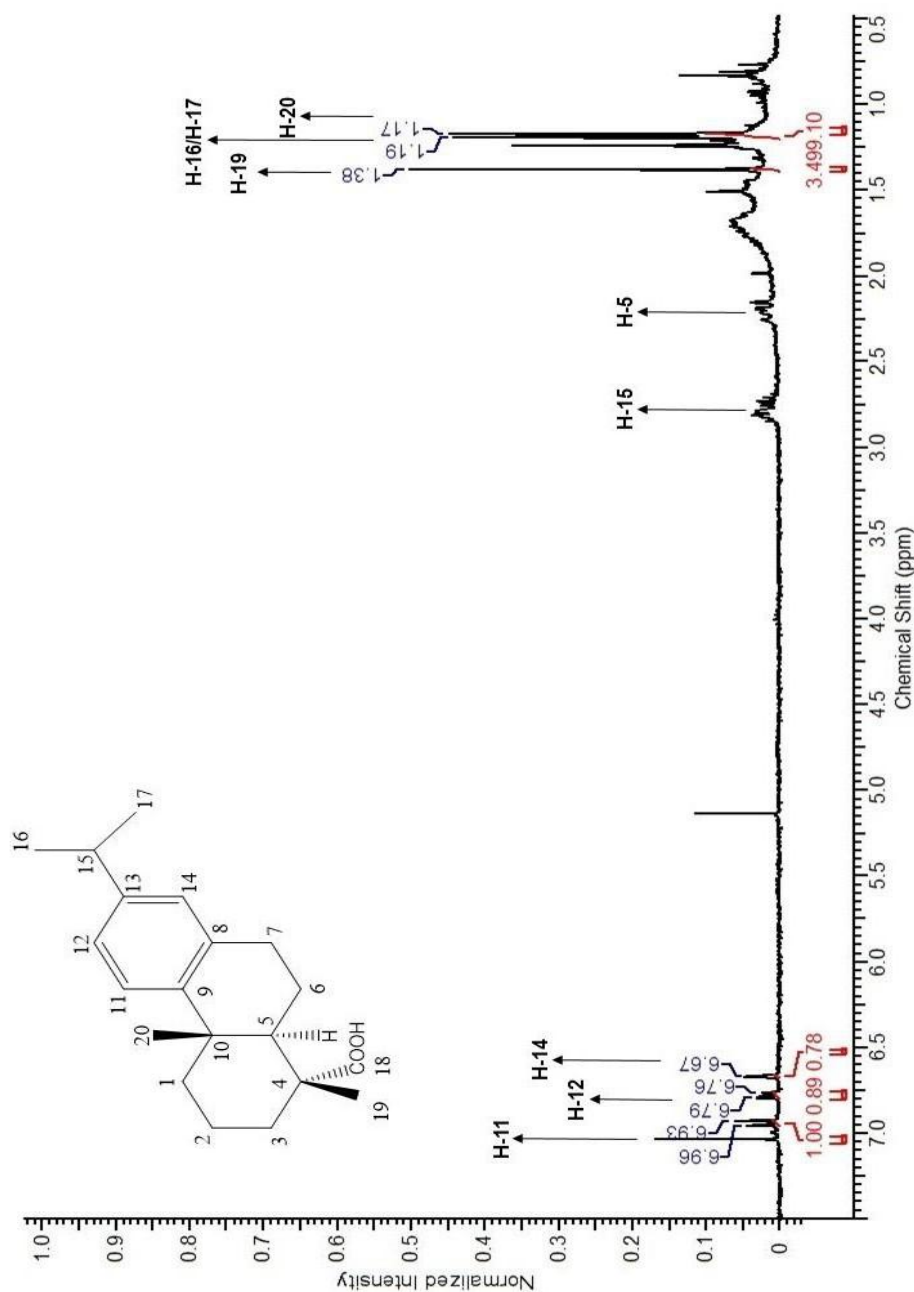
H-20

1.22

1.17

Figure 12

^1H NMR spectrum of dehydroabietic acid, 400 MHz, CDCl_3



5 CONCLUSIONS AND PERSPECTIVES

Resins from the genus *Pinus* are an important source of secondary metabolites, particularly terpenoids. Comparative GC-MS analyses showed that the “mass” and “oil” portions of each *Pinus* resin exhibit essentially identical profiles, whereas the three resins

differ markedly in the relative abundances of α -pinene, β -pinene, β -phellandrene, and *p*-cymene, enabling the use of simple chemical markers to distinguish the species and their hybrid. This study also demonstrated that the “oil” fractions yield more essential oil than the corresponding “mass” fractions and that the combination of VLC, CCC, and CTLC constitutes an effective strategy to isolate dehydroabietic acid (DI) from *P. elliottii* in preparative quantities, with ^1H NMR data providing robust confirmation of its molecular structure.

These findings support the use of *Pinus* resins as practical commercial sources of DI and other terpenoids and establish a workflow that can be scaled to larger batches and extended to additional *Pinus* species to access a broader range of abietane and pimarane diterpenes. Furthermore, the application of systematic bioassays to chemically profiled resins, together with the integration of quantitative NMR, is expected to facilitate the development and evaluation of semi-synthetic abietane libraries for diverse applications, including agrochemicals, medicinal agents, and other bioactive products.

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HEALTH SCENARIO REGARDING CARE FOR NEONATES AFTER HOSPITAL ADMISSION

CENÁRIO DE SAÚDE SOBRE CUIDADOS COM NEONATOS APÓS INTERNAÇÃO HOSPITALAR

ESCENARIO DE SALUD SOBRE LOS CUIDADOS DE NEONATOS DESPUÉS DE LA HOSPITALIZACIÓN

 <https://doi.org/10.56238/sevened2025.036-146>

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ABSTRACT

Considering that the neonatal period represents a phase of high vulnerability to infant health, marked by biological, environmental, and social risks, the continuity of care after hospital discharge is a challenge for families and health services. This study aims to understand the continuity of care and follow-up of newborns after hospitalization. To this end, a descriptive, cross-sectional study with a quantitative approach was conducted in a referral outpatient clinic in the city of Recife/PE, with the participation of 11 caregivers of newborns previously hospitalized for more than 24 hours and under outpatient follow-up. Data collection was carried out using a structured questionnaire, including sociodemographic information, clinical data, and aspects of the post-discharge scenario, with the data analyzed using descriptive statistics. Thus, it was observed that the median age at admission was 17 days, with an average length of stay of 10 days, the main causes of hospitalization being infections and jaundice. It was identified that only 45.5% of families left the consultation with a scheduled follow-up appointment, and that 81.8% required unscheduled care. The difficulties reported involved insecurity in care, emotional overload, and socioeconomic barriers, while the solutions suggested included prior scheduling of

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consultations, clearer guidelines, and systematic use of the Child's Health Record. It is concluded that the continuity of neonatal care after discharge presents clinical and social weaknesses, reinforcing the need for supervised professional follow-up.

Keywords: Neonate. Hospital Discharge. Childcare. Nursing Care Planning.

RESUMO

Considerando que o período neonatal representa uma fase de elevada vulnerabilidade à saúde infantil, marcada por riscos biológicos, ambientais e sociais, a continuidade do cuidado após a alta hospitalar configura-se como um desafio para famílias e serviços de saúde. Objetiva-se conhecer a continuidade do cuidado e o acompanhamento de neonatos após a hospitalização. Para tanto, procede-se a um estudo descritivo, transversal e de abordagem quantitativa, realizado em ambulatório de referência no município de Recife/PE, com a participação de 11 responsáveis por neonatos previamente internados por período superior a 24 horas e em seguimento ambulatorial. A coleta de dados ocorreu por meio de questionário estruturado, contemplando informações sociodemográficas, dados clínicos e aspectos do cenário pós-alta, sendo os dados analisados por estatística descritiva. Desse modo, observou-se que a mediana de idade ao internamento foi de 17 dias, com tempo médio de internação de 10 dias, sendo as principais causas de hospitalização infecções e icterícia. Identificou-se que apenas 45,5% das famílias saíram da consulta com retorno agendado e que 81,8% necessitaram de atendimentos não programados. As dificuldades relatadas envolveram insegurança no cuidado, sobrecarga emocional e barreiras socioeconômicas, enquanto as soluções apontadas incluíram agendamento prévio das consultas, orientações mais claras e utilização sistemática da Caderneta da Criança. Conclui-se que a continuidade do cuidado neonatal pós-alta apresenta fragilidades clínicas e sociais, reforçando a necessidade de acompanhamento profissional supervisionado.

Palavras-chave: Neonato. Alta Hospitalar. Puericultura. Planejamento da Assistência de Enfermagem.

RESUMEN

Considerando que el período neonatal representa una fase de alta vulnerabilidad para la salud infantil, marcada por riesgos biológicos, ambientales y sociales, la continuidad de la atención tras el alta hospitalaria representa un desafío para las familias y los servicios de salud. Este estudio busca comprender la continuidad de la atención y el seguimiento de los recién nacidos tras la hospitalización. Para ello, se realizó un estudio descriptivo, transversal y cuantitativo en una clínica ambulatoria de referencia de la ciudad de Recife/Perú, con la participación de 11 cuidadores de recién nacidos hospitalizados previamente durante más de 24 horas y en seguimiento ambulatorio. La recolección de datos se realizó mediante un cuestionario estructurado que incluyó información sociodemográfica, datos clínicos y aspectos del contexto posterior al alta, y se analizaron mediante estadística descriptiva. Así, se observó que la mediana de edad al ingreso fue de 17 días, con una estancia media de 10 días, siendo las principales causas de hospitalización las infecciones y la ictericia. Se identificó que solo el 45,5% de las familias abandonaron la consulta con una cita de seguimiento programada, y que el 81,8% requirió atención no programada. Las dificultades reportadas incluyeron inseguridad en la atención, sobrecarga emocional y barreras socioeconómicas, mientras que las soluciones sugeridas incluyeron la programación previa de las consultas, directrices más claras y el uso

sistemático de la Historia Clínica Infantil. Se concluye que la continuidad de la atención neonatal tras el alta presenta deficiencias clínicas y sociales, lo que refuerza la necesidad de un seguimiento profesional supervisado.

Palabras clave: Neonato. Alta Hospitalaria. Cuidado Infantil. Planificación de la Atención de Enfermería.

1 INTRODUCTION

The neonatal period, which comprises the first 28 days postpartum, is a phase considered to be vulnerable to child health due to biological, environmental, social and cultural risks. This requires adequate care, greater vigilance and monitoring by the health professional, in order to ensure better growth and development of the child. This period is also responsible for 60% to 70% of infant deaths in recent decades, occurring mainly up to the 6th day of life, being the fundamental indicator of the quality of care for the newborn (Pinheiro *et al.*, 2016).

Newborn health care is of fundamental importance for reducing infant mortality, which is still high in Brazil, as well as promoting a better quality of life and reducing health inequalities. In the neonatal period, a time of great vulnerability in life, where biological, environmental, socioeconomic and cultural risks are concentrated, with the need for special care, with timely, comprehensive and qualified social and health protection, rights recognized by the Statute of the Child and Adolescent (ECA).

It is in the first week of life, especially in the first day of life (representing 25%), that infant deaths in the country are concentrated. Health promotion, prevention and care actions aimed at pregnant women and newborns are of great importance, as they influence the health condition of individuals, from the neonatal period to adulthood. The determining relationship between intrauterine life, health conditions at birth and in the neonatal period, and chronic-degenerative problems in adult life, such as obesity, diabetes, cardiovascular diseases, and mental health, among others, has been increasingly highlighted (Ministry of Health, 2014).

The literature highlights the importance of guidance for the preparation of the newborn's family members, provided by health professionals, during hospital discharge from an intensive care unit or neonatal unit (Conceição, 2023). Intersectorality, the technical and scientific knowledge of professionals to care for NICU discharged, public policies, multicenter research, as well as the construction of bonds between health service professionals and families, are important strategies for the construction of care for neonates and their families after hospital discharge (Braga *et al.*, 2012).

Studies have revealed that there are already innovative initiatives and practices that have signaled a reconfiguration of neonatal care, among which we mention: the implementation of strategies that enable the participation of the family in the daily care routine, by recognizing that it should be a protagonist in neonatal care and that it should be

assured the possibility of establishing a bond and attachment with the newborn; dialogical care practices that enable the expansion of knowledge, recognition of practices and the effective participation of the subjects involved in the daily care routine; care initiatives centered on the demands and needs of newborns and their families, understanding that in addition to the biological recovery of the newborn, there are psychosocial demands that permeate and determine the daily life (Duarte; Sena; Xavier, 2011).

In this context, the present study is justified, since the transition of the newborn from the hospital environment to the home represents a critical moment, in which risks and vulnerabilities that can compromise the continuity of care are concentrated. Despite advances in public policies aimed at neonatal health, there are still gaps related to communication between services, the preparation of families at the time of discharge, and articulation with primary care. Knowing the health scenario of neonates after hospitalization is essential to contribute to more qualified professional practices, strengthen health education and reduce avoidable complications and rehospitalizations. Thus, the guiding question of this study is: "What are the conditions and challenges faced by families in the care of neonates after hospitalization, considering clinical and social aspects?".

From this perspective, the main objective of this study is to know the continuity of care and follow-up of neonates after hospitalization.

2 METHODOLOGY

This is a descriptive cross-sectional study with a quantitative approach that seeks to know the health scenario of neonates after hospital discharge and to analyze its factors. The quantitative-descriptive study is presented through empirical-based research that aims to present and/or interpret occurrences or phenomena, evaluate programs or analyze main parts or variables, with standardized data collection techniques (Marconi; Lakatos, 2011).

The research was conducted in the outpatient sector of reference in child and women's health care of a reference maternity hospital located in the Metropolitan Region of Recife - PE. The target population of the study comprised legal guardians of neonates who had a history of hospitalization for a period of more than 24 hours and who were under outpatient follow-up at the referral service. Those who agreed to participate by signing the Informed Consent Form (ICF) and who were present at the time of the follow-up visit of the newborn were included.

The sample was defined by convenience, depending on the availability of the participants and the practical feasibility of collection in the flow of the service. Although more than 100 families were approached during the collection period, only 11 fully met the inclusion criteria and made up the final sample of the study. This difference occurred due to the specificity of the theme, the required clinical profile (previous neonatal hospitalization) and logistical limitations of the field process.

As an instrument for data collection, a structured questionnaire was used, elaborated based on the objectives of the research and the literature review. The questionnaire was composed of three blocks:

1. Sociodemographic profile of the family (sex/gender of the caregiver, age, income, economic class, marital status, level of education, living at home with the newborn, among others);
2. Clinical data of the newborn (comorbidities, diagnoses and conditions, therapy used, length and age of hospitalization, number of consultations performed);
3. Post-hospital discharge scenario (care recall, guidance received, use of the Child's Handbook, outpatient follow-up, family difficulties and strategies).

The data obtained were organized in an electronic spreadsheet and analyzed by means of descriptive statistics, with absolute and relative frequencies, measures of central tendency and exploratory analysis of correlations between variables. The exploratory nature and the small sample size made it impossible to perform inferential tests, so the results were presented in a descriptive and interpretative way.

3 RESULTS AND DISCUSSIONS

100 families were approached in person during the collection period at the CISAM/UPE outpatient clinic. However, only 11 fully met the inclusion criteria, i.e., neonates who had been previously hospitalized and were under outpatient follow-up at the service, and agreed to answer the questionnaire in a reserved place. This contrast between the families approached and included highlights the difficulties inherent in data collection in such a specific theme and in a scenario of continuous flow care.

The sociodemographic profile of the participants revealed main caregivers living with the neonate, mothers (100.00%), with high daily time (more than 12 hours) dedicated to care. Diversity was observed in relation to education, marital status and family income, and

part of the families made use of social benefits. These findings suggest that care burden is a relevant factor, and that the available support network varies according to the context of each family.

Table 1 presents the sociodemographic characterization of the parents or guardians of the neonates monitored in the study, highlighting relevant aspects of the social and economic context of the families. It is observed that most participants (72.7%) reported participation in the Bolsa Família Program, which indicates the significant presence of families in situations of socioeconomic vulnerability. This finding reinforces the influence of social determinants of health on neonatal care, since limited financial conditions can impact access to resources, transportation, and continuity of health follow-up.

Regarding marital status, there was a balanced distribution between married and single guardians, both corresponding to 45.5% of the sample, while stable unions were less frequent (9.1%). This result suggests diversity in family configurations, which may reflect different levels of social support available for the care of the newborn, an aspect that can interfere with the burden of the main caregiver and the organization of home care.

Regarding schooling, most of the parents or guardians (63.6%) had 13 or more years of schooling, while 36.4% had up to 12 years of schooling. The absence of participants with up to four years of schooling indicates a relatively high educational level in the sample. However, even in the face of higher education, difficulties related to the continuity of care persist, which indicates that barriers in post-discharge follow-up are not restricted only to the level of education, but also to the organization of health services and the clarity of the guidance provided by professionals.

Regarding family income, it was observed that 36.4% of the heads of households did not have a fixed income and 27.3% lived on less than one minimum wage, totaling 63.7% of the households in an unfavorable economic condition. Only 36.4% reported income equal to or greater than one minimum wage. These data show a scenario of financial instability, which can increase difficulties in the continuous care of newborns, especially with regard to travel to consultations, acquisition of supplies and maintenance of outpatient follow-up.

Regarding insertion in the labor market, most of the parents or guardians (72.7%) did not have a profession or occupation at the time of data collection, which may be related to their full dedication to the care of the newborn or to the limitations imposed by the socioeconomic context. Although the availability of time can favor direct care, the absence

of work activity can intensify dependence on social benefits and increase the financial vulnerability of families.

Table 1

Distribution of synthesized data on the sociodemographic characteristics of the caregivers of the neonates (n = 11)

Variables	n	%
Participation in the Bolsa Família Program		
Yes	8	72,7
No	3	27,3
Marital status of the responsible adult		
Married	5	45,5
Single	5	45,5
Stable union	1	9,1
Number of years of study		
≤ 4 years	0	0,0
5 to 9 years	3	27,3
10 to 12 years	1	9,1
≥ 13 years	7	63,6
Family income		
No fixed income	4	36,4
Less than 1 minimum wage	3	27,3
1 minimum wage	2	18,2
2 or more minimum wages	2	18,2
Has a profession/occupation		
Yes	3	27,3
No	8	72,7

Source: The authors, 2025.

Taken together, the sociodemographic data reveal that those responsible for the newborns live, for the most part, in contexts of social vulnerability, characterized by low income, dependence on social programs and occupational instability, although with

relatively high levels of education. This scenario reinforces the need for post-discharge care strategies that consider not only the clinical aspects of the neonate, but also the social conditions of the families, strengthening the articulation between health services and the social support network, in order to promote comprehensive care and reduce the risk of care discontinuity.

Table 2 describes the clinical and care characterization of neonates after hospitalization, showing a profile marked by clinical vulnerability and weaknesses in the organization of health follow-up. It is observed that the highest proportion of neonates were in the age group of 22 to 28 days of life (36.4%), followed by those up to 7 days (27.3%), which indicates that a significant part of the hospitalizations occurred in the late neonatal period, a phase that is equally sensitive for clinical complications and demand for continuous follow-up.

Regarding the causes of hospitalization, a wide diversity of diagnoses was identified, covering both acute clinical conditions and diseases that require specialized follow-up. Diseases of the lower airways and inguinal hernia stood out (both with 18.2%), in addition to other homogeneously distributed causes, such as infections, jaundice, immunization-preventable diseases, gastrointestinal alterations, and malformations. This heterogeneity of causes reinforces the clinical complexity of neonates followed and highlights the need for individualized care strategies after hospital discharge. In addition, the possibility of more than one cause per newborn signals multifactorial disease trajectories, which increase the risk of rehospitalizations and require continuous surveillance.

Regarding the type of birth, most of the neonates were born at term (81.8%), while 18.2% were preterm. Although prematurity is recognized as a risk factor for neonatal morbidity and mortality, the data indicate that even full-term neonates presented clinical conditions that required hospitalization, showing that neonatal vulnerability is not restricted to gestational age, but involves multiple clinical and contextual determinants.

With regard to health follow-up after discharge, there was a high frequency of consultations, and 63.6% of the neonates had already had more than six Child Health consultations. This finding may reflect both the need for intensive monitoring, due to the clinical conditions presented, and possible failures in the problem-solving capacity of consultations, leading to repeated visits. It was also observed that more than half of the neonates (54.5%) did not leave the appointment with the next previously scheduled

appointment, which evidences weaknesses in the organization of outpatient follow-up and in the articulation of the care network.

In addition, the high proportion of neonates who required unscheduled care in urgent and emergency services (81.8%) stands out. This result suggests that the absence of structured planning of post-discharge care, associated with the clinical complexity of the cases, may contribute to the recurrent use of more complex services, often for situations that could be followed up in the context of primary or outpatient care.

Table 2

Distribution of synthesized data on the clinical and care characteristics of neonates after hospitalization (n = 11)

Variables	n	%
Age of the neonate		
0–7 days	3	27,3
8–14 days	2	18,2
15–21 days	2	18,2
22–28 days	4	36,4
Cause of hospitalization*		
Immunization-preventable diseases/sensitive conditions	1	9,1
Infectious gastroenteritis and complications	1	9,1
Bacterial pneumonias	1	9,1
Asthma	1	9,1
Lower airway diseases	2	18,2
Functional diversity	1	9,1
Accidents	1	9,1
Inguinal hernia	2	18,2
Urethral stricture	1	9,1
Jaundice	1	9,1
Congenital constipation	1	9,1
Adenoid hypertrophy	1	9,1
Type of birth		
Term	9	81,8

Preterm	2	18,2
Number of Child Health Consultations		
A	1	9,1
Two	1	9,1
Four	1	9,1
Five	1	9,1
More than six	7	63,6
Leaves the appointment with a scheduled return		
Yes	5	45,5
No	6	54,5
Unscheduled emergency care		
Yes	9	81,8
No	2	18,2

*Possibility of more than one cause per neonate.

Source: The authors, 2025.

In summary, the data show that the neonates followed up have a heterogeneous clinical profile and a high demand for health services after hospital discharge. The high frequency of unscheduled appointments, associated with the absence of prior scheduling of appointments, points to weaknesses in the continuity of care, reinforcing the need to strengthen discharge planning, counter-referral and articulation between the different levels of care, in order to reduce avoidable readmissions and promote comprehensive neonatal care.

Table 3 presents the data regarding the guidance provided by health professionals and the use of the Child's Handbook in the post-discharge follow-up of neonates, evidencing advances, but also important gaps in communication and standardization of care. It is observed that, in most of the consultations, the professionals requested the Child's Handbook (81.8%), which indicates recognition of this instrument as a relevant tool for monitoring child growth and development. However, the isolated request does not guarantee its effective use, an aspect that is reflected in the subsequent results.

Regarding the completion of the booklet, a little more than half of the parents or guardians (54.5%) reported that the information is recorded systematically, while 27.3% reported that it is filled out only occasionally and 18.2% stated that there is no record during

consultations. These data reveal inconsistency in the use of the instrument, suggesting weaknesses in the continuity of the recording of information and in the standardization of professional practices, which may compromise the longitudinal follow-up of the child.

Regarding guidance on healthy eating and exclusive breastfeeding up to six months, it was found that most of the parents or guardians (72.7%) reported receiving these guidelines continuously, while a smaller portion reported receiving them only occasionally (18.2%) or not receiving them (9.1%). Although this finding indicates progress in the approach to a central axis of neonatal care, the absence or irregularity of these guidelines in part of the care can negatively impact fundamental practices for the health and development of the newborn.

Regarding the guidance on the growth curve, the results point to a more worrying scenario. Almost half of the parents or guardians reported not receiving explanations about the meaning of the child's positioning on the curve (45.5%), as well as about the recognition of risk signs associated with growth (45.5%). Only 45.5% stated that they received these explanations systematically, which evidences an important gap in health education. Considering that the interpretation of the growth curve is an essential instrument for monitoring child development and for the early identification of diseases, the absence of these guidelines can contribute to caregivers' insecurity and delay in seeking adequate care.

With regard to guidance on the vaccination schedule, it was observed that 54.5% of the parents or guardians reported that professionals continuously call attention to the date of the next vaccine, while 27.3% reported that this occurs only occasionally and 18.2% reported the absence of this guidance. Although most receive information about vaccination, the irregularity observed can compromise adherence to the vaccination schedule and expose neonates to avoidable risks.

Table 3

Distribution of synthesized data on the orientations and use of the Child's Handbook in post-discharge follow-up (n = 11)

Variables	n	%
Request for the Child's Handbook		
Yes	9	81,8

No	2	18,2
Filling out the Booklet		
No	2	18,2
yes, sometimes	3	27,3
Yes, always	6	54,5
Guidelines on breastfeeding and healthy eating		
No	1	9,1
yes, sometimes	2	18,2
Yes, always	8	72,7
Explanation of the positioning on the growth curve		
No	5	45,5
yes, sometimes	1	9,1
Yes, always	5	45,5
Risk Signal Recognition Explained		
No	5	45,5
yes, sometimes	1	9,1
Yes, always	5	45,5
Guidance on the date of the next vaccine		
No	2	18,2
yes, sometimes	3	27,3
Yes, always	6	54,5

Source: The authors, 2025.

In general, the data indicate that, despite the recognition of the Child's Handbook as a follow-up instrument, its use still occurs in a heterogeneous and poorly systematized way. The gaps in the guidelines, especially related to the growth curve and risk signs, highlight the need to strengthen educational practices, standardize professional conducts and value the Child's Handbook as a central tool for the promotion of comprehensive and safe care in the post-neonatal discharge period.

The guidance provided by the hospital to families after discharge covered central themes for home neonatal care, such as identification of alarm signs, safe sleep practices, adequate nutrition and compliance with the vaccination schedule. To a lesser extent, guidance emerged on the support network and flows for seeking help in situations of

complications. However, the need for unscheduled returns indicates that such guidelines, although pertinent, still lack greater clarity and uniformity.

From the point of view of family experiences, almost half of the caregivers reported difficulties in adapting to the post-discharge period (45.5%). Social support, when present, proved to be a protective resource, but it was described in a heterogeneous way and, in some cases, insufficient. Among the coping strategies reported were the active search for information with the service, the use of the booklet as a guide, family support and early return in the face of doubts.

Although the sample size limits inferences, some descriptive associations were observed. Families who did not leave with the next scheduled appointment had a greater need for unscheduled appointments, suggesting that the previous organization of the segment can reduce emergency visits. Similarly, the presence of social support seemed to soften the difficulties of adaptation, although the data do not allow statistical confirmation.

Among the main difficulties reported, the following stood out: fear of clinical complications due to the baby's fragility, insecurity in the face of poorly understood risk signs, emotional and physical overload of the main caregiver, difficulty in accessing transportation and financial resources to maintain follow-up, as well as barriers in communication with health services, especially in scheduling appointments and in the clarity of the guidance received.

When asked about what could help overcome these challenges, the families suggested the following as the most desired solutions: immediate scheduling of the next appointment at the end of the service, more detailed guidance in accessible language, greater social and psychological support in the post-discharge period, better use of the Child's Handbook as a monitoring tool, and public policies that expand material support (such as transportation, health benefits and resources close to home).

In summary, the results reveal a scenario in which the continuity of care for the newborn after hospital discharge is weakened. The absence of structured scheduling, the variability in the guidance provided, and the frequent need for additional care point to the importance of strategies that promote standardization of conduct, strengthening health education, and valuing the Child's Handbook as a central monitoring instrument.

The results of this study show that, although hospital care for neonates is decisive for their clinical stabilization, the transition to home remains marked by weaknesses, especially with regard to continuity of care and family safety in post-discharge management.

The sample studied showed that less than half of the families left the outpatient appointment with the next scheduled date, and most needed unscheduled care, revealing that the absence of planning and effective counter-referral still compromises the comprehensiveness of care.

This scenario converges with the findings of Vieira and Whitaker (2016), who identified that the perception of children's health care in the post-discharge period is directly associated with the quality of the information received and the clarity of the dialogue established between the team and the family. For the authors, the lack of adequate communication at the time of discharge generates insecurity, increases family overload and increases the risk of avoidable rehospitalizations. In the present study, insecurity in the face of signs of risk and fear of complications were some of the main difficulties reported by the families, confirming the relevance of this aspect.

Silva and Ramos (2011) also highlight that one of the main limits of the hospital discharge process lies precisely in the absence of articulation between the hospital and primary care. According to the authors, when there is no effective counter-referral, the continuity of care is compromised and families tend to resort to urgent and emergency services to solve problems that could have been monitored in the primary care network. This finding dialogues directly with the high proportion of families who, in the present study, sought additional care outside the scheduled appointment.

Another fundamental point refers to the standardization and clarity of the guidelines offered. Although topics such as food, breastfeeding, risk signs and vaccination schedule have been addressed, the reports of the families demonstrate that the way these guidelines are transmitted is not always accessible or uniform. Paranhos, Pina and Mello (2011) point out that strategies such as Integrated Care for Childhood Illnesses (IMCI) were developed precisely to fill these gaps, by integrating the most common conditions of childhood and training both professionals and family members to identify warning signs and adopt appropriate conducts. In this sense, the lack of standardization observed in our study reinforces the need to strengthen tools such as the IMCI and the Child's Handbook.

In addition, the present study revealed social and emotional challenges, such as the overload of the main caregiver, financial difficulties and limited access to transportation, factors that increase the vulnerabilities faced by families. These questions are supported by the literature, which recognizes that post-discharge home care is influenced not only by clinical factors, but also by social determinants of health. For Silva and Ramos (2011), the

potential to strengthen the Family Health Strategy lies precisely in welcoming these demands in the territory, promoting continuous and comprehensive support.

It is interesting to note that the solutions pointed out by the families in this study, such as immediate scheduling of the next appointment, clearer guidance in accessible language, greater social and psychological support, and strengthening the use of the Children's Handbook, coincide with the recommendations of the literature analyzed. Vieira and Whitaker (2016) emphasize the need to expand the dialogue between team and caregivers, while Paranhos, Pina and Mello (2011) emphasize the importance of integrated protocols that ensure continuity of care and avoid other hospitalizations.

Thus, the findings of the present study, although based on a small sample, reaffirm that the continuity of care for the post-discharge newborn depends on three central pillars: (1) structured discharge planning, with prior scheduling of appointments; (2) clear, accessible and standardized guidelines that guarantee autonomy to families in home care; and (3) articulation between hospital and primary care, ensuring that caregivers have support in the territory, reducing the unnecessary use of emergency services.

4 CONCLUSION

The present study allowed us to understand that the care of the newborn after hospital discharge is still a challenge, permeated by clinical and social vulnerabilities that require continuous attention from health services. Although advances in neonatal care have contributed to the reduction of infant mortality, the results revealed that gaps persist in the transition process from hospital to home, especially regarding the standardization of orientations, planning of outpatient follow-up and social support for families.

The difficulties reported by those responsible for them, such as insecurity in the face of signs of risk, emotional overload and access barriers, reinforce the need for strategies that expand communication between the health team and the family, promote health education in accessible language and ensure the continuity of care at different levels of care. In this sense, the importance of strengthening primary care, the systematic use of the Children's Handbook as an instrument of registration and guidance, and intersectoral articulation to ensure social support to families is highlighted.

Thus, the findings of this study offer relevant support for managers, health professionals, and public policy makers, pointing out ways to improve neonatal care practices after hospital discharge. Finally, this study fulfills its role by revealing critical points

of care for newborns after hospitalization and by proposing reflections that can guide future studies of greater scope. It is reinforced, therefore, that the continuity of neonatal care is not restricted to the hospital environment, but depends on an articulated, welcoming and prepared network to support the family in its role as protagonists in the care of the child.

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BETWEEN RIGHTS AND SILENCES: A HISTORICAL-CRITICAL ANALYSIS OF THE EARLY CHILDHOOD EDUCATION CURRICULUM IN TOCANTINS

ENTRE DIREITOS E SILENCIAMENTOS: UMA ANÁLISE HISTÓRICO-CRÍTICA DO CURRÍCULO DA EDUCAÇÃO INFANTIL NO TOCANTINS

ENTRE DERECHOS Y SILENCIOS: UN ANÁLISIS HISTÓRICO-CRÍTICO DEL CURRÍCULO DE EDUCACIÓN INFANTIL EN TOCANTINS

 <https://doi.org/10.56238/sevened2025.036-147>

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ABSTRACT

Considering that curricular documents are not neutral, but historical productions shaped by societal projects and ideological disputes, this article problematizes the Tocantins Curricular Document – Early Childhood Education and the documents that guide Early Childhood Education in the municipality of Palmas-TO, in light of Historical-Dialectical Materialism, Historical-Critical Pedagogy, and Cultural-Historical Theory. It aims to analyze the pedagogical and curricular conceptions present in these documents, identifying foundations, limits, and contradictions related to the social function of Early Childhood Education and the role of teacher mediation. To this end, qualitative documentary research is conducted, using as corpus the Tocantins Curricular Document – Early Childhood Education, approved in 2019, and municipal regulations that govern the curricular and pedagogical organization of Early Childhood Education in Palmas. In this way, it is observed that the analyzed documents, although they recognize the child as a subject rights and value play, interaction, and experiences, maintain alignment with the National Common Curricular Base, prioritizing lived experiences, children's protagonism, and learning rights over systematic teaching, cultural transmission, and the teacher's intentional mediation. This allows us to conclude that such curricular guidelines have structural limitations, as they remain silent on the concrete material conditions of childhoods in Tocantins, reinforce neo-schoolist concepts, and weaken the school's social function as a space for the socialization of historically produced knowledge, indicating the need for a curriculum reorganization based on critical, historical-dialectical, and emancipatory perspectives for public Early Childhood Education, in the context of contemporary Brazilian educational policies.

Keywords: Early Childhood Education. Curriculum. Palmas.

RESUMO

Considerando que os documentos curriculares não são neutros, mas produções históricas atravessadas por projetos societários e disputas ideológicas, este artigo problematiza o Documento Curricular Tocantins – Educação Infantil e os documentos que orientam a Educação Infantil no município de Palmas-TO, à luz do Materialismo Histórico-Dialético, da Pedagogia Histórico-Crítica e da Teoria Histórico-Cultural. Objetiva-se analisar as concepções pedagógicas e curriculares presentes nesses documentos, identificando

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fundamentos, limites e contradições relativos à função social da Educação Infantil e ao papel da mediação docente. Para tanto, procede-se a uma pesquisa qualitativa, de natureza documental, tendo como corpus o Documento Curricular Tocantins – Educação Infantil, homologado em 2019, e normativas municipais que regulamentam a organização curricular e pedagógica da Educação Infantil em Palmas. Desse modo, observa-se que os documentos analisados, embora reconheçam a criança como sujeito de direitos e valorizem o brincar, a interação e as experiências, mantêm alinhamento à Base Nacional Comum Curricular, priorizando vivências, protagonismo infantil e direitos de aprendizagem em detrimento do ensino sistematizado, da transmissão cultural e da mediação intencional do professor. O que permite concluir que tais orientações curriculares apresentam limites estruturais, ao silenciarem sobre as condições materiais concretas das infâncias, reforçarem concepções neoescolanovistas e fragilizarem a função social da escola como espaço de socialização dos conhecimentos historicamente produzidos, indicando a necessidade de reorganização curricular fundamentada em perspectivas críticas e emancipadoras para a Educação Infantil pública, no contexto das políticas educacionais contemporâneas brasileiras.

Palavras-chave: Educação Infantil. Currículo. Palmas.

RESUMEN

Considerando que los documentos curriculares no son neutrales, sino producciones históricas atravesadas por proyectos sociales y disputas ideológicas, este artículo problematiza el Documento Curricular Tocantins – Educación Infantil y los documentos que orientan la Educación Infantil en el municipio de Palmas-TO, a la luz del Materialismo Histórico-Dialéctico, la Pedagogía Histórico-Crítica y la Teoría Histórico-Cultural. Se objetiva analizar las concepciones pedagógicas y curriculares presentes en estos documentos, identificando fundamentos, límites y contradicciones relativos a la función social de la Educación Infantil y al papel de la mediación docente. Para ello, se procede a una investigación cualitativa, de naturaleza documental, teniendo como corpus el Documento Curricular Tocantins – Educación Infantil, homologado en 2019, y las normativas municipales que regulan la organización curricular y pedagógica de la Educación Infantil en Palmas. De este modo, se observa que los documentos analizados, aunque reconocen al niño como sujeto de derechos y valoran el juego, la interacción y las experiencias, mantienen alineación con la Base Nacional Común Curricular, priorizando vivencias, protagonismo infantil y derechos de aprendizaje en detrimento de la enseñanza sistematizada, de la transmisión cultural y de la mediación intencional del docente. Lo que permite concluir que tales orientaciones curriculares presentan límites estructurales al silenciar sobre las condiciones materiales concretas de las infancias tocantinenses, reforzar concepciones neo-escolanovistas y debilitar la función social de la escuela como espacio de socialización de los conocimientos históricamente producidos, indicando la necesidad de una reorganización curricular fundamentada en perspectivas críticas, histórico-dialécticas y emancipadoras para la Educación Infantil pública, en el contexto de las políticas educativas contemporáneas brasileñas.

Palabras clave: Educación Infantil. Currículo. Palmas.

1 INTRODUCTION

In recent decades, Early Childhood Education has come to occupy a central place in the Brazilian educational debate, especially due to the expansion of legal and normative frameworks that have redefined its role in the scope of Basic Education. The consolidation of this stage as a right of children and a duty of the State brought with it the need for curricular reorganization, redefinition of pedagogical practices and the production of guiding documents that standardize educational work in public school networks. In this scenario, curriculum documents assume a strategic role, as they guide the organization of the curriculum, the training of professionals and the pedagogical practices developed in educational institutions.

However, from the perspective of Historical-Dialectical Materialism, it is understood that such documents are not neutral or merely technical instruments. On the contrary, they are historically situated productions, crossed by ideological disputes, pedagogical conceptions and societal projects in tension. Thus, the analysis of a curricular proposal requires going beyond the normative reading of its statements, seeking to apprehend the conceptions of childhood, education and society that sustain it, as well as the silencing related to the concrete material conditions of children, the teaching work and the social function of the school.

It is in this context that the Tocantins Curriculum Document – Early Childhood Education (DCT-EI) is inserted, approved in 2019 and instituted as an official reference to guide the state's municipal education systems, including the municipality of Palmas. Prepared in collaboration with the 139 municipalities of Tocantins, the DCT-EI is based on the National Common Curricular Base, organizing the curriculum based on learning rights and fields of experience. Although this orientation is presented as an advance in the recognition of the child as a subject of rights, it raises relevant problematizations regarding its limits to ensure intentional teacher mediation and the socialization of historically produced knowledge.

The direct link between the DCT-EI and the BNCC inserts the state curriculum policy in the set of contemporary educational reforms, marked by the centrality of experiences, child protagonism and meaningful learning. From the perspective of Historical-Critical Pedagogy and Historical-Cultural Theory, such conceptions tend to displace the centrality of teaching and weaken the role of the teacher as a mediator of the educational process, reducing the formative power of the school and obscuring its social function of access to

systematized knowledge.

At the municipal level, these guidelines are materialized through specific normative documents that regulate the curricular and pedagogical organization of Early Childhood Education in Palmas. The articulated analysis between state and municipal documents becomes, therefore, fundamental to understand how these orientations are appropriated, reaffirmed or tensioned in the local context, considering the territorial specificities and the concrete conditions of the childhoods served by the municipal public network.

In view of this, the following research question emerges: what pedagogical and curricular conceptions guide the Tocantins Curriculum Document – Early Childhood Education and the normative documents of Early Childhood Education in the municipality of Palmas, and what are their limits and contradictions in the light of Historical-Critical Pedagogy? The relevance of this study is justified by the need to deepen the critical understanding of the curricular policies that focus on Early Childhood Education, a fundamental stage in the process of human formation, contributing to the academic debate and to the reflection on pedagogical practices committed to teacher mediation, systematized teaching and the omnilateral formation of children.

Thus, this article aims to critically analyze the Tocantins Curriculum Document – Early Childhood Education and the documents that guide Early Childhood Education in the municipality of Palmas, in the light of Historical-Critical Pedagogy and Historical-Dialectical Materialism, identifying the conceptions of childhood, curriculum and teaching that underlie them, as well as the limits and contradictions of these proposals with regard to teacher mediation, to the curricular organization and the social function of the school in the socialization of historically produced knowledge.

2 THE TOCANTINS CURRICULUM DOCUMENT – EARLY CHILDHOOD EDUCATION (DCT-EI) IN THE LIGHT OF DIALECTICAL HISTORICAL MATERIALISM

The present analysis seeks to understand the Tocantins Curriculum Document – Early Childhood Education DCT-IE (TOCANTINS, 2019) in the light of Historical-Dialectical Materialism. This theoretical approach is a method of interpreting and analyzing reality starting from the material and real (concrete) conditions of society, as well as the historical relations of production that constitute it. In this way, it is not seen as a neutral document, built as a mere technical or pedagogical tool. Like all human construction, given in a given historical and social context, it is the result of a historically and socially determined production, expressing interests, disputes and contradictions typical of class societies.

That said, the document is not analyzed only from the point of view of its explicit content. The main focus will be on what he demonstrates and also silences about social relations, the living conditions of children, the forms of organization of educational work and the project of society that sustains it.

The analysis of a curriculum document requires more than a simple examination of its guidelines or the internal coherence of its chapters. It requires, above all, recognizing that no document is born neutral, nor does it hover above the historical and social conditions that cross it. As highlighted in the previous text, it is understood that a curricular proposal is always an expression of a time, of a societal project and of the disputes that constitute it. It is in this critical, historical and profoundly human perspective that we seek to develop this analysis.

The document itself states that it was produced "in collaboration with the 139 municipalities of Tocantins", respecting "their regionality, their culture and various artistic expressions" (TOCANTINS, 2019, p. 11). It also states that it seeks to strengthen cultural identity and promote "meaningful and playful actions for all children" (TOCANTINS, 2019, p. 15). These statements demonstrate, at first, an important effort to recognize that Early Childhood Education cannot be conceived detached from the territory and the childhoods that compose it.

However, when we look at the document as a whole and situate it in the totality of national education policies, we perceive significant tensions that deserve to be discussed. As the DCT-EI itself announces, its "guiding thread was the national curriculum policies aimed at Basic Education that today materialize through the National Common Curriculum Base – BNCC, a guideline that underpins the framework presented here" (TOCANTINS, 2019, p. 9). This direct link to the BNCC is not secondary, as it carries with it all the logic that structured the educational reforms of the last decades, marked by standardization, control and curricular narrowing.

From the PHC, this alignment reveals a fundamental limit: by assuming as a foundation a curricular policy of a national and generalizing character, the document ends up reducing the strength of local singularities and silencing the concrete conditions of children in Tocantins and, specifically, in the municipality of Palmas. Saviani (2011) reminds us that the starting point of the educational process is the initial social practice, and not a set of previously defined competencies. However, in the DCT-EI, there is no analysis of the

real conditions of the Early Childhood Education units, the inequalities between the capital and the countryside or the precariousness that mark a good part of the schools.

When dealing with the child, the document adopts a conception centered on protagonism. It states that Early Childhood Education should "conceive the child as the protagonist of their development and learning processes" (TOCANTINS, 2019, p. 15). It also advises that the teacher must ensure that the student is "centrality of teaching and learning" (TOCANTINS, 2019, p. 9). Although these expressions may sound welcoming, they carry a pedagogical conception that approaches spontaneism and moves away from the principle of intentional mediation, which is fundamental in PHC. Duarte (2011) problematizes the discourse of protagonism by recalling that the emphasis on the child's autonomy, when unaccompanied by the transmission of systematized knowledge, reinforces a naturalized conception of child development.

The DCT-EI reinforces the centrality of the experience by stating that Early Childhood Education should provide "meaningful experiences and experiences in the lives of children" (TOCANTINS, 2019, p. 15). Play, described as "the most important experience in the lives of a man and a woman" (TOCANTINS, 2019, p. 16), appears as a structuring element of pedagogical work. However, the document establishes that playing "should not be conceived as a teaching strategy" (TOCANTINS, 2019, p. 23), emptying its pedagogical character, precisely where PHC and Historical-Cultural Theory locate one of the most powerful activities for the development of higher psychic functions.

The selection of the materials analyzed was not limited to the DCT-EI (2019), but also covered the documents that guide Early Childhood Education in the municipality of Palmas, considering that the municipal curriculum policy materializes, tensions, adapts or reaffirms state and national guidelines. Thus, understanding how the municipality interprets and implements such guidelines is a fundamental part of the analytical process, especially when it seeks to capture continuities, ruptures and silencing between different scales of educational policy.

The documentary analysis carried out included, therefore, three other documents that regulate the teaching performance in the Municipal Education Network of Palmas, in Early Childhood Education: the School Regiment of Early Childhood Education, curricular structure for partial early childhood education, curricular structure for integral urban and rural early childhood education. The set of these materials allows us to observe not only

what is prescribed, but also what is reiterated, omitted or stressed between the different curricular versions.

In order to systematize the materials that make up this stage of the investigation, a summary table of the municipal documents used in the analysis is presented below.

Table 1

Municipal Documents of the Palmas Network Used in the Documentary Study

Document	Object / Relevance	Link
School Regiment of Early Childhood Education – Municipal Education Network of Palmas-TO	Regulates the administrative, pedagogical and disciplinary organization of the CMEIs. It defines institutional principles, management, evaluation, routines and functioning of Early Childhood Education.	https://www.palmas.to.gov.br/media/documentos/17_12_2019_9_5_0_58.pdf
Curriculum Document for Early Childhood Education – Municipal Education Network of Palmas-TO	It establishes curricular and pedagogical guidelines for work in the CMEIs, organizing objectives, fields of experience, planning and pedagogical foundations.	https://educacao.palmas.to.gov.br/files/ugd/dd59cb_4109379a33b5495aa401d854d0ec8c28.pdf
Curriculum Document of the Territory of Tocantins – DCT	State reference adopted as a basis for the elaboration of the municipal curriculum, articulated with the BNCC and the territorial, cultural and educational specificities of Tocantins.	https://central3.tocantins.gov.br/arquivo/478046/
Guiding Document for Early Childhood Education – Municipal Education Network of Palmas-TO	It presents pedagogical guidelines, formative principles and operational guidelines that complement the curriculum and the school regulations of Early Childhood Education.	https://educacao.palmas.to.gov.br/files/ugd/dd59cb_cd8f658f01784dedb74be765aacc778b.pdf

Source: Prepared by the author based on official documents from the Municipal Education Network of Palmas-TO (2019–2024).

The curricular organization by "Learning and Development Rights" — to live together, play, participate, explore, express and get to know each other — reinforces the emphasis on individual experiences. Chapter V describes these rights in detail, stating that children must "participate in everyday situations", "express needs and feelings" and "explore environments and situations" (TOCANTINS, 2019, p. 54). Such formulations, although important, are not sufficient as a formative matrix, as they do not present essential contents, do not explain conceptual progression and do not situate the school as a mediator of culture.

It is at this point in the analysis, when we observe the emphasis given to experiences, child protagonism and the centrality of experiences, that it becomes necessary to broaden our view to a dimension that crosses the document without being made explicit: the marks of a New New School perspective that permeate the curriculum presented. This presence does not occur in a declared way, but appears in the way the curriculum assigns to the child

the conduction of his own processes and to the teacher the function of monitoring, observing and ensuring "sensitive listening".

It is a conception that, although wrapped in a welcoming and valuing discourse of childhood, takes up principles of traditional renewing pedagogies — now coated by the contemporary language of competencies and meaningful learning. Thus, by affirming that the child is "the protagonist of his or her own development processes" and by organizing the pedagogical work around subjective experiences, the regulation under study updates a pedagogical matrix that shifts the centrality of knowledge to children's spontaneity, which, as the authors of the PHC problematize, tends to weaken teacher mediation and reduce the formative power of the school. To identify these links is not to construct a deserving critique, but to understand that the document also expresses the movement of current educational policies, marked by disputes and tensions that do not always harmonize with the historical-critical perspective.

Thus, by recognizing this neo-new school presence, it becomes even more evident that the curricular organization by rights and fields of experiences, although it brings important contributions, remains limited when it does not dialogue with the structuring contents and with the concrete material conditions of the children of Tocantins.

In this sense, in order to understand more deeply how these conceptions materialize in the daily life of the municipal network, it is necessary to triangulate them with the curricular documents prepared by the Municipal Department of Education of Palmas itself. This comparison is fundamental because it reveals how the municipality interprets, adheres to or tensions such guidelines — and, above all, what continuities are observed between the documents.

The "Curricular Structure for Early Childhood Education – Partial" determines that the pedagogical work is organized by the "five Fields of Experience" and by the "06 Rights of Learning and Development: Living together, playing, participating, exploring, expressing and getting to know oneself", reinforcing that cultural practices involving reading and writing "should not be understood as a literacy process". This formulation corroborates what is prescribed by the guidelines by reaffirming the centrality of experiences and avoiding the systematization of written knowledge, reproducing the same adherence to the BNCC.

The "Curricular Structure for Early Childhood Education – Integral, Urban and Rural" deepens this logic by reiterating the six rights on a daily basis and stating again that "this is not the time to systematize literacy". The proposal for rural schools adopts the alternation

regime, where domestic and community activities are conceived as "research activities related to the thematic axes, under the guidance of the teacher". Although it recognizes territories and identities, this orientation risks naturalizing inequalities by treating domestic experiences as equivalent to school pedagogical work — a central critique of PHC.

The previous document from 2019 reinforces the same orientation by stating that Early Childhood Education should be organized "in everyday experiences, in the expression of feelings and in the freedom to explore environments and situations", reaffirming, like the DCT-EI (TOCANTINS, 2019), a matrix centered on experiences and subjectivity, without making explicit conceptual progression or structuring contents.

Thus, the three municipal documents confirm and deepen the analyses made: all fully adhere to the BNCC matrix (BRASIL, 2017); all of them shift the centrality of knowledge to experiences and sensibilities; all prioritize subjective rights over objects of knowledge; everyone is silent about structural inequalities and the real material conditions of children.

In the field of diversity, the document recognizes indigenous, quilombola, riverside and rural childhoods, stating that indigenous children are "free, respected in their ways of being, living, playing and producing" (TOCANTINS, 2019, p. 27). However, the approach remains descriptive, not reaching the broader social determinations that constitute these childhoods. As Martins (2019) reminds us, an approach that only describes differences, but does not analyze their insertion in the set of social relations, runs the risk of reinforcing inequalities instead of overcoming them.

Thus, it is understood that the DCT-EI and the Palmas documents reveal, simultaneously, discursive advances and structural limits. They advance by recognizing the plurality of Tocantins childhoods, but they are limited when they assume a curricular matrix that prioritizes experiences, protagonism and subjective rights to the detriment of teacher mediation and the appropriation of systematized knowledge.

By presenting themselves as progressive documents, but maintaining a curricular organization centered on experiences and skills, Palmas' proposals express — as the historical-dialectical perspective would say — the contradictions typical of a historical time in which education is crossed by distinct and often irreconcilable interests.

Thus, this analysis, inspired by the commitment to understand the determinations presented in the concreteness of its determinations, reveals that its proposal — as well as those adopted in the municipality — although it announces integral education, does not

mobilize categories that allow the school to fulfill its social function of socializing historically produced knowledge.

3 CONCLUSION

The analysis developed throughout this article allowed us to understand that the Tocantins Curriculum Document – Early Childhood Education (DCT-EI), as well as the normative documents that guide Early Childhood Education in the municipality of Palmas, express the contradictions inherent to contemporary educational policies, situated in a historical context marked by disputes between different conceptions of education, childhood and curriculum. In the light of Historical-Dialectical Materialism, Historical-Critical Pedagogy and Historical-Cultural Theory, it was evident that such documents are not configured as neutral productions, but as provisional syntheses of societal projects in tension.

The results of the analysis indicate that, although the documents advance in the recognition of the child as a subject of rights and value elements such as play, interaction and the diversity of childhoods, they maintain a strong alignment with the National Common Curricular Base, prioritizing experiences, experiences and child protagonism. This curricular orientation, marked by neo-escolanovist traits, displaces the centrality of teaching and weakens intentional teacher mediation, emptying the role of the school as a privileged space for the socialization of scientific, artistic and cultural knowledge historically produced.

It was also observed that both the DCT-EI and the municipal documents of Palmas are silent about the concrete material conditions of children and educational institutions, as well as about the structural inequalities that cross the childhoods of Tocantins. By treating diversity in a predominantly descriptive way and by equating everyday experiences with systematized pedagogical work, the proposals analyzed run the risk of naturalizing inequalities, instead of facing them critically.

Thus, it is concluded that the curricular organization of Early Childhood Education in Palmas has structural limits that compromise the effectiveness of an integral education guided by human emancipation. Overcoming these limits requires the incorporation of critical theoretical foundations, the strengthening of teacher mediation and the curricular reorganization based on the centrality of teaching and systematized knowledge. It is hoped that this analysis will contribute to the academic debate and to the critical reflection on the curricular policies of Early Childhood Education, especially in the context of public

education, reaffirming the commitment to a socially referenced school and to the full human formation of children.

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**THE PÉ-DE-MEIA PROGRAM AS A PUBLIC POLICY TO ENCOURAGE
STUDENTS TO STAY IN SCHOOL AND COMPLETE HIGH SCHOOL:
EVIDENCE FROM THE FIRST RESULTS**

**O PROGRAMA PÉ-DE-MEIA COMO POLÍTICA PÚBLICA DE INCENTIVO À
PERMANÊNCIA E À CONCLUSÃO DO ENSINO MÉDIO: EVIDÊNCIAS DOS
PRIMEIROS RESULTADOS**

**EL PROGRAMA PÉ-DE-MEIA COMO POLÍTICA PÚBLICA DE INCENTIVO A LA
PERMANENCIA Y LA FINALIZACIÓN DE LA ENSEÑANZA SECUNDARIA:
EVIDENCIAS DE LOS PRIMEROS RESULTADOS**

 <https://doi.org/10.56238/sevened2025.036-148>

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ABSTRACT

Dropout and evasion in secondary education are historical challenges in Brazilian education, strongly associated with socioeconomic inequalities that compromise the permanence and completion of this stage by young people in the public school system. In this context, the Pé-de-Meia Program emerges as a public policy of financial incentive aimed at the permanence and completion of secondary education by vulnerable students in the public school system. This article aims to analyze initial evidence of the implementation of the Pé-de-Meia Program in light of selected indicators of school performance, flow, and transition, discussing the extent to which the policy design is compatible with improvements observed in the 2020-2024 period. Methodologically, this is a quantitative, descriptive, and ex post study based on secondary data from official databases (Inep, Nilo Peçanha Platform, and Enem statistics), with an emphasis on Figureical analysis and the comparison of historical series. The results point to signs of an association between the Program's duration and higher pass rates, lower dropout and age-grade distortion indicators, and increased participation of public school graduates in the Enem, especially among students more exposed to the need for early entry into the labor market. It can be concluded that, although still preliminary and subject to important methodological limitations, the findings indicate the relevance of Pé-de-Meia as a policy to support high school retention and completion, highlighting the need for continued monitoring and more robust impact assessments as new data sets and series become available.

Keywords: Public Education Policies. Secondary Education. School Dropout Rates. Financial Incentives. Pé-de-Meia Program.

RESUMO

O abandono e a evasão no ensino médio constituem desafios históricos da educação brasileira, fortemente associados a desigualdades socioeconômicas que comprometem a permanência e a conclusão desta etapa pelos jovens da rede pública. Nesse contexto, o

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Programa Pé-de-Meia surge como política pública de incentivo financeiro voltada à permanência e à conclusão do ensino médio por estudantes da rede pública em situação de vulnerabilidade. O presente artigo tem como objetivo analisar evidências iniciais da implementação do Programa Pé-de-Meia, à luz de indicadores selecionados de rendimento, fluxo e transição escolar, discutindo em que medida o desenho da política se mostra compatível com melhorias observadas no período 2020-2024. Metodologicamente, trata-se de estudo quantitativo, descritivo e ex post, baseado em dados secundários de bases oficiais (Inep, Plataforma Nilo Peçanha e estatísticas do Enem), com ênfase na análise gráfica e na comparação de séries históricas. Os resultados apontam sinais de associação entre a vigência do Programa e a elevação das taxas de aprovação, a redução de indicadores de abandono e distorção idade-série e o aumento da participação de concluintes da rede pública no Enem, especialmente entre estudantes mais expostos à necessidade de inserção precoce no mercado de trabalho. Conclui-se que, embora ainda preliminares e condicionados a importantes limitações metodológicas, os achados indicam a pertinência do Pé-de-Meia como política de apoio à permanência e à conclusão do ensino médio, evidenciando a necessidade de monitoramento continuado e de avaliações de impacto mais robustas à medida que novos recortes e séries de dados se tornem disponíveis.

Palavras-chave: Políticas Públicas Educacionais. Ensino Médio. Evasão Escolar. Incentivos Financeiros. Programa Pé-de-Meia.

RESUMEN

El abandono y la evasión en la enseñanza secundaria constituyen retos históricos de la educación brasileña, fuertemente asociados a las desigualdades socioeconómicas que comprometen la permanencia y la finalización de esta etapa por parte de los jóvenes de la red pública. En este contexto, el Programa Pé-de-Meia surge como una política pública de incentivo financiero orientada a la permanencia y la finalización de la enseñanza secundaria por parte de los estudiantes de la red pública en situación de vulnerabilidad. El presente artículo tiene como objetivo analizar las primeras evidencias de la implementación del Programa Pé-de-Meia, a la luz de indicadores seleccionados de rendimiento, flujo y transición escolar, discutiendo en qué medida el diseño de la política es compatible con las mejoras observadas en el período 2020-2024. Metodológicamente, se trata de un estudio cuantitativo, descriptivo y ex post, basado en datos secundarios de bases oficiales (Inep, Plataforma Nilo Peçanha y estadísticas del Enem), con énfasis en el análisis gráfico y la comparación de series históricas. Los resultados apuntan a una asociación entre la vigencia del Programa y el aumento de las tasas de aprobación, la reducción de los indicadores de abandono y distorsión edad-serie y el aumento de la participación de los graduados de la red pública en el Enem, especialmente entre los estudiantes más expuestos a la necesidad de incorporarse precozmente al mercado laboral. Se concluye que, aunque aún son preliminares y están condicionados por importantes limitaciones metodológicas, los resultados indican la pertinencia del Pé-de-Meia como política de apoyo a la permanencia y la finalización de la enseñanza secundaria, lo que pone de manifiesto la necesidad de un seguimiento continuo y de evaluaciones de impacto más sólidas a medida que se disponga de nuevos recortes y series de datos.

Palabras clave: Políticas Públicas Educativas. Educación Secundaria. Abandono Escolar. Incentivos Económicos. Programa Pé-de-Meia.

1 INTRODUCTION

The universalization of access to primary education in Brazil was not accompanied, in the same proportion, by the guarantee of permanence and completion of secondary education, a stage marked by high dropout rates, failure and age-grade distortion, phenomena closely associated with socioeconomic inequalities that affect school-age young people. Several studies identify the need to work, low family income, and precarious living conditions as the main determinants of school withdrawal in this phase of basic education, perpetuating cycles of exclusion and limiting trajectories of social mobility.

Recent data from the Continuous National Household Sample Survey (Continuous PNAD), 2nd quarter of 2025 (IBGE, 2025), reveal that about 8.8 million Brazilians between 15 and 29 years old have not completed high school and do not attend basic education in 2024. The economic factor is the most relevant determinant for this situation, with almost half of the young people pointing to the need to work as the main reason for dropping out, which highlights the difficulty of reconciling study and work in a context of social vulnerability. Also according to the Continuous PNAD (IBGE, 2024, p. 7-8), the adjusted net school attendance rate – young people aged 15 to 17 attending or having completed high school – reached 76.7% in 2024, a value that represents an increase of 1.7 p.p. in relation to 2023, but remains 8.3 p.p. below the target of 85% established by the National Education Plan (PNE) 2014-2024 (Law No. 13,005, of June 25, 2014).

The Report of the 5th Monitoring Cycle of the PNE Goals, released by Inep (2024a, p. 95-96), summarizes the structural nature of these challenges:

Eight years after the 2016 deadline, universal access to school for young people aged 15 to 17 – underlying Indicator 3A³ – has not yet been achieved, with 94.0% reaching this indicator in 2023, 6.0 percentage points (p.p.) below the target. Between 2012 and 2023, there was a 5.2 p.p. increase in access to school for this age group, but there is still a significant distance to reach the goal of universalization.

[...] Regarding Indicator 3B⁴, referring to net enrollment rates among the young population aged 15 to 17 years, the results suggest that, in 2023, 76.9% of young people attended [high school] or had completed basic education, an increase of 13.5 p.p. in relation to 2012, but still 8.1 p.p. below the target of 85.0%.

³ Indicator 3A: Percentage of the population aged 15 to 17 that attends school or has already completed basic education. Goal: 100% coverage of this population by 2016 (Brasil, 2014).

⁴ Indicator 3B: Percentage of the population aged 15 to 17 years that attends high school or has completed basic education. Goal: Reach 85% net enrollment in secondary education by 2024 (Brasil, 2014).

In addition, the most recent data from the national indicators of school flow for public secondary education, cycle 2021-2022, released by Inep in July 2025 (Inep, 2025g), record a repetition rate of 4.6%, dropout of 9.5% and migration to Youth and Adult Education (EJA) of 2.0%, configuring a scenario of persistent difficulty in regular progression.

In this context, socioeconomic inequalities have a disproportionate impact on low-income students, who face limitations in access to essential resources such as school materials, transportation, and adequate study conditions, contributing to the maintenance of the cycle of poverty and transforming education – which could be a vector of social mobility – into an additional barrier to inclusion (Madaloz *et al.*, 2024). Educational public policies of conditional financial incentive have been consolidated, nationally and internationally, as strategies to mitigate these effects, acting on the economic determinants of dropout and promoting qualified permanence.

The Pé-de-Meia Program, instituted by Law No. 14,818/2024 and regulated by Decree No. 11,901/2024, is part of this set of initiatives by creating an innovative mechanism for educational savings conditional on enrollment, minimum attendance of 80% of teaching hours, annual approval and participation in the National High School Exam (Enem), with benefits totaling up to R\$ 9,200 per eligible student. The policy transcends the mere transfer of income by establishing explicit strategic objectives of reducing school retention, dropout, and dropout rates (art. 2, item III), mitigating social inequalities, and stimulating the transition to higher and technical education, breaking the intergenerational cycle of poverty (Brasil, 2024a; Brazil, 2024b).

According to data from the⁵ Federal Government's Transparency Portal, in its first year of execution (2024), the Program reached R\$ 9.2 billion in expenditures, benefiting 4.1 million students. Coverage reached about 60% of public high school enrollments, considering data from the 2024 School Census (Inep, 2025a), with high relevance for the EPCT Federal Network⁶, whose profile of socioeconomic quota students reinforces its priority eligibility (Law No. 12,711/2012).

According to Pereira (2016, p. 77),⁷ the central innovation of design lies in the creation of a financial reward for the student, to combat the temporal myopia typical of adolescence,

⁵ <https://portal.datatransparencia.gov.br/beneficios?ano=2024>

⁶ Federal Network of Professional, Scientific and Technological Education.

⁷ In the original: "The literature from neuroscience shows that adolescence is a period of intense structural change in the brain (Spear, 2000). The maturation changes in the brain during adolescence contribute to some of the behavioral differences from adolescence to other ages, as the higher predisposition to take risky attitudes

in which the immediate opportunity cost of work often overlaps with the future benefits of education, bringing immediate decision horizons closer to long-term educational returns.

The neuroscience literature shows that adolescence is a period of intense structural change in the brain (Spear, 2000). Maturation changes in the brain during adolescence contribute to some of the differences in behavior between adolescence and other ages, such as a greater predisposition to take risky actions and a tendency to focus on the present and ignore future consequences. In the presence of this myopic behavior, the financial rewards for completing high school can effectively decrease school dropout.

In this sense, formulating a public policy that minimizes this scenario requires initiative and interest from the public sector in contributing to the improvement of the conditions of the most vulnerable, as well as the success of its contribution to the permanence of these students. Given this perspective, it is necessary to understand how the new policy has been decisive in reducing dropout rates and increasing the completion rates of high school among young people in situations of social vulnerability in the first year of its implementation.

Thus, this article analyzes the first results of the Program as a public educational policy, verifying to what extent its initial objectives are reflected in the indicators of school flow, performance and transition observed in the 2020-2024 time series, with the hypothesis that the financial incentive acts as a determining factor for the permanence and completion of high school among vulnerable students in the public network. The success of the initiative will be measured precisely by the ability to consistently change academic performance indicators in the next census cycles, with a more evident impact on the groups historically most affected by school exclusion.

The article is organized into five main sections. After this introduction, the theoretical framework discusses school dropout, architecture of financial incentives and *ex post evaluation* of public policies. The methodology section details the quantitative-descriptive design, secondary data sources (Inep, Nilo Peçanha Platform, Enem) and analytical limitations. The analysis of the results and discussion presents the evolution of the indicators of enrollment, approval, age-grade distortion, dropout, academic efficiency and participation in Enem, confronting them with the objectives of the Program. Finally, the conclusion summarizes the preliminary findings, their implications for public educational policies, and recommendations for future monitoring.

and a tendency to focus on the present and ignore future consequences. In the presence of this myopic behavior, financial rewards for high school graduation can effectively decrease dropout".

2 THEORETICAL FRAMEWORK

2.1 SCHOOL DROPOUT AND FINANCIAL INCENTIVES

The Law of Guidelines and Bases of National Education – LDB (Law No. 9,394, of December 20, 1996) – defines the recommended ages for each stage of basic education, whose attendance is mandatory from 4 to 17 years of age. For secondary education, the ideal age range is between 15 and 17 years old (Brasil, 1996). Understanding the presence and absence of young people in this cycle is an essential step for diagnosing school exclusion and for planning educational policies aimed at permanence. The estimate of the population of young people aged 15 to 17 who are out of school is based on the Continuous PNAD, conducted by the Brazilian Institute of Geography and Statistics (IBGE), the main source of updated information on the educational and socioeconomic conditions of the Brazilian population.

School dropout in Brazilian high school is a multicausal phenomenon, located at the intersection between socioeconomic conditions, school trajectories marked by failures and age-grade distortion, and subjective dimensions linked to the meaning of schooling for young people. Recent studies indicate that socioeconomic inequalities affect low-income students more intensely, whose access to basic resources – such as teaching materials, transportation and minimum study conditions – is often limited, which contributes to the intergenerational reproduction of poverty and transforms the school, many times, from a potential instrument of social mobility into another barrier to inclusion. In this scenario, the need for early insertion in the labor market appears recurrently as a central reason for dropout, especially among young people aged 14 to 29 years.

According to Branco *et al.* (2020), dropout tends to grow as the level of education advances, driven by external factors (such as economic pressure and the need to contribute to family income) and internal factors (such as the disconnection between the school curriculum and students' life projects). In a similar vein, Madaloz *et al.* (2024) point out that the absence of financial incentives is a determining factor for withdrawal from school among low-income students, highlighting that the lack of financial incentives negatively impacts students' permanence in school, along with access barriers such as precarious transportation and scarcity of resources to pay for school life.

The international literature on the economics of education also highlights that adolescents tend to underestimate or "overdiscount" the future benefits of education, favoring immediate gains over long-term returns, such as completing high school. Pereira (2016, p.

63), ⁸when analyzing the Better Youth Income program in Rio de Janeiro, shows that, despite the "substantial gains associated with completing high school", dropout rates remain high, which has led many economists to suggest that young people "ignore or discount the benefits of completing high school", in line with evidence from neurology and psychology that characterizes adolescence as a period especially prone to myopic behavior.

In this context, conditional financial incentive policies are conceived as mechanisms to correct this "temporal myopia", bringing the benefits perceived by students closer to the short-term decision horizon. Pereira (2016, p. 76)⁹ documents evidence that a performance bonus deposited in a linked account, with full withdrawal only at the end of high school, combined with penalties in case of failure or dropout, produces statistically significant effects in increasing pass rates and reducing dropout among adolescents in situations of extreme poverty.

This article presents evidence that achievement awards that pay poor high school students for high school completion can substantially reduce school dropout and increase high school completion rates among economically disadvantaged youth. The program's design exploits students' loss aversion by paying for each grade completed but locking the transferred amount in a bank account and releasing the full amount to the student only after timely completion of high school. This rule possibly creates a strong incentive for students who are loss-averse and is likely to influence students who discount the future too much or who exhibit nearsighted behavior.

In our preferred specification, being eligible to receive the incentive award decreases dropout rates by about 37% and increases pass rates in grades by 14%.

Results of recent research on the Pé-de-Meia Program, although at an early stage, partially converge in this direction: case studies indicate that the benefit works, for some students, as a direct incentive to permanence, although for others, it is appropriated primarily

⁸ In the original: "Despite substantial gains associated with high school completion, high school dropout rates are still large both in the US as well as in many countries of the developing world. [...] The inconsistency between such large returns from high school completion and high dropout rates has led many economists to suggest that adolescents either ignore or highly discount the benefits of completing high school. This reasoning is consistent with the literature on neurology and psychology (Spear, 2000) that indicate adolescence as a period especially susceptible to myopic behavior".

⁹ In the original: "This paper presents evidence that attainment awards that pay poor high school students for graduating from high school can substantially reduce dropout and increase high school graduation rates among economically disadvantaged youths. The program design exploits students' loss aversion by paying for each grade passed, but by locking the amount transferred in a bank account, and only releasing the full amount to the student after timely graduation from high school. This rule possibly creates a strong incentive for students who are loss averse, and is likely to influence students who highly discount the future or who present myopic behavior. In our preferred specification, being eligible to receive the incentive award decreases dropout rates by roughly 37%, and increases grade passing rates by 14%".

to cover basic needs, which reveals both its potential and its limits to face, alone, the problem of dropout.

Thus, the theoretical debate on school dropout and financial incentives points, on the one hand, to the relevance of monetary instruments aimed at vulnerable young people, and, on the other hand, to the need to understand them as components of broader strategies to combat educational inequalities, articulated with pedagogical policies, social protection and improvement of school conditions.

Analyzing the international experience and in the light of the Brazilian reality, Haddad *et al.* (2022, p. 6) established recommendations to increase the chance of effectiveness of financial incentive policies for completing high school, including:

The program should not be seen as the great solution to the problems of Brazilian high school. Most of the articles analyzed point to the beneficial effects of financial incentives for students in terms of schooling. However, although significant, the magnitude of the effects is not enough to solve, as a whole, the serious Brazilian educational problem. This conclusion applies to all the variables analyzed: flow, dropout, completion and access to higher education, among others. For example, in Brazil, the net enrollment rate in high school is only 75% for young people between 15 and 17 years old. The largest effects found in the literature of financial aid programs on tuition are around 3 to 5 percentage points.

2.2 ARCHITECTURE OF INCENTIVES AND CONDITIONALITIES: LAW NO. 14,818/2024

The operationalization of the Pé-de-Meia Program, as instituted by Law No. 14,818/2024 and regulated by Decree No. 11,901/2024, is structured in four types of financial-educational incentives articulated with each other. This architecture was designed to act simultaneously on the easing of immediate economic constraints and on the formation of long-term savings, conditioning the receipt to the fulfillment of academic and social requirements. From an analytical perspective, the design of the Program is similar to international experiences of awards for performance or for timely completion of high school, such as the Better Youth Income, which combine deposits in a linked account, partial access to resources during the course and severe penalties in case of failure or dropout, exploring both positive incentives and the aversion to loss of students (Pereira, 2016).

To be eligible for the Program, the student must be between 14 and 24 years old, be a member of a low-income family enrolled in the Unified Registry for Social Programs (CadÚnico) and be enrolled in public high school (federal, state, district or municipal). The

legislation provides for the granting of the following benefits, totaling up to R\$ 9,200, per eligible student, until the completion of public high school:

- a) Enrollment Incentive: single and annual amount of R\$ 200, paid per enrollment registered at the beginning of each academic year;
- b) Attendance Incentive: monthly amount of R\$ 200, paid in 9 (nine) installments throughout the year, totaling R\$ 1,800, subject to proof of minimum school attendance of 80% of the monthly teaching hours, a level higher than the minimum of 75% provided for in the Law of Guidelines and Bases of National Education (LDB) for regular approval;
- c) Incentive-Conclusion: annual amount of R\$ 1,000, deposited at the end of each school year completed with approval, accumulating up to R\$ 3,000, with withdrawal allowed only at the end of high school;
- d) Enem-Incentive: a single amount of R\$ 200 for third-year high school students from the public network who register and participate in the two days of application of the Enem tests, under the terms of Decree No. 11,901/2024 and MEC Ordinance No. 470/2025 (Brasil, 2024b; Brazil, 2025a).

It is imperative to highlight the hybrid nature of the availability of these resources. While the Enrollment Incentive and the Attendance Incentive can be moved monthly by the student, acting as mitigators of the need for immediate work and material barriers to access school, the Completion Incentive is configured as a blocked educational savings, whose full withdrawal is only allowed after the certified completion of all high school. This combination is close to the mechanism described by Pereira (2016), in which the accumulated balance can only be fully withdrawn at the end of the cycle, and the student simultaneously experiences the prospect of future gain and the risk of loss in case of abandonment or failure.

Recent studies on the Pé-de-Meia emphasize that this structure of benefits and conditionalities reinforces the objective of not only guaranteeing access, but ensuring qualified permanence and completion of basic education, directly combating dropout motivated by economic factors and mitigating inequalities of opportunity between students from different social backgrounds. Madaloz *et al.* (2024) define the Program as "a proactive and structured measure to strengthen the Brazilian educational system", by directing resources specifically to students in vulnerable situations, with a view to promoting financial inclusion and equal opportunities in the completion of high school.

Finally, according to article 5, item III, of Decree No. 11,901/2024, the student may be dismissed from the Program in case of dropout, dropout, or failure for two consecutive times or for a period of two years, which gives the institutional arrangement an additional disciplinary component and reinforces the character of commitment to academic success. This logic dialogues with the literature on conditional transfer programs, according to which the careful definition of what is incentivized, how the incentive is framed, and the sanctions associated with non-compliance with conditionalities is decisive for maximizing the effectiveness and cost-benefit ratio of the policy (Pereira, 2016, p. 65).¹⁰

The correct choice of what to encourage (Barrera-Osorio et al., 2011), how to frame the incentive (Barrera-Osorio and Filmer, 2013) or how to label it (Benhassine *et al.*, 2015) has important consequences on the magnitude of the program's impact. The correct targeting and design of the incentive portion of CCT [conditional cash transfer] programs is crucial to maximize their cost-effectiveness.

2.3 EVALUATION OF PUBLIC POLICIES: THE *EX POST PERSPECTIVE*

The evaluation of public policies occupies a central place in the contemporary agenda of state management, constituting a fundamental instrument to assess efficiency (use of resources), effectiveness (achievement of goals) and effectiveness (social impacts) of government interventions. According to the Practical Guide for *Ex Post Analysis* of the Civil House, the evaluation after implementation allows not only to verify whether the objectives have been achieved, but also to identify design and execution flaws, guide adjustments and improvements, and support decisions on continuity, expansion, or redirection of policies (Brasil, 2018a).

In the specific field of educational policies, Haddad *et al.* (2022) emphasize that "all public policy must be evaluated *ex post* to ensure that its objectives have been achieved", emphasizing that evaluation is important "also for adjustments in the design of the program in order to make it increasingly efficient according to the objectives outlined", and may even identify "spillover effects on actors that are not the focus of the programs, but that have the possibility of generating desired and positive results" (Haddad *et al.*, 2022, p. 8). Such a perspective is particularly pertinent for student financial incentive programs, whose impact

¹⁰ In the original: "Right choosing what to incentivize (Barrera-Osorio et al., 2011), how to frame the incentive (Barrera-Osorio and Filmer, 2013) or how label it (Benhassine et al., 2015) has important consequences over the magnitude of the program impact. Correctly targeting and designing the incentive portion of CCT [conditional cash transfers] programs is crucial in order to maximize its cost effectiveness".

depends both on the individual response of beneficiaries and on broader changes in school and family dynamics.

In the case of the Pé-de-Meia Program, the *ex post* perspective implies monitoring whether the design of the policy – based on payment conditioned to enrollment, attendance, completion and participation in Enem – translates into consistent improvement in indicators of permanence, performance and educational transition, explicitly considering its temporal and methodological limitations. As this is a high-cost policy and of recent implementation, the consolidation of a robust monitoring and evaluation system, with clear goals and defined indicators, becomes an indispensable condition both to qualify the public debate on its merits and to ensure the best use of available resources.

3 METHODOLOGY

3.1 DESIGN AND NATURE OF THE RESEARCH

This research is characterized as a quantitative, descriptive and exploratory study, with an *ex post design* for the evaluation of public policies, focused on the analysis of secondary indicators of performance, flow and school transition in the 2020-2024 time series. The methodological focus is on the verification of variations and trends in academic indicators in the first year of implementation of the Pé-de-Meia Program (2024), assuming an observational character appropriate to the identification of preliminary signs of alignment between the empirical results and the normative objectives of the policy, recognizing the impossibility of causal inference in such a restricted time horizon (Brasil, 2018a).

3.2 DATA SOURCES

The data comes from official educational statistics databases:

- a) Synopses Annual Statistics of Basic Education and Educational Indicators of Inep, covering enrollments, public high school graduates, school performance rates (pass, fail, dropout) and age-grade distortion at the national level (Inep, 2025a; Inep, 2025b);
- b) Statistical Synopses and Microdata of Enem, with numbers of high school graduates from the public network enrolled and present on the two days of application of the tests (Inep, 2025c; Inep, 2025d); and
- c) Nilo Peçanha Platform (PNP), official statistics environment of the Federal EPCT Network established by Setec/MEC Ordinance No. 1/2018, which subsidizes

management indicators such as Dropout Rate, Academic Efficiency Index and Retention Index by Cycle (Brasil, 2018b; Brazil, 2021; Brazil, 2025b).

Inep conceptualizes enrollment as formal registration in the Educacenso System on the reference date of the Census (last Wednesday of May) (Inep, 2024b), while the PNP considers enrolled those who have maintained an active bond for at least one day a year, according to the Methodological Reference Guide of Educational Statistics of the Federal Network (Brasil, 2020; Brazil, 2021). The series analyzed (2020-2024) contextualizes the implementation framework of the Pé-de-Meia, with the exception of the preliminary nature of the 2024 evidence.

3.3 ANALYTICAL STRATEGY

The analysis adopts descriptive and comparative procedures:

- a) Analysis of time series with absolute and relative variations (percentage points) between consecutive years and in the total period;
- b) Identification of trends and inflections temporally correlated to the implementation of the Program;
- c) Comparison between aggregate levels (national x Federal Network) to highlight institutional singularities; and
- d) Exploratory interpretation aligning observed variations with the mechanisms of the Nest Egg, recognizing alternative factors such as post-COVID-19 recovery and complementary policies (Haddad *et al.*, 2022).

3.4 INDICATORS ANALYZED

The main educational indicators of academic efficiency and performance analyzed in this article, listed below, are defined in the Dictionary of Educational Indicators of Inep (Inep, 2004) and in the Methodological Reference Guide of Educational Statistics of the Federal Network (Brasil, 2020):

- a) Approval Rate: percentage of approved over enrolled (Inep, 2025e);
- b) Failure Rate: percentage of failed over enrolled (Inep, 2025e);
- c) Dropout Rate: percentage of students who dropped out of some grade before the end of the school year (Instituto Unibanco, 2024; Inep, 2025e);

- d) Age-Grade Distortion Rate: percentage of students with two or more years of school delay, according to the Inep methodology (Unicef, 2018; Inep, 2025f);
- e) Dropout Rate: percentage of students who dropped out of school before completing a course or stage of education, not renewing their enrollment in the following school year, even if they passed or failed the previous one, resulting in the definitive interruption of studies (Instituto Unibanco, 2024; Inep, 2025g);
- f) Retention Index per Cycle: specific to the Federal EPCT Network, percentage of enrollees exceeding the deadline for completion of the course (+1 year) (Brazil, 2025b);
- g) Academic Efficiency Index: specific to the Federal EPCT Network, percentage of graduates within the expected period (+1 year), plus a percentage (projection) of students retained in the reference year who will be able to complete the course (Brasil, 2025b); and
- h) Enem Graduation Participation Rate: percentage of graduates enrolled in Enem in relation to the total number of students enrolled in the third year of high school registered in the School Census (Inep, 2025a; Inep, 2025c; Inep, 2025d), also considering studies that deal with student participation in Enem (Silva; Rosistolato, 2021).

3.5 METHODOLOGICAL LIMITATIONS

The present study recognizes the following limitations:

- a) Absence of granular disaggregation: the data used are aggregated at the national and Federal Network levels, not allowing differentiated analysis by school unit, municipality or individual characteristics of students;
- b) Lack of control for confounding variables: the analysis does not apply matching, stratification or statistical modeling techniques to isolate the specific effect of the Pé-de-Meia Program from other factors that also influence educational indicators;
- c) Limited time horizon: only one year of full implementation (2024) is available for review, insufficient to establish sustained effects or identify cyclical patterns;
- d) Impossibility of causal inference: the variations observed in the indicators cannot be attributed exclusively to the Program, and must be interpreted as signs of temporal association and compatibility with policy objectives;

e) Influence of alternative factors: the 2020-2024 series comprises a critical period of post-pandemic recovery from COVID-19, during which multiple educational policies at the federal and state levels were implemented, making it difficult to isolate specific effects.

Although the research is based on official and methodologically robust data, the interval of approximately three years between the reference year and the disclosure of longitudinal indicators at the national level restricts the ability to assess, in a timely manner, the adherence of empirical results to the normative objectives established by Law No. 14,818/2024, especially with regard to the reduction of retention rates, repetition and school dropout, whose results related to the transition of the 2024-2025 cycle, which covers the first year of implementation of Pé-de-Meia, are expected to be released by Inep in mid-2028. In this sense, the time limitation in the availability of national school flow indicators introduces an important structural bias in the analyses developed in this study, since the effects of the Pé-de-Meia Program on central variables such as dropout and repetition cannot be observed in the same time horizon in which the policy is implemented.

In this sense, the evaluation of the Program at the national level, in this article, is predominantly anchored in short-term outcome indicators – such as approval and age-grade distortion – which, although relevant, do not fully capture the dynamics of transition between grades and stages, nor do they allow the identification of trajectories interrupted over time. Such delimitation implies that the conclusions presented here are necessarily preliminary, aimed at identifying trends and initial signs of alignment with the purposes of the policy, and not at the exhaustive measurement of its effectiveness on the school flow in the strict sense.

In addition, the lag in the disclosure of longitudinal indicators reduces the capacity of public managers, researchers and social control bodies to carry out timely monitoring and reassessments, which, consequently, delays the adoption of route adjustments and the correction of any distortions in the implementation of the Program. In this context, the analysis developed in this work should be understood as an analytical approach conditioned by the limitations of the national statistical production system, which reinforces the need for caution in extrapolating the findings and in formulating inferences about the medium and long-term impact of the Pé-de-Meia on school flow indicators.

4 RESULTS AND DISCUSSIONS

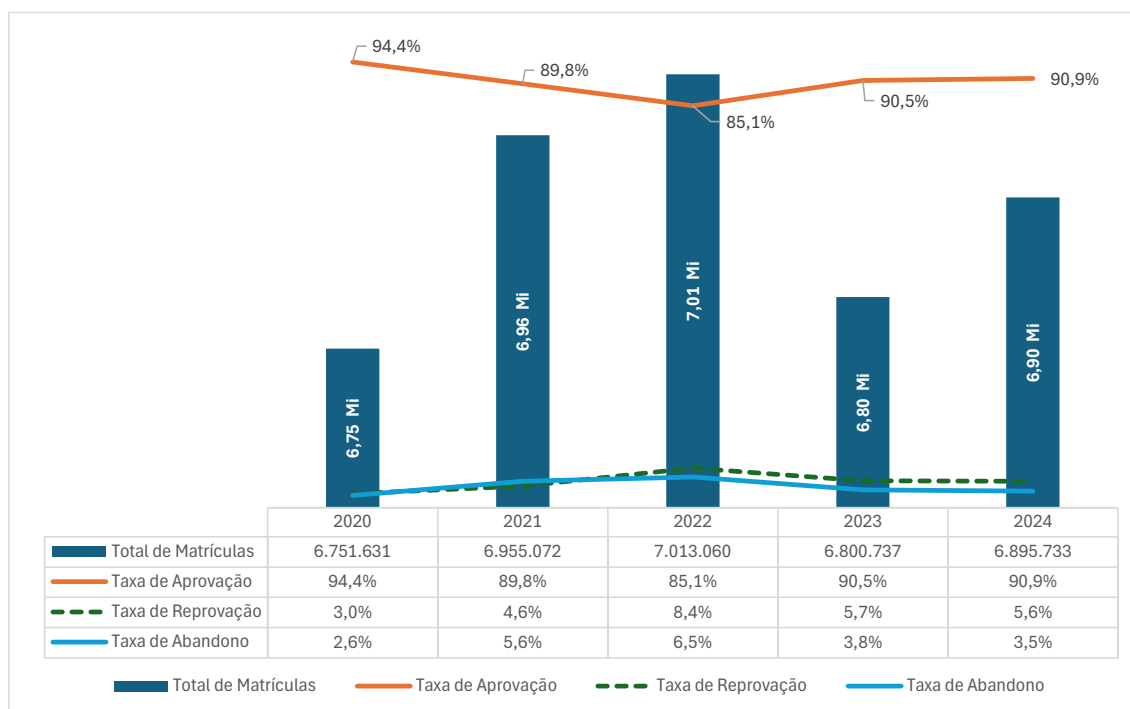
In this section, the results related to the main indicators of performance and school flow are presented and discussed, with emphasis on the comparison between the period immediately prior to the implementation of the Pé-de-Meia Program and the first year of its validity. The analysis seeks to identify trends and possible signs of alignment between the behavior of the indicators and the objectives of the policy, respecting the methodological limitations already explained. The results of the indicators come from publicly available data at the national level on enrollment, school performance rates (pass, fail and dropout) and age-grade distortion rates, released by the National Institute of Educational Studies and Research Anísio Teixeira (Inep), an autarchy linked to the Ministry of Education, as well as on school flow/transition rates (dropout) and retention rates per cycle and academic efficiency in high school in the Federal Public Network extracted from the Nilo Peçanha Platform (PNP).

4.1 ENROLLMENT AND SCHOOL PERFORMANCE RATES IN PUBLIC HIGH SCHOOL

Figure 1 shows that total enrollment in public secondary education (1st to 3rd grade) remained relatively stable in the 2020-2024 period, oscillating around 6.75 to 6.90 million students, without abrupt variations in coverage. This stability in the volume of enrollments indicates that any changes in performance indicators are mainly due to internal dynamics of school flow, and not to significant movements of expansion or retraction of access.

Figure 1

Number of public high school enrollments¹¹ in Brazil and respective School Performance Rates (2020 to 2024)



Source: Prepared by the authors based on the Annual Statistical Synopses of Basic Education and the Educational Indicators related to School Performance Rates.

With regard to income rates, a more volatile behavior is observed, especially in the years immediately after the Covid-19 pandemic. In 2022, the worst performance in the series is recorded, with the pass rate falling to 85.1%, accompanied by a significant increase in failure (8.4%) and dropout (6.5%), suggesting a scenario of strong disorganization of school trajectories. As of 2023, however, there is a gradual recomposition of these indicators: approval returns to levels above 90% (90.5% in 2023 and 90.9% in 2024), while disapproval and dropout retreat to levels below those observed at the height of the crisis (5.6% and 3.5%, respectively, in 2024).

In the context of the first year of implementation of the Pé-de-Meia Program (2024), this improvement in school performance is compatible with the objectives of the policy, which seeks to reduce failures and dropouts through financial incentives conditioned to enrollment, attendance, and completion. Although it is not possible to attribute direct causality, the maintenance of high pass rates, associated with the reduction of failure and dropout in a

¹¹ The total of High School includes enrollments in regular High School Propedeutic, Integrated Technical Course (Integrated High School) and Normal High School/Teaching).

scenario of enrollment stability, suggests a more favorable environment for the permanence and completion of high school, especially among students in situations of socioeconomic vulnerability.

4.2 AGE-GRADE DISTORTION RATE IN HIGH SCHOOL

Figure 2 shows the evolution of the age-grade distortion rate in secondary education in Brazil, disaggregated by education system (public, private, and total), in the period 2020-2024. The results point to a consistent trajectory of reduction of distortion in the public network, which goes from 28.9% in 2020 to 19.7% in 2024, indicating a drop of more than 9 percentage points over the time series. A similar trend, although at a lower level, is observed in the private network, so that the total indicator also shows a continuous decline in the period.

Figure 2

Age-Grade Distortion Rate in High School in Brazil by school system (2020 to 2024)



Source: Prepared by the authors based on the Educational Indicators related to the Age-Grade Distortion Rates.

From an analytical point of view, these results show a double movement: on the one hand, the progressive correction of accumulated school delays, with a lower proportion of students attending grades incompatible with the expected age; on the other hand, the persistence of important asymmetries between networks, which reflect structural inequalities

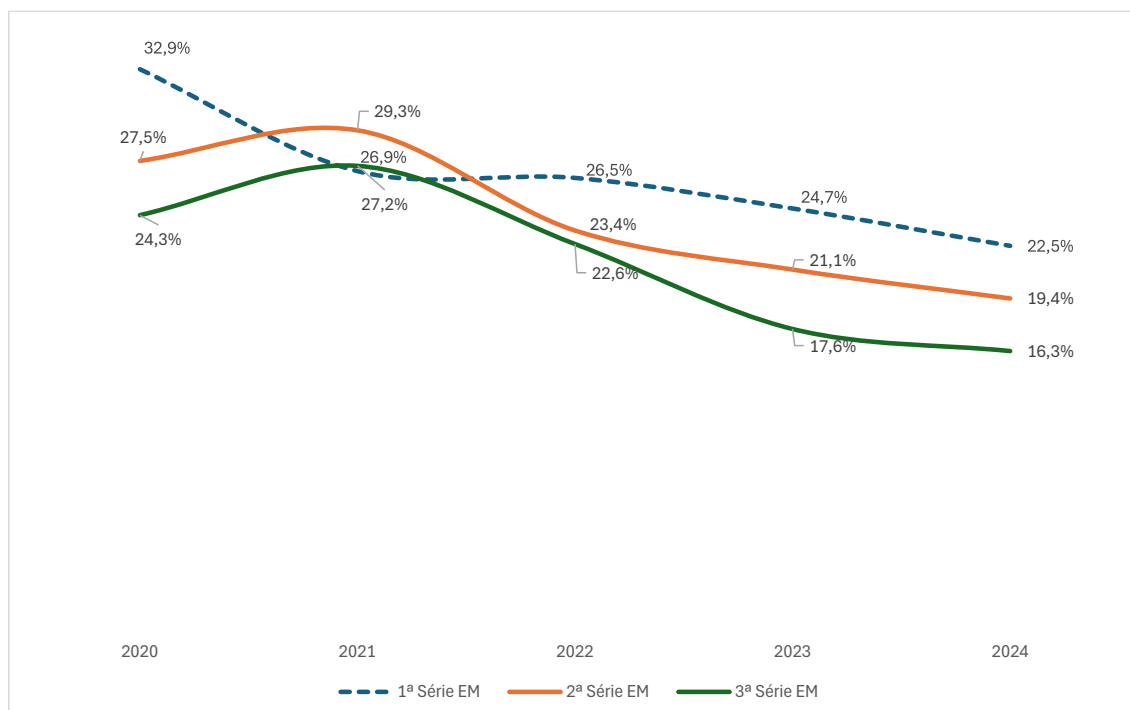
in supply, teaching conditions and the socioeconomic profile of the students. The combination of the reduction in the age-grade distortion and the improvement in the pass rates observed in 2023 and 2024 suggests a more favorable environment for the regularization of the school flow, although part of this improvement is due to policies and efforts prior to the creation of the Pé-de-Meia Program.

It is also important to highlight that the reduction in the age-grade distortion in the public school system observed in the 2020-2024 period, although consistent, does not eliminate the gap in relation to the private school system, which shows that financial incentives, by themselves, are insufficient to equalize school trajectory patterns between such unequal socioeconomic contexts. The literature on financial incentive policies indicates positive effects, but of moderate magnitude, which reinforces the need to combine programs such as Pé-de-Meia with structural measures to improve the quality of the offer, the curricular organization and the learning conditions, at the risk of only partially reducing a problem that is, at the same time, a problem that is at the same time a problem that is not only partially reduced. symptom and cause of broader educational inequalities.

Figure 3 shows the evolution of the age-grade distortion rate in Brazilian public high school, disaggregated by school grade (1st, 2nd and 3rd grades), in the period 2020-2024, revealing distinct patterns of school delay throughout the trajectory of high school. It is observed that the distortion is more pronounced in the 1st grade in all the years analyzed, with values consistently higher than those of the subsequent grades, which suggests that late entry or initial repetition accumulate effects that are perpetuated throughout the cycle. In the time series, all three grades show a downward trend in the distortion, although with different intensities and rhythms, indicating a progressive correction of the school flow in the public network.

Figure 3

Age-Grade Distortion Rate by public high school grade in Brazil (2020 to 2024)



Source: Prepared by the authors based on the Educational Indicators related to the Age-Grade Distortion Rates.

Analytically, the results show that the age-grade distortion is not evenly distributed throughout high school, but is concentrated preferentially at the beginning of the cycle (1st grade), where the higher values signal problems of late access, accumulated repetition of elementary school or migration from other educational systems. The reduction observed in all grades, especially between 2022 and 2024, suggests that school regularization policies – including continued progression, parallel recovery, and incentives to remain – have generated positive cumulative effects on the flow, with a lower proportion of students attending grades incompatible with the expected age (15-16 years for 1st grade, 16-17 for 2nd, and 17-18 for 3rd).

In the first year of implementation of the Pé-de-Meia Program (2024), this downward trajectory acquires strategic relevance, since the indicator is recognized in the literature as an important predictor of future dropout: students who accumulate repetitions and are "out of age" tend to drop out of school more frequently, especially when pressured by economic needs. By mitigating the urgency of early insertion in the labor market and creating financial incentives associated with the permanence and completion of secondary education, the Program acts precisely on one of the mechanisms that feed the distortion, even though the

data available until 2024 only allow us to identify compatibility between the design of the policy and the observed trend. and not to attribute to it, exclusively, the inflection of the indicator.

However, relevant asymmetries persist between the grades that require specific attention. The persistently higher distortion in the 1st grade points to bottlenecks at the time of entry into high school, possibly associated with the transition from elementary school, while the relative convergence between the 2nd and 3rd grades indicates that retention policies are more effective in the intermediate and final phases of the cycle. This heterogeneity reinforces that financial incentives such as the Pé-de-Meia, although pertinent to mitigate economic pressures on vulnerable students (especially in the 3rd grade, close to the eligibility age), are insufficient in isolation to equalize trajectories marked by structural inequalities in access and quality.

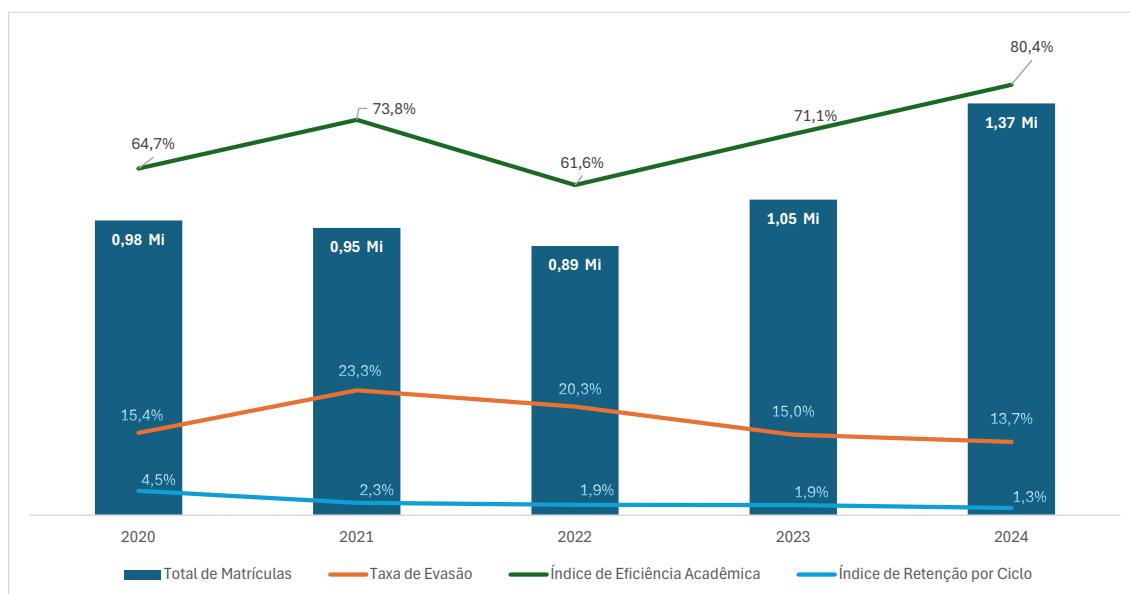
The literature on educational policy evaluation emphasizes that reductions in the age-grade distortion, although positive, should be interpreted with caution over short time horizons, as they may reflect both real flow improvements and compositional effects (lower enrollment of students with severe discrepancy). In the case of Pé-de-Meia, the 2024 data only allow the identification of preliminary signs of alignment with its objectives of reducing retention and dropout (art. 2, item III, Law No. 14,818/2024), requiring future longitudinal analyses to verify whether the decrease in distortion is sustained and associated with higher rates of effective completion of high school in the public network.

4.3 DROPOUT RATES AND RETENTION RATES BY CYCLE AND ACADEMIC EFFICIENCY IN HIGH SCHOOL IN THE FEDERAL PUBLIC NETWORK

Figure 4 summarizes the evolution of the number of enrollments in high school in the Federal Network of Professional, Scientific and Technological Education, as well as the dropout rate, the Academic Efficiency Index and the Retention Index per Cycle, in the period 2020-2024. There is a significant growth in enrollments, which went from 0.98 million in 2020 to 1.37 million in 2024, suggesting an expansion in the supply of vacancies and the presence of the Federal Network in secondary education.

Figure 4

Number of high school enrollments in the Federal Public Network/PNP¹² and respective results of the Academic Performance Indicators (2020 to 2024)



Source: Prepared by the authors based on data extracted from the Nilo Peçanha Platform.

From the point of view of the flow, it is verified that the dropout rate, although still high in some years, shows a downward trend at the end of the series, while the Academic Efficiency Index increases, indicating a higher proportion of students completing the courses within the expected time (or with a slight delay) and greater use of the training effort. At the same time, the Retention Index per Cycle tends to decrease, which signals a reduction in the number of students who excessively exceed the period of payment, contributing to a more regular and efficient flow.

In the context of the implementation of the Pé-de-Meia Program, these results suggest that the Federal Network – already characterized by performance indicators higher than the national average – presents favorable institutional conditions to enhance the effects of the financial incentive on academic permanence and success. The combination of expanding enrollments, reducing dropouts, increasing academic efficiency, and decreasing prolonged retention is consistent with the Program's strategic objectives and indicates an environment in which the policy can reinforce trajectories of school success, especially among low-income students who enter the Federal Network through inclusive access policies. such as the Quota Law (Law No. 12,711/2012).

¹² Filters in the PNP: [Type of Course] = Professional Qualification (FIC), High School, Technical; [Offer Type] = Not Applicable, Concurrent, Integrated.

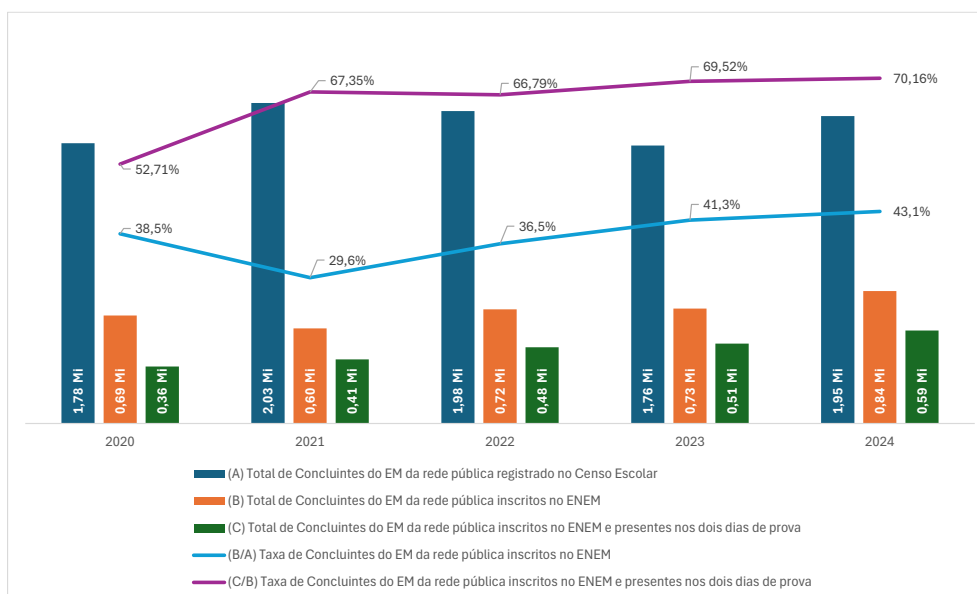
However, it is necessary to recognize that these improvements result from a wide range of factors, including investments in infrastructure, specific pedagogical policies and the selective profile of the Federal Network itself, which prevents the direct attribution of results to the Pé-de-Meia. Even so, the articulated reading of the indicators reinforces the hypothesis that financial incentive programs, when combined with high-quality institutional environments, tend to generate positive synergies in reducing dropout and optimizing school flow.

4.4 PARTICIPATION RATE IN ENEM OF GRADUATES IN PUBLIC HIGH SCHOOL

Figure 5 shows the evolution of the number of graduates of regular high school in the public network (federal, state and municipal), specifically enrolled in the third year, as well as the registration and effective participation rates (presence on the two days of the test) in Enem, in the period 2020-2024. In absolute terms, the total number of graduates enrolled in Enem oscillates between 0.69 and 0.84 million, without abrupt variations, while the number of graduates enrolled and present on the two days of application of the Enem tests grows more pronounced throughout the series.

Figure 5

Number of third-year high school graduates in the public school system in Brazil and respective Enem registration and participation rates¹³ (2020 to 2024)



Source: Prepared by the authors based on the Annual Statistical Synopses of Basic Education; Synopses Annual Enem Statistics; and Enem Microdata.

The rates derived from these quantities reveal two relevant movements. First, the proportion of public school graduates enrolled in Enem increases from 38.5% in 2020 to 43.1% in 2024, indicating that a growing fraction of graduates seek the exam as a gateway to higher education. Secondly, the attendance rate among enrolled graduates – that is, the proportion of those who actually attend the two days of the test – rises from 52.71% in 2020 to 70.16% in 2024, suggesting greater engagement and commitment to taking the exam.

These results are particularly significant in light of the design of the Pé-de-Meia Program, which institutes the Enem Incentive as a specific benefit conditioned to registration and participation in the two days of the exam. The simultaneous increase in enrollment and attendance rates among graduates of the public network is compatible with the objective of stimulating the transition from basic education to higher education, reducing material and symbolic barriers for low-income students to participate in the main university entrance exam.

¹³ To calculate the variable "Total number of EM graduates from the public network enrolled in Enem and present on the two days of the test", the following filters were used in the Enem Microdata: [TP_ST_CONCLUSAO] = 2; [TP_DEPENDENCIA_ADM_ESC] = 1, 2, and 3; [TP_PRESENCA_CN] = 1; [TP_PRESENCA_CH] = 1; [TP_PRESENCA_LC] = 1; and [TP_PRESENCA_MT] = 1. For the year 2024, due to the changes in the Enem Microdata model carried out by INEP, the data on this variable were obtained through a request for access to information on the Fala.BR Platform.

Although the trend of recovery in participation in Enem is already manifesting itself after the most critical period of the pandemic, the level observed in 2024 suggests that the financial incentive may be contributing to consolidate this recovery, expanding adherence to the exam precisely among groups historically underrepresented in higher education. Still, given the short time horizon and the existence of other competing factors (such as fee exemption policies, mobilization campaigns, and changes in the exam itself), the analysis should be interpreted as preliminary evidence of alignment between the behavior of graduates and the objectives of the Program, and not as definitive proof of its impact on participation rates.

5 CONCLUSION

The results analyzed in this article indicate that the Pé-de-Meia Program has relevant potential as a public policy to encourage the permanence and completion of high school, especially among public school students in situations of socioeconomic vulnerability. Initial evidence suggests a positive correlation between the granting of financial-educational incentives and the improvement of performance indicators, such as approval, reduction of dropout, and increased participation in Enem, although such findings should be interpreted as associations compatible with the objectives of the policy, and not as conclusive proof of causal impact.

However, it should be noted that the six formal objectives of the Program are broad and ambitious, ranging from the reduction of dropout and retention to the mitigation of social inequalities and the encouragement of the continuity of studies in higher and technical education. In light of this multiplicity of purposes, it is unlikely that a single policy instrument – centered on financial incentives – will be able to produce profound changes in all these dimensions on its own, especially in a time horizon as short as the first year of implementation. This finding reinforces the need to situate the Pé-de-Meia as part of a broader arrangement of policies for secondary education, and not as a self-sufficient solution to the historical problems of this stage.

From the evaluative point of view, it is also observed that the policy lacks clear operational goals and an explicit set of key indicators to be monitored, which makes it difficult to construct objective criteria to assess its effectiveness. Unlike other recent federal initiatives, such as the National Literate Child Commitment and the Full-Time Schools Program, which announce specific quantitative targets for coverage and performance over a

defined horizon, Pé-de-Meia does not explain, for example, what reduction in dropout or dropout is expected to be achieved in three or five years, nor what equity goals should guide its implementation. This absence of measurable goals weakens the *ex post evaluation* of the policy and makes it more difficult to be accountable to society about the use of the resources involved.

This point is particularly sensitive because it is a policy of high fiscal cost, with an estimated annual expenditure of billions of reais, an amount higher than that of other structuring programs recently implemented in the Brazilian educational agenda. In contexts of budget constraints, the literature on public policy evaluation emphasizes the importance of comparing relative costs and benefits between programs, identifying whether the resources employed could not generate greater impact in alternative or complementary arrangements. Thus, it is essential that the Pé-de-Meia be the object of frequent evaluations, using more robust methods and longer historical series, capable of estimating with greater precision the magnitude of its effects on school flow, educational inequalities and transition to higher education, in order to understand its impacts and make eventual improvements and adjustments in the design.

Even when international and national studies point to positive effects of financial incentive policies for young people, the magnitude of these impacts is usually moderate – often in the order of a few percentage points in indicators such as enrollment, attendance or completion – which is below the structural transformation required by the current framework of Brazilian secondary education. In a scenario in which the net enrollment rate still remains below what is desirable and deep inequalities in access, permanence and learning persist, a financial support program tends to function as a relevant piece within a more complex "gear", but not as the only or sufficient solution to reverse the situation of exclusion and school failure alone.

The findings of this study, while showing promising signs of alignment between the design of the Program and the evolution of some indicators, also reinforce the centrality of integrated policies that combine monetary incentives with pedagogical strategies, psychosocial support actions, improvement of teaching working conditions, improvement of governance and financing of secondary education, expansion of professional and technological education and expansion of the school day, among other fronts. If the school does not become more attractive, welcoming and connected to the life projects of young

people, non-attendance, dropout and dropout tend to remain structural challenges, although they can be partially reduced by transfer programs or educational savings.

It is concluded, therefore, that the Pé-de-Meia Program constitutes an important advance in the agenda of equity and social justice in education, by explicitly recognizing the weight of economic restrictions in the school trajectory of young people in vulnerable situations and by seeking to address them through financial-educational incentives. For its potential to be fully realized, however, it will be necessary to: (i) make explicit goals and result indicators in the medium and long term; (ii) institutionalize a system of continuous monitoring and evaluation, with a focus on cost-effectiveness; and (iii) articulate the Program with a broader set of structural reforms and policies for secondary education. In this sense, the Pé-de-Meia-se should be understood less as a definitive solution and more as a strategic component of a systemic project to reconfigure the stage, whose effectiveness will depend on the quality of its coordination with other initiatives and the rigor with which it is monitored and improved over time.

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TILAPIA SKIN (OREOCHROMIS NILOTICUS) IN THE REPAIR AND PROTECTION OF THE PALATAL SURGICAL BED AFTER AUTOGENOUS GRAFT REMOVAL: A LITERATURE REVIEW

PELE DE TILÁPIA OREOCHROMIS NILOTICUS NO REPARO E PROTEÇÃO DO LEITO CIRÚRGICO PALATINO APÓS REMOÇÃO DE ENXERTO AUTÓGENO: REVISÃO DE LITERATURA

PIEL DE TILAPIA (OREOCHROMIS NILOTICUS) EN LA REPARACIÓN Y PROTECCIÓN DEL LECHO QUIRÚRGICO PALATINO TRAS LA REMOCIÓN DE INJERTO AUTÓGENO: REVISIÓN DE LA LITERATURA

 <https://doi.org/10.56238/sevened2025.036-148>

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ABSTRACT

The removal of autogenous palatal grafts is widely used in reconstructive periodontal surgeries to restore the anatomy and functionality of gingival tissues; however, it may cause pain, bleeding, discomfort, and postoperative morbidity due to healing by secondary intention at the donor site. Therefore, alternatives are sought to reduce these effects and promote faster and more comfortable repair. Nile tilapia skin (*Oreochromis niloticus*) has emerged as a promising biomaterial due to its high concentration of type I collagen, as well as mechanical strength, elasticity, biocompatibility, low antigenicity, sustainability, and low cost. This study analyzed scientific evidence regarding the use of tilapia skin as an occlusive biological dressing for the protection and repair of the palatal surgical bed after autogenous graft removal, considering its structural properties, clinical performance, and advantages compared with conventional dressings. The literature review was conducted using the PubMed, SciELO, Google Scholar, MEDLINE, and BVS databases, employing descriptors in Portuguese and English, following inclusion and exclusion criteria for publications from 2015 to 2025. The studies indicate that tilapia skin promotes faster epithelialization, reduces postoperative discomfort, effectively protects the surgical bed, improves aesthetic outcomes, and presents no relevant complications. Moreover, its versatility allows application in different forms, such as membranes, sponges, and hydrogels. Thus, tilapia skin represents a safe,

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effective, and promising alternative for regenerative dentistry, although more robust clinical studies are needed to standardize protocols and expand its use in surgical practice.

Keywords: Wound Healing. Periodontal Surgery. Biological Dressings. Graft. Tilapia Skin.

RESUMO

A remoção de enxertos autógenos do palato é amplamente utilizada em cirurgias periodontais reconstrutivas para restabelecer a anatomia e a funcionalidade dos tecidos gengivais, mas pode causar dor, sangramento, desconforto e morbidade pós-operatória devido à cicatrização por segunda intenção do leito doador. Por isso, buscam-se alternativas que reduzam esses efeitos e tornem o reparo mais rápido e confortável. A pele da tilápia-do-Nilo (*Oreochromis niloticus*) tem se destacado como biomaterial promissor por apresentar alta concentração de colágeno tipo I, além de resistência mecânica, elasticidade, biocompatibilidade, baixa antigenicidade, sustentabilidade e baixo custo. Este estudo analisou evidências científicas sobre o uso da pele de tilápia como curativo biológico oclusivo na proteção e reparo do leito cirúrgico palatino após a remoção de enxertos autógenos, considerando suas propriedades estruturais, seu desempenho clínico e suas vantagens em comparação com curativos convencionais. O levantamento bibliográfico foi realizado nas bases PubMed, SciELO, Google Acadêmico, MEDLINE e BVS, utilizando descritores em português e inglês, seguindo critérios inclusivos e exclusivos em publicações entre 2015 e 2025. Os estudos mostram que a pele de tilápia favorece epitelização mais rápida, reduz o desconforto pós-operatório, protege eficazmente o leito cirúrgico, melhora o resultado estético e não apresenta complicações relevantes. Além disso, sua versatilidade permite aplicações em diferentes formas, como membranas, esponjas e hidrogéis. Assim, a pele de tilápia apresenta-se como uma alternativa segura, eficaz e promissora para a odontologia regenerativa, embora sejam necessários estudos clínicos mais robustos para padronizar protocolos e ampliar sua utilização na prática cirúrgica.

Palavras-chave: Cicatrização. Cirurgia Periodontal. Curativos Biológicos. Enxerto. Pele da Tilápia.

RESUMEN

La remoción de injertos autógenos del paladar es ampliamente utilizada en cirugías periodontales reconstructivas para restablecer la anatomía y la funcionalidad de los tejidos gingivales; sin embargo, puede provocar dolor, sangrado, incomodidad y morbilidad postoperatoria debido a la cicatrización por segunda intención del lecho donante. Por ello, se buscan alternativas que reduzcan estos efectos y hagan la reparación más rápida y confortable. La piel de la tilapia del Nilo (*Oreochromis niloticus*) se ha destacado como un biomaterial prometedor por presentar una alta concentración de colágeno tipo I, además de resistencia mecánica, elasticidad, biocompatibilidad, baja antigenicidad, sostenibilidad y bajo costo. Este estudio analizó evidencias científicas sobre el uso de la piel de tilapia como apósito biológico oclusivo en la protección y reparación del lecho quirúrgico palatino tras la remoción de injertos autógenos, considerando sus propiedades estructurales, su desempeño clínico y sus ventajas en comparación con los apósitos convencionales. La revisión bibliográfica se realizó en las bases PubMed, SciELO, Google Académico, MEDLINE y BVS, utilizando descriptores en portugués e inglés, siguiendo criterios de inclusión y exclusión en publicaciones entre 2015 y 2025. Los estudios muestran que la piel de tilapia favorece una epitelización más rápida, reduce la incomodidad postoperatoria, protege eficazmente el lecho quirúrgico, mejora el resultado estético y no presenta complicaciones relevantes. Además, su versatilidad permite aplicaciones en diferentes formas, como membranas,

esponjas e hidrogeles. Así, la piel de tilapia se presenta como una alternativa segura, eficaz y prometedora para la odontología regenerativa, aunque se requieren estudios clínicos más robustos para estandarizar protocolos y ampliar su uso en la práctica quirúrgica.

Palabras clave: Cicatrización. Cirugía Periodontal. Apósitos Biológicos. Injerto. Piel de Tilapia.

1 INTRODUCTION

Autogenous soft tissue grafts are often used in the treatment of periodontal lesions (Silva *et al.*, 2021). The palate region is one of the most used sites as a donor area, due to the quality and quantity of the tissues, as well as the histological and structural characteristics of the adjacent tissues (Manfredi *et al.*, 2021). However, the removal technique can cause great discomfort and pain, interfering with the quality of life of patients.

In recent years, regenerative medicine and tissue engineering studies have sought methods to restore the function of damaged tissues and organs through the use of cells, biomaterials, and growth factors. A biomaterial, in order to be used, must have mechanical properties (strength and flexibility) similar to those of healthy human tissue, coating and integrating until the injured tissue is replaced. In addition, it must have low toxicity and be free of any type of microbiological contamination, in addition to being easy to handle and widely available (Gaharwar *et al.*, 2020).

Since 2015, the biomaterial from tilapia skin has been studied as an alternative, mainly with regard to histologically demonstrating similarity with human skin, presenting a large amount of collagen and high mechanical resistance (Alves *et al.*, 2015). Nile tilapia (*Oreochromis niloticus*) is an abundantly farmed fish in Brazil and has great acceptance in the market. Fish skin is considered a by-product discarded by the food industry, making it a low-cost input due to its high availability and the national technology consolidated in cultivation (Lima-Junior *et al.*, 2017).

The structure of the skin has a dermis formed by long bundles of compacted and well-organized collagen, predominantly type I collagen arranged in a parallel/horizontal and transverse/vertical manner. In addition, the amount of type I and III collagen was significantly increased compared to human skin (Alves *et al.*, 2015).

With all these advantages, the high concentration of collagen in the fish dermis culminated in the development of the lyophilized biological dressing of tilapia skin (Lima-Junior *et al.*, 2021). The product is biosustainable and accessible to the population, representing an innovation that can be manufactured at low cost and generate a positive ecological impact. The lyophilized biological dressing contributes to the healing process and tissue regeneration, presenting potential for insertion in several biomedical areas, with socioeconomic impact on the public health system in Brazil, such as the treatment of vaginoplasties, the correction of syndactyly in children with Apert syndrome, the treatment of

burns and as an occlusive dressing in reconstructions of the palate, among other applications (Monte *et al.*, 2022; Rodríguez *et al.*, 2020; Lima-Junior *et al.*, 2017; Manfredi, 2022).

Several studies and therapeutic strategies aim to reduce pain and accelerate the tissue regeneration process after the removal of autogenous grafts from the palate (Miranda and Brandt, 2019; Manfredi *et al.*, 2021; Silva *et al.*, 2021). However, a protocol considered ideal has not yet been established.

Tilapia skin is highly studied in dermatological treatments and wound healing; however, its application in periodontal surgeries is still little studied. Therefore, the objective of this study is to analyze scientific evidence on the biomaterial developed through tilapia skin as an alternative dressing in the repair and protection of the palatal surgical bed after autogenous grafts, highlighting the benefits and challenges of its use in the field of periodontal surgery. Specifically, to characterize the biophysical properties of the skin, evaluate its clinical efficacy in the healing of surgical beds, and identify challenges and limitations in its application in periodontal surgery.

2 DEVELOPMENT

2.1 METHODOLOGY

The present study is a narrative literature review, with a descriptive approach, contemplating a qualitative analysis of the literature on the subject in question: tilapia skin used in reconstructive dental surgeries.

To search for scientific articles, the search engines (Google Scholar) were used as search support and the National Library of Medicine -MEDLINE and Virtual Health Library (VHL), Pubmed Central, Scientific Electronic Library Online (SciELO) databases using the following descriptors: Tilapia skin, healing, periodontal surgery, biological dressings and graft, in combinations in Portuguese and English.

The work was organized with the following inclusion criteria: titles and abstracts related to the subject, in addition to experimental clinical studies that address treatments with conventional materials in dentistry, and also investigations on the application of tilapia skin as a biomaterial and its regenerative properties, considering national and international studies published from 2015 onwards.

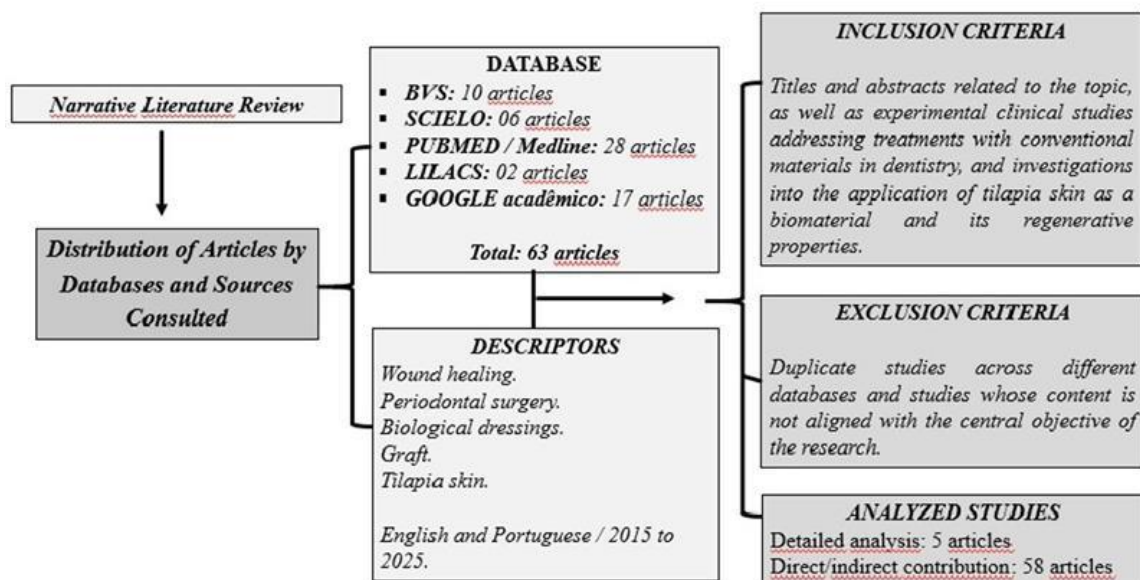
The exclusion criteria include the duplication of studies in different databases and works whose content is detached from the central objective of the research.

The variables observed in the selected studies involve periodontal plastic surgery techniques, characteristics of the graft and surgical bed, types of dressings used, morbidity associated with the procedure, use of tilapia skin and its clinical applications.

The selection of articles was carried out in stages. Initially, titles and abstracts were analyzed to verify their adequacy to the theme. Subsequently, the eligible studies were fully evaluated, considering the previously defined criteria. The distribution of the articles found and selected in academic search engines and databases is presented in Figure 1.

Figure 1

Study methodology and distribution of the articles found and selected by database and documentary sources consulted



Source: Prepared by the authors (2025).

With the application of the inclusion and exclusion criteria, five of the studies were selected for detailed analysis. The works are organized in table 2, which managed to serve as a basis for the discussion and elaboration of the final considerations. The other scientific works, presented numerically in the Figure, contributed directly and/or indirectly to the construction of the scope of this text considering the variables presented.

2.2 LITERATURE REVIEW

2.2.1 Periodontal Surgeries and Grafts

Periodontal surgeries provide a balance between functionality and aesthetics for the patient. In this sense, dental professionals have been increasingly encouraged to conduct research and seek techniques, with new approaches, based on a more current understanding of periodontal diseases and their relationship with general health (Neto *et al.*, 2024).

Miller, in 1993, defined periodontal plastic surgery as surgical interventions indicated for the protection and repair of losses resulting from trauma, anatomical factors and diseases. A classification was established in which characteristics such as width and length are determined in relation to the gingival mucus boundary or the inserted gingiva and the loss of papillae tissues. This division establishes a variation from type I to type IV (Saad and Bassani, 2011).

Factors such as variation in gingival position related to bone defects, invasion of biological space, gingival position associated with recessions, or gingival hyperplasia covering the crown of the tooth directly influence the patient's functionality and aesthetics. In order to correct these conditions, several validated surgical techniques have been developed (Silveira, Silva, and Madureira, 2023)

Recent clinical studies and systematic reviews have highlighted the importance of periodontal plastic surgeries not only for tissue reconstruction, but also for improving the quality of life of patients. According to Tonetti *et al.* (2022), individuals who underwent root covering procedures observed a significant decrease in dentin hypersensitivity, improvements in aesthetics, and an increase in self-esteem, going beyond the clinical aspect, demonstrating the significant relevance of an integrated approach involving oral health, functionality, and psychological well-being.

These current periodontal surgical techniques present satisfactory results, enabling the dental surgeon (DC) to perform these procedures successfully. Proper planning is fundamental, and requires assessing the patient's systemic conditions and risk factors, combined with technical training and the necessary attention, the expected results of excellence will be guaranteed (Rocha and Oleira, 2022).

The use of biomaterials in the periodontal surgical context, such as acellular dermal matrices (ADM), is another important point, as they have been increasingly used. According to Tavelli *et al.* (2020), these substitutes have great biocompatibility and considerably reduce postoperative discomfort, particularly in cases of multiple recessions. In addition, research

such as that of Farias *et al.* (2024) show that, when properly indicated, these techniques offer clinical and aesthetic results comparable to those achieved with connective tissue grafting.

In the search to improve these procedures, periodontal surgery techniques are often associated with the use of grafts. The mucosa of the palate is the most common and favorable donor site, due to the quantity and quality of tissue available (Manfredi, 2022). The removal of the graft from the donor site (palate) can cause discomfort that can vary, usually requiring the use of pain control medications. In addition, other complications become possible, such as cases of hemorrhages, which can make it difficult for the patient to speak and chew (Zucchelli *et al.*, 2020; Manfredi, 2021).

As an option, xenogenous materials, such as acellular dermal matrices (ADM) and collagen matrices (XCM), have been investigated as alternatives to palatal grafting, particularly in patients who have anatomical restrictions or comorbid conditions, showing positive clinical results at short and medium term (Santamaria *et al.*, 2023; Farias *et al.*, 2024).

2.2.2 Graft donor site and healing.

The tissue removed from the patient's own donor area is characterized as an autogenous material, being widely used in dental procedures, especially in the treatment of periodontal plastic surgery (Zucchelli *et al.*, 2020). The similar characteristics present in the antero/posterior region of the palate, in relation to the adjacent tissues, make them ideal sites for donation (Manfredi, 2021).

The hard palate region is one of the most commonly used sites as a donor area, both for connective tissue grafting methods and for grafts in areas of gingival recession. The extraction of the epithelialized graft leaves the donor area exposed, which can interfere with the daily activities of patients (Manfredi, 2021). Faced with these challenges, studies are carried out to develop biocompatible biomaterials, which reduce surgical time and provide comfort to patients, reducing post-surgery morbidity (Andrade *et al.*, 2021).

In addition to traditional methods, the use of autologous biomaterials, especially leukocyte membranes and platelet-rich fibrin (LPRF), has shown significant importance in the healing process in palatal donor areas. A randomized controlled clinical study indicated that the use of LPRF significantly reduces pain, burning sensation and bleeding in the first two weeks after surgery, in addition to accelerating the reduction of the wound area and improving

clinical healing rates between the third and fourth weeks, compared to treatment by second intention (Miron *et al.*, 2020; Keceli *et al.*, 2022).

The removal of a connective tissue graft in union with the flap is a successful procedure. However, it should be taken into account that these techniques, when in a vast surgical area, can lead to greater discomfort in the donor area (Stela *et al.*, 2023).

When the graft is removed, the wound healing processes begin, with coagulation in the region, which acts as a temporary matrix for cell migration, resulting in the release of growth factors and protective substances against bacteria (Manfredi, 2021).

The inflammatory process is gradual and initiates the formation of new blood vessels and the production of collagen in the clot, replacing it with granulation tissue, with an increase in the presence of fibroblasts, whose function is to promote traction between the edges of the wound. With the development of healing, the granulation tissue matrix is replaced by connective tissue, a process that is completed on average three weeks after surgery (Balbino, Pereira and Curi, 2015).

The beginning of the healing process can cause the patient some discomfort, such as pain, burning and difficulties when chewing. Such postoperative complications influence studies aimed at the use of materials that have the function of healing and protection, seeking to reduce patient discomfort (Manfredi, 2021).

Photobiomodulation with LED or low-intensity laser (PBM) has been widely used as an effective method for healing palatal wounds. Experimental studies conducted in animal models have shown that irradiation of the donor site with 660nm LED favors faster re-epithelialization, greater collagen production, and stimulates the formation of new blood vessels, in addition to reducing inflammatory infiltration (Wang *et al.*, 2015; Deana *et al.*, 2022). Narrative reviews confirm that PBM plays a role in modulating cellular metabolism, resulting in increased ATP (Adenosine Triphosphate) production, fibroblast proliferation, and extracellular matrix synthesis, contributing to the healing process (Alves *et al.*, 2015).

In graft removal surgeries, in the donor area, dressings must be placed in direct contact with the wound caused by the removed tissue, which allows comfort to the patient, protection and helps or accelerates healing. The materials used in these dressings can be categorized as passive and bioactive, with bioactive ones accelerating healing. Among some dressings mentioned in the literature, we can find surgical cement that stands out in its wide use, fibrin-rich plasma, collagen sponge with cyanoacrylate, collagen matrix, and hyaluronic acid (Ribeiro and Martuscelli, 2018; Manfredi, 2021). Surgical cement stands out because,

although considered in disuse, it is still widely used in some works because it favors protection against trauma, pain and hemorrhage. Cements can be classified in three ways: containing zinc oxide and eugenol (wondrpak), not containing eugenol (coe-pak); containing neither zinc oxide nor eugenol (cyanoacrylate). Chart 1 presents some advantages and disadvantages to the use of surgical cement after periodontal surgery (Manfredi, 2021).

Table 1

Some advantages and disadvantages to the use of surgical cement after periodontal surgery

ADVANTAGES	CONS
<i>Protection of the surgical wound from mechanical trauma</i>	<i>Little effect on healing</i>
<i>Stability of the surgical bed during the healing phase</i>	<i>Increased plaque buildup</i>
<i>Patient comfort</i>	<i>Greater painful symptomatology</i>
<i>Prevention of postoperative hemorrhage or infection</i>	<i>Subsequent microbial invasion</i>
<i>Decreased tooth sensitivity</i>	<i>Irritation to tissues, increasing the chance of infection</i>
<i>Clot protection during speech and chewing</i>	<i>Difficulty chewing</i>
	<i>Discomfort in speech and chewing</i>
	<i>Bad breath</i>
	<i>Alteration of taste</i>
	<i>Possibility of allergic reaction</i>

Source: (Manfredi, 2021, p. 32).

The uses of surgical cement have a physical and therapeutic function, each with its respective benefits. Regarding physical function, it encompasses tissue stabilization, thus reducing direct contact with external agents. The therapeutic benefits, on the other hand, involve the mechanical protection of the surgical wound region, which drives better healing (Manfredi, 2021; Gusmão *et al*, 2022).

Although surgical cement is still widely used to protect donor areas in periodontal surgeries, recent research presents more options with the potential to reduce some of the undesirable effects. Among these alternatives, resorbable collagen membranes have highlighted benefits by offering mechanical protection, less chance of tissue irritation, and not requiring removal. In addition, these membranes act as selective barriers in the healing process (Basma *et al.*, 2022). A promising option is platelet-rich fibrin (PRF), which acts as a biological dressing, releasing growth factors gradually, aiding in angiogenesis, inflammation management, and accelerated re-epithelialization of the donor region (Miron *et al.*, 2017).

Table 2 describes some of the products that are used in periodontal plastic surgeries and their applicability.

Table 2

Materials that are used in periodontal plastic surgeries and their applicability

Material	Description	Source
Surgical cement / Periodontal dressing	<i>Applied to protect the surgical site, immobilization and patient comfort, they cause allergic reactions.</i>	PMID: 26056525
Resorbable collagen plugs or sponges	<i>They act as a mechanical and hemostatic barrier, promote healing and are low irritating.</i>	PMID: 34483577
Collagen membranes.	<i>Biodegradable membranes (porcine, bovine, or human origin) serve as a selective barrier. They stimulate the migration of osteoblasts and fibroblasts.</i>	PMID: 28593053
PRF (Platelet-Rich Fibrin)	<i>Autogenous membrane prepared from the patient's blood; rich in growth factors.</i>	DOI: 10.1002/JPER.22-0172
Palatine stensil.	<i>Rigid prostheses/plates molded to cover the surgical bed, protecting from trauma during chewing and speech in the first days.</i>	DOI: 10.1002/JPER.22-0172
Natural membranes (gelatin, chitosan, silk, fibroin)	<i>Biocompatible materials with regenerative potential, still in the experimental or preclinical stage; they have good properties, but less stiffness and consistency in batches.</i>	DOI: 10.1016/j.cden.2022.05.011

Source: Data available in the literature.

The proposed solutions, applied alone or together, have the potential to expand the alternatives available in clinical practice. They allow the customization of wound protection, adjusting to the particular needs of each patient and favoring more significant results.

2.2.3 Tilapia skin (*Oreochromis niloticus*) as a biological dressing

Collagen has been increasingly studied, explored, and analyzed in regenerative procedures. This protein, with abundance in the extracellular matrix, is a natural macromolecule and has a low inflammatory reaction, in addition to favoring cell adhesion and proliferation. The main sources for obtaining collagen currently come from cattle, pigs and horses. However, recently, research has been exploring alternative products and materials derived from fish (Rodrigues, 2009; Manfredi, 2021).

The tilapia skin is formed by an epidermis covered by a stratified squamous epithelium, followed by abundant layers of collagen. This concentrated bioactive collagen makes tilapia skin a possible option to be used as a surgical bed protection dressing after graft removal (Melo *et al.*, 2024).

Based on the scientific works found, five studies in the literature between 2021 and 2025 stood out for presenting uniqueness with what is proposed by the project. The studies present the applicability of lyophilized tilapia skin and extracted collagen in reconstructive dental surgeries, according to the clinical approach.

Table 2

Scientific studies evaluated in detail

Scientific articles available in the literature.	
1	Evaluation of the healing potential of Nile tilapia skin collagen in traumatic oral ulcers in male rats DOI: 10.1016/j.archoralbio.2023.105793
2	Characterization of collagen from the skin of Nile tilapia (<i>Oreochromis Niloticus</i>) used in occlusive dressings and evaluation of the potential for guided bone regeneration in mandibular angle defects in rats URI: http://www.repositorio.ufc.br/handle/riufc/71036
3	Use of tilapia skin for repair and protection of the palate after graft removal URI: https://doi.org/10.11606/T.25.2021.tde-08122021-124815
4	The use of Nile Tilapia skin as an occlusive biological dressing for palatal wound healing: A case series DOI: 10.33448/rsd-v10i8.17146.
5	Surgical techniques in periodontics: evaluation of the donor site for mucogingival grafts. URI: https://revista.aborj.org.br/index.php/rbo

Source: Data available in the literature.

Currently, the main source of medical collagen comes from mammalian connective tissue (Yamada, 2015). However, they have a limited source, high cost, risk of transmission

of zoonoses, and still have religious restrictions in some Asian countries. Such limitations have opened space for the use of other sources of biological materials (Sun *et al.*, 2018).

In this scenario, the raw material of biological grafts or dressings derived from tissues of aquatic animals presents itself as a very promising alternative (Park, 2017; Bronzino, 2017), as in the case of tilapia skin (*Oreochromis niloticus*) (Lima *et al.*, 2017). The studies carried out by researchers from the Center for Research and Development of Medicines at the Federal University of Ceará (NPDM-UFC). These advances have made it possible to produce the lyophilized biological dressing made from tilapia skin, initially developed and used in the treatment of burns, which usually result from domestic and work accidents; they are more common among socioeconomically less favorable people, of working age, and can generate debilitating sequelae. In the Brazilian public network, burns are usually treated with antibiotic ointment, which requires daily changes of wound dressing and causes intense pain. The new dressing reduces outpatient treatment costs by almost 50% and reduces patient pain, improving their recovery and quality of life (Lima *et al.*, 2017).

The lyophilized tilapia skin dressing has also been used in vaginoplasties performed in women with vaginal agenesis or with the vagina occluded after cancer treatments, enabling the complete recovery of the genital structure and function (Dias *et al.*, 2019). Likewise, the material has also been used in sex reassignment surgeries in transgender women (Rodríguez *et al.*, 2020). In all these cases, tilapia skin dressing reduced or eliminated the need for autografting, reducing postoperative morbidity, increasing the patient's quality of life, and accelerating recovery. Recently, the dressing has also been used in preparation for autografting in complex reconstructive plastic surgeries of the hands in patients with Apert Syndrome, with great success, as well as in dental (palate reconstruction) and veterinary (traumatic wounds in horses) applications (Monte *et al.*, 2022; Manfredi *et al.*, 2022; Costa *et al.*, 2020).

The use of tilapia skin has shown excellent results in the treatment of burns and vaginoplasties, being successfully applied to more than 500 patients — with no records of rejection or infection. The research provided 26 specialized publications and more than 700 journalistic articles, in addition to winning 16 scientific awards in first place. The success of the freeze-dried tilapia skin dressing has influenced new research for the creation of other products for internal use, as well as the decellularized protein matrix (*scaffold*) and added *crosslinker* and the extraction of collagen for use in pharmaceuticals and cosmetics, opening new avenues as a new biomedical device for regenerative medicine (Lima *et al.*, 2023).

The great success is due to the fact that tilapia skin is composed of compacted, long and organized collagen bundles, predominantly type I. The content of type I collagen and total collagen of tilapia skin is higher than that of human skin (Alves *et al.*, 2015), which makes it a raw material of interest for the manufacture of medical devices.

The scientific literature shows that regenerative protein matrices, known as biological meshes or dressings, need to be non-toxic, non-immunogenic, adherent to the wound bed, biocompatible, and absorbable. These biomaterials should not convey toxic substances in the body, for obvious reasons, nor should they initiate an exaggerated inflammatory response, with the potential to damage the host tissue itself. In addition, biological screens should not promote an immune response so intense that it results in rejection (acute or chronic) by the recipient organism. When used as a cover, they should prevent the loss of fluids, proteins, and nutrients in the form of exudate, in addition to preventing the entry of invading microorganisms (Moerbeck-Filho *et al.*, 2019; Pires, Bierhalz and Moraes, 2015).

The beneficial histological properties of tilapia skin have favored the creation of a device capable of meeting these requirements. In dentistry, with excellent results, Manfredi *et al.* (2021) investigated the application of Nile tilapia skin (*Oreochromis niloticus*) as an occlusive biological dressing in the repair of the palatal surgical bed after the removal of an autogenous gingival graft. The study, conducted as a randomized clinical trial, had 24 patients divided equally between a control group (treated with Coe-Pak surgical cement) and a test group (treated with tilapia skin). The results showed significant advantages in the group that received the tilapia dressing, including lower intensity pain, faster healing and better aesthetic results.

At the same time, Manfredi *et al.* (2021) published clinical cases, in which they reported the experience of patients undergoing the same type of procedure. The study demonstrated that the palate covering with tilapia skin was well accepted, with no occurrence of complications, with reduced levels of pain and without interference in speech and chewing functions. Healing was considered satisfactory after 30 days. In the studies by Soares *et al.* (2023), using topical gel 1% from tilapia skin collagen for the treatment of surgically induced ulcers in the oral mucosa of Wistar rats. Simple orobase (negative control), drug orabase (positive control) and tilapia collagen orabase (test) were compared. It was demonstrated that tilapia accelerated ulcer closure, promoted complete repithelialization, intensified angiogenesis, higher density of type I and III collagen, and increased expression of TGF β , α SMA, and PECAM1. Treatable animals gained more weight until day 20 ($p < 0.05$).

Collagen taken from tilapia skin is a very promising material, with several possibilities for use in dentistry. It can be applied in different forms, such as sponges, hydrogels, membranes, and even nanocollagen fibers (Putri *et al.*, 2024). Its therapeutic potential has applicability in the treatment of wound healing, dry socket healing, bone necrosis, grafts, flap surgery and periodontal tissue regeneration. In the studies by Lima Verde (2023), the mineral composition and compatibility of tilapia collagen in guided bone regeneration (GBR) in rat mandibular defects was analyzed. The results showed that tilapia collagen performed as well as the commercial product used as a control, facilitating bone regeneration, with little inflammatory reaction and excellent biocompatibility.

Due to its excellent biocompatibility and because it is non-toxic, the potential of hydrolyzed collagen extracted from tilapia skin is studied in the viability and differentiation of periodontal ligament fibroblasts *in vivo* with the prospect of its use in the recovery of periodontal tissues (Manfredi, 2021). When compared to the submucosa of the small intestine of the pig in healing processes, tilapia skin did not show inferiority compared to other biomaterials, indicating an excellent biocompatibility and inflammatory process (Baldursson *et al.*, 2015). The use of collagen from fish influences the biological environment to the formation of collagen in the wound (Cruz *et al.*, 2021).

In several areas of regenerative medicine, tilapia skin (*Oreochromis niloticus*) has been standing out as a great alternative biomaterial for its excellent cost-benefit ratio. In the first studies with 1st and 2nd degree burns, the therapy helped reduce morbidities suffered by patients (Alves *et al.*, 2015). In view of its applicability in dentistry, the use of collagen dressing has already denoted a rapid healing of the graft donor bed, reducing morbidity, compared to surgical cement available on the market. Thus, the efficacy and success of healing is observed from the use of dressings made of collagen (Manfredi, 2021). All these studies highlight that the use of tilapia skin in dentistry is multidimensional: from mucosal treatments, periodontal regeneration and possible support to guided bone regeneration, through the use of collagen in different therapeutic forms.

3 FINAL CONSIDERATIONS

The use of tilapia skin (*Oreochromis niloticus*) as a biological dressing has shown promise in the field of regenerative dentistry, especially in periodontal reconstruction surgeries. This biomaterial, rich in type I collagen, highly available, low cost and with excellent biocompatibility, has been shown to be effective in the healing of palatal surgical beds,

comfort, faster epithelialization and better aesthetic result compared to other dressings available on the market.

From the scientific evidence, it was found that, although clinical studies are still initial in number, the results obtained so far point to a high therapeutic potential of tilapia skin not only in dentistry, but in several medical specialties. In addition to accelerating tissue regeneration, the material contributes to the reduction of morbidity associated with the removal of autogenous grafts, representing an important advance in the quality of life of patients undergoing these interventions.

Despite the positive results, more controlled clinical studies are still needed, with larger samples and long-term follow-up, to define specific application protocols in dental practice. In view of this, it is concluded that tilapia skin stands out as a biosustainable, safe and effective alternative, with great potential for insertion in the therapeutic arsenal of periodontal dental surgery and regenerative medicine as a whole.

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**MENTAL HEALTH CARE FOR INDIVIDUALS WITH ANTISOCIAL
PERSONALITY DISORDER: AN INTEGRATIVE REVIEW**

**ASSISTÊNCIA À SAÚDE MENTAL PARA INDIVÍDUOS COM TRANSTORNO DE
PERSONALIDADE ANTISOCIAL: INTEGRATIVE REVIEW**

**ASISTENCIA A LA SALUD MENTAL PARA INDIVIDUOS CON TRASTORNO DE
PERSONALIDAD ANTISOCIAL: REVISIÓN INTEGRADORA**

 <https://doi.org/10.56238/sevened2025.036-150>

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ABSTRACT

This study conducts a systematic review of the literature on mental health care for individuals with antisocial personality disorder. This is, characterized by a persistent pattern of disregard for the rights of others and violation of social norms, presents significant challenges for treatment due to comorbidity with other disorders, resistance to treatment, and social stigma. The review highlights the complexity of managing antisocial personality disorder and the need for specific therapeutic approaches. Programs such as Systems Training for Emotional Predictability and Problem Solving and psychoeducation have shown potential for reducing symptoms and increasing treatment adherence. Additionally, mentalization-based therapy and pharmacotherapy, with the use of medications such as inhaled loxapine, emerge as promising therapeutic tools. However, the literature points to the need for more research and greater investment in training healthcare professionals. Integrating scientific evidence into

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clinical practice is essential to optimize care for these patients and reduce the impact of antisocial personality disorder on the lives of individuals and society.

Keywords: Antisocial Personality Disorder. Mental Health Services. Nursing Care.

RESUMO

O presente estudo realiza uma revisão sistemática da literatura acerca da assistência à saúde mental de indivíduos com Transtorno de Personalidade Antissocial. Este é caracterizado por um padrão persistente de desrespeito aos direitos dos outros e violação de normas sociais, apresenta desafios significativos para o tratamento, devido à comorbidade com outros transtornos, à resistência ao tratamento e ao estigma social. A revisão evidencia a complexidade do manejo do transtorno de personalidade antissocial e a necessidade de abordagens terapêuticas específicas. Programas como o Systems Training for Emotional Predictability and Problem Solving e a psicoeducação demonstram potencial para a redução de sintomas e o aumento da adesão ao tratamento. Além disso, a terapia baseada em mentalização e a farmacoterapia, com o uso de medicamentos como a loxapina inalatória, emergem como promissoras ferramentas terapêuticas. No entanto, a literatura aponta para a necessidade de mais pesquisas e de maior investimento em treinamento de profissionais de saúde. A integração de evidências científicas à prática clínica é fundamental para otimizar o cuidado a esses pacientes e reduzir o impacto do transtorno de personalidade antissocial na vida dos indivíduos e da sociedade.

Palavras-chave: Transtorno da Personalidade Antissocial. Serviços de Saúde Mental. Cuidados de Enfermagem.

RESUMEN

El presente estudio realiza una revisión sistemática de la literatura sobre la asistencia a la salud mental de individuos con Trastorno de Personalidad Antisocial. Este se caracteriza por un patrón persistente de desprecio por los derechos de los demás y de violación de las normas sociales, y presenta desafíos significativos para el tratamiento debido a la comorbilidad con otros trastornos, la resistencia al tratamiento y el estigma social. La revisión pone de manifiesto la complejidad del manejo del trastorno de personalidad antisocial y la necesidad de enfoques terapéuticos específicos. Programas como Systems Training for Emotional Predictability and Problem Solving y la psicoeducación muestran potencial para la reducción de síntomas y el aumento de la adherencia al tratamiento. Además, la terapia basada en la mentalización y la farmacoterapia, con el uso de medicamentos como la loxapina inhalatoria, emergen como herramientas terapéuticas prometedoras. No obstante, la literatura señala la necesidad de más investigaciones y de una mayor inversión en la capacitación de los profesionales de la salud. La integración de la evidencia científica en la práctica clínica es fundamental para optimizar la atención a estos pacientes y reducir el impacto del trastorno de personalidad antisocial en la vida de los individuos y de la sociedad.

Palabras clave: Trastorno de la Personalidad Antisocial. Servicios de Salud Mental. Cuidados de Enfermería.

1 INTRODUCTION

Antisocial Personality Disorder (APD) is demonstrated by the Diagnostic and Statistical Manual of Mental Disorders – DSM-V having as its main characteristic, a diffuse pattern of indifference and violation of the rights of others, which appears in childhood or early adolescence and continues in adult life. This pattern has also been referred to as psychopathy, sociopathy, or dissocial personality disorder. This conduct disorder must have its onset before the age of 15 and cannot be diagnosed in patients under 18 years of age. In addition, antisocial personality disorder has a continuity until adulthood, thus having a chronic course (DSM-V, 2014).

Epidemiological studies have shown a prevalence of 2-3% of individuals with APD in the general population, with a higher percentage among men (3%) than women (1%). Since the diagnostic criteria for APD are currently based on behavior, they are thus different from psychopathy, which is based on interpersonal and affective relationships. However, there is controversy involving such differentiations, given that authors such as Coid and Ullrich (2010) claim that APD and Psychopathy are not distinct diagnostic entities and that they are in a continuous scale of evolution of severity, with psychopathy having the place of greatest severity in this continuous scale.

The etiology of APD has been the subject of studies in recent years. Through a meta-analytic review, Ferguson (2010) identified that 56% of the variation in antisocial behavior can be explained through genetic influences. However, in addition to this fact, in large proportion, there are environmental factors, which contribute to the development and maintenance of the TPA. Such environmental factors, particularly early in life, can significantly affect brain development and thus increase the risk of antisocial behavior (Glenn; Johnson; Raine, 2013). In line with these statements, Kumari *et al.* (2013), observed a direct relationship between the role of psychosocial deprivation, physical and/or sexual abuse in childhood, and reduction in the thalamic volume of the brain of these individuals in adulthood, a fact that caused an additional brain deficit, which may have negative implications for the management of APD.

APD has high rates of comorbidity with different psychiatric disorders, and according to Mueser *et al.* (2012), when APD is co-morbid, the negative effects will be exacerbated. This is due to the fact that individuals with APD face significant difficulties in seeking appropriate help, adhering to treatment, coping with the disease, and building a therapeutic

alliance. Thus negatively impairing the prognosis, management, and treatment of both mental illness and many concomitant physical conditions.

Finally, the fact that TPA has been recognized by Glenn is a point of discussion and problematic; Johnson; Raine (2013), as one of the most difficult forms of psychopathology to treat. Based on factors such as the rare search for treatment by these individuals or even low adherence to treatment, as well as factors external to the patient himself, such as health care providers opposed to the treatment of these individuals or the lack of trials on the treatment of APD. However, although there is still much work to be done in the treatment domain due to the fact that there is a narrow range of recommendations for the treatment of adults with APD (McGauley *et al.*, 2011). The evidence emerging from treatments over the past few decades suggests that the latest methods hold promise in effectively treating this extremely complex disorder.

These challenges point to the need for a more integrated, empathetic, and evidence-based approach to improving health care for people with antisocial personality disorder. Understanding these dynamics is crucial to improving mental health services, formulating more effective health policies, and promoting an integrated care approach that addresses the complex needs of this population. Thus, the objective of this study was to identify in the literature the mental health care offered to individuals with antisocial personality disorder.

2 METHODOLOGY

This is an integrative review of the literature, which followed the guidelines of the PRISMA Protocol (Moher, 2009). The research question was formulated based on the PICO strategy (Hulley; Newman; Cummings, 2015). This investigation is based on an exploratory review of scientific production, relevant studies in a certain area. It is described in five stages: identification of the research question; identification of relevant studies; selection of studies; data analysis; synthesis and presentation of data (JBI, 2015).

The research question, the objective of the study and the agreement descriptors were elucidated by the mnemonic combination PICO: P Population; I Interest; Co Context. And it presents the following guiding question: how is mental health care offered to individuals with antisocial personality disorder described in the literature?

The inclusion criteria were: original articles, published in the last ten years (between July 2014 and August 2024), available in full electronically, not restricted to the language, the place of origin of the productions and the method used. The exclusion criteria were: articles

that distanced themselves from the reflections proposed by this study, literature reviews/reflection, editorials, brief communication, clinical trial projects, abstracts of proceedings, theses, dissertations, course completion work, epidemiological bulletins, management reports, books, official documents of national and international programs.

Data collection took place in August 2024, in the following databases: PubMed, Web of Science, SCOPUS, Cochrane Library, and Virtual Health Library (VHL). These will be searched in the CAPES Journal Portal, based on identification through the Federated Academic Community (CAFe), as a way to standardize the collection in these databases. The following terms included in *the Medical Subject Headings* (MeSH) were used: *Antisocial Personality Disorder*; *Health Service*; *Mental Health Service*. It is noteworthy that, for the collection, only keywords were used, discarding the synonyms presented. In order to enhance the collection of articles, a cross-search between keywords was used by means of the Boolean connector "AND", adopting the same combination in all search locations.

The articles were then selected and identified in three stages: 1) Reading of the titles and abstracts of the studies and exclusion of those that did not fit any of the criteria; 2) Full reading of all the articles selected in the first stage; 3) Selection of works that fit the eligibility criteria. The steps were carried out by two researchers independently, and disagreements were discussed until there was consensus. It should be noted that duplicate articles in the databases were excluded after reading in full in order to avoid exclusion errors.

The Rayyan® platform was used to assist in the pre-analysis of articles, selection of duplicates, and analysis of the titles and abstracts of studies appropriate to the inclusion criteria (Ouzzani *et al.*, 2016). In addition, a flowTable was used for transparency of the selection process of the review corpus.

For the level of evidence, the following classification was considered: level I systematic reviews or meta-analyses of Randomized Controlled Clinical Trials (RCTs); level II evidence obtained from at least one well-designed RCT; level III well-designed clinical trials without randomization; level IV from well-defined case-control and cutting studies; level V obtained from systematic reviews of descriptive or qualitative studies; level VI from a single descriptive or qualitative study; and level VII evidence originating from the opinion of authorities and/or a committee of experts (Galvão, 2006).

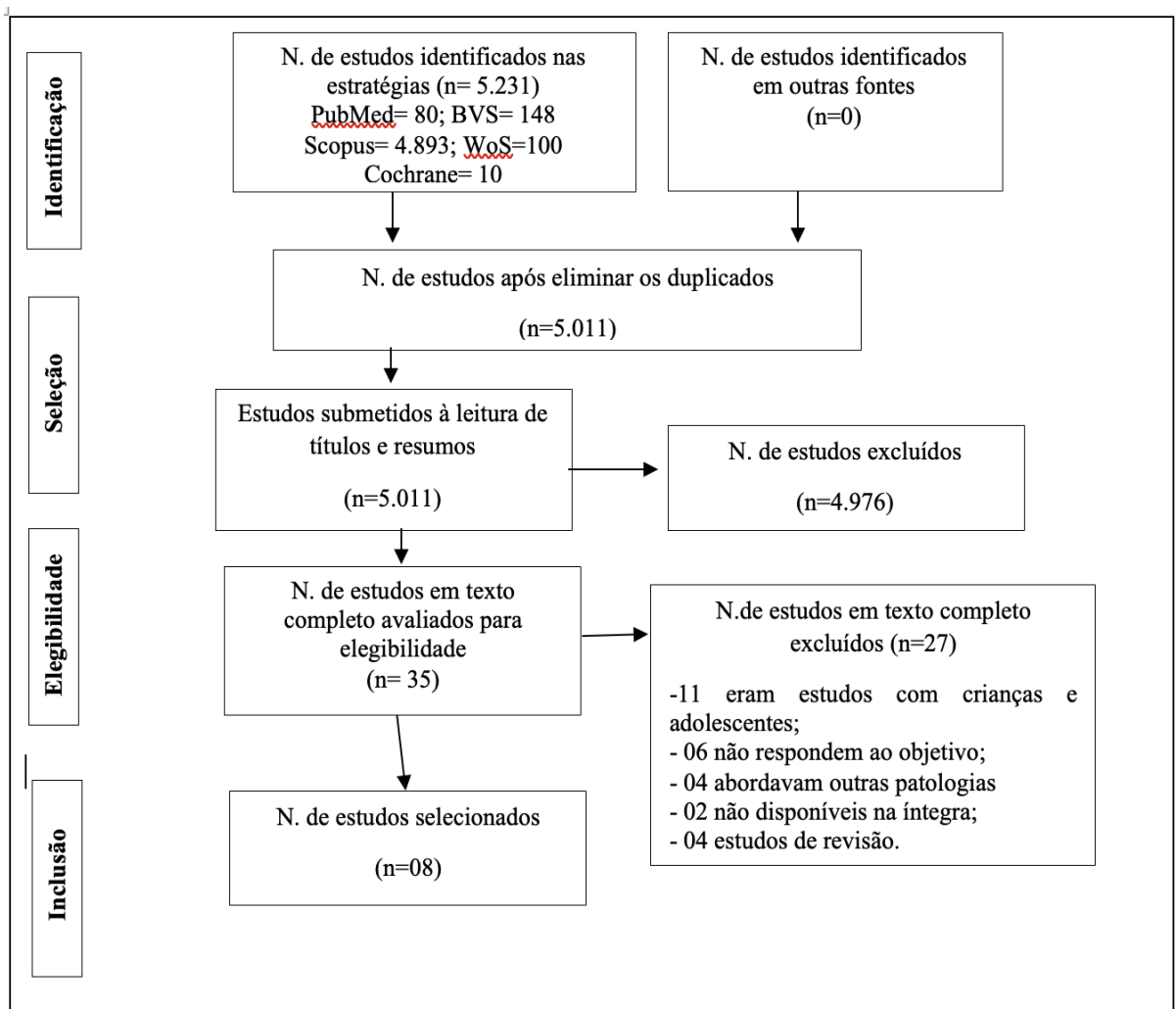
The results were typed into electronic spreadsheets available in the Microsoft Excel 2023® program. It is noteworthy that the study was carried out with data in the public domain, so ethical appreciation was not necessary.

3 RESULTS

A total of 5,231 works were found in the analyzed databases, after a thorough reading and application of the eligibility criteria, 08 articles remained, which include this integrative review (as shown in Figure 1).

Figure 1

Flow of information with the different phases of the systematic review according to the guidance of the PRISMA protocol, 2024



Source: Moher et al., 2009.

All selected studies were published in English (n=8) and were developed in Denmark (n=2), Spain (n=1), United States of America (USA) (n=1), England (n=2), Liberia (n=1) and Norway (n=1). Of the selected works, five are quantitative and three qualitative. The methods used ranged from randomized clinical trials (n=4) classified as evidence level II, to descriptive qualitative studies (n=3) and cross-sectional prospective studies with evidence level VI.

The study population ranged from two to 999 individuals (mean = 500.5). The target subjects were defined as only the adult population, with representation of both sexes, offenders in a semi-open regime, as well as professionals (doctors, nurses, psychologists, therapists, social workers). As expected, the main mental disorder addressed was Antisocial Personality Disorder (n=8), and in addition to this there were: Borderline Personality Disorder (n= 2), Substance Use Disorder (n=1) and Personality Disorder in general (n= 1), as shown in Table 01.

Table 1

Characterization of the articles selected for this integrative review, in the period from 2014 to 2024. Brazil

D	Title	Year/Country	Main results
01	Inhaled Loxapine as a Rapid Treatment for Agitation in Patients with Personality Disorder: A Prospective Study on the Effects of Time (Ferrer <i>et al.</i>)	2022/Spain	Agitation is frequent in patients with personality disorders, especially those with low tolerance and high impulsivity, such as BPD and APD. A quick treatment is essential to avoid consequences such as prolonged hospitalization and use of restraint. Inhaled loxapine, which is rapidly absorbed, appears as an effective alternative, indicated for agitated but non-aggressive patients, as long as they consent. In a study of 30 patients in moderate to severe agitation, loxapine showed significant improvement and no adverse effects, suggesting safety and efficacy in the management of agitation in psychiatric settings.
02	Antisocial personality disorder in group therapy, kindling pro-sociality and mentalizing (Morken <i>et al.</i>)	2022/Norway	The therapists' experience with APD patients in MBT groups revealed four main themes. First, the therapists initially showed insecurity and prejudice, fearing aggressive behavior from the patients, but were positively surprised by their motivation to work on emotional issues. Second, they found it difficult to set clear

			boundaries, and they realized that patients prefer direct communication. Third, they reported that patients often exceed the therapists' comfort level, even though monthly one-on-one sessions help create a healthy distance. Finally, therapists faced challenges in intervening and controlling patients' mental states, often feeling exhausted. Supervision among therapists and an attachment-based approach were pointed out as essential to better deal with countertransference and the emotional challenges of this work.
03	Do People with Borderline Personality Disorder Complicated by Antisocial Personality Disorder Benefit from the STEPPS Treatment Program? (Black <i>et al.</i>)	USA 2016/	Both studies demonstrated a significant improvement in the clinical appearance of patients with APD comorbid to BPD, and this improvement even had characteristics of being greater in the groups of people with BPD plus APD. Thus, STEPPS treatment has been shown to be beneficial for patients diagnosed with APD and who have comorbid BPD. Due to the great overlap between these syndromes, there is a great advantage in the implementation of this evidence-based treatment in patients with APT comorbid to BPD, since at the moment there is no standard treatment for APD.
04	Impulsive lifestyle counseling to prevent dropout from treatment for substance use disorders in people with antisocial personality disorder: A randomized study (Tylstrup; Hesse)	Denmark 2016/	The highest dropout rate was found in patients with APD assigned to TAU (54.1%). The lowest dropout rate was among patients with APD assigned to CLI (41.9%). The present study found support for the efficacy of the Method to reduce treatment abandonment among patients with comorbid SUD and ADT. Concluding that from the evidence of the study it was possible to affirm that people with APD can be treated.

05	Combining cash transfers and cognitive behavioral therapy to reduce antisocial behavior in young men: A mediation analysis of a randomized controlled trial in Liberia (Carpena <i>et al.</i>)	Liberia 2023/L	One of the main findings of this study was that neither Cognitive Behavioral Therapy (CBT) nor Unconditional Cash Transfer (ICT) alone influenced the antisocial behavior of the patients studied, but through the combination of both approaches significant reductions in antisocial behavior were observed.
C	Exploring therapeutic engagement with individuals with a diagnosis of personality disorder in acute psychiatric inpatient settings: A nursing team perspective (Acford; Davies)	England 2021/ d	Study participants reported having lower levels of perceived understanding and positive emotional response to APD compared to mental health nurses in another study. And they also reported having less therapeutic involvement and greater emotional difficulties with this group of patients.
07	"They're Really PD Today": An Exploration of Mental Health Nursing Students' Perceptions of Developing a Therapeutic Relationship With Patients With a Diagnosis of Antisocial Personality Disorder (Jones; Wright)	England 2015/ d	This qualitative study investigated the perceptions of nursing students about the challenges of establishing therapeutic relationships with patients diagnosed with APD. This bond is essential to promote positive outcomes, but it can be difficult to establish due to the distrust of these patients. In addition, the article highlights the stigma associated with the diagnosis of APD, often compounded by criminal histories, and recommends that the focus be on the person, not just the disorder. The education and preparation of professionals are essential to offer individualized and effective care, aiming to see the patient beyond their negative characteristics.
08	Psycho-education for substance use and antisocial personality disorder: a randomized trial	Denmark 2015/ ark	This randomized clinical trial provides evidence that through the ILC+ program the usual treatment for individuals with substance abuse disorder comorbid to ADD. There was an improvement in the

	(Thylstrup; Schröder; Hesse)		treatment of these substance use disorders and that more days of abstinence were observed in patients who underwent this treatment, compared to those who underwent only the usual treatment against substance abuse. Regarding the levels of aggression of the patients, no significant effects were found in the psychoeducational treatment compared to the usual treatment. It is possible that the changes cannot be observed, given the short period of the survey.
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Source: The authors (2024).

3.1 STRATEGIES AND EFFICACY OF TREATMENT FOR AGITATION IN PATIENTS WITH PERSONALITY DISORDERS

Among one of the greatest demands in psychiatric emergency services is that of patients with agitation, which is characterized by an excess of motor activity, associated with a feeling of internalized tension. If not properly treated, it can trigger violent/aggressive behavior, requiring the use of mechanical or pharmacological restraint, which usually leads to a longer hospitalization time (Ferrer *et al.*, 2022).

Patients diagnosed with personality disorders have a tendency to develop agitation at some point, especially those who have a low tolerance for managing negative emotions, among them: Borderline Personality Disorder and Antisocial Personality Disorder.

Among the treatment options that exist for moderate/severe acute agitation and that are commonly used in emergency services is the oral or intramuscular administration of drugs of the benzodiazepine or antipsychotic class. These medications, as effective as they are, can generate side effects such as: muscle hypotension in the case of benzodiazepines, as well as excessive sedation and antipsychotics can cause extrapyramidal reactions (Ferrer *et al.*, 2022).

Therefore, there is a need for a medication that is effective, easy to apply, with a short latency period and that has its effect in a stable way. Loxapine stands out in its inhaled form. A drug of the class of antipsychotics, but classified as atypical, capable of promoting significant improvement in symptoms of moderate/severe agitation within a short period, and still without side effects recorded by the article. Proving to be a viable and very effective option

in the treatment of agitation, keeping the patient awake and aware of their treatment process, becoming more protagonist of their care (Ferrer *et al.*, 2022).

However, inhaled loxapine demonstrates a restriction regarding its use in cases of agitation where there are already established levels of aggressiveness, or with total lack of control of body movements, due to the fact that it can only be used with the patient's consent (Ferrer *et al.*, 2022).

In this way, the research brings a new formulation for the treatment of agitation, especially in patients with personality disorders, especially APD. It is extremely relevant, given that the treatment of patients with APD is on a global scale, including moments of aggravation and aggravation (Ferrer *et al.*, 2022).

3.2 SCOPE OF TREATMENT OF COMORBIDITIES IN PATIENTS WITH ANTISOCIAL PERSONALITY DISORDER AND THE OPPORTUNITY TO LINK TO HEALTH SERVICES

Individuals diagnosed with APD have a high rate of comorbidities associated with a primary diagnosis. The characteristics that aggregate APD with other personality disorders aggravate the clinical picture of these patients, since the synergism between the disorders results in a more intense impairment of the individual (Tylstrup; Hesse, 2016).

Among the main comorbidities to APD, the following were identified in the articles: Borderline personality disorder (BPD) and Substance use disorder (SUD), which were established as points of contact between these individuals and health services, providing them with the opportunity to seek treatment for these disorders (Black *et al.*, 2016; Tylstrup; Hesse, 2016).

Given the fact that patients diagnosed with APD present great resistance because they seek treatment for this diagnosis in isolation, as well as being marginalized, many times, within the psychiatric care services themselves, the search for treatment of their comorbidities is a window of opportunity to generate changes, in order to reduce antisocial behaviors in these individuals. (Tylstrup; Hesse., 2016).

Through the implementation of the STEPPS program: *Systems Training for Emotional Predictability and Problem Solving*, originally developed for patients diagnosed with Borderline Personality Disorder, but which was comparatively applied to patients with comorbid APD in the study. It obtained a surprising result: There was a significant improvement in the clinical appearance of patients with ADT comorbid with BPD. The

improvement even had characteristics of being greater in the groups of people with BPD plus APD (Black *et al.*, 2016).

Patients with ADP comorbidized with TUS are presented with an approach through psychoeducation, called ILC. Acronym from English: *Impulsive Lifestyle Counseling*. Through this approach, it is intended that patients not only have a lower dropout in treatment, but also to become more self-aware of their behavioral difficulties and how this can affect them and others (Tylstrup; Hesse, 2016).

The study found evidence supporting the effectiveness of the ILC method in reducing treatment dropout among patients with comorbid substance use disorder and antisocial personality disorder. Given the evidence from this study and other recent research, it is demonstrated that individuals with APD can be treated, refuting the theory that has been established among mental health professionals, that these patients are untreatable (Tylstrup; Hesse, 2016).

The implementation of these treatments can provide the generation of bonds between patient and health professional, promoting the creation of a therapeutic relationship, a relationship that has been shown to be capable of generating positive treatment results and an improvement in the individual's own functioning. As well as the results previously demonstrated that demonstrate an alternative to the treatment of ADD patients with comorbidities (Jones; Wright, 2015).

3.3 DIFFICULTIES OF THERAPISTS AND MENTAL HEALTH PROFESSIONALS IN THE CARE OF PATIENTS WITH APD AND THE CHALLENGE OF ESTABLISHING THERAPEUTIC RELATIONSHIPS

The analysis of the texts reveals a comprehensive view of the difficulties faced by therapists and mental health professionals when caring for patients with Antisocial Personality Disorder. These challenges involve developing effective therapeutic bonds, managing negative countertransference, and structuring approaches that respect professional boundaries (Morken *et al.*, 2022; Acford; Davies, 2021; Jones; Wright, 2015).

Mentalization-based treatment (MBT) emerges as a promising option, especially in groups, to help patients with APD develop greater self-awareness and emotional control. However, one of the main obstacles encountered by therapists is negative countertransference, characterized by feelings of aggression, helplessness, and guilt in the face of patients' challenging behaviors. This phenomenon affects the therapist's ability to

maintain the emotional detachment necessary for an empathetic approach, especially when dealing with explosive or aggressive behaviors. Studies show that therapists benefit from peer support and supervision to manage emotional distress and prevent burnout (Morken *et al.*, 2022).

A study demonstrated that the nurses' perspective illustrates similar emotional difficulties when interacting with patients with APD. The stigma associated with personality disorders often intensifies feelings of anger and frustration, which ultimately results in less therapeutic engagement on the part of professionals. To minimize this emotional burden, nurses emphasize the importance of structured approaches and the use of tools to monitor the emotional state of patients, such as "Recovery Action Plans" and "Early Warning Signs". These strategies facilitate the management of interactions with patients and contribute to the creation of a stronger bond that is less affected by emotional stress (Acford; Davies, 2021).

In addition, a well-defined treatment structure is essential for the development of an efficient therapeutic bond with patients diagnosed with APD. At MBT-TPA, biweekly group and monthly one-on-one sessions provide balance between closeness and emotional boundaries, benefiting both patients and therapists. Similarly, nurses report that the presence of a clear admission and discharge plan contributes to the creation of more productive and therapeutic bonds, reducing the negative impact of the emotions involved (Morken *et al.*, 2022; Acford; Davies, 2021).

Setting boundaries and emotional self-control emerge as recurring challenges for professionals. Both therapists and nurses report difficulties in establishing and maintaining boundaries with patients, which is especially important in the case of patients with APD, who often ignore or disrespect these boundaries. The ability to control one's emotions is essential to prevent negative interactions from compromising the quality of treatment. This challenge intensifies in the context of MBT, where therapists report the difficulty of intervening at the right time without compromising the patient's autonomy (Jones; Wright, 2015).

Another critical point is the perception of safety and trust in the work environment. Professionals with experience in forensic environments report a more negative perception and a lower sense of security when dealing with patients with APD, indicating that prior exposure to forensic contexts can increase stigma and hinder the construction of an effective therapeutic relationship. This factor suggests the need for specific training for these professionals to learn to manage their own perceptions and emotions when dealing with this type of patient (Thylstrup; Schrøder; Hesse, 2015).

In summary, the data presented confirm the complexity of working with patients diagnosed with APD, especially due to the emotional impact on the professionals involved. The challenge of maintaining a therapeutic relationship without negative countertransference or stigma compromising care is great, but it can be mitigated with continuous supervision, emotional support among colleagues, and structured approaches. These factors are key to improving the engagement and treatment effectiveness of patients with APD (Morken *et al.*, 2022; Acford; Davies, 2021; Jones; Wright, 2015; Thylstrup; Schröder; Hesse, 2015).

4 DISCUSSION

The results demonstrate that mental health care for people with APD is complex, and still requires many advances. Several obstacles in the treatment and social reintegration of people with APD need to be overcome, among these difficulties: the development of a bond between patient and professional, as well as the stigma that still permeates mental disorders. However, innovative treatments are under development in order to support professionals in the management of these patients, such as the STEPPES Program and Psychoeducation.

In view of the findings of this study, psychomotor agitation is a common and recurrent event among psychiatric patients, as highlighted by Garriga *et al.* (2016). These authors point out that this symptom can occur not only in emergency departments, but also in hospital admissions and even in outpatient settings.

According to the same authors, agitation is characterized by an activity that is generally unproductive and semi-structured. Which usually does not begin with the intrinsic purpose of an aggressive action or violent acts, but can with the escalation of agitation, lead to behavior of such nature (Garrida *et al.*, 2016).

Agitation is a broad and multifactorial syndrome, and it encompasses many psychiatric conditions. Previous studies (Battaglia, 2005; Fountoulakis; Vieta, 2008; Nordstrom; Allen, 2007, apud Garriga *et al.*, 2016), had already shown that it is closely linked to the schizophrenia, personality disorder, (especially borderline and antisocial), as well as other disorders. And that the management of agitation in patients with Personality Disorder, especially APD and BPD, is seen as complex and challenging, given the high prevalence of patients in psychiatric emergency departments.

As pointed out by Patrizi *et al.* (2018), the reassurance of agitated patients is a challenge and it is essential to address the acute symptoms of psychological distress and the beginning of agitation more quickly, avoiding as much as possible the escalation of agitation

to a more serious point that requires more imposing interventions and without being able to count on the patient's cooperation.

Verbal intervention, or verbal de-escalation, consists of talking to the patient with the aim of leading him to a calmer state (Stevenson; Otto, 1998). Garriga *et al.* (2016), corroborate this definition, highlighting the importance of verbal de-escalation to reduce the risk of violence. However, despite the potential of this technique, there is still little scientific evidence to prove its effectiveness (Richamond *et al.*, 2012 apud Garrida *et al.*, 2016).

Drug treatment for episodes of acute agitation is considered an effective way to reassure the patient. It is used when non-pharmacological treatments fail. Drugs of the benzodiazepine class or typical antipsychotics may be recommended, which are sedative drugs, but which can cause serious adverse effects, deleterious to the patient, such as exacerbated sedation, extrapyramidal symptoms, restricting their use (Patrizi *et al.*, 2018).

Thus, the treatment of agitation with a focus on patients diagnosed with personality disorder, among which the most prevalent are Borderline Personality Disorder and Antisocial Personality Disorder, has proven to be a challenge, and there is still no consensus regarding the standard treatment (Patrizi *et al.*, 2018).

Thus, among the options of medications to control agitation, atypical antipsychotics emerge, among which the study by Ferrer *et al.* (2022), describes loxapine in the inhaled form that can reach maximum concentration in the body after just two minutes, being extremely fast to provide the expected results in patients, as well as causing fewer extrapyramidal and sedation symptoms compared to medications commonly used in the clinic.

An international study corroborates the findings of this study, and demonstrates that through a prospective randomized clinical trial, with 41 patients diagnosed with Personality Disorder, 2.4% obtained "better" results after ten minutes of the administration of inhaled loxapine and in twenty minutes a percentage of 48.8% were considered "much better". Demonstrating that inhaled loxapine was fast, effective, safe, and well accepted in agitated patients with personality disorder (Patrizi *et al.*, 2018).

It is worth noting that both studies converge on the importance of this therapy as being able to provide a state of calm in the patient, without the need to impose sedation, and that its non-invasive method facilitates the acceptance of the treatment by individuals with agitation (Patrizi *et al.*, 2018; Ferrer *et al.*, 2022).

Also, Garriga's study *et al.* (2016) points out that in a literature review evidence of clinical trials was found (Allen *et al.*, 2011; Lesem *et al.*, 2011; Kwentus *et al.*, 2012), which corroborate the efficacy of inhaled loxapine in the treatment of acute agitation.

On the other hand, it should be noted that this method of administration, via inhalation, brings with it the limitation that only collaborative patients in a state that is not yet violent/aggressive can be treated. Due to this restriction in the profile of patients who fit as possible users of this medication, this point becomes a caveat to this treatment (Shader; Richard, 2017).

In addition, inhaled loxapine emerges as a promising new therapeutic option in the treatment of agitated patients with personality disorders, among which APT stands out. Promoting the return to a basal state in the patient, as well as allowing him to be autonomous in the choice of his treatment, and not to be sedated and/or to necessarily remain hospitalized. Being able to reestablish calm quickly and effectively (Garriga *et al.*, 2016).

In line with the findings of this review, studies have demonstrated the high prevalence of the diagnosis of APD and other mental disorders in a comorbid manner (Black *et al.*, 2016; Thylstrup; Hesse, 2016; Yakeley; Williams, 2014), states that this comorbidity is considerably and complex, particularly substance use disorder. And that shows itself It is important to diagnose comorbid conditions, as the presence of antisocial personality disorder acts as a negative moderator of treatment response when these conditions are treated by conventional approaches.

Two types of comorbidities were highlighted in the articles analyzed, between BPD and APD, as well as by the diagnoses of concomitant SUD and APD. As well as presenting different treatment strategies: The first being analyzed the effectiveness of the treatment *Systems Training for Emotional Predictability and Problem Solving* (STEPPS) and the second psychoeducational program, the *Impulsive Lifestyle Counseling* (ILC). Both analyzed the effectiveness of these treatments in comparison with traditional approaches carried out in health systems. Demonstrating a superiority in the results of these approaches compared to conventional ones (Black *et al.*, 2016; Thylstrup; Hesse, 2016).

In both treatments, a group approach was used, which can be seen intrinsically as a mode of psychic change, being highlighted for its advantages for individuals with high impulsivity and low affectivity, as it is less provocative than individual therapy, as well as for bringing these individuals closer to their group partners, being able to understand others (Bateman; Tyrer, 2004 apud Yakeley; Williams, 2014).

Patient engagement and maintenance in substance abuse treatment are aimed at in the study of Thylstrup; Hesse (2016), because according to the authors, for the treatment to be effective, it is essential that there is no premature abandonment. Since the Patients who are not on treatment cannot be treated.

According to Yakeley; Williams (2014), up to 75% of individuals with APD abandon treatment, presenting worse clinical outcomes. The authors suggest psychoeducation as a strategy to increase adherence to treatment. Corroborating the findings of this study, which tested the impact of the addition of a brief psychoeducational program, the aforementioned ILC program on the level of abandonment of patients in outpatient treatment of substance abuse comorbid to APD.

Thylstrup *et al.* (2015), emphasize that the brief intervention carried out in the study is in no way a cure for APD, but that it is inserted as a step towards the treatment of this neglected disease. Reiterating that with the reduction of substance use, the possibility of additional interventions and support is opened, potentially increasing the social and psychological stability of the patient.

Due to the wide overlap of comorbidities with APD, many people have likely been excluded from participating in an evidence-based treatment program. The exclusion of individuals with APD from treatment programs, due to concerns about disruptive behaviors, is a common but questionable practice. Studies indicate that these concerns are largely unfounded. Exclusion of these patients limits access to effective treatments and can perpetuate the cycle of problems associated with APD. It is essential to develop therapeutic approaches that take into account the specific needs of these patients (Black *et al.*, 2016).

The beginning of a treatment also symbolizes the creation of a relationship. Where this therapeutic alliance exists, there is the possibility of establishing a relationship of approximation, with the strengthening of the therapeutic bond or the distancing and weakening of this relationship (Bender, 2005).

The concept of therapeutic alliance is usually related to Freud, who in his works observed that it is necessary to convey interest and sympathy to the patient in order to involve them in a collaborative treatment. The term therapeutic alliance was later defined, using psychoanalytic language, as a division by the therapist of the patient's ego, allowing him to differentiate and work with the healthiest elements of the individual, against possible resistances and against his own pathology (Bender, 2005).

This definition is useful in relation to personality disorders because it first recognizes that there will be parts of the personality, that is, the individual's ego, that due to their pathology can affect and frustrate professional help in the treatment of the patient. And it is necessary for the professional to be creative in differentiating and dividing the healthiest elements of the individual, observing their potentialities (Bender, 2005).

Corroborating with Acford and Davies (2021), an international article shows that among the reasons given by patients for the failure of the treatment proposed to them are frustration with treatment and lack of social support. Thus, involvement in treatment is essential for a successful outcome and, according to the authors, requires the development of a constructive and progressive dialogue between patients and clinicians. Because patients with personality disorders may often present fluctuations in their motivations and level of interest, but the function of involvement is to collaboratively prevent a break in treatment, and gradually bring more trust to this therapeutic relationship (Bateman; Tyrer, 2004).

Perhaps the main problem in engaging the patient is creating the patient's analytical trust. Due to the fact that the patient has a systemic difficulty in trusting and believing in the people around them, including their caregivers, as well as in the world itself as a reliable place (Bender, 2005).

In line with this, it is demonstrated that patients with "dramatic" Cluster B personality disorder (antisocial, borderline, histrionic and narcissistic) have as their main problem the formation of a therapeutic alliance and the crossing of limits. Thus, it is of paramount importance to avoid crossing inappropriate lines, in the search to build an alliance with the patient (Bender, 2005).

Through empirical evidence, it was possible to observe that some patients with APD were able to form true therapeutic alliances, which generated positive results. However, according to the same author, patients with this type of disorder have a tendency to build a pseudo-alliance in order to obtain advantages for themselves, especially in correctional environments. Where the therapist is sought to obtain undue privileges for him (Bender, 2005). In this way, the mental health professional has to maintain the ability to be firm, skillful and competent, despite provocation, anxiety and pressure to transgress limits (Bateman; Tyrer, 2004).

Currently, the focus has been placed on training and continuous learning as extremely relevant factors in the development of excellent professionals. And through critical analysis,

the current standard training of mental health professionals is not sufficient to treat and care for patients with APD (Bateman; Tyler, 2004).

Still, another factor that can interfere in the care of patients diagnosed with APD and other mental disorders is countertransference, which was initially introduced by Sigmund Freud, identifying that the patient's influence on the analyst's unconscious feelings can be detrimental to the treatment (Betan *et al.*, 2005).

A number of studies have attempted to operationalize the concept of countertransference by defining countertransference responses as therapists' reactions to patients, which are based on therapists' unresolved conflict. This operationalization was carried out through avoidant behaviors that were analyzed, where it was defined whether a professional performed countertransference through gestures of disapproval, silence, ignoring, among others. Thus, seeking a way to empirically demonstrate this fact, which has already been discussed so much in a theoretical way (Betan *et al.*, 2005).

Study carried out by Betan *et al.* (2005), classifies countertransference into eight dimensions, and relates these dimensions to the type of personality disorder. Demonstrating that it is possible to observe a pattern of countertransference for DSM-IV personality disorders divided by Clusters (A, B, C). Thus, the countertransference mode that the cluster B factor (dramatic/erratic), which is among the pathologies of APD, would be associated with the professional who had behaviors and feelings of being disorganized and overloaded, of feeling helpless and inadequate, or of having an over-involved behavior.

Through this finding, countertransference, which is very common among professionals who treat patients with APD, can use this to their advantage, as the interpellations between countertransference patterns and the characteristics of the personality disorder support the broad view of countertransference reactions as useful in the agnostic understanding of patient dynamics. particularly those involving repetitive interpersonal patterns (Betan *et al.*, 2005).

In short, mental health care for people with APD reveals a challenging scenario, with significant gaps to be filled. Building solid bonds and demystifying mental disorders are crucial to overcoming existing obstacles. However, hope lies in research advances, with initiatives such as STEPPES and Psychoeducation opening up new perspectives for treatment and rehabilitation.

Regarding the limitations of the present study, it is worth noting the small number of articles selected at the end of all phases of refinement of the research, thus having a small

sample of articles to be analyzed, and it may not be possible to verify other sources or relevant data that were not included in the selection of the databases. Finally, it should be stated that due to the fact that all the articles selected for reading in full are of an international nature, inaccuracies regarding the understanding of the content in a more reliable way may have occurred, due to the difference in languages.

The present study can contribute to the addition of scientific content at the national level regarding how health care is provided to individuals with antisocial personality disorder, given that all the selected articles and a large part of the database are produced in English, produced mainly in first world countries. Helping to understand the aspects that involve this disorder that for so many decades have been neglected, even being considered untreatable.

5 FINAL CONSIDERATIONS

The results of this review demonstrated that health care for people with APD is complex and has several obstacles. People with APD tend to develop psychomotor agitation, which is common to the disorder. Thus, some treatment strategies are used by health professionals, such as benzodiazepine medications or antipsychotics. Other treatments can be used in the management of patients with APD, the STEPPS Program and psychoeducation are among the innovative programs in the area.

It was also possible to highlight the difficulties encountered by health professionals, such as: the development of a professional-patient and patient-health service bond, negative countertransference, personalized and effective therapeutic approaches, and the stigma of professionals in relation to TPA.

Thus, there is a gap within the content addressed, given the reduced number of articles selected after rigorous analysis of the seized database. This demonstrates the need and urgency with which this topic needs to be addressed in studies of high methodological quality, providing and outlining the treatment of patients with ADT with greater clarity and reliability.

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LEARNING STYLES IN DIDACTIC PLANNING OF HIGHER EDUCATION

ESTILOS DE APRENDIZAGEM NO PLANEJAMENTO DIDÁTICO DA EDUCAÇÃO SUPERIOR

ESTILOS DE APRENDIZAJE EN LA PLANEACIÓN DIDÁCTICA DE LA EDUCACIÓN SUPERIOR

 <https://doi.org/10.56238/sevened2025.036-151>

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ABSTRACT

Objective: To develop a methodological proposal to identify the characteristics of the students in a group (personality, academic level, context, cognitive structure and learning styles), to guide didactic planning towards comprehensive training, meaningful and personalized learning.

Theoretical Framework: Students with heterogeneous characteristics in their biography and academic history converge in the classroom. Its identification by means of various diagnostic models (Briggs-Myer; Honey-Mumford; Kolb; VARK; 4MAT-System) allows for the adaptation of didactic planning improving students' academic results.

Method: A qualitative, descriptive, literature review study was carried out, analyzing didactic planning and several models of learning styles, to develop a methodological proposal that identifies the characteristics of students in a school group (personality, academic level, context, cognitive structure, learning styles).

Results and Discussion: The characteristics and learning styles identified by the models reviewed are personality (Briggs-Myer), attitude and behavior (Honey-Mumford; Honey-Alonso), experiential learning (Kolb), preferential sensory modality for perceiving and processing information (VARK, Fleming-Mills model), laterality and specificity of the cerebral hemispheres (Bernice McCarthy's 4MAT-System), interaction between students and teachers (Grasha-Riechmann). It included also an initial diagnostic examination, individual and group interviews and team building.

Research implications: Didactic planning oriented towards the characteristics and learning styles of students is an innovative strategy to achieve meaningful and personalized learning.

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Originality/Value: The relevance of the study is to emphasize the need to identify the differences between the students of a group, in order to generate changes both in didactic planning and at the institutional level, benefiting the community.

Keywords: Learning Styles. Didactic Planning. Higher Education.

RESUMEN

Objetivo: Elaborar una propuesta metodológica para identificar estilos de aprendizaje y características del alumnado en un grupo (personalidad, nivel académico, contexto, estructura cognitiva), para orientar la planeación didáctica favoreciendo la formación integral, el aprendizaje significativo y personalizado.

Marco Teórico: En el aula confluyen estudiantes con características heterogéneas en su biografía e historia académica. Su identificación mediante diversos modelos diagnósticos (Briggs-Myer; Honey-Mumford; Kolb; VARK; 4MAT-System) permite adecuar la planeación didáctica para mejorar los resultados académicos.

Método: Se realizó un estudio cualitativo, descriptivo, tipo revisión bibliográfica, analizando la planeación didáctica y varios modelos de estilos de aprendizaje, para elaborar una propuesta metodológica que identifique las características del alumnado en un grupo escolar (personalidad, nivel académico, estructura cognitiva, estilos de aprendizaje y contexto).

Resultados y Discusión: Las características y estilos de aprendizaje que identifican los modelos analizados son: personalidad (Briggs-Myer), forma de actuar (Honey-Mumford; Honey-Alonso), aprendizaje experiencial (Kolb), modalidad sensorial preferente para percibir y procesar la información (modelo VARK, Fleming y Mills), lateralidad y especificidad de los hemisferios cerebrales (4MAT System de Bernice McCarthy), interacción alumnado-docentes (Grasha-Riechmann). Se incluyó: examen diagnóstico inicial, entrevistas e integración de equipos.

Implicaciones de la investigación: La planeación didáctica orientada hacia las características y estilos de aprendizaje del alumnado, es una estrategia innovadora para lograr el aprendizaje significativo y personalizado.

Originalidad/Valor: Este estudio destaca la necesidad de identificar las diferencias entre el alumnado de un grupo, para generar cambios en la planeación didáctica e institucionales, beneficiando a la comunidad.

Palabras clave: Estilos de Aprendizaje. Planeación Didáctica. Educación Superior.

RESUMO

Objetivo: Elaborar uma proposta metodológica para identificar estilos de aprendizagem e características do alunado em um grupo (personalidade, nível acadêmico, contexto e estrutura cognitiva), a fim de orientar o planejamento didático, favorecendo a formação integral e a aprendizagem significativa e personalizada.

Referencial teórico: Na sala de aula coexistem estudantes com características heterogêneas em suas trajetórias pessoais e histórias acadêmicas. A identificação dessas características por meio de diferentes modelos diagnósticos (Briggs-Myers; Honey-Mumford;

Kolb; VARK; sistema 4MAT) permite adequar o planejamento didático, contribuindo para a melhoria dos resultados acadêmicos.

Método: Foi realizado um estudo qualitativo, descritivo, do tipo revisão bibliográfica, analisando o planejamento didático e diversos modelos de estilos de aprendizagem, com o objetivo de elaborar uma proposta metodológica capaz de identificar as características do alunado em um grupo escolar (personalidade, nível acadêmico, estrutura cognitiva, estilos de aprendizagem e contexto).

Resultados e discussão: As características e estilos de aprendizagem identificados pelos modelos analisados incluem: personalidade (Briggs-Myers), forma de agir (Honey-Mumford; Honey-Alonso), aprendizagem experiencial (Kolb), modalidade sensorial preferencial para perceber e processar informações (modelo VARK, de Fleming e Mills), lateralidade e especificidade dos hemisférios cerebrais (sistema 4MAT, de Bernice McCarthy) e interação entre estudantes e docentes (Grasha-Riechmann). Foram incluídos, ainda, exame diagnóstico inicial, entrevistas e integração de equipes.

Implicações da pesquisa: O planejamento didático orientado pelas características e estilos de aprendizagem do alunado constitui uma estratégia inovadora para promover a aprendizagem significativa e personalizada.

Originalidade/valor: Este estudo destaca a necessidade de identificar as diferenças entre os estudantes de um grupo, a fim de promover mudanças no planejamento didático e institucional, beneficiando a comunidade acadêmica.

Palavras-chave: Estilos de Aprendizagem. Planejamento Didático. Educação Superior.

1 INTRODUCTION

“... The most important factor influencing learning, it is what the student already knows. Find this out and teach yourself accordingly.”
D. Ausubel (1983).

For most of the last century, in the field of education, traditionalist pedagogy privileged teaching over learning, thus highlighting the leading role of teachers over that of students. Also notable in educational programs was the supremacy of thematic content, over the application, construction and reconstruction of knowledge, as well as teaching work where strategies, teaching techniques and learning assessment focused on the cognitive functions of the left cerebral hemisphere (memorization and reproduction of content or information); likewise, the context of the educational process was significantly ignored.

However, it was from the emergence of the constructivist approach in educational models in the seventies and eighties of the twentieth century, essentially based on (Carretero M, 1993; Lozano A, 2001):

1. The theory of cognitive development (1936-1950) by Jean Piaget (1896-1980), which relates the first stages of human development, from birth, to the improvement of cognitive functions (cognitive constructivism, 1971).
2. The theory of significant learning (1960-1970) by David Ausubel (1918-2008), which is developed by relating new information with previous knowledge in a non-linear way.
3. The theory of socio-cultural learning (1978) by Lev Vygotsky (1896-1934), which emphasizes the importance of social, cultural, and linguistic interaction between people and their environment for the development of learning (social constructivism, 1978).

When the panorama of teaching work began to change, tending to prioritise learning over teaching, so that the main protagonist of the teaching-learning process began to be the students and not the teachers (Guerra GJ, 2020).

Current pedagogical trends promote comprehensive training, meaningful, student-centered learning, and personalized learning (Ausubel D, 1983; Delors J, 1996; UNESCO-OIE 2017). How to develop an appropriate environment in the classroom to achieve this objective? It is difficult to answer this question, but achieving it means for teachers to accept the challenge and responsibility, truly understanding what their role should be as teachers of the 21st century: to assume the position of guide, facilitator, mediator and example throughout the educational process, but above all, to be a promoter of learning and a researcher of the

characteristics and learning styles of the students. of their own teaching practice and educational context (Valarezzo JW, 2019; UNESCO, 1996, 2017).

On the other hand, it is a reality that in a classroom, students with very diverse characteristics and needs converge, related to their personal biography, academic level, personality, cognitive structure and learning styles, as well as their interests and abilities (Alonso CM, 1997, 2007).

Likewise, UNESCO's International Bureau of Education (IBE) has emphasized the importance of recognizing the diversity of learning styles and addressing the needs of each student, paying attention to the relevance of what is taught and stimulating the capacity for inquiry (UNESCO-IBE, 2017).

Hence, the organization of the educational institution and the planning of the teaching work ("*Didactic Planning*") must contemplate this perspective, especially to help students achieve their maximum potential for human and professional development.

OBJECTIVE: To develop a methodological strategy that allows the identification of the individual characteristics of the students of a group, in relation to their personality, academic level, context, cognitive structure and learning styles, to guide didactic planning favoring the development of comprehensive training, meaningful and personalized learning of students.

2 METHODOLOGY

2.1 RESEARCH DESIGN: QUALITATIVE, DESCRIPTIVE, BIBLIOGRAPHIC REVIEW.

2.2.1 Materials and method

The models related to different learning styles of various authors (available in academic Internet search engines such as Google Scholar, Redalyc, SciElo, Dialnet) designed to identify the characteristics, preferences and learning styles of the students were analyzed. Based on the different methodological approaches analyzed, a strategy proposal was developed to identify the personal characteristics of the students who make up a class group, in relation to their personal history, personality type, cognitive structure and learning styles. Likewise, strategies were added to assess the academic level and personal context, in order to improve the student's academic result, through the adaptation of didactic planning.

3 RESULTS

The different models designed to assess learning styles, which were reviewed and analyzed, are: the Kolb model, Honey-Mumford, 4MAT System, Briggs and Myers, VARK (N.

Fleming, and C. Mills) and the Grasha-Riechmann model. Among its main characteristics and the aspects they investigate are:

3.1 KOLB MODEL

Developed by David A. Kolb, at the beginning of the 70's. Identify two fundamental dimensions of the learning process: perception and processing, finding that in each of them there are 2 opposite types:

- a) In perception: concrete experience and abstract conceptualization.
- b) In processing: active experimentation and reflective observation.

With the above, Kolb built a 4-quadrant model where he explains and describes four learning styles: convergent, divergent, assimilator and accommodating. Each person shows a style that is predominant, but not exclusive.

To locate each learning style, he developed an instrument called the Learning Style Inventory (LSI); this "inventory" is obtained through a 12-question questionnaire, which he formulated based on his *"theory of experiential learning"* (Kolb, 1984).

3.2 HONEY-MUMFORD MODEL

Produced by Peter Honey and Allan Mumford in 1986. It consists of a questionnaire of 20 questions, which locate the learning style according to 4 categories: active, reflective, theoretical and pragmatic. From the first results they obtained, they elaborated a detailed description of each style, based mainly on the *"way people act"*.

Based on this proposal, Alonso, Gallego and Honey (1992) prepared a list of the characteristics and skills of each style (Honey-Alonso questionnaire), concluding that: *"the four learning styles can present combinations between them, in a logical order and of cultural significance"*

3.3 MODEL 4MAT SYSTEM

It was developed by Bernice McCarthy in 1987, based on proposals by Kolb and Briggs-Myers. It consists of applying a questionnaire devised by Kolb (2008), which contains 18 questions, which are based on *"the laterality and specialization of the two cerebral hemispheres"*. This author proposes 4 learning styles: imaginative, analytical, common sense and dynamic. He even considers that these styles integrate a *"natural learning cycle"*, so that this proposal states that optimal learning is only achieved when the person goes through the

four styles.

The 4MAT System integrates the levels of:

1. Comprehension (experimenting with information and integrating it into oneself).
2. Conceptualization (internalizing concepts).
3. Operationalization (applying knowledge through practice and customization).
4. Evaluation (creating knowledge and integrating it into personal life).

3.4 BRIGGS AND MYERS MODEL

These authors based their proposal on the model of "*personality types*" of Carl G. Jung (1921), which allows correlating learning styles with interpersonal relationships. They identified two perceptual processes (sensitive and intuitive) and two for decision-making (rational and emotional), which people use daily in any activity. The difference is in the process used predominantly, which according to Jung, characterizes the personality type (Almaguer TE, 1998).

Katharine Cook Briggs (1875-1968) and Isabel Briggs Myer (1897-1980), mother and daughter respectively, designed a questionnaire in the 40's called Myers-Briggs Type Indicator (MBTI), which allows people to know their own personality type; It was first published in 1962. It consists of questions whose answers are a pair of opposites, which describe their preferences in relation to the following aspects, where the respondent chooses the one that is closest to their reality:

1. Flow of interest (directing or receiving energy): focusing on the outside world (E = extroversion), or on the inner world (I = introversion).
2. Attention (assimilating information): focused on facts (S = sensory), or on the big picture (I = intuition).
3. Decision-making (deciding and reaching conclusions): with an objective (T = thinking) approach, or empathetic (F = feeling).
4. How one wishes to live life: seeking closure (J = judgment), or being open to new information (P = perception).

From them, 16 possible combinations are generated (four-letter code) which describe the "*different types of personality, normal, healthy and the differences that exist between people*", which are not static but dynamic, being able to move from one to another during the course of a day and throughout life. Finally, he emphasizes that understanding, appreciating,

and valuing personality differences can lead people to collaborate with others more constructively (Myers & Briggs Foundation, 1975).

3.5 VARK MODEL

Developed in 1992, by Neil Fleming and Collen Mills. Their model takes the name VARK from the sensory modalities that are identified: V = visual, A = auditory, R = reading/writing, and K = kinesthetic or kinesic.

To this end, they developed a questionnaire that initially consisted of 13 multiple-choice questions, but in 2006 3 more were added, in which the sensory preferences of the students are investigated, which allows them to identify the dominant sensory modality to receive and select the information according to their personal interests (Fleming, ND & Mills C, 2006).

It is also possible to identify students who are multimodal, that is, who use various sensory perceptions to process information. These students have greater ease of learning in relation to unimodal students.

3.6 GRASHA-RIECHMANN MODEL

Designed in 1974 by Anthony Grasha and Cerril H. Riechmann, it is based on the preferences of the student body with respect to *"interaction with their peers and faculty"*. The teaching style assessment instrument is called the Teaching Styles Inventory (TSI) and has 5 categories: expert, authority, model, facilitator and delegator, which are usually combined. The learning styles they propose are contrasted and are located in 6 categories: participatory-elusive, competitive-collaborative and dependent-independent (Grasha A, 2001).

Based on the approaches formulated above, we present the following Table, with a proposal as a possible strategy to contextualize and improve the design, planning, execution and academic results of the teaching work, by identifying the characteristics and differences in the various learning styles of the students who coincide in a school group. Finally, an attempt was made to balance the three basic aspects in this regard, such as: academic level, learning styles and the personal context of the students.

Table 1

Strategies for identifying students' characteristics and learning styles

STRATEGY SUGGESTED	JUSTIFICATION OF CHOICE STRATEGY	ADJUSTMENTS IN DIDACTIC PLANNING
1. Initial diagnostic exam (knowledge) (Brief oral or written exam applied at the beginning of the course or unit; evaluates the level of prior knowledge necessary for the optimal development of the study program).	It allows the ACADEMIC LEVEL to be assessed, in relation to: ✓ Oral and written language management. ✓ Mastery of technical language. ✓ Mastery of support disciplines. ✓ Theoretical-practical knowledge of the curricular discipline. ✓ To guide the development of the study program.	1. Adequacy of objectives and contents of the syllabus. 2. Implement leveling. 3. Rethink the Activities of learning. 4. Redesign the evaluation.
2. Survey to detect LEARNING STYLES and PERSONALITY TYPE of the students. (Written instrument that is applied to each student at the beginning of the course, based on some methodological model).	It allows you to identify the LEARNING STYLE(s) and characteristics of your PERSONALITY to: ✓ Identify individual learning style(s). ✓ Determine the predominant learning style(s) in the group. ✓ Observe the personality type ✓ Detect individual learning needs. ✓ To guide teaching and learning techniques and activities in didactic planning.	Design and elaboration of the survey, based on the models of: 1. Kolb. 2. Honey-Mumford. 3. 4MAT System. 4. Briggs and Myers. 5. VARK. 6. Grasha-Riechmann. 7. Others. Adapt the didactic planning, according to the results.
3. Personal presentation to the group and interviews (Institutional Tutoring Program). (Brief presentation of each student and the teacher in the first class. Periodic, individual or group interviews of students with the teacher	It allows us to know the personal CONTEXT: ✓ Knowledge of the student as a human person and his/her family and social context. ✓ Management of oral communication. ✓ Promote satisfactory intra- and interpersonal relationships. ✓ Identify the needs for comprehensive training and meaningful learning.	Institutionalize and systematize the strategy.
4. Integration of collaborative work groups.	It allows us to improve the RESULTS of meaningful learning:	Institutionalize and systematize the strategy

(Formation of heterogeneous work teams made up of 3 – 4 students, during the first week of the course)	✓ Promote collaborative, independent and participatory learning. ✓ Teamwork with research projects and PBL. ✓ Provide feedback on the teaching and learning process. ✓ Ensure the fulfillment of the objectives. ✓ Establish timely remedial measures.	
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4 DISCUSSION

According to the evolutionary psychology of J. Piaget (1896-1980), the student should be considered as an individual, unique and unrepeatable being, with characteristics common to his or her age group. On the other hand, their personal development is influenced both by their genetic inheritance and by their interaction with the environment, and especially with other people (family, friends, classmates, teachers, authorities, etc.), which will determine significant differences related to their gender, age, character, personality, previous experiences, interests, motivations, abilities, skills and needs, as well as their cognitive structure and learning styles or traits intellectuals (Ferreiro E, 1999; Delors J, 1996 UNESCO).

This supports the assertion that individual differences among students in a classroom have always been present and constitute a reality at any educational level or environment, as well as in all areas of human knowledge (Bahamón M, 2012).

Basically, teachers must take these differences into account as key elements for the design and planning of teaching work, in order to provide opportunities for access to comprehensive training, meaningful learning and personalized learning to all students (UNESCO-IBE, 2017), which can be translated into: *"providing different paths to acquire content, process information and generate a result"* (Tomlinson, 1995).

It is therefore necessary to identify the different personal histories, the different learning styles and personality styles that converge in the classroom. To this end, there is the possibility of using various diagnostic models, some focused on personality types (Briggs & Myer, 1940), others on the way people act (Honey-Mumford, 1986; Honey-Alonso, 1992), or based on the *"theory of experience-based learning"* (Kolb, 1971, 1984). Similarly, the VARK model, which allows identifying the preferred sensory modality for perceiving and processing information (Neil Fleming & Collen Mills, 1992), the 4MAT System model (Bernice

McCarthy, 1987) which proposes a natural learning cycle taking into account the laterality and specificity of the two cerebral hemispheres, and the Grasha-Riechmann model (1974) which focuses on the type of student-student and student-teacher interaction.

Current pedagogical models promote meaningful learning (Ausubel D, 1980; Moreira M, 2017), and personalized learning (Pérez Guerrero J, Ahedo Ruiz J, 2020) where the student becomes the main protagonist of the educational act as a being capable of creating, innovating, thinking and reflecting, actively participating in the construction, reconstruction and application of knowledge focused on problem solving, research, collaborative work and project design.

To achieve this, it has been proposed that teaching practice should be oriented towards being personalized to facilitate the learning process in a more natural and scientific way, thus supporting each student to reach their full potential, both in their human and professional development (UNESCO-IBE, 2017).

5 CONCLUSIONS

Among the many current challenges of higher education (in all its areas), as well as at other educational levels, is to achieve the quality of the various academic programs, which guarantees comprehensive training, meaningful and personalized learning, together with the development of professionalism and ethics of the students.

Didactic planning oriented towards the characteristics and learning styles of students (*"personalized learning"*) is undoubtedly the most suitable and innovative strategy to achieve these objectives in higher education, and even in other educational levels.

In the contemporary world, the student is projected as a responsible, supportive, creative, innovative and participative person, with the ability to work in a team, maintain satisfactory intrapersonal and interpersonal relationships, solve problems, self-learning, continuous and collaborative learning, if the conditions and opportunities for access are provided.

A proposal is presented as a possible strategy to contextualize and improve the didactic planning and the academic results of the teaching work, by identifying the characteristics and learning styles of the students in a group of classes. It was also a matter of balancing the basic aspects in this regard: academic level, learning styles, personality type and personal context.

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SOCIAL CARE FOR DOGS – LACLIMPA: AN EXPERIENCE REPORT

ATENDIMENTO SOCIAL PARA CÃES - LACLIMPA: UM RELATO DE EXPERIÊNCIA

ATENCIÓN SOCIAL PARA PERROS – LACLIMPA: UN RELATO DE EXPERIENCIA

 <https://doi.org/10.56238/sevened2025.036-152>

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ABSTRACT

The present study, characterized as an experience report in university extension, aims to describe the experience of members of the Academic League of Small Animal Internal Medicine – LACLIMPA, in the development of a veterinary social care project aimed at dogs owned by guardians in situations of socioeconomic vulnerability. Activities are carried out weekly at the veterinary teaching clinic of the State University of Bahia (UNEB), Campus IX, in the municipality of Barreiras, and are conducted by undergraduate students under the direct supervision of the faculty member responsible for the Small Animal Internal Medicine area. The project targets low-income communities, including guardians duly registered in the Unified Registry for Federal Government Social Programs (CadÚnico), ensuring greater equity and social targeting of the extension action. Clinical consultations, basic examinations, outpatient procedures, and guidance on vaccination, sanitary management, animal welfare, and responsible ownership are provided. In addition to expanding access to animal health care for vulnerable populations, the initiative contributes to the prevention of zoonoses and to the promotion of the One Health concept. From an academic perspective, the project enables students to develop technical and ethical competencies, integrating theory and practice in a real professional context. Thus, the social care provided by LACLIMPA constitutes an extension activity of social, academic, and educational relevance, strengthening the university tripod of teaching, research, and extension, while promoting animal welfare and the social responsibility of the veterinarian in training.

Keywords: Extension. CadÚnico. Teaching Clinic. Academic League.

RESUMO

O presente trabalho, caracterizado como um relato de experiência em extensão universitária, tem como objetivo descrever a vivência dos membros da Liga Acadêmica de Clínica Médica de Pequenos Animais – LACLIMPA, no desenvolvimento de um projeto de atendimento social veterinário destinado a cães pertencentes a tutores em situação de vulnerabilidade socioeconômica. As atividades são realizadas semanalmente na clínica-escola de Medicina Veterinária da Universidade do Estado da Bahia (UNEB), Campus IX, no município de Barreiras, sendo conduzidas por estudantes de graduação sob supervisão direta do docente

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responsável pela área de Clínica Médica de Pequenos Animais. O projeto tem como público-alvo a comunidade de baixa renda, contemplando tutores devidamente cadastrados no Cadastro Único para Programas Sociais do Governo Federal (CadÚnico), o que garante maior equidade e direcionamento social da ação extensionista. São ofertadas consultas clínicas, exames básicos, procedimentos ambulatoriais, orientações sobre vacinação, manejo sanitário, bem-estar animal e guarda responsável. Além de ampliar o acesso da população vulnerável à saúde animal, a iniciativa contribui para a prevenção de zoonoses e para a promoção do conceito de saúde única. Do ponto de vista acadêmico, o projeto possibilita aos discentes o desenvolvimento de competências técnicas e éticas, integrando teoria e prática em um contexto real de atuação profissional. Dessa forma, o atendimento social promovido pela LACLIMPA configura-se como uma ação extensionista de relevância social, acadêmica e formativa, fortalecendo o tripé universitário ensino, pesquisa e extensão, ao mesmo tempo em que promove o bem-estar animal e a responsabilidade social do médico-veterinário em formação.

Palavras-chave: Extensão. CadÚnico. Clínica-Escola. Liga-Acadêmica.

RESUMEN

El presente trabajo, caracterizado como un relato de experiencia en extensión universitaria, tiene como objetivo describir la vivencia de los miembros de la Liga Académica de Clínica Médica de Pequeños Animales – LACLIMPA, en el desarrollo de un proyecto de atención social veterinaria destinado a perros pertenecientes a tutores en situación de vulnerabilidad socioeconómica. Las actividades se realizan semanalmente en la clínica-escuela de Medicina Veterinaria de la Universidad del Estado de Bahía (UNEB), Campus IX, en el municipio de Barreiras, y son llevadas a cabo por estudiantes de pregrado bajo la supervisión directa del docente responsable del área de Clínica Médica de Pequeños Animales. El proyecto tiene como público objetivo a la comunidad de bajos ingresos, incluyendo tutores debidamente registrados en el Registro Único para Programas Sociales del Gobierno Federal (CadÚnico), lo que garantiza mayor equidad y orientación social de la acción extensionista. Se ofrecen consultas clínicas, exámenes básicos, procedimientos ambulatorios y orientaciones sobre vacunación, manejo sanitario, bienestar animal y tenencia responsable. Además de ampliar el acceso de la población vulnerable a la salud animal, la iniciativa contribuye a la prevención de zoonosis y a la promoción del concepto de Una Sola Salud. Desde el punto de vista académico, el proyecto permite a los estudiantes desarrollar competencias técnicas y éticas, integrando teoría y práctica en un contexto real de actuación profesional. De este modo, la atención social promovida por LACLIMPA se configura como una acción extensionista de relevancia social, académica y formativa, fortaleciendo el trípede universitario de enseñanza, investigación y extensión, al mismo tiempo que promueve el bienestar animal y la responsabilidad social del médico veterinario en formación.

Palabras clave: Extensión. CadÚnico. Clínica-Escuela. Liga Académica.

1 INTRODUCTION

The bond between humans and companion animals has increased more and more, being characterized as a relationship of affection, emotional support and social belonging. The denomination of multispecies families consists of a family arrangement in which individuals recognize and legitimize their animals as integral members of the family nucleus (FARACO, 2008; KNEBEL, 2012). Dogs, in particular, are present in millions of Brazilian homes, including in contexts marked by socioeconomic vulnerability, playing a relevant role in the emotional, social, and psychological dynamics of families.

The intensification of this human-animal relationship has been widely discussed in the scientific literature, especially with regard to the psychosocial benefits provided by living with pets, such as reducing stress, improving mental health, stimulating socialization, and strengthening affective bonds (FINE, 2019). However, the growing proximity between humans and animals also imposes challenges related to the shared responsibility for the care, health, and well-being of these nonhuman individuals, especially in communities with limited access to basic services.

The animal's condition falls under well-being at the moment when it is well nourished, healthy, safe, free from suffering and unpleasant sensations (MENDONÇA, 2019). This concept is aligned with the five freedoms of animal welfare, widely recognized by the World Organization for Animal Health (WOAH), which include freedom from hunger and thirst, discomfort, pain, injury and disease, fear and stress, and freedom to express natural behaviors (BROOM; FRASER, 2015). However, such conditions become difficult to be fully achieved in scenarios of social vulnerability, in which financial resources and access to specialized services are limited.

In the Brazilian context, social inequality directly impacts access to veterinary medicine, especially in peripheral regions and municipalities in the interior, where the supply of public veterinary hospitals is still incipient or non-existent (SOUZA et al., 2021). The city of Barreiras, located in the west of the state of Bahia, is part of this reality, since it does not have a public veterinary hospital, which restricts the access of the low-income population to clinical care, diagnostic tests and surgical procedures, whose high cost makes it impossible to seek private veterinary care.

The absence of effective public policies aimed at animal health compromises not only the well-being of companion animals, but also collective health, considering the potential risk of spreading zoonoses in contexts of sanitary negligence (WHO, 2020). Studies show that

the lack of adequate veterinary monitoring favors the occurrence of infectious, parasitic, and reproductive diseases, directly impacting the quality of life of animals and their owners (LOPES et al., 2022).

In view of this scenario, the extension actions developed by public universities play a strategic role in promoting health, animal welfare and social inclusion. Academic leagues, in particular, are important devices for bringing the university and the community closer together, allowing the practical application of scientific knowledge and the training of more critical, ethical, and socially committed professionals (CAVALCANTE et al., 2018; OLIVEIRA; SILVA, 2020). By working in vulnerable territories, these initiatives contribute to the democratization of access to health services and to the consolidation of the social role of the university, reaffirming the idea of CAVALCANTE *et al.* (2018), in which it is notorious that the academic league can add in a positive way, as it is one more opportunity to enrich learning.

Academic leagues in the health area are characterized as student organizations guided by professors, based on the principles of teaching, research and extension, providing students with experiences that go beyond the formal curriculum (TORRES et al., 2008). In the field of Veterinary Medicine, such experiences favor the development of clinical skills, decision-making, teamwork, and social sensitivity, fundamental aspects for contemporary professional training (BARBOSA et al., 2021).

In addition, the extension action enables the integration of the concept of One Health, which recognizes the interdependence between human, animal, and environmental health, being essential for facing complex health challenges (DESTOUMIEUX-GARZÓN et al., 2018). By promoting the care of companion animals in vulnerable communities, veterinary social care projects simultaneously contribute to the prevention of zoonoses, health education and strengthening the responsible bond between owners and their animals.

In this context, the present work aims to report the experience of veterinary social care provided at the teaching clinic of the State University of Bahia (UNEB), aimed at dogs belonging to tutors enrolled in the Unified Registry for Social Programs of the Federal Government (CadÚnico), an instrument that identifies families in situations of socioeconomic vulnerability. The initiative sought to expand access to basic animal health, promote welfare and encourage responsible guardianship practices, while providing Veterinary Medicine students with a space for practical, ethical and humanized learning.

This extension experience is supported by the principle of inseparability between teaching, research and extension, since "teaching, research and extension represent, with

equal importance, the tripod that supports any university" (VASCONCELOS, 1996, p. 8). In this way, the project developed by the Academic League of Small Animal Medical Clinic (LACLIMPA) reaffirms the social commitment of the public university, by articulating quality academic training with a direct impact on the community, promoting social transformation and contributing to the construction of a fairer, more inclusive and animal-sensitive society.

2 METHODOLOGY/MATERIAL AND METHODS

The present study is characterized as an experience report, of a descriptive and qualitative nature, developed from the extension activities carried out by the Academic League of Small Animal Medical Clinic (LACLIMPA). Experience reports are relevant instruments in the health area, as they allow the systematization of practical experiences, critical reflections, and analysis of interventions developed in real contexts, contributing to the production of applied knowledge and to the improvement of academic and professional practices (PEREIRA et al., 2018).

The extension actions took place on the premises of the Veterinary Medicine School Clinic of the State University of Bahia (VETUNEB), located on Campus IX of UNEB, in the municipality of Barreiras, Bahia. The project was developed between November 2024 and June 2025, including weekly services aimed exclusively at dogs belonging to tutors in situations of socioeconomic vulnerability.

2.1 TARGET AUDIENCE AND INCLUSION CRITERIA

The target audience of the project was made up of dog owners residing in the municipality of Barreiras and region, as long as they were duly registered in the Unified Registry for Social Programs of the Federal Government (CadÚnico). The use of CadÚnico as an inclusion criterion aimed to ensure greater equity in access to the service, directing care to the population in situations of social vulnerability, as recommended by public policies for social inclusion (BARROS; CARVALHO; MENDONÇA, 2009).

To confirm eligibility, tutors should present, at the time of consultation, an official document with a photo, proof of residence and the Social Identification Number (NIS). Only clinically stable animals, suitable for outpatient care, were included in the project, and urgent or emergency cases were not contemplated, which were duly instructed to seek specialized care.

2.2 ORGANIZATION AND SCHEDULING OF APPOINTMENTS

The appointments were previously scheduled through LACLIMPA's official profile on the social network Instagram, a strategy that enabled greater community reach and demand organization. Online scheduling proved to be an efficient communication and management tool, in addition to facilitating the population's access to the services offered, as pointed out by studies on the use of digital media in extension actions (SANTOS; FERREIRA, 2021).

The activities took place weekly, on Fridays, in the morning (8 am to 11 am) and afternoon (2 pm to 4 pm) shifts, with an average of seven appointments per day, respecting the structural capacity of the school clinic and the number of students involved in each action. The limitation of the number of consultations aimed to ensure the quality of the care provided, as well as the adequate follow-up of the cases.

2.3 PROCEDURES PERFORMED

The services included clinical consultations, general physical evaluation, basic outpatient procedures, collection of biological material for laboratory tests, when indicated, in addition to screening for castration programs and guidance to tutors regarding vaccination, parasite control, feeding, sanitary management and responsible guardianship. All procedures strictly followed biosafety, professional ethics, and animal welfare protocols, according to the guidelines of the Federal Council of Veterinary Medicine (CFMV, 2022). Subsequently, Figure 1 portrays a moment of this practical activity, in which the students, under the guidance of the professors, develop clinical care.

Figure 1

Clinical care provided at the VETUNEB teaching clinic



Source: Personal collection (2025).

The clinical records of the animals treated were made in the medical records of the school clinic, containing information on the identification of the animal, clinical history, physical examination, conduct adopted and guidance provided to the tutors. These records contributed to the follow-up of the cases and to the teaching-learning process of the students involved.

2.4 STUDENT PARTICIPATION AND FACULTY SUPERVISION

The consultations were performed by students regularly enrolled in the Veterinary Medicine course, members of LACLIMPA, organized according to a previously defined schedule, in order to ensure that all members had the opportunity to experience the clinical practice of extension. The students' performance was continuously supervised by a Veterinarian who taught the discipline of Small Animal Medical Clinic at the school clinic,

ensuring the correct execution of the procedures, the safety of the animals and the quality of the care provided.

Teacher supervision played a fundamental role in the pedagogical process, promoting clinical discussions, technical guidance and ethical reflections during consultations, in line with active teaching-learning methodologies, such as problem-solving education (BOROCHOVICIUS; TORTELLA, 2014).

2.5 ETHICAL ASPECTS

All activities developed respected the ethical principles of Veterinary Medicine, valuing animal welfare, respect for tutors and the social responsibility of the university. The procedures were conducted in a humanized, safe and responsible manner.

2.6 ANALYSIS OF THE EXPERIENCE

The analysis of the experience was based on the direct observation of the activities, on the records of the services performed and on the collective reflections between students and the supervising professor, allowing the identification of the main impacts, challenges and contributions of the project both for the community served and for the academic training of the students. This reflective process made it possible to build a critical view of the role of university extension in the promotion of animal health and in the strengthening of professional training.

3 THEORETICAL FRAMEWORK AND DISCUSSION

3.1 GENERAL CHARACTERIZATION OF THE SERVICES PROVIDED

The veterinary social care extension project, developed by the Academic League of Small Animal Medical Clinic (LACLIMPA) was carried out from November 2024 to June 2025, totaling approximately 100 dogs treated at the Veterinary Medicine teaching clinic of the State University of Bahia (UNEB), Campus IX. Figure 2 shows a clinical care of a dog performed by the students. All animals belonged to tutors duly enrolled in the Unified Registry for Social Programs of the Federal Government (CadÚnico), characterizing a public in a situation of socioeconomic vulnerability. The services resulted in significant impacts both for the community served and for the academic training of the students involved, including consultations, outpatient procedures, collections, screening for castration and responsible guidance to tutors on vaccination protocols, health and animal welfare.

Figure 2

Clinical care of a dog



Source: Personal collection (2025).

The services took place in a continuous and organized manner, respecting the structural capacity of the teaching clinic and the availability of students and supervising faculty. A high demand for the service was observed in the first weeks of the project's execution, which shows the existence of a repressed demand for basic veterinary care in the municipality of Barreiras, a reality similar to that described in other studies carried out in regions with a lack of public veterinary hospitals (SOUZA et al., 2021). Table 1 presents a general characterization of the services provided throughout the period of execution of the project.

Table 1

General characterization of the services provided by the LACLIMPA project (2024–2025)

Variable analyzed	Description
Project period	November/2024 to June/2025
Approximate number of animals served	100 dogs
Frequency of care	Weekly

Average number of animals per day	7
Public served	Tutors registered in CadÚnico
Location	VETUNEB School Clinic – UNEB Campus IX

Source: Personal collection (2025).

These data reinforce the role of university extension as a strategy to expand access to animal health services, especially in contexts marked by social inequality.

3.2 SOCIOECONOMIC PROFILE OF OWNERS AND ACCESS TO VETERINARY HEALTH

The Unified Registry for Social Programs (CadÚnico) is the registration of low-income Brazilian families, with their name and address included in the registry, in addition to containing various information about the situation of these families, allowing people in this census to be included in programs aimed at the public, although poverty is not taken as synonymous with insufficient income (IPEA, 2009).

Many tutors reported not having prior access to veterinary care for financial reasons, evidencing a repressed demand for basic care, since the city of Barreiras still does not have a veterinary hospital that contemplates this social portion. Thus, as long as the records are updated, monitored and analyzed in inclusion and exclusion criteria by the municipality, the CadÚnico as a selection criterion proved to be an efficient tool to reach the most vulnerable population (IPEA, 2009).

The analysis of the profile of the tutors assisted revealed that most had limited family income, dependent on government social programs, which made it difficult to have prior access to private veterinary services. Many reported that that consultation represented the first veterinary care received by the animal throughout its life, evidencing the direct impact of socioeconomic conditions on the health and well-being of dogs.

The use of CadÚnico as a selection criterion proved to be efficient in directing care to the population in situations of greater social vulnerability, ensuring greater equity in the provision of the service. As discussed by Barros, Carvalho and Mendonça (2009), CadÚnico is a fundamental tool for the identification of low-income families, enabling the implementation of more assertive public policies and social actions. In the context of this project, this instrument contributed to the organization of demand, to the transparency of the process of

inclusion of tutors and to ensure that care was intended for the population with the greatest need, reducing inequalities in access to animal health.

The lack of regular veterinary follow-up is associated with the worsening of preventable diseases and greater exposure to health risks, both for animals and owners, which reinforces the importance of extension actions such as the one developed by LACLIMPA (LOPES et al., 2022).

3.3 MAIN CLINICAL DEMANDS IDENTIFIED

During the consultations, several clinical complaints were recorded, the most frequent being related to dermatological, parasitic and gastrointestinal diseases. These conditions are widely described in the literature as prevalent in canine populations without continuous veterinary assistance (MENDONÇA, 2019). Table 2 presents the main clinical demands observed.

Table 2

Main clinical complaints identified in the consultations

Clinical Category	Observed examples
Dermatological disorders	Dermatitis, pruritus, alopecia
Endoparasitosis	Intestinal worms
Ectoparasitosis	Fleas and ticks
Gastrointestinal disorders	Diarrhoea, vomiting

Source: Personal collection (2025).

These findings reinforce the importance of basic care and the need for preventive actions, such as vaccination, deworming and guidance to tutors, as fundamental and effective strategies to promote animal welfare, reduce the occurrence of avoidable diseases and health problems.

3.4 PROCEDURES PERFORMED AND GUIDANCE PROVIDED

The services provided included routine clinical consultations, general physical evaluation, basic outpatient procedures, collection of material for laboratory tests, screening for castration and educational guidance to tutors, related to the importance of vaccination and its effective protocols, parasite control, adequate nutrition, reproductive control and

responsible care. Next, Figure 3 presents a record of this practical experience, in which the students, accompanied by professors, perform clinical care within the scope of the project, demonstrating the active participation of the students in all phases of the extension activity.

Figure 3

Project students performing clinical care



Source: Personal collection (2025).

It was observed that a significant portion of the animals cared for had no previous veterinary follow-up, a condition often associated with the financial limitations of the owners, corroborating the findings of studies that point to socioeconomic inequality as a determining factor in access to animal health (SOUZA et al., 2021; LOPES et al., 2022).

Health education was a fundamental component of the project, since a significant portion of the tutors demonstrated a lack of knowledge about basic practices of sanitary management, disease prevention and routine care of the animals. In this context, the guidance provided during the extension actions contributed to the promotion of animal welfare and to the awareness of those responsible for the importance of preventive medicine. Table 3 summarizes the main procedures carried out throughout the project activities.

Table 3

Educational procedures and actions developed in the project

Type of action	Description
Clinical consultation	General physical assessment
Outpatient procedures	Dressings, medication administration
Exam collection	Hematology and parasitologic
Reproductive screening	Referral for castration
Health education	Guidance on vaccination and well-being

Source: Personal collection (2025).

These actions are aligned with the concept of One Health, which integrates animal, human and environmental health (DESTOUMIEUX-GARZÓN et al., 2018).

3.5 IMPACTS OF THE PROJECT ON THE ACADEMIC TRAINING OF STUDENTS

In the academic sphere, the project provided a relevant training experience for Veterinary Medicine students, the extension experience enabled students to develop clinical, technical and professional ethical skills essential to the training of veterinarians. Direct interaction with different social and economic contexts required from students not only technical knowledge, but also social sensitivity, empathetic posture, and interpersonal communication skills with tutors, aspects often pointed out as challenges in health education (BARBOSA et al., 2021). The practical experience favored the integration between theory and practice, consolidating contents covered in the classroom, enabling students to adapt to structural limitations.

Supervised action allowed the application of active teaching-learning methodologies, such as problem-based education, in which students are encouraged to observe reality, identify problems, formulate hypotheses and propose scientifically based solutions (BOROCHOVICIUS; TORTELLA, 2014). This approach contributed to the development of clinical reasoning, decision-making, and ethical posture in the face of structural and social limitations encountered during care.

For the students, the experience based on problem-solving education and experiences represented a valuable opportunity for practical and humanized learning. The contact with

various socioeconomic realities required the development of clinical skills, contributing to the formation of more qualified professionals, sensitive to social issues and aligned with the concept of one health. The stages of problem-solving education can be better understood by Azevedo's studies; Pacheco and Santos:

"The observation of reality is important for teaching to make sense, in which the student can visualize the problem close to his experience. Key points need to be established so that there is a direction about what should be solved, that is, it is a specification without losing generalization. Having reached this point, it begins to theorize and discuss supposed hypotheses to solve the problem, and finally, apply them to reality." (p.06, 2019).

Studies show that extension experiences favor the training of more humanized and socially committed professionals (BARBOSA et al., 2021), which was clearly observed in the development of LACLIMPA members throughout the project.

3.6 CHALLENGES FACED DURING THE EXECUTION OF THE PROJECT

However, despite the positive results, the project faced relevant challenges. Among the main challenges faced, the high demand for care in relation to the operational capacity of the school clinic stands out, as "pets are seen as as close as the child itself, by humans" (SANTOS, 2008, p. 23), driving tutors to seek care and quality of life for the animal, however, the limitation of material resources and medications, in addition to the difficulty of continuity in the follow-up of clinical cases. The reduced mobility of some tutors made it impossible to return frequently to the clinic, impacting the follow-up of treatments.

These obstacles are similar to those reported by other extension projects developed in contexts of social vulnerability, evidencing the need to expand public policies aimed at animal health (OLIVEIRA; SILVA, 2020).

3.7 SOCIAL RELEVANCE AND CONTRIBUTION TO PUBLIC HEALTH

According to TORRES *et al.* (2008), the academic leagues are groups with a wide reach, which allows the academic greater contact with society and ascension in social transformation, expanding critical sense and scientific reasoning based on theoretical-practical knowledge with the purpose of benefiting the population. However, it is not restricted only to the deepening of knowledge, but seeks to value academic and personal development, symbolizing a social contribution. Figure 4 shows a group of students who are members of

the Academic League of Small Animal Medical Clinics (LACLIMPA), gathered in the context of the activities developed by the league.

They are developed as extracurricular activities, being composed mostly of students with a common study purpose, in which they are instructed by teachers who act as a bridge in learning and in the promotion of activities based on Teaching, Research and Extension. They are entities of great scope, which provide the student with greater contact with society and communities, promoting health and social transformation, developing theoretical and practical knowledge with the aim of benefiting the population, expanding critical thinking and scientific reasoning. It is not limited only to deepening knowledge, seeking to add value to academic and personal construction, representing a contribution to society TORRES *et al.* (2008). Figure 4 shows a group of students who are members of the Academic League of Small Animal Medical Clinic (LACLIMPA), gathered in the context of the activities developed by the league.

Figure 4

Members of the Academic League of Small Animal Medical Clinic



Source: Personal collection (2025).

From the point of view of collective health, the care provided was also relevant with regard to the prevention of zoonoses. Guidance on rabies vaccination, parasite control, and adequate sanitary management represents a fundamental strategy to minimize risks to human, animal, and environmental health, in line with the concept of One Health

(DESTOUMIEUX-GARZÓN et al., 2018; WHO, 2020). In this way, the project went beyond individual care for the animal, contributing to the promotion of public health.

Another relevant aspect refers to the perception of tutors about their pets. Many reported intense affective bonds, considering dogs as family members, which reinforces the concept of multispecies families described by Faraco (2008). According to Santos (2008), pets occupy a symbolic place of great importance in the lives of tutors, which justifies the search for veterinary care even in the face of financial difficulties. Such a perception reinforces the need for public policies and extension actions aimed at animal health.

In view of this, the results obtained show that the veterinary social care promoted by LACLIMPA plays an essential role in the promotion of animal welfare, in the prevention of public health problems and in humanized academic training. The integration between university and community proved to be effective in meeting emerging social demands, reaffirming the importance of university extension as an instrument of social transformation and strengthening of the ethical commitment of the future professional.

4 FINAL CONSIDERATIONS

The experience report presented showed the social, academic and health relevance of the veterinary social care project developed by the Academic League of Small Animal Medical Clinic (LACLIMPA), within the scope of the Veterinary Medicine teaching clinic of the State University of Bahia (UNEB), Campus IX. The initiative proved to be an effective strategy to expand access to basic animal health for dogs belonging to owners in situations of socioeconomic vulnerability, identified through the Unified Registry for Social Programs of the Federal Government (CadÚnico).

The results obtained showed a significant repressed demand for social veterinary services in the municipality of Barreiras, reinforcing the need for public policies and extension actions aimed at animal health, especially in locations that do not have public veterinary hospitals. The offer of clinical consultations, outpatient procedures and educational guidance contributed directly to the promotion of animal welfare, prevention of preventable diseases and reduction of risks related to zoonoses, reflecting positively on public health.

From a training point of view, the project has consolidated itself as a privileged space for practical and humanized learning for Veterinary Medicine students. The extension experience allowed the development of technical, ethical and social skills, stimulating clinical reasoning, decision-making and communication with tutors, in addition to strengthening the

understanding of the social role of the veterinarian. Teacher supervision and the application of active methodologies, such as problem-based education, favored the integration between theory and practice, contributing to a critical academic education committed to social reality.

The experience also reinforced the importance of the concept of One Health, by highlighting the interdependence between animal, human and environmental health. Working with vulnerable communities enabled students to understand the impacts of social inequality in the care of companion animals and the need for preventive strategies that promote responsible custody and proper sanitary management. Despite the positive results, the project faced challenges, such as the limitation of material resources, the high demand for care and the difficulty of continuous monitoring of clinical cases. Such limitations highlight the need for institutional strengthening, expansion of intersectoral partnerships and investments in public policies that ensure greater sustainability of extension actions aimed at animal health.

Thus, it is concluded that the veterinary social care promoted by LACLIMPA is configured as an extension action of great social and educational impact, reaffirming the commitment of the public university to social transformation, citizenship training and the promotion of animal welfare. The continuity and expansion of similar initiatives are essential to consolidate socially responsible academic practices, contribute to public health, and strengthen the role of Veterinary Medicine in building a more just, inclusive, and animal-sensitive society.

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**EMERGING TECHNOLOGIES APPLIED TO THE POULTRY PRODUCTION
CHAIN AS “PRECISION TOOLS”**

**TECNOLOGIAS EMERGENTES APLICADAS À CADEIA PRODUTIVA AVÍCOLA
COMO “FERRAMENTAS DE PRECISÃO”**

**TECNOLOGÍAS EMERGENTES APLICADAS A LA CADENA PRODUCTIVA
AVÍCOLA COMO “HERRAMIENTAS DE PRECISIÓN”**

 <https://doi.org/10.56238/sevened2025.036-153>

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ABSTRACT

According to the 2024 Annual Report from the Brazilian Animal Protein Association (ABPA), Brazil produced 52.4 billion eggs in 2023, with 99% allocated to the domestic market and 1% exported. This production scale demands that poultry operations integrate advanced data-driven methodologies to optimize performance and meet evolving consumer expectations. As a global benchmark, the Brazilian poultry sector must adopt innovative technologies tailored to local conditions, ensuring product quality and maintaining competitive advantage. Strategic management now requires real-time decision-making supported by digital platforms and Industry 4.0 technologies, with emphasis on animal welfare, environmental sustainability, and corporate social responsibility. The rapid evolution of Internet of Things (IoT) systems and cloud-based infrastructures underpins the emergence of smart agriculture. These technologies enable the deployment of sophisticated mathematical models and real-time algorithms for predictive analytics and operational optimization. Research findings highlight the applicability of emerging precision technologies across the poultry production chain. These tools enhance analytical capabilities and support managerial decision-making, surpassing earlier frameworks such as Smart Poultry Farming. By streamlining processes, reducing operational costs, and generating new business opportunities, digital transformation reinforces sectoral competitiveness and aligns with strategic, environmental, and social governance objectives.

Keywords: Smart Poultry Farming. Precision Agriculture. Industry 4.0 Technologies. Real-Time Decision Making. Sustainability in Poultry Production.

RESUMO

De acordo com o Relatório Anual de 2024 da Associação Brasileira de Proteína Animal (ABPA), o Brasil produziu 52,4 bilhões de ovos em 2023, sendo 99% destinados ao mercado interno e 1% exportado. Essa escala de produção exige que as operações avícolas integrem metodologias avançadas baseadas em dados para otimizar o desempenho e atender às crescentes expectativas dos consumidores. Como referência global, o setor avícola brasileiro deve adotar tecnologias inovadoras adaptadas às condições locais, garantindo a qualidade do produto e mantendo a vantagem competitiva. A gestão estratégica agora exige a tomada de decisões em tempo real, apoiada por plataformas digitais e tecnologias da

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Indústria 4.0, com ênfase em bem-estar animal, sustentabilidade ambiental e responsabilidade social corporativa. A rápida evolução dos sistemas de Internet das Coisas (IoT) e das infraestruturas baseadas em nuvem sustenta o surgimento da agricultura inteligente. Essas tecnologias permitem a implantação de modelos matemáticos sofisticados e algoritmos em tempo real para análise preditiva e otimização operacional. Os resultados da pesquisa destacam a aplicabilidade de tecnologias de precisão emergentes em toda a cadeia produtiva avícola. Essas ferramentas aprimoram as capacidades analíticas e apoiam a tomada de decisões gerenciais, superando estruturas anteriores, como a Avicultura Inteligente. Ao otimizar processos, reduzir custos operacionais e gerar novas oportunidades de negócios, a transformação digital reforça a competitividade setorial e se alinha aos objetivos estratégicos, ambientais e de governança social.

Palavras-chave: Avicultura Inteligente. Agricultura de Precisão. Tecnologias da Indústria 4.0. Tomada de Decisão em Tempo Real. Sustentabilidade na Produção Avícola.

RESUMEN

Según el Informe Anual 2024 de la Asociación Brasileña de Proteína Animal (ABPA), Brasil produjo 52.400 millones de huevos en 2023, de los cuales el 99% se destinó al mercado interno y el 1% se exportó. Esta escala de producción exige que las operaciones avícolas integren metodologías avanzadas basadas en datos para optimizar el rendimiento y satisfacer las crecientes expectativas de los consumidores. Como referente mundial, el sector avícola brasileño debe adoptar tecnologías innovadoras adaptadas a las condiciones locales, garantizando la calidad del producto y manteniendo una ventaja competitiva. La gestión estratégica exige ahora una toma de decisiones en tiempo real, respaldada por plataformas digitales y tecnologías de la Industria 4.0, con énfasis en el bienestar animal, la sostenibilidad ambiental y la responsabilidad social corporativa. La rápida evolución de los sistemas del Internet de las Cosas (IoT) y las infraestructuras basadas en la nube impulsa el surgimiento de la agricultura inteligente. Estas tecnologías permiten la implementación de sofisticados modelos matemáticos y algoritmos en tiempo real para el análisis predictivo y la optimización operativa. Los resultados de la investigación destacan la aplicabilidad de las tecnologías de precisión emergentes en toda la cadena de producción avícola. Estas herramientas mejoran las capacidades analíticas y apoyan la toma de decisiones gerenciales, superando estructuras anteriores, como la Avicultura Inteligente. Al optimizar procesos, reducir costos operativos y generar nuevas oportunidades de negocio, la transformación digital fortalece la competitividad del sector y se alinea con los objetivos estratégicos, ambientales y de gobernanza social.

Palabras clave: Avicultura Inteligente. Agricultura de Precisión. Tecnologías de la Industria 4.0. Toma de Decisiones en Tiempo Real. Sostenibilidad en la Producción Avícola.

1 INTRODUCTION

According to Connolly (2017), the growth of poultry farming has been relentless. In fact, despite the continued preference for pork in Asia, current growth trends indicate that global chicken consumption will surpass that of pork by 2022, making it the world's leading meat.

Conab (2023) stated that chicken meat production projections in 2024 pointed to a volume of around 16 million tons and chicken meat shipments could reach 5.25 million tons in 2024, an increase of 3.6% compared to the volume projected in 2023.

Confirming CONAB's projections, the Brazilian Ministry of Agriculture and Livestock (2024) highlights that, according to the Secretariat of Trade and International Relations (SCRI), Brazil exports chicken meat to 172 countries, making it the largest exporter and third-largest producer. In 2023, exports totaled more than US\$9.61 billion, representing 5 million tons. As of March, of this year, more than 1.1 million tons had been exported, generating a value of US\$2.10 billion.

According to ABPA's 2024 annual report (2024), Brazil is the world's 2nd largest producer of chicken meat and the world leader in exports.

Data obtained from the United States Department of Agriculture, USDA (2018), show that, in terms of exports, Brazil, in 2017, was the leader, reaching a total of 34.4% of chicken meat exports in the world, and according to the annual report of the Brazilian Animal Protein Association, Brazil exported 5.138 million tons of chicken meat (including all products, both fresh and processed) in 2023 (ABPA, 2024).

Connolly (2017) further states that egg consumption continues to grow because eggs are inexpensive, mild-tasting, and easy to process and incorporate into other foods. He adds that universal acceptance by nearly all cultures and religions ensures that birds will continue to thrive. He also states that, in the next 30 years, we will see another 3 billion people inhabit the Earth, and the urban middle class will continue to grow.

The annual report of the Brazilian Animal Protein Association for the year 2024 indicates that in the year 2023, Brazil produced 52.4 billion units of eggs, of which 99% were directed to the domestic market and the remaining 1% were directed to exports (ABPA, 2024).

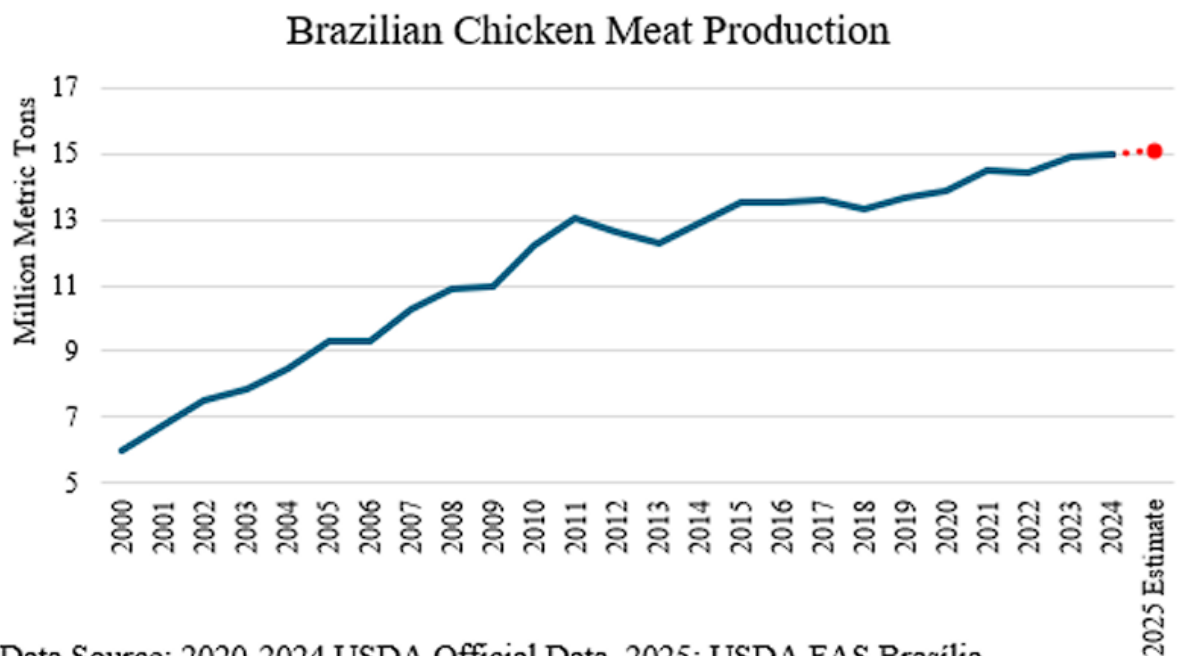
Thus, poultry farming must respond to this demand. Farmers increasingly need to "cultivate data," not just raise chickens, and, in doing so, leverage new technologies and digital information to improve efficiency and respond to growing consumer demands.

The poultry production chain has evolved significantly in Brazil, and its dynamism is linked to constant productivity gains, primarily through improved feed conversion rates, nutritional technology, genetic research, increased automation, and better production management (PATRÍCIO et al., 2012). This advancement is supported by the significant reduction of losses in the chain, the increasing optimization of production processes, and the corresponding improvement in productivity, all without losing sight of cost control, in order to ensure competitiveness (NÄÄS, 2018). The author also emphasizes that, as the Brazilian poultry industry is also a market leader, it must adopt innovative technologies, developed or adapted to our reality, and that preserve quality and competitiveness factors.

Figure 1 illustrates data obtained from the United States Department of Agriculture, USDA (2025), which shows that, in terms of chicken protein production, Brazil has shown growth since 2000, and the projection for 2025, according to the Semi-Annual report, published in March 2025, estimates another jump by the end of the year.

Figure 1

Brazilian Chicken Meat Production and Projections for 2025



Data Source: 2020-2024 USDA Official Data. 2025: USDA FAS Brasília

Chart Source: USDA FAS Brasília

Source: (USDA, 2025).

This scenario demands that managers constantly seek to make intelligent decisions, and if possible, in real time, aiming at animal welfare, the sustainability of the production

process and social responsibility. To meet these requirements, it is necessary to apply digital platforms and new 4.0 technologies (the fourth technological revolution, with strong digital content and high connectivity) that allow the extension of the functionalities of existing traditional (or legacy) production systems, seeking a new integration that allows the implementation of the concepts of "Smart Poultry Farming" in their facilities (NÄÄS, 2018).

Csótó (2010) states that in the Internet age, where information plays a fundamental role in people's lives, agriculture is rapidly becoming a highly data-intensive industry, requiring farmers to collect and evaluate a vast amount of information from various devices using different technologies. These new technologies, known as 4.0 technologies, are implemented based on the concepts of precision poultry production, combined with precision tools. These tools are essentially composed of sensors, actuators, and signal acquisition, conditioning, and processing systems. These systems are collected from the real world and, after filtering and adjustment, converted from analog to digital format. With the data in digital format, processing takes place to transform numbers into information, into meaning, into valuable elements to support managers' decision-making, leading them to problem-solving (KALOXYLOS et al., 2012; SØRENSEN et al., 2010).

In the work of Rupnik et al. (2018), we can observe that decision support occurs through decision support software (DSS) (Decision Support Systems) that are connected to sensors and actuators, and to users through graphical visualization and data entry interfaces.

According to the work of Rupnik et al. (2018), in recent years, dedicated DSS, or Farm Management Information Systems (FMIS), have evolved from simple agricultural recordkeeping to sophisticated and complex systems supporting all aspects of production management, a fact reinforced by Fountas et al. (2015).

Nääs (2018) states that scientific and technological research, based on national research groups that focus on analyzing these data, seeking to adapt new technologies to the realities of companies in the sector or generating new technologies that better adapt to our production parks, are likely those that will have the greatest impact on the future development of the sector. Thus, this research aims to identify emerging technologies that have been studied, developed, or already applied to the poultry production chain and evaluate their practical use in data analysis to promote decision support for sector managers.

Dessa forma, o problema central deste trabalho é compreender qual é a aplicabilidade de tecnologias de precisão emergentes em toda a cadeia produtiva avícola. Essas ferramentas permitem aprimorar as capacidades analíticas e apoiam as tomadas de

decisões gerenciais, superando estruturas anteriores, como a Avicultura Inteligente, por meio da busca das tecnologias empregadas, buscando sua análise, como foram descritos na literatura científica. O objetivo do trabalho é investigar as ferramentas utilizadas e os seus padrões, bem como revisar e discutir as metodologias utilizadas em sua adoção.

2 MATERIALS AND METHODS

This study presents a descriptive analysis, through a review of available literature, on the adoption of advanced data-driven methodologies in the Brazilian poultry sector, and the adoption of innovative technologies that have been adapted to the local conditions of poultry farms to optimize performance and meet the growing expectations of consumers.

The searches for research papers were conducted in the Scopus and Web of Science databases, due to their international scope and academic reliability. The research profile was not limited to articles, but also used data obtained from secondary sources such as annual reports from associations and from government agricultural information websites and portals, such as the National Supply Company. Secondary data were also obtained from the United States Department of Agriculture.

Topics related, preferably, to the areas of: Precision tools, Emerging Infrastructure Technologies for New 4.0 Technologies, encompassing Sensors and Actuators, Internet of Things, Big Data, Cloud computing, Bioenergetic models, complex algorithms, Analysis Tools with Digital Technologies 4.0, Environmental Control with precision, Physiological control with precision, and Behavior control with precision were explored.

3 RESULTS AND DISCUSSION

As a result of the research conducted on the topics indicated in the materials and methods section, the following texts were compiled with discussions:

3.1 PRECISION TOOLS

According to Pivoto et al. (2018), the term Smart Farming (SF) or "Intelligent Agriculture" involves the incorporation of information and communication technologies into machinery, equipment, and sensors for use in agricultural production systems. The authors argue that new technologies such as the Internet of Things, Big Data, robotics, decision-making and statistical processes, cloud computing, mapping technologies, and geomatics for spatial data acquisition and management, cartography, topographic support, digital mapping,

remote sensing, geographic information systems, hydrography, among others, are expected to advance this development, introducing more robots and artificial intelligence into agricultural and animal husbandry production processes.

The most promising Smart Agriculture technologies, according to Pivoto et al. (2018), incorporate advances in sensors, data analysis, telemetry, and positioning technologies, but the development and dissemination of these technologies may require time and investment. "Smart agriculture," as the same authors point out, is a concept that originated with software engineering and computer science, which arrived with the addition of computing and data transmission technologies from agriculture, within a global environment of virtualization and ubiquitous computing that foresees the omnipresence of information technology in people's daily lives. These computing elements are embedded in objects and interconnected with each other and with the internet.

Pivoto et al. (2018) reinforce these concepts, stating that these technologies, when used individually or in combination, are called "Precision Tools." They enable the generation of a large volume of data and information obtained through the progressive introduction of automation into processes, helping managers improve their decision-making for production, as well as for strategic and managerial issues. They also emphasize that problems related to the intensification of climate change will continue to alter growing conditions, such as temperature, precipitation, and soil moisture, in increasingly unpredictable ways. Thus, they note that these tools can help reduce these impacts, maintain them constant, or reduce production costs in other agricultural activities, and can also help minimize environmental constraints.

Rapid developments in Internet of Things (IoT) technology and cloud computing are driving the phenomenon known as smart agriculture. The basis for advancement in this sector involves a combination of internet technologies and future-oriented technologies for use as smart objects in agriculture (LACERDA and MARQUES, 2015; CONNOLLY, 2017; PIVOTO et al., 2018).

3.2 EMERGING INFRASTRUCTURE TECHNOLOGIES FOR NEW 4.0 TECHNOLOGIES SENSORS AND ACTUATORS

The use of precision tools is made possible by sensors in agriculture. A sensor is an electronic device that measures physical quantities in the environment and converts these measurements into a signal that can be read by an instrument. These devices are constantly

evolving, and new sensors for different physical quantities are being created in short periods of time thanks to the development of electronics. Possible measurements read by sensors include: temperature, humidity, light, pressure, noise levels, the presence or absence of certain types of objects, mechanical stress levels, speed, direction, and size of objects (O'GRADY and O'HARE, 2017). Animal behavior modeling, machine learning, and feed monitoring, according to the same authors, are invariably supported by sensors and/or sensor networks.

Sensing technologies have proven fundamental to precision agriculture since its early days, evolving from sensor deployments to specialized crops. A good example of a development for poultry farms is the ammonia sensor studied in the work of Lin et al. (2016).

According to information provided by Progressive (2014), actuators enable the movement of all types of machines. These devices use a power source, such as a motor, to convert energy into motion. They are used in agriculture in various ways during the production process. Because they often operate in dusty, caustic, or changing environments, actuators intended for agricultural use are designed for durability, maximum functionality, and continuous use. These actuators can be found in poultry house and storage bin doors, in ventilation, sprinkler, and heating systems, conveyors, silos, storage sheds, and even at the farm gate. Because farms generally operate on a regular sunrise and sunset schedule, many are connected to timers. They are especially useful in a variety of applications, such as opening and closing poultry house curtains, activating timed lighting in a barn, as well as controlling other utilities, also reducing energy consumption (PROGRESSIVE, 2014).

3.3 INTERNET OF THINGS

Also noteworthy is the Internet of Things (IoT), which, according to Pivoto et al. (2018), is the term that describes one of the technologies related to Smart Agriculture, and which shares the concept of a smart environment with agricultural management information systems.

The same authors emphasize that IoT allows objects to be controlled remotely through an existing network infrastructure, creating opportunities for more direct integration between the physical world and computer-based systems. The use of IoT depends on Internet infrastructure, and this presents several challenges, especially when dealing with a large number of network devices and integration with other systems.

According to Lacerda and Marques (2015), the potential of IoT is determined by its ability to capture, process, store, transmit, and present information, in which objects interconnected by a network are capable of performing actions independently, generating a large quantity and variety of data.

According to Cisco's (2011) forecast, by 2020, there will be approximately 50 billion connected objects for 7.6 billion people. We can infer that among this large number of connected objects will certainly be devices that are part of the production processes of the new 4.0 technologies, and among these, food production devices installed in poultry houses stand out.

According to Connolly (2017), the IoT connects many of a poultry house's sensors to a smartphone, iPad, local computers, or a wired or wireless (Wi-Fi) network, or other devices. For example, the IoT-based microcontroller project can be used to automate poultry farm processes at low cost. The author states that this type of project allows for the incorporation of lighting systems controlled by light sensors, which regulate the photoperiod and the predominant color of the poultry house's lighting. The project also includes actuators, such as servo motors, that help distribute feed, automate the temperature control system for barn ventilation, and adjust the relative humidity. Similarly, pneumatic motors and actuators control conveyors that remove bird waste and conveyor belts that transport eggs, as well as other barn utilities.

3.4 BIG DATA

According to research by Pivoto et al. (2018), much of the data remains underexplored by farmers, and today, researchers and companies are working to develop more tools that can connect to Big Data. Big Data is a collection of very large data sets with a wide variety of types, making it difficult to process using traditional data processing platforms. Big Data is particularly challenging for farmers, especially those running livestock operations.

The term "Big Data" is related to technology and electronics and is associated with "Smart Agriculture." Big Data is used to refer to an increasing volume of data that is difficult to store, process, and analyze using traditional database technologies (HASHEM et al., 2015).

Connolly (2017) states that as we gather more information about animals—data from the production process, a multitude of sensors, IoT devices, and even the bacteria in the birds' digestive tracts and how they respond to nutrition at the genetic level—it's clear that

farmers are learning how to manage large amounts of data, just as much as they used to. Thus, it's understood that "cultivating data" to predict the growth of an individual animal requires the ability to interpret the "Big Data" coming from their herd.

According to Jackman's research (2016), the ability to interpret "Big Data" involves strict control of all variables in the production and process chain in order to eliminate small losses, providing a noticeable overall gain. The essential characteristics of precision agriculture, according to Jackman's studies (2016), are: (i) Measurement automation; (ii) Automation of the interpretation of measurements taken; (iii) Diagnosis of control violations; and (iv) Insertion of local automated control systems.

Currently, complex algorithms are being created using artificial intelligence (AI) techniques to interpret the information collected from the microbiome and nutrigenomics, and thus track pathogens such as *Campylobacter* or antibiotic-resistant bacteria. Similarly, nutrigenomics allows us to generate information to accurately feed animals, and we can access DNA profiles to know exactly which specific bacteria are present. In this scenario, without a powerful data analysis tool, there is no way to take advantage of this (CONNOLLY, 2017).

3.5 CLOUD COMPUTING

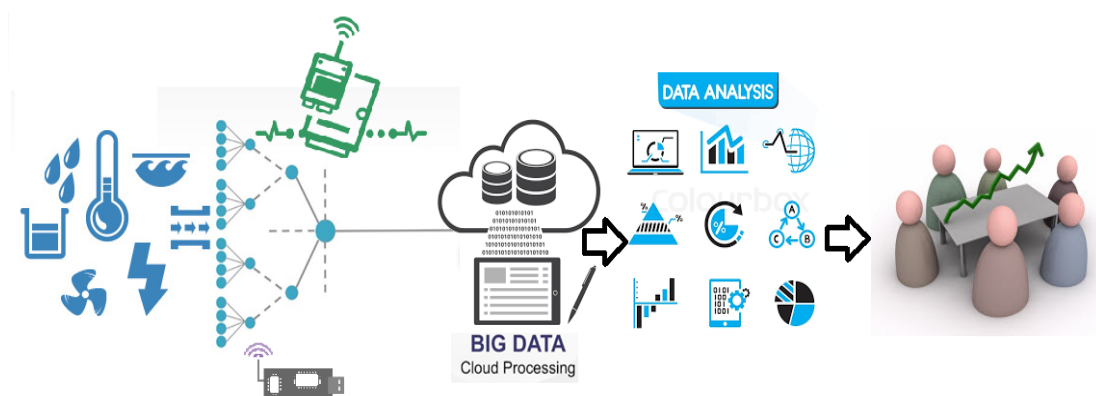
According to Jackman's research (2016), cloud computing technology enables the use of "Smart Agriculture" with its growing data volumes by creating a repository accessible via the internet, facilitating the use of Big Data tools for analysis. The author highlights that this term first appeared in the literature in 2011, with observations from data security experts who believe the field requires attention to data security and privacy.

Cloud computing technology, as described by Microsoft (2018), is the provision of computing services—servers, storage, databases, networking, software, analytics, and other services—over the internet. According to Microsoft (2018), the main benefits of cloud computing are related to the fact that cloud computing represents a significant shift in the traditional way companies think about IT resources. It leads to cost reduction, increased implementation and maintenance speed, global scalability in resource utilization, increased team productivity and performance, and increased reliability by enabling data backup, disaster recovery, and business continuity, as data can be mirrored across multiple redundant sites within the adopted cloud provider's network.

Figure 2 presents the shift in thinking currently underway with the advent of 4.0 technologies, which are based on the collection of individual data by sensors, led by IoT devices, and the use of efficient telemetry, whether wired or Wi-Fi, with an infrastructure that allows for the storage of large volumes of data (Big Data) in a collaborative (web) environment and that has the qualities described by Microsoft (2018) to ensure smooth operation and cost reduction based on an improved decision-making process.

Figure 2

Infrastructure and processes of 4.0 technologies



Source: Author.

3.6 BIOENERGETIC MODELS

According to research by Fournel et al. (2017), the assessment of heat loads from poultry losses and heat from poultry farms has been carried out through numerous studies of calorimetric systems since the 1950s. The authors report that measuring heat transfer between an animal and its environment has led to the development of bioenergetic models over time. Mathematical modeling of animal heat and moisture production for analysis can then, for the purposes of comparing evolution and level of technological input, be divided into three main categories: based on empirical data, mechanistic, and dynamic models (AERTS et al., 2003; WATHES et al., 2008). Empirical Approach: Empirical heat production models are generally developed from measured information, experimental observations, or experience and are not necessarily based on theory or the interactions of the described system components (AERTS, BERCKMANS, SAEVELS, DECUYPERE, & BUYSE, 2000; BRIDGES & GATES, 2009; GREEN & PARSONS, 2006). Empirical models for predicting environmentally influenced growth and thermal performance of animals were developed primarily during the 1940s and 1970s.

Mechanistic Approach: Mechanistic models of the physiological and behavioral responses of animals to their physical microenvironment are based primarily on the laws of physics and chemistry or on equations with known characteristics derived specifically to represent the perceived mechanisms of a system, supplemented with empirical values as needed. They offer a means of predicting heat production under a wider range of conditions than empirical models, integrating, for example, nutrition, genetics, and environment (BLACK, 2014; BRIDGES & GATES, 2009; WATHES et al., 2008).

Data-driven dynamic approach: This approach recognizes that, due to dynamic changes in inputs (e.g., animal heat production and ventilation rate) and disturbance factors (external weather), calculated internal conditions change rapidly over time (BANHAZI, THUY et al., 2009).

Consequently, data-driven dynamic models imply that the following assumptions are met: (i) animal responses to the microenvironment are measured continuously, and the information is fed back to the controller; and (ii) a mathematical model of the system allows the process response to be accurately predicted under static and/or dynamic conditions. Data-driven dynamic models use advanced, modern mathematical identification techniques to rapidly estimate unknown model parameters from an abstract mathematical model framework based on real-time measurements of process inputs and outputs, resulting in an adaptive model that can handle the time-varying character of bioprocesses such as poultry farming (AERTS et al., 2000, 2003)..

3.7 DEVELOPMENT OF COMPLEX ALGORITHMS

Digital 4.0 technologies allow researchers and designers to utilize advanced and current mathematical modeling tools to develop new, complex algorithms for real-time analysis.

Using Big Data stored online, these algorithms can interrelate stored and current variables that were previously inaccessible and prohibitively large due to insufficient technology. This allows for dynamically identifying new knowledge for immediate application to solving new production challenges.

A good example of this would be the real-time prediction of the incidence of heat waves, based on historical data, current weather forecasts, and sensors that indicate the microclimate situation. This allows for the possibility of not only alerting to the approaching situation but also initiating a process of acclimatization for the birds, acting on environmental

controllers to better adapt to the upcoming climate event and, if necessary, suggesting changes to the feed components to be fed during the period, thus reducing the impact on mortality in the poultry farm.

The techniques applied range from statistical analysis and quality tools to the application of Artificial Intelligence (AI) principles and techniques.

Among these techniques, we can list the most commonly found for application in expert systems (FMIS or DSS) focused on "Smart Agriculture," which, as seen in the work of Rupnik et al. (2018), are: (i) Probabilistic and optimization models; (ii) Supervised learning models; (iii) Bayesian models; (iv) Time series analysis; (v) Genetic programming; (vi) Neural networks; (vii) Fuzzy logic; (viii) Paraconsistent logic; (ix) Data mining; (x) Monte Carlo simulation; (xi) Big data visualization; (xii) Business analysis tools; (xiii) Predictive and behavioral analytics with forecasting and projection calculations; among others. The systems can even consider the interrelationships of data obtained from Big Data with the well-known performance management methodologies, such as: PDCA (Plan-Do-Check-Act), BSC (Balanced Scorecard) or GDP (Management by Guidelines), and others available on the market, which can even consider compositions between the first three listed.

3.8 ANALYSIS TOOLS WITH DIGITAL TECHNOLOGIES 4.0

Connolly (2017), based on the question "What would improve poultry production?", highlights the data sources that can leverage analyses, making decision support more effective:

From a production perspective, he highlights that individual body weights, if obtained in real time, would allow for better decisions about feed and water consumption.

From a livestock and welfare perspective, a better understanding of stress levels in bird comfort, assessed through meteorological data, body temperature, and air quality factors such as carbon dioxide and ammonia levels, would bring many benefits.

From a disease management perspective, the ability to detect the risk of pathologies in advance or mitigate their potential impacts through the automated location of morbid or dead birds in different areas of the housing, before part or all of the flock is affected.

From a food safety perspective, improving detection techniques for Salmonella, Campylobacter, and E. coli would be of great value to the entire production process and to end consumers.

From a food processing perspective, increasing yields by eliminating bottlenecks in the production process and seeking new, more efficient, and lower-cost techniques and equipment would be beneficial.

Dynamic, data-driven models would be very welcome to overcome these challenges, which are currently being researched in laboratories here in Brazil and around the world.

The following are some of the recent digital technologies identified in this research. They provide a useful framework for describing the multitude of new devices coming to market, as well as others still in research and development. These devices can help producers manage their farms more efficiently and sustainably, collecting valuable data that allows for refined analysis to improve their processes, increasingly seeking to answer the question posed by Connolly (2017).

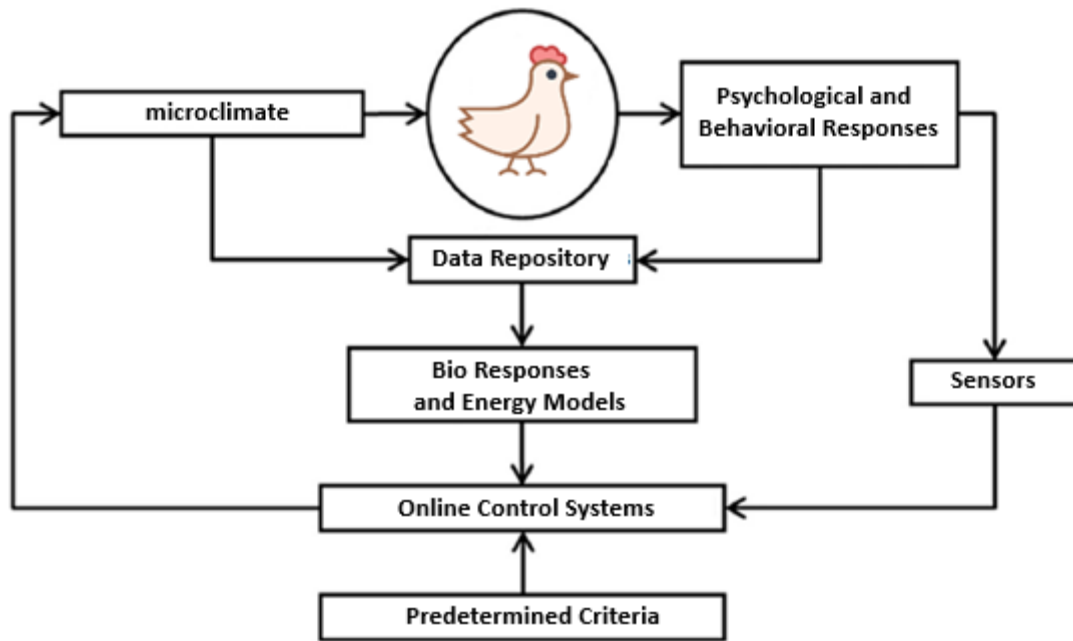
Fournel et al. (2017) state that data collection using sensors and Big Data should enable new advances in updating, due to climate change, thermal index indicators for animals, such as comfort indexes, radiation and air velocity indexes, indexes that explain the intensity and duration of heat stress, and an index that accounts for heat and cold conditions.

Regarding the sensors to be used, Fournel et al. (2017) state that the following can be considered: (i) For environmental measurements: Ambient temperature, relative humidity, radiation, and air velocity; (ii) For physiological measurements: Body temperature, respiration rate, heart rate, and body weight; (iii) For behavioral measurements: Feeding and water intake, presence, and activity or behavior of birds.

Figure 3 presents a schematic summary of the main components of environmental, physiological, and behavioral controls using precision tools with a dynamic, data-driven approach.

Figure 3

Schematic summary of the main components of dynamic environmental control through the precision tools of 4.0 technologies



Source: Autor, adapted from: (FOURNEL et al., 2017; VANSTEELANT, DESHAZER, & MILANUK, 1988; AERTS et al., 2003; WATHES et al., 2008).

3.9 ENVIRONMENTAL CONTROL WITH PRECISION

Climate represents one of the main limiting factors for production efficiency. Heat stress events can cause reduced performance, morbidity, and mortality, resulting in significant economic losses and animal welfare concerns.

Fournel et al. (2017), in their review, state that environmental control in confined animal housing systems is typically based on heat and humidity production rates at predetermined ambient temperature levels, measured between 1950 and 1980. They emphasize that this traditional control method may no longer meet the animals' true thermal needs, as it fails to account for factors now recognized as affecting animal productive responses to surrounding conditions, such as humidity, drafts, radiation, physiological status, and social interactions. Furthermore, advances in animal genetics, nutrition, and management practices have led to considerable changes in the sensible and latent heat loads of modern livestock buildings. In this context, according to the authors, precision livestock technologies (sensors, detectors, cameras, microphones, etc.) have enabled the automatic monitoring of environmental, physiological, and behavioral variables, which can be used to continuously assess livestock performance and welfare in relation to their production and the environment. Fournel et al.

(2017) state that an innovative strategy for environmental control of livestock buildings could include the analysis of:

(i) heat and humidity production rates using the latest bioenergetic models; ii) heat stress through multifactorial animal comfort indices based on several environmental and physiological measures; and (iii) animal behavior in response to changing environmental conditions.

The development of precision environmental control for livestock facilities should: (i) be carried out in close collaboration between researchers and manufacturers to favor the integration of accurate, automated measurements and analysis of data retrieved from multiple sensors in different formats and frequencies that can be interpreted based on the underlying biological or physical processes; (ii) include a comprehensive visualization tool so that farmers can easily identify production inefficiencies; (iii) use the results of data analysis as inputs in an automated decision-making process that triggers certain management actions; and (iv) demonstrate the economic benefit of such a global system of precision tools (BANHAZI & BLACK, 2009; KOENDERS et al., 2015; WATHES et al., 2008).

3.10 PHYSIOLOGICAL CONTROL WITH PRECISION

Reliable and affordable electronic data loggers with thermocouple, infrared, and thermistor sensors have been used for continuous temperature measurements since the 1980s, replacing short-term measurements using early mercury thermometers (Eigenberg et al., 2009). However, remote temperature measurement is not straightforward. Some difficulties may arise depending on the measurement location, as the physiological function of the body part in question, or the invasiveness of the device, can cause temperature changes. There are basically two categories of temperature sensors: those that are surgically implanted and those that are non-implanted (Sellier et al., 2014). These sensors can be linked to data loggers from which data is retrieved or to radio transmitters that send data to a receiving unit.

In addition to deep body temperature, surface temperature can be measured. A commonly used and moderately non-invasive method involves the installation of a contact thermistor or thermocouple (RENAUDEAU, KERDONCUFF, ANAIS, & GOURDINE, 2008). Other methods of measuring skin temperature include the use of data loggers mounted on radio collars or securely glued with epoxy to the skin to track temperature over several days (MCCAFFERTY et al., 2015). Infrared thermography, which is a non-invasive technique

based on the hypothesis that any variable that influences heat production is transmitted through blood vessels and dissipated in infrared waves (MITCHELL, 2013; SEJIAN et al., 2015), can also be used to monitor surface body temperature responses through the use of cameras or laser thermometers (MITCHELL, 2013; YANAGI et al., 2002). Respiration rate is also of particular interest as a physiological response because a large number of studies have shown a correlation with dry bulb temperature, solar radiation, and wind speed. As a result, respiration rate is a good indicator of heat stress. It also has the advantage of being readily observable and demonstrating a short lag time relative to temperature (Eigenberg et al., 2009). Existing automated respiration rate equipment is quite limited. Respiration rate can be detected using a device attached to the bird's beak, but this method has not been widely used. New techniques for this procedure are being tested in the laboratory.

Another physiological indicator of heat stress is changes in heart rate (Lefcourt, Erez, Varner, Barfield, and Tasch, 1999). Heart rate is measured based on electrocardiography or arterial pulse counting (Kovács et al., 2014).

An animal's weight is another important indicator of its well-being. Any unusual weight change can provide an early warning of health problems or simply problems with feeding or ventilation equipment (FROST et al., 1997). Traditional bird weight measurements require the animal to be perched on weighing devices (mechanical scales or electronic scales), which is physically stressful for both the animals and the keepers (LI, LUO, TENG, & LIU, 2014). Because there is a strong correlation between an animal's weight and its planar field of view, a system that includes a video camera connected to a computer equipped with the appropriate hardware and software was developed to quantify the resulting relationship. Computer algorithms segment the bodies in the visual scene, extract the planar field of view, and then estimate the animal's weight (FROST et al., 1997; WANG et al., 2008).

3.11 BEHAVIOR CONTROL WITH PRECISION

Food and water intake and feeding behavior have become useful indicators of animal health (BROWN-BRANDL et al., 2013; KASHIHA et al., 2013). Research has also indicated that feed consumption and changes in feeding behavior may be related to thermal conditions (NIENABER & HAHN, 2000).

Systems that measure feed consumption (total and feeding rate) in association with feeding behavior (meal duration, meal interval, number of meals per day, and total time spent feeding) have been tested in birds (PUMA et al., 2001). Some of the systems are equipped

with an antenna that detects the passive tag of a radiofrequency transponder located on the bird as it approaches the feed or water box. For each visit, a computer records the data sent by the antenna, which includes data related to the bird, and then calculates the duration of visits to waterers, feeders, or a nest, for example. Other systems consist of electronic feeding stations with a weighing system or solid flow sensor (MEISZBERG et al., 2009; PUMA et al., 2001).

An animal's behavior can be a clear indicator of its physiological state: (i) a sick animal may be less active than a healthy animal; (ii) animals in a cold environment may huddle together for warmth or move away to reduce their temperature; and (iii) an animal's activity level may be linked to its stage in the reproductive cycle (FROST et al., 1997).

Behavioral activity data are most commonly collected by a human through direct observation or analysis of video recordings. However, these methods are time-consuming and labor-intensive. Automatic activity recording can be achieved using various sensor systems: ultrasonic proximity sensors (BROWN-BRANDL, EIGENBERG, & NIENABER, 2000), mercury tilt switches, and accelerometers (OUELLET et al., 2016).

4 CONCLUSIONS

This research concluded that important emerging technologies can be applied to the poultry production chain, such as "Precision Tools," to assist in analysis processes and promote better decision-making support for sector managers. These technologies, known as 4.0 technologies, enhance and update fewer complex procedures previously applied as "Smart Poultry Farming," or more generally as "Smart Farming," further reducing costs and generating new opportunities that leverage competitiveness and social responsibility, as well as addressing the strategic and managerial issues involved. These technologies provide better information that supports more assertive decision-making, combined with technological innovation for the herd.

ACKNOWLEDGEMENTS

The authors thank the Graduate Program in Agribusiness and Development (PGAD) at Unesp, Tupã/SP campus, for their support of this research

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EFFECT OF THE USE OF MULTIPLYING STRAINS WITH EFFICIENT MICROORGANISMS IN THE BIOREMEDIATION OF AQUACULTURE AND WASTEWATER FROM PRODUCTIVE FISH-FARMING LAKES

EFEITO DO USO DE CEPAS MULTIPLICADORAS COM MICRORGANISMOS EFICIENTES NA BIORREMEDIAÇÃO DE ÁGUAS DE CULTIVO E RESIDUAIS DE LAGOS PRODUTIVOS PISCÍCOLAS

EFFECTO DEL USO DE CEPAS MULTIPLICADORAS CON MICROORGANISMOS EFICIENTES EN LA BIORREMEDIACIÓN DE AGUAS DE CULTIVO Y RESIDUALES DE LOS LAGOS PRODUCTIVOS PISCÍCOLAS

 <https://doi.org/10.56238/sevened2025.036-154>

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ABSTRACT

The intensification of aquaculture activity has increased the generation of organic waste and toxic compounds, such as nitrogen and phosphorus, threatening the quality of surface water bodies and environmental sustainability. This study aimed to evaluate the effectiveness of multiplying strains of efficient microorganisms (EM) in the bioremediation of culture water and wastewater from fish-farming lakes. The methodology consisted of physicochemical and microbiological characterization of the waters and the application of three experimental EM doses (1/110, 1/1000, and 1/3000) in 250-liter units, compared with a control over a 45-day period. The evaluated parameters included COD, total solids, nitrogen compounds (ammonium, nitrites, nitrates), phosphates, sulfates, and microbiological counts (coliforms and heterotrophs). The results showed that although there was an increase in dissolved oxygen over time, there were no statistically significant differences between the EM treatments and the control for most variables, including the removal of coliforms and nitrogen compounds. The exception was sulfate levels, for which a significant reduction was observed in the EM treatments. It was also observed that the highest dose (1/110) was counterproductive, inducing a eutrophication process and macrophyte growth that increased the organic matter and phosphate load. It is concluded that, under the studied conditions, EM were effective specifically for sulfate removal, and lower doses are recommended for future studies to avoid eutrophication.

Keywords: Bioremediation. Aquaculture. Efficient Microorganisms (EM). Wastewater Treatment. Sulfates.

RESUMO

A intensificação da atividade aquícola tem aumentado a geração de resíduos orgânicos e de compostos tóxicos, como nitrogênio e fósforo, ameaçando a qualidade dos corpos d'água superficiais e a sustentabilidade ambiental. Esta pesquisa teve como objetivo avaliar a eficácia de cepas multiplicadoras de microrganismos eficientes (EM) na biorremediação de

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águas de cultivo e águas residuais provenientes de lagos piscícolas. A metodologia consistiu na caracterização físico-química e microbiológica das águas e na aplicação de três doses experimentais de EM (1/110, 1/1000 e 1/3000) em unidades de 250 litros, comparadas a um controle durante um período de 45 dias. Os parâmetros avaliados incluíram DQO, sólidos totais, compostos nitrogenados (amônio, nitritos, nitratos), fosfatos, sulfatos e contagens microbiológicas (coliformes e heterotróficos). Os resultados demonstraram que, embora tenha havido aumento do oxigênio dissolvido ao longo do tempo, não foram observadas diferenças estatisticamente significativas entre os tratamentos com EM e o controle para a maioria das variáveis, incluindo a remoção de coliformes e de compostos nitrogenados. A exceção foi o parâmetro sulfatos, para o qual se evidenciou redução significativa das concentrações nos tratamentos com EM. Observou-se ainda que a dose mais elevada (1/110) foi contraproducente, induzindo um processo de eutrofização e crescimento de macrófitas, o que elevou a carga de matéria orgânica e de fosfatos. Conclui-se que, nas condições estudadas, os EM foram eficazes especificamente na remoção de sulfatos, recomendando-se a investigação de doses menores para evitar a eutrofização.

Palavras-chave: Biorremediação. Aquicultura. Microrganismos Eficientes (EM). Tratamento de Águas Residuais. Sulfatos.

RESUMEN

La intensificación de la actividad acuícola ha incrementado la generación de residuos orgánicos y compuestos tóxicos, como nitrógeno y fósforo, lo que amenaza la calidad de los cuerpos de agua superficiales y la sostenibilidad ambiental. Esta investigación tuvo como objetivo evaluar la eficacia de cepas multiplicadoras de microorganismos eficientes (EM) en la biorremediación de aguas de cultivo y residuales provenientes de lagos piscícolas. La metodología consistió en la caracterización físicoquímica y microbiológica de las aguas y la aplicación de tres dosis experimentales de EM (1/110, 1/1000 y 1/3000) en unidades de 250 litros, comparadas frente a un control durante un periodo de 45 días. Los parámetros evaluados incluyeron DQO, sólidos totales, compuestos nitrogenados (amonio, nitritos, nitratos), fosfatos, sulfatos y recuentos microbiológicos (coliformes y heterótrofos). Los resultados demostraron que, si bien hubo un aumento del oxígeno disuelto en el tiempo, no existieron diferencias estadísticas significativas entre los tratamientos con EM y el control para la mayoría de las variables, incluyendo la remoción de coliformes y compuestos nitrogenados. La excepción fue el parámetro de sulfatos, donde se evidenció una reducción significativa de las concentraciones en los tratamientos con EM. Se observó además que la dosis más alta (1/110) resultó contraproducente, induciendo un proceso de eutrofización y crecimiento de macrófitas que elevó la carga de materia orgánica y fosfatos. Se concluye que, bajo las condiciones estudiadas, los EM fueron efectivos específicamente para sulfatos, y se recomienda investigar dosis menores para evitar la eutrofización.

Palabras clave: Biorremediación. Acuicultura. Microorganismos Eficientes (EM). Tratamiento de Aguas Residuales. Sulfatos.

1 INTRODUCTION

Microorganisms have a nutritional versatility that can be used for the biodegradation of contaminants. This type of process is called bioremediation and consists of the ability of certain microorganisms to convert, modify and use toxic pollutants for the production of energy and biomass in the process (Abatenh et al, 2017). Instead of collecting the contaminant and storing it, bioremediation is a microbiological activity that is applied to break down or transform pollutants into elemental forms and less toxic or non-toxic compounds.

Bioremediators are biological agents used to clean up contaminated sites, including bacteria, archaea, and fungi as the main agents (Strong et al, 2008). The application of bioremediation as a biotechnological process involves microorganisms to resolve and eliminate the dangers of many pollutants through the biodegradation of the environment. Microorganisms act as an important tool for removing contaminants in soil, water, and sediments; due to their advantage over other remediation protocols, they restore the original natural environment and prevent further contamination (Demnerova et al, 2005).

In the case of wastewater treatment, microorganisms play an important role. The rationale for using these strains of EM microorganisms is that they contain various organic acids due to the presence of lactic acid bacteria, which secrete organic acids, enzymes, antioxidants, and metal chelates (Okuda and Higa). Creating an antioxidant environment by MS helps improve solid-liquid separation, which is the basis for water cleanliness (Mandalaywala et al, 2017). One of the main benefits of using MS is the reduction in the volume of sludge, as the beneficial organisms present in MS they break down organic matter by converting it into carbon dioxide (CO₂), methane (CH₄), or using it for growth and reproduction. Effective microorganisms significantly reduce the volumes of wastewater sludge produced by eliminating associated odors (Shalaby, 2011). On the other hand, wastewater treatment carried out with conventional methods is more expensive because the chemical products used are of greater value in the market, so the implementation of a more economical and environmentally friendly technology is of greater interest (Cardona and García, 2008). In the Center's Bioinputs Unit there are multiplier strains that are used for the production of bioinputs, these strains in addition to having efficient microorganisms (EM) are enriched with other organic waste compounds that are produced in the unit and have had good results.

1.1 PROBLEM STATEMENT

The quality and quantity of the water supply worldwide and in the country is being threatened by the impact of industrial and agricultural activities. The degradation of water resources was initially due to contamination by organic waste and salinization of irrigation systems, later aggravated by the presence of suspended solids, heavy metals, radioactive waste, nitrates, organic micropollutants, acidification of lakes and streams and eutrophication of lakes and coastal waters (Salazar, 2008).

Intensive aquaculture is one of the productive activities that is increasingly booming in food security, which generates greater risks of environmental impact, like most human activities. Gondwe et al. (2012) and Vezzulli et al. (2008) indicated that aquaculture is one of the main activities contributing to the increasing levels of organic waste and toxic compounds. When not properly treated, aquaculture wastes can cause emerging diseases due to antibiotic resistance and harmful algal blooms (Hegaret, 2008; Rubert, 2008).

Wastewater effluent from the aquaculture industry contains nitrogenous compounds (ammonia, nitrite and nitrate), phosphorus and dissolved organic carbon that can lead to environmental deterioration at high concentrations (Ali et al., 2005). Ammonia (NH_3) is the product of fish respiration and the decomposition of excess organic matter. Chemoautotrophic bacteria (*Nitrosomonas* and *Nitrobacter*) act by oxidizing ammonium ions (NH_4) to nitrites (NO_2) and nitrate ions (NO_3). In nature, these ions are absorbed by aquatic plants, algae and bacteria, as they are assimilated into biomass as a source of nitrogen. Nitrogenous compounds present in excessive amounts are responsible for generating eutrophication, which disrupts the balance of the aquatic ecosystem and could lead to a massive mortality of aquatic fauna (Lananan et al, 2014). The conservation of water resources allows optimizing production in terms of profitability and sustainability for the fish farming industry, since it must be delivered again in the same or better conditions than those found at the time of capture, complying with quality standards (Botero and Jimenez et al, 2006), in addition to promoting the environmental sustainability of this resource, which is one of the most affected. Wastewater treatment carried out with conventional methods is more expensive because the chemicals used are of higher value in the market, so the implementation of a more economical and environmentally friendly technology such as the use of efficient microorganisms for bioremediation is of greater interest (Cardona and García, 2008).

1.2 HYPOTHESIS

Environmental water decontamination with the effective use of EM (efficient microorganisms) in aquaculture effluents, avoiding eutrophication in surface water bodies.

2 OBJECTIVES

2.1 GENERAL OBJECTIVE

To evaluate the effect of multiplier strains with efficient microorganisms in the bioremediation of the culture and wastewater water of the productive lakes of the fish farming unit at the "La Granja" Agricultural Center.

2.2 SPECIFIC OBJECTIVES

- Perform a physical, chemical and microbiological characterization of the multiplier strains that contain efficient microorganisms, produced in the bioinputs unit of the "La Granja" Agricultural Center
- Perform a physical, chemical, microbiological and phytoplankton characterization of the culture and wastewater water of the productive lakes of the fish farming unit.
- To evaluate the effect of different doses of multiplier strains on the treatment of culture and wastewater from the productive lakes of the fish farming unit.
- Analyze the quality of the water of the productive lakes of the fish farming unit and the wastewater of these productive areas in its initial state and after the application of efficient microorganisms, according to parameters established in the current regulations.

3 THEORETICAL FRAMEWORK ORIGIN OF AQUACULTURE IN COLOMBIA

Aquaculture in Colombia began at the end of the 30s of the twentieth century with the introduction of rainbow trout for restocking in waters for public use in natural lagoons located in highlands of more than 2,500 meters above sea level in the Andean Region; later, common carp (*Cyprinus carpio*) and *Tilapia rendalli* were introduced and culture experiments began with the tucunaré (*Cichla ocellaris*) to control the reproduction of tilapia in the ponds. Also at that time, studies began with native species, especially with the bocachico of the Magdalena river basin *Prochilodus magdalenae* and in 1968 experimental cultivation with mangrove oysters (*Crassostrea rizophorae*) began. (AUNAP-2014)

Continental aquaculture is represented exclusively by fish farming, mainly by the production of red and silver tilapia, cachama, trout and some native species, the first two being the ones that show a greater dynamic in production and market share; the native species with the highest participation are the white and black cachamas, the bocachico, the yamú (*Brycon amazonicus*) and other species such as catfish (*Pseudoplatystoma* sp). (AUNAP-2014)

Aquaculture must be framed within sustainable development criteria, defined by the FAO as "The management and conservation of the natural resource base and the orientation of technological and institutional change, in such a way as to ensure the continuous satisfaction of human needs for present and future generations". This sustainable development (in the agricultural sectors, 9 National Plan for the Sustainable Development of Aquaculture in Colombia AUNAP - FAO forestry and fisheries) conserves land, water and genetic resources plant and animal, does not degrade the environment and is technically appropriate, economically viable and socially acceptable." This is classified as a sustainable and beneficial practice for food security in supplying and supplying food demand, such small, medium and large-scale production requires an artificial or natural aquatic environment, inputs and raw material that generates waste that alters the physical, chemical and microbiological parameters of the water, however these aspects reveal that aquaculture is not sustainable and requires more planning and waste management that they discharge into surface water bodies.

3.1 ENVIRONMENTAL IMPACT ON AQUACULTURE

The level of environmental pollution caused by aquaculture is directly related to the farming production system (extensive, semi-intensive and intensive). The more the system is intensified, the more inputs and raw materials are used. For example: Commercial food leaves residues, part of which is not consumed and degrades in the water column producing sediments. (Elizabeth et al 2018) Residues are also produced by the accumulation of fish excreta, resulting from the food consumed and metabolized (Eley et al., 1972). This degradation of waste alters various physical and chemical parameters of the water, as well as stimulates bacterial production due to the high content of organic matter, thus changing the chemical composition, structure and functions of the water-sediment interface (Tsutsumi and Kikuchi, 1983) (Brown et al., 1987). Aquaculture is an activity closely related to the anthropogenic effects that are caused by this economic activity, which must be analyzed and

reconstructed in order to reach a balance between the support elements (soil, water, air, flora and fauna) and the producer.

The generation of aquaculture waste and dumping has become a global public health concern (Martins et al., 2010).

In general terms, there are two types of aquaculture/fish farming waste: dissolved solids. The former are considered to have the greatest environmental impact and are mainly made up of uneaten food and undigested substances. The main dissolved components are nitrogen and phosphorus (Dauda et al., 2019).

The water column is mainly affected in the discharge of nutrients from cultivated animals and the production process, if the flow of these compounds in particular concentrations of phosphorus and nitrogen are discarded into the environment and exceed the assimilation capacity of the ecosystem, it can cause severe impacts on both the water column and the benthos. such as eutrophication, oxygen depletion, and alteration of local biodiversity (Buschmann and Fortt, 2005). Similarly, the use and quantity of chemical substances and antibiotics depends on the species and the intensity of the crop; although they are used in a very dilute form, they are dissolved in the water and are accumulated in the sediments, affecting the quality and nature of these two factors (Read et al., 2003).

In the same sense, (Milthon et al. 2011) determine that, for fish farming activity, one of the main management concerns is focused on effluents, which, being rich in nitrogen and phosphorus, impact the receiving water bodies with an increase in primary productivity that accelerates eutrophication processes. As in other economic activities, aquaculture produces waste that must require other environmental services to be assimilated or recycled; when there is no control, sustainability is ultimately compromised (Buschmann, 2001).

Aquaculture produces sediments that are the product of nutrients, soil particles and concentrate that are not consumed in their entirety, all this is degraded producing sediments, all this generates a degree of contamination that is directly proportional to the size of the crop. (Elizabeth et al-2018)

It is found that organic matter in fish farms is generated by the accumulation of elements such as: food, fish feces, metabolic waste, benthos, plankton, fungi, bacteria and organisms of animal and plant origin in different stages of decomposition such as: carbon, oxygen, nitrogen and phosphorus, (González, 2015). since at the bottom the soil of a lake is in a constant exchange of compounds between the two environments, water and sediments,

thus producing effects on the composition of the water of the natural environment. (Boyd, 1995).

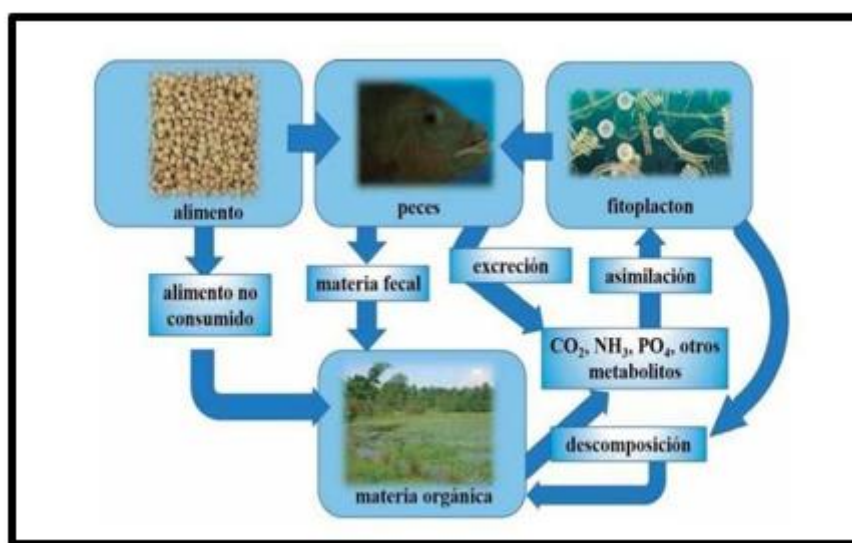
3.2 NEGATIVE ASPECTS OF (N)NITROGEN CONCENTRATION IN FISH EFFLUENTS

Nitrogen (N) is a contaminant present in wastewater that must be removed for multiple reasons:

Reduces dissolved oxygen in surface waters Is toxic to the aquatic ecosystem. It poses a risk to public health and together with (P). They are responsible for the overgrowth of photosynthetic organisms (eutrophication). (Aqualia-2019)

Figure 1

Nitrogen cycle, organic matter that produces pollutants in aquaculture lakes. Taken from Aunap (2019)



According to the above information, it can be mentioned that the culture of fish in confined environments biochemically alters the quality of the water in which they are produced; The most important alterations are related to the increase in organic matter produced mainly by excretions, by the feed supplied and by the contributions of the inputs added in the culture ponds; which generates variations in the concentration of oxygen (DO), increase in the concentration of suspended solids (TSS), increase in the biological oxygen demand (BOD), increase in the chemical oxygen demand (COD), increase in nitrogenous compounds (ammonium, nitrite and nitrate), increase in carbon dioxide and phosphate,

exaggerated growth of algae and eutrophication. Studies have shown that BOD₅ from effluents from aquaculture ponds normally has a range between 5 and 20 mg/l. (Corpoamazonia-2018)

Likewise, it is important to highlight that the contamination of surface waters by nutrients can induce adverse effects on human health, especially the ingestion of nitrites and algal toxins, because they can cause diarrhea, vomiting, gastroenteritis, among others (Camargo & Alonso, 2006). In addition, the accumulation of phytoplankton, the death and decomposition of plant material in the receiving sources, can generate unpleasant odor and taste, reducing its use as a recreational and consumption resource (Figueroelo & Marino, 2004).

3.3 BIOREMEDIATION PRACTICES

It consists mainly of the use of different organisms such as (plants, yeasts, fungi, bacteria, etc.) as a medium to neutralize toxic substances, either transforming them into less toxic substances or making them harmless to the environment and human health. One of the most widely used biocorrective measures in the use of microorganisms for the decontamination of natural resources, this decontamination system is based on the absorption of organic substances by these microorganisms, which use them as a source of carbon necessary for their growth and energy for their metabolic functions. (Duilio Torres Rodriguez-2003).

3.3.1 Bioremediation in aquaculture

Wastewater management in aquaculture ecosystems is essential to maintain the good health status of animals, as well as counteract negative impacts on the environment. Bioremediation, which is nothing more than the application of microorganisms (BACTERIA) to remove hazardous waste, is a very helpful tool for the on-site treatment of contaminated wastewater and sediments. For the bioremediation of nitrogenous compounds, bacteria have to perform the function of nitrification and denitrification (Chávez-Crooker & Obrique-Contreras, 2010). this biological process is carried out by ammonium oxidizing bacteria (BOA) and nitrate oxidizing bacteria (BON). Although a wide range of bacterial species are capable of to perform nitrification or denitrification, not all species are applicable for bioremediation products. The strains *Paracoccus* sp. and *Thiobacillus* sp. have recently gained great interest

due to their degrading abilities. On the other hand, *Bacillus* sp can also carry out several functions in water cleaning (Nakano et al., 1998)

3.4 DENITRIFYING BACTERIA

3.4.1 Nitrification

It is an aerated biological process where ammonia is oxidized until its conversion to nitrate, it is divided into two stages, the first is defined by the oxidation of NH_4^+ to nitrite (NO_2^-) and the second stage defined by the oxidation of (nitrites) NO_2^- to (nitrates) NO_3^- .

3.4.2 Denitrification

It is a biological process that takes place in the absence of oxygen in which nitrate is transformed into gaseous nitrogen that is incorporated into the atmosphere.

Figure 2

Nitrogen denitrifying bacteria cycle



Note. nitrification and denitrification process. Taken from (Saubot, 2002)

The process of decomposition of organic matter, leads to greater oxygen consumption and the generation of CO_2 and anoxic environments (Magni et al 2008).

Origin of Efficient Microorganisms in the Use of Bioremediation

The term "effective microorganisms" (EM) is used to denote specific mixed cultures of known beneficial microorganisms, which are effectively employed as microbial inoculants

(Higa and Parr, 1994). E.M is a technology developed by Dr. Teruo Higa in the eighties in Okinagua, Japan and has been used in different fields such as agriculture, industry, animal, environmental remediation, among others, and is currently widely distributed (Sangkara, 2002).

3.5 MAIN EFFICIENT MICROORGANISMS (EM)

Figure 3

Efficient microorganisms



Note. view of efficient microorganisms. Taken from Fundases laboratory

3.5.1 Photosynthetic bacteria (*Rhodopseudomonas* spp)

They use natural light and the heat of the sun as a source of energy, organic matter and harmful gases, decompose offensive gases such as ammonia and hydrogen sulfide into gases with non-offensive odors (Fernando et al, 2018).

Regarding Colombia, Roldán et al., (2007) found that after the application of EM, both in domestic and synthetic wastewater, significant decreases in the content of total coliforms were evidenced.

3.5.2 Photosynthetic bacteria in agriculture

Phototropic bacteria are a group of independent, self-sustaining microbes. These bacteria synthesize useful substances from root secretions, organic matter, and/or harmful gases (e.g., hydrogen sulfide) with the use of sunlight and soil heat as energy sources. These useful substances include amino acids, nucleic acids, bioactive substances, and sugars, all of which promote plant growth and development. The metabolites made by these microorganisms are absorbed directly by plants and act as a substrate for the population

increase of beneficial microorganisms. For example, in the rhizosphere, vesicular and arbuscular mycorrhizae (VA) are increased thanks to the availability of nitrogenous compounds (amino acids) that are secreted by phototropic bacteria. VA mycorrhizae in response increase the solubility of phosphates in the soil and therefore provide phosphorus that was not available to plants. VA mycorrhizae can also coexist with azobacter and rhizobiums, increasing the ability of plants to fix nitrogen from the atmosphere.

3.5.3 Lactic acid bacteria (*Lactobacillus* Spp)

Lactic acid bacteria (*Lactobacillus*) were found in yogurt, suppress pathogenic microorganisms, are a strong sterilizer, attack pathogens, accelerate the decomposition of organic matter, prevent putrefaction and bad odors (Fernando et al 2018).

3.5.4 Lactic acid bacteria in agriculture

Lactic acid bacteria produce lactic acid from sugars and other carbohydrates, produced by phototropic bacteria and yeast. For this reason, some foods and drinks such as yogurt and pickles have been made with lactic acid bacteria since ancient times. However, lactic acid is a strong sterilizing compound that suppresses harmful microorganisms and aids in the breakdown of materials such as lignin and cellulose by fermenting them, removing undesirable effects from unbroken organic matter. Lactic acid bacteria have the ability to suppress diseases including microorganisms such as fusarium, which appear in continuous culture programs. Under normal circumstances, species such as fusarium weaken plants, exposing them to diseases and large populations of pests such as nematodes. The use of lactic acid bacteria reduces nematode populations and controls the spread and dispersal of fusarium, thereby inducing a better environment for crop growth.

3.5.6 Yeasts (*Saccharomycetes* spp.)

They synthesize or ferment the substances secreted by PHOTOTROPHIC bacteria, they produce proteins and sugars that are taken up by LACTIC BACTERIA. (Fernando et al 2018).

3.5.7 Yeasts in agriculture

Yeasts synthesize antimicrobial and other useful substances required by plants for their growth from amino acids and sugars secreted by phototropic bacteria, organic matter

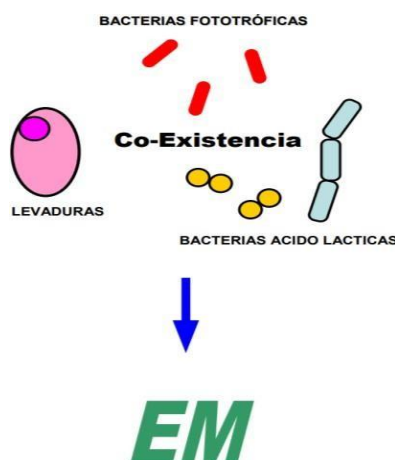
and plant roots. Bioactive substances such as hormones and enzymes produced by yeast promote active cell and radical division. These secretions are also useful substrates for MS such as lactic acid and actinomycetes bacteria. The different species of effective microorganisms (Phototropic bacteria, lactic acid and yeast) have their respective functions. However, phototropic bacteria can be thought of as the core of MS activity. Phototropic bacteria reinforce the activities of other microorganisms. This phenomenon is

called "coexistence and co-prosperity". The increase in MS populations in soils promotes the development of beneficial microorganisms existing in the soil. Since the microflora of the soil becomes abundant, and therefore the soil develops a well-balanced microbial system. In this process, specific microbes (especially harmful ones) are suppressed, in turn reducing disease-causing soil microbial species. In contrast, in these developed soils, EM maintains a symbiotic process with plant roots next to the rhizosphere. Plant roots also secrete substances such as carbohydrates, amino acids, organic acids, and active enzymes. The MS uses these secretions for growth. In the course of this process, MS also secretes and delivers amino acids, nucleic acids, a wide variety of vitamins and hormones to plants. This means that the EM in the rhizosphere coexists with plants. Therefore, in soils dominated by EM, plants grow exceptionally well.

3.6 BENEFITS OF USING EFFICIENT (ME) MICROORGANISMS

Figure 4

Relationship between beneficial bacteria



Note. Taken from (Tencio, 2011)

Efficient Microorganisms are almost all facultative in terms of their respiration. (which grows in both the presence and absence of oxygen).

They are saprophytic, feed on inert organic matter and are not adapted to live in the pantries of living beings; It is not harmful to the health of plants, animals and man.

The species contained in MS were selected for fulfilling one or more of the following functions

Solubilize nutrients (N, O, P, K, MG, CA, FE, ZN, CU, CO, SI, S, C) contained in the clays, in the parent material distributed in the soil profile.

Agricultural use.

Microbial inoculant, they restore the microbiological balance of the soil, improving its physical conditions. Chemicals, increase crop production and protection.

Animal production use.

It reduces bad odors (ammonia) and populations of pest insects, as a result of the fermentation process of excreta in situ.

To collect excreta and urine, reducing the frequency of water use.

Reduces the requirement and utilization of disinfectants and production and maintenance costs.

Organic solid waste management.

Reduces bad odors from manure and urine Eliminates pathogenic microorganisms and weed seeds

It prevents the decomposition of organic matter by oxidation in which gases generated by bad odors (sulfurous, ammoniacal and mercaptans) are released

It prevents the proliferation of insect vectors, such as flies, it does not find a suitable environment for its development

It speeds up the composting process to a third of the time of a conventional process.

Wastewater management.

Transforms and synthesizes organic matter and COD (non-biodegradable organic matter contained in water)

Increases oxygen values

Reduces sludge production in conventional treatment systems Reincorporates wastewater as irrigation water

Effectively removes more than 99% of total and fecal coliforms. (Fernando et al 2018).

Parameters and optimal values for life resolution 631 of 2015

Table 1

Parameters and optimal values for life

Parameter	Units	Maximum Limit Values Permissible
Temperature (T°)	°C	40 °C
Dissolved Oxygen (DO)	mg/l	Analysis and reporting
Ph	Units of Ph	6.00 to 9.00
Chemical oxygen demand (BOD)	mg/l O ₂	150,00
Biochemical Oxygen Demand (BOD ₅)	mg/l O ₂	50,00
Total Solids (TS)	mg/l	Analysis and reporting
Sulfates (So ₄)	mg/l	250,0
Sulfides (S ₂)	mg/l	1,00
Ammonium (Nh ₄)	mg/l	Analysis and reporting

Table 2

Parameters and Optimal Values for Life Resolution 2115 of 2007

Parameter	Expressed as	Maximum Acceptable Value (mg/l)
Nitrites	No ₂	0,1
Nitrates	No ₃	10
Phosphates	PO ₄	0,5
Total Coliforms	CT	Analysis and reporting

Eschericia Coli	E. Coli	Analysis and reporting
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4 STUDY AREA

The research project was carried out in the bio-inputs and fish farming unit of the "La Granja" Agricultural Center of the National Learning Service (SENA), Espinal Tolima.

5 METHODOLOGY

To evaluate the effect of different doses of the multiplier strains with effective microorganisms, on the quality of the waters of the productive lakes of the fish farming unit and the wastewater of the same (productive area – Lakes) of the Agricultural Center "La Granja", the analysis of some physicochemical and microbiological parameters, the process of characterization of the water of the lakes, of wastewater and multiplying strains, tend to identify in the first instance the initial microbial and physicochemical loads to establish monitoring indicators according to concentrations, protocols and techniques of parameter analysis, standardization of doses of microorganisms, in general establish removal capacity in adequate ranges.

Physicochemical and microbiological characterization of the water of fish farming lakes. The physicochemical parameters to be measured were: COD, Total Dissolved Solids (TDS), NO₃, NO₂, NH₄, PO₄, SO₄, Dissolved Oxygen and pH. Likewise, the microbiological characterization of the samples was carried out to establish the microbial concentration of both fecal contamination indicators (total and fecal coliforms), total heterotrophs and microorganisms present in MS on specific culture media.

Evaluation of different doses of multiplier strains in wastewater treatment

Three doses were used to evaluate the effect of the doses of the multiplier strains in wastewater treatment: 1/110, 1/1000, 1/3000 (vEM/vAR). As an experimental unit, cans with a capacity of 250L were used. For both treatments and control (without MS doses), three replications were performed for a total of 12 experimental units. On the other hand, the samplings were carried out on the first day, at 15, 30 and 45 days after the application of the doses and finally the results were analyzed taking into account the current regulations.

Figure 5

Assembly of experimental units



5.1 STATISTICAL ANALYSIS

Descriptive statistics of the data were performed, then the analysis of Shapiro-Wilks ($p < 0.05$) and Q-Q graphs to observe the distribution of the data. It was determined whether the data present a normal distribution to establish whether parametric or non-parametric statistics are used, because they did not present a normal distribution, non-parametric tests

were used for all analyses. To establish which treatments there were statistically significant differences, the LSD Fisher comparison test was performed. Finally, a principal component analysis was performed to observe the relationship of the variables studied. The InfoSTAT package was used for statistical analysis.

6 RESULTS AND DISCUSSION

6.1 INITIAL CHARACTERIZATION OF WASTEWATER

Table 3

Initial microbiological characterization of wastewater

Microorganisms	Count (CFU/ml)
Lactobacilli	0
Phototrophic	0
Yeasts	3 x 10 ⁴
Heterotrophs	1.2 x 10 ⁵
Coliforms	Countless

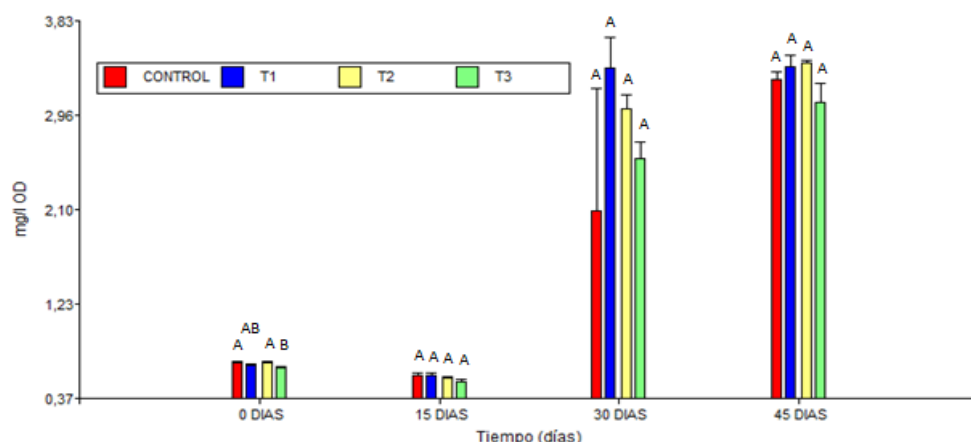
Table 4

Initial physicochemical characterization of wastewater

Physicochemical parameters	Concentration
COD	
Total solids	173
Ammonia	0,38
Sulfate	27,6
Phosphate	1,43
Nitrate	0,63
Nitrite	0,0028

Figure 6

Dissolved oxygen concentration in treatments



Dissolved oxygen concentrations increased over time, with significant differences at 30 and 45 days of study; however, no statistically significant differences were observed between control and treatments. Dissolved oxygen concentrations in the first days were between 0.58 and 0.70 mg/L, which are low values considering that a minimum of 5 - 6 mg/L O₂ is required to maintain aquatic biodiversity (APHA, 2005). For the COD parameter, no significant differences were observed, except with treatment 3, whose results in COD concentration were higher compared to the other treatments and control, due to the eutrophication process that occurred in this treatment. The results obtained coincide with what has been reported, since as the easily degraded compounds are exhausted and the microorganisms begin to consume other more complex substances, there comes a certain point at which the microorganisms do not have the enzymes or nutrients required to continue with the process that allows the reduction of COD, this, added to the lack of oxygen, limits degradation, as observed in the similar value where there is no significant change for COD due to the presence of compounds whose complex chemical structure does not allow their easy degradation (Cardona & García, 2008).

Figure 7

Chemical oxygen demand in the treatments analyzed

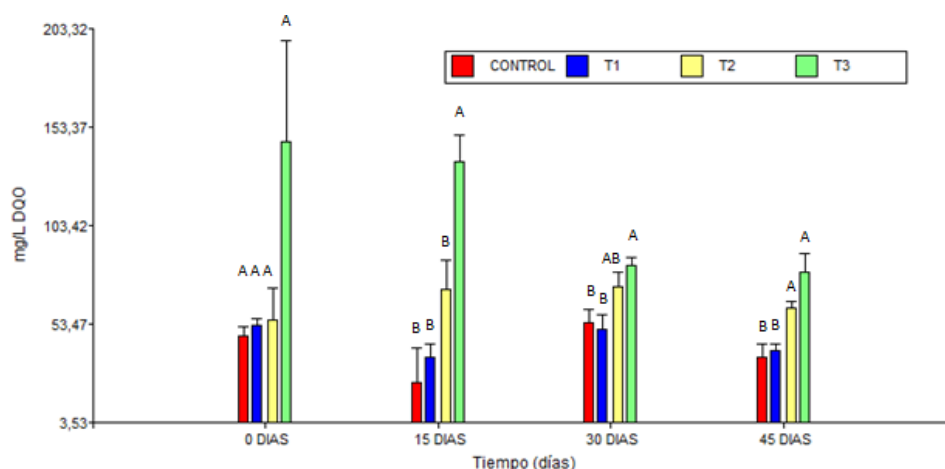
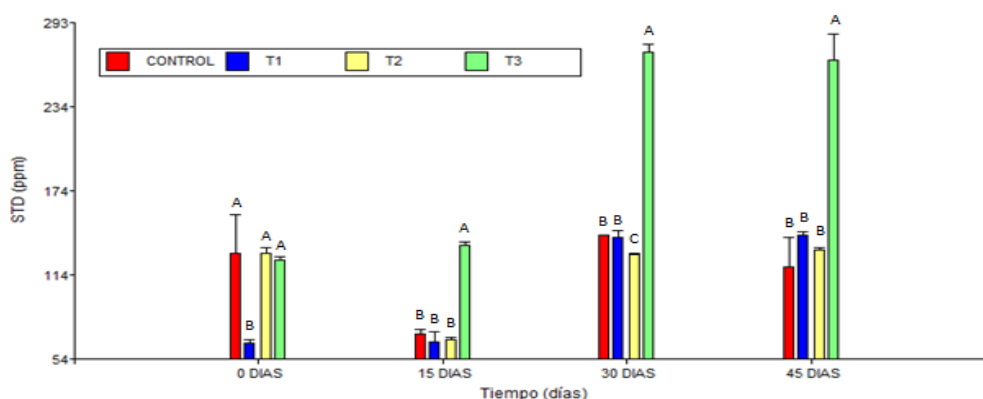


Figure 8

Total solids dissolved in treatments



In general, there were no significant differences between the control and the treatments for the dissolved total solids variable. For this reason, it is stated that there were no significant differences in STD concentrations after the application of MS in the wastewater. The concentration of STDs increased over time in treatment 3, due to the presence of aquatic plants, which is consistent with the increase in ammonium and phosphate concentrations.

6.2 PH

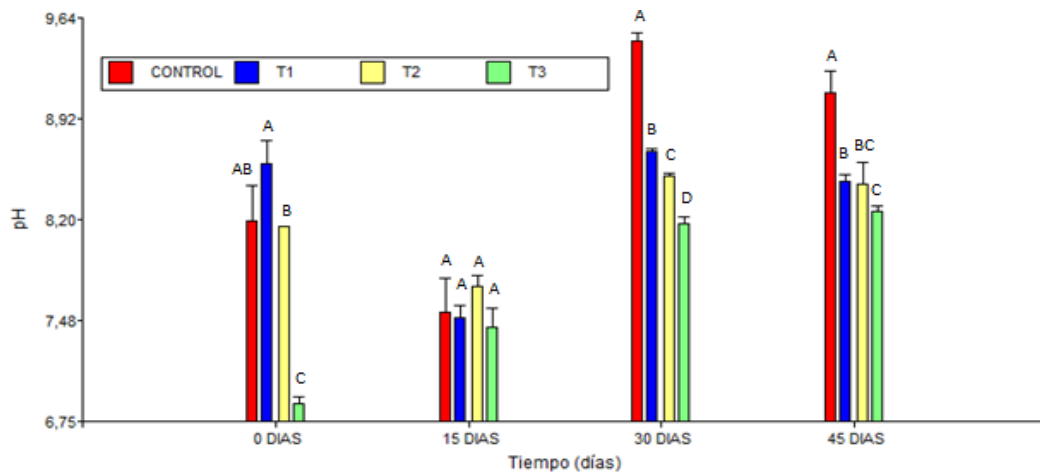
In the initial phase, the pH tended to alkalinity; however, for treatment 3 it was more neutral (6.88). Fifteen days after the application of the treatments, there were no significant differences between them, but there was a decrease to neutrality with respect to the initial day. For control, alkalinity increased considerably by day 30 (9.47) and 45 days (9.10).

The trend towards alkalinity does not coincide with the findings of Fioravanti (2005) who evaluated efficient microorganisms as stabilizers of wastewater, presenting a decrease from 6.3 to 4.5, despite the fact that in the present study such a drastic decrease in pH was not observed, comparing the treatments with the control if there was a significant decrease in the last days of treatment.

In the study carried out by Roldán et al. (2007), the pH values did not present statistically significant differences, likewise, Gómez and Galindo (2008) did not observe statistically significant differences in this variable.

Figure 9

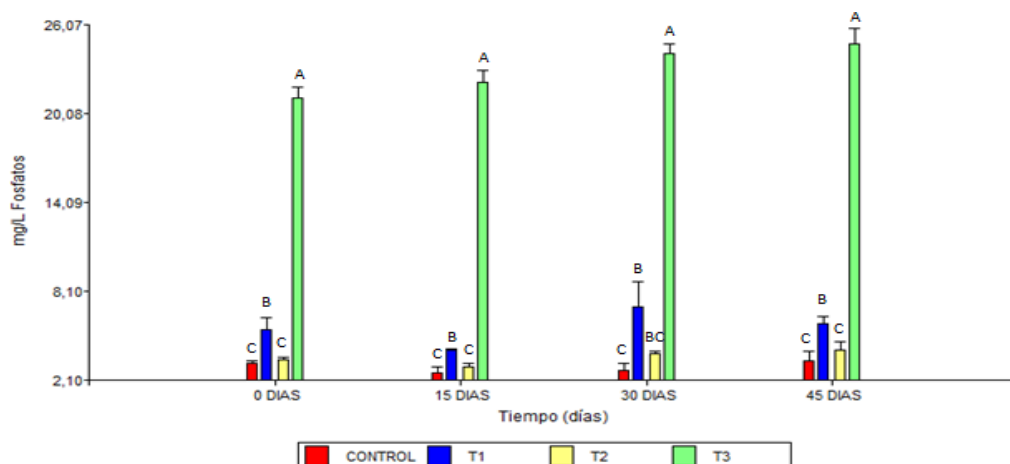
Hydrogen potential in treatments



6.3 PHOSPHATES

Figure 10

Phosphate concentration in treatments



There were significant differences with treatment 1 and 3 compared to treatment 2 and control and a slight increase in concentration over time. Phosphate is one of the main compounds that contributes to the pollution of water bodies.

According to the classification of Metcalf and Eddy (2003), wastewater with a high concentration of organic phosphorus is considered to be that with more than 5mg/L, so the concentration presented in the treatments is high, especially in treatment 3, possibly this was due to the fact that in the experimental units with this treatment there was the growth of aquatic plants and this promoted the eutrophication process. In this variable, control was better than treatments.

6.4 NITROGENOUS COMPOUNDS

Figure 11

Ammonia concentration in treatments

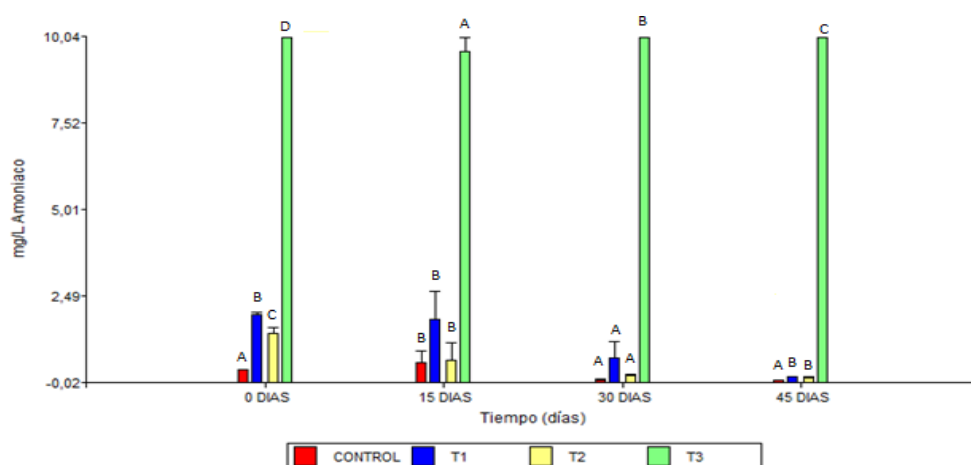


Figure 12

Nitrite concentration in treatments

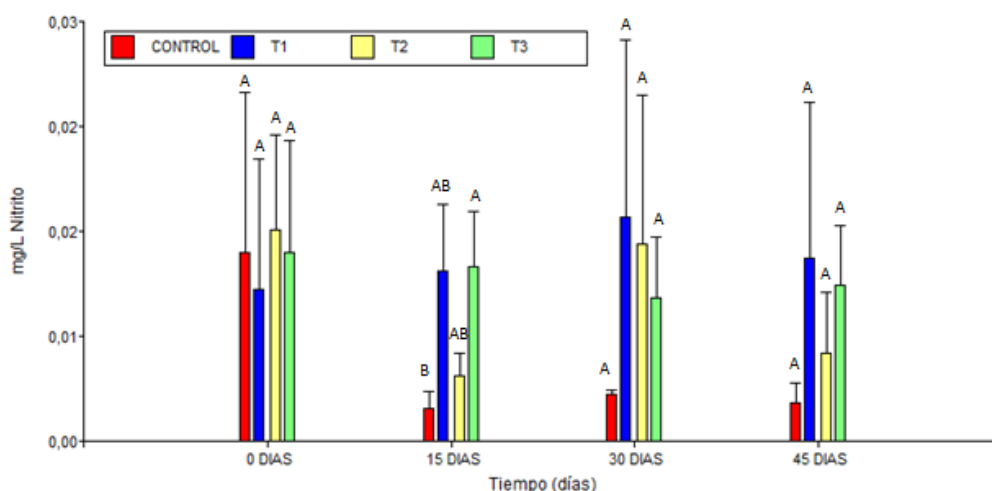
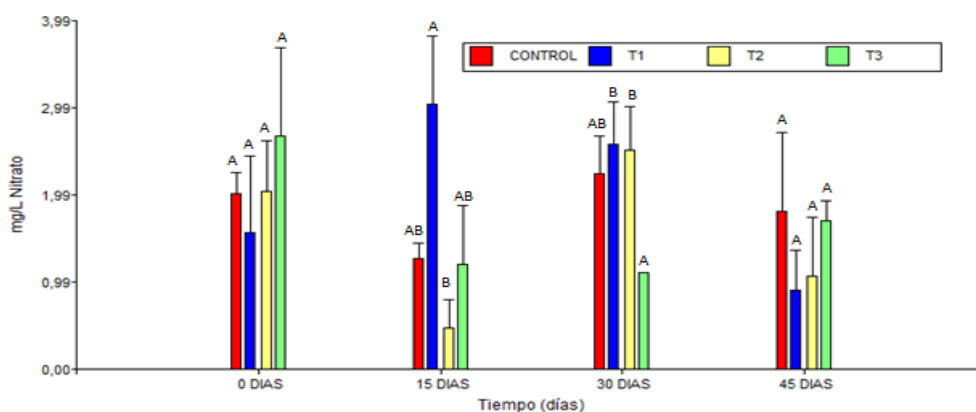


Figure 13

Nitrate concentration in treatments



Nitrogenous compounds formed by reduction reactions such as ammonium showed a tendency to decrease over time, with the exception of treatment 3 which presented high concentrations due to the growth of aquatic plants.

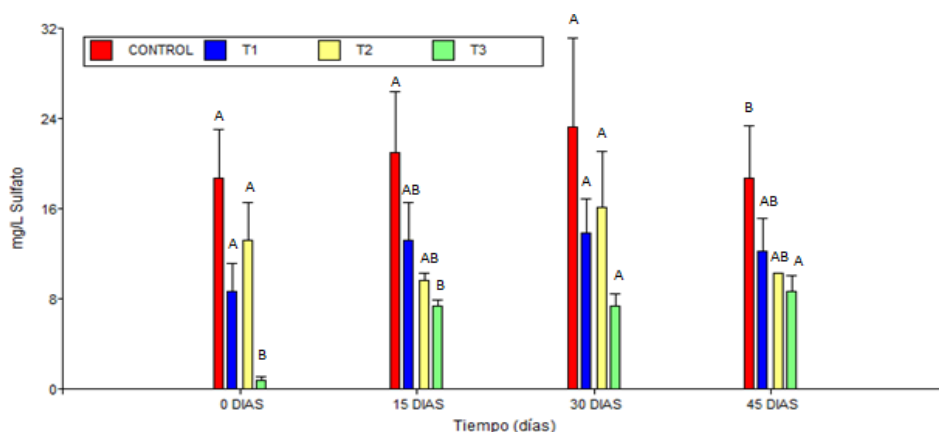
The nitrite and nitrate compounds had no statistically significant differences between treatments and control, nor over time.

Cardona and García (2008) and Romero and Vargas (2017) in their research observe results similar to those obtained in this work, the non-regular behavior of nitrogenous compounds. The authors mention the situations regarding the variability of the NH_4^+ , NO_2^- and NO_3^- ions with the use of EM on wastewater, in close relation to the concentration of oxygen, which was low in the first days and which in a certain way is responsible for the nitrification and denitrification processes that occur in wastewater.

6.5 SULFATES

Figure 14

Concentration of sulfates in treatments



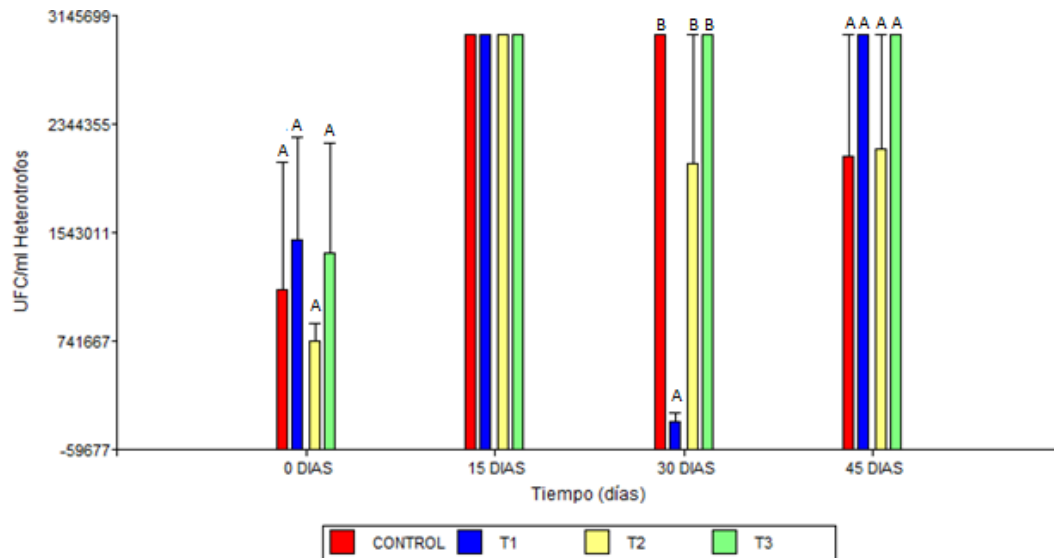
Sulphate was the only compound that presented significant differences between the control and the treatments, with lower sulfate concentrations in the treatments. It has been

It has been reported that phototrophic bacteria that are present in efficient microorganisms remove sulfur compounds, which was evidenced in the present study (García, 2006). Microbiological parameters

No significant differences were observed between treatments and controls in relation to total heterotroph and total coliform counts in sampling events between control and treatments. Therefore, after the application of MS to the wastewater, no significant treatment effect was observed. The behavior of heterotrophs was potentially related to the other microbial groups evaluated in the study.

Figure 15

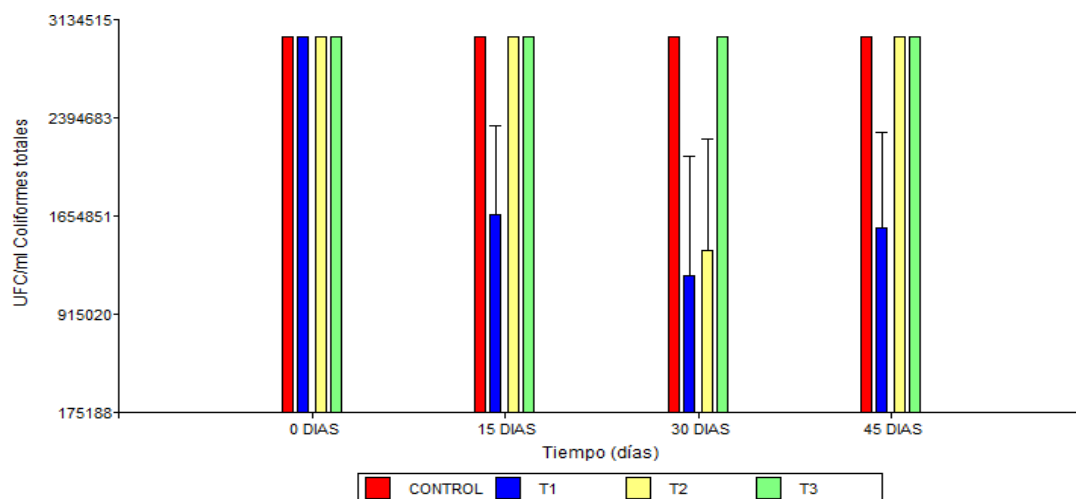
Heterotroph colony-forming units in treatments



For heterotrophs, there were no statistically significant differences between control and treatments, except at 30 days for treatment 1 where there was a significant decrease in heterotrophs; however, over time there was an increase in this microbial population over time.

Figure 16

Total coliform colony-forming units in treatments



The concentration of total coliforms did not present statistically significant differences between the control and the treatments or over time, however, there was a decrease in the concentration of these microorganisms with treatment 1. Although no statistically significant differences were observed over time, the decrease in colony-forming units in the culture

media was visually evident, possibly a higher dilution should have been used in stocking because the total coliform populations in fish wastewater are very high.

In a study conducted by Roldán et al. (2007), the effect of the application of ME (1/3000 v/v) on wastewater was evaluated for 60 days, in which a significant reduction in total coliform counts was obtained in both cases on day 30 of the study. This is because the metabolites produced by the microorganisms present in MS such as acids, ethanol and bacteriocins, inhibit the populations of pathogens of fecal origin that are

They are found in contact with these microorganisms, possibly because they lower the pH of the medium and/or limit their growth by destabilizing transport across the membrane by blocking receptors or generating changes in the ionic balance (Miklota et al, 2004).

Figure 17

Lactobacilli colony-forming units in treatments

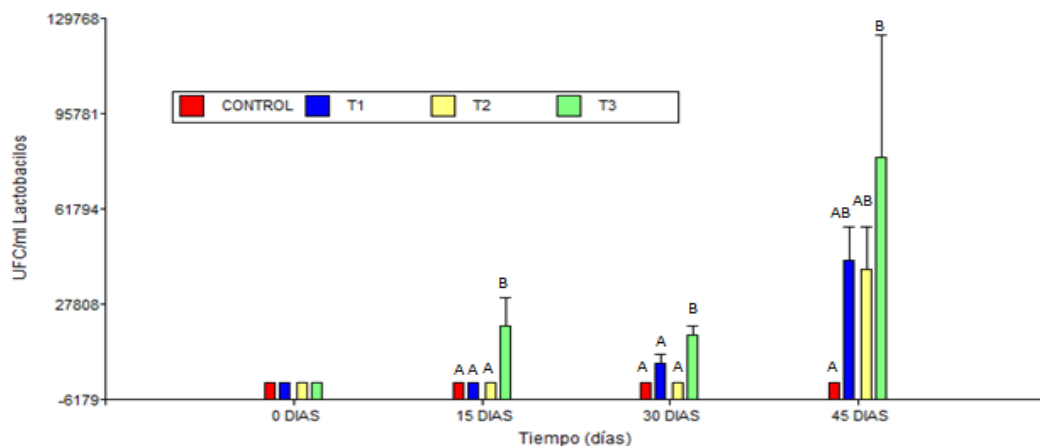
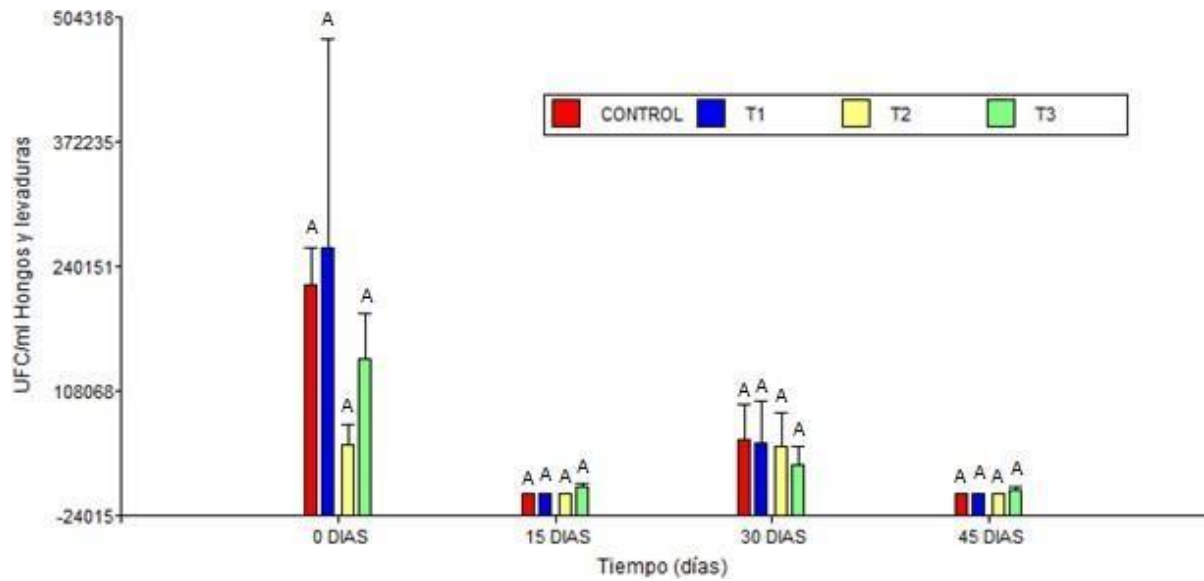


Figure 18

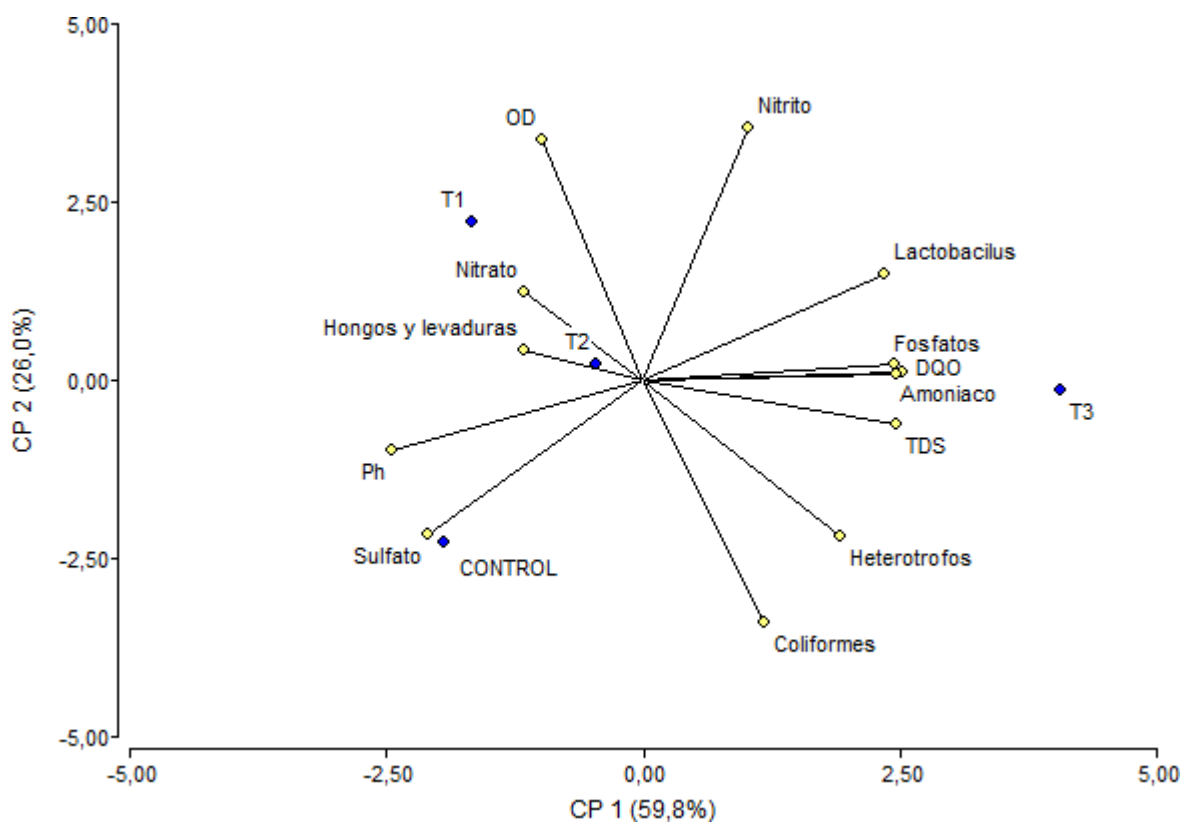
Colony-forming units of fungi and yeasts in treatments



The concentration of fungi and yeasts did not present significant differences between treatments, while a decrease was observed over time. On the other hand, lactobacilli increased over time.

Figure 19

Principal component analysis of all the variables studied



The principal component analysis allowed a summary analysis of all the variables studied. Component 1 explained 59.8% of the total variability of the data and component 2 explained 26% of the total variability. Each vector corresponds to each of the parameters evaluated. Vectors that are presented in opposite directions with an angle of 180 degrees, have a negative correlation and those that are in the same direction very close have a positive correlation, for example, the concentration of COD is correlated with the high presence of phosphates, ammonia and total solids.

In treatment 3 there were high concentrations of COD, phosphates, ammonia and total solids, the control treatment with high concentrations of sulfate and treatment 1 with dissolved oxygen and nitrates.

7 CONCLUSIONS

For most of the parameters evaluated, no statistically significant differences were observed between the control and the treatments, with the exception of sulfate, which presented lower concentrations in the treatments with efficient microorganisms. In treatment

3, which had the highest concentration of EM, the growth of aquatic plants occurred, which caused a process of eutrophication of the water so that nitrogenous compounds and phosphates increased. It is recommended to perform an analysis of the effect of efficient microorganisms in the removal of these compounds at lower concentrations than those used in this study.

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**STRATEGIC INTEGRATION OF CIVIL SERVANTS IN STATE PUBLIC
ADMINISTRATION: THE EXPERIENCE OF THE ONBOARDING PROGRAM OF
SEPLAN/PI**

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DE INCORPORACIÓN DE LA SEPLAN/PI**

 <https://doi.org/10.56238/sevened2025.036-155>

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ABSTRACT

This chapter analyzes the experience of the Onboarding Program of the State Secretariat for Planning of Piauí (SEPLAN/PI) as an innovative initiative for the institutional integration of public servants. Developed in 2025, the program was designed to welcome the first Government Analysts of the Government Management Career, structuring an intentional onboarding journey aligned with the institution's strategic planning. Using an analytical-descriptive approach, the text discusses the conceptual foundations of state professionalization and strategic people management, contextualizes the methodological design of the program, and examines its main components, highlighting institutional training, competency-oriented placement, and mentoring support during the first months of service. The results indicate positive impacts on adaptation, engagement, and the sense of belonging among civil servants, as well as the strengthening of organizational integration and institutional culture. The chapter concludes that qualified integration of new public servants constitutes a relevant strategy for strengthening state capacity, presenting the Onboarding Program as an experience with potential for institutionalization and replication in other public administration contexts.

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Keywords: Public Innovation. Strategic People Management. Institutional Integration. Onboarding in the Public Sector. State Capacity.

RESUMO

Este capítulo analisa a experiência do Programa de Embarque da Secretaria de Estado do Planejamento do Piauí (SEPLAN/PI) como iniciativa inovadora de integração institucional de servidores públicos. Desenvolvido em 2025, o programa foi concebido para acolher os primeiros Analistas Governamentais da Carreira de Gestão Governamental, estruturando uma jornada intencional de onboarding alinhada ao planejamento estratégico institucional. A partir de uma abordagem analítico-descritiva, o texto discute os fundamentos conceituais da profissionalização do Estado e da gestão estratégica de pessoas, contextualiza o desenho metodológico do programa e examina seus principais componentes, com destaque para a formação institucional, a lotação orientada por competências e o acompanhamento por meio de mentoria nos primeiros meses de exercício. Os resultados indicam impactos positivos na adaptação, no engajamento e no sentimento de pertencimento dos servidores, além do fortalecimento da integração organizacional e da cultura institucional. O capítulo conclui que a integração qualificada de novos servidores constitui estratégia relevante para o fortalecimento da capacidade estatal, apresentando o Programa de Embarque como experiência passível de institucionalização e replicação em outros contextos da administração pública.

Palavras-chave: Inovação Pública. Gestão Estratégica de Pessoas. Integração Institucional. Onboarding no Setor Público. Capacidade Estatal.

RESUMEN

Este capítulo analiza la experiencia del Programa de Embarque de la Secretaría de Estado de Planificación de Piauí (SEPLAN/PI) como una iniciativa innovadora de integración institucional de servidores públicos. Desarrollado en 2025, el programa fue concebido para acoger a los primeros Analistas Gubernamentales de la Carrera de Gestión Gubernamental, estructurando una trayectoria intencional de incorporación (onboarding) alineada con la planificación estratégica institucional. A partir de un enfoque analítico-descriptivo, el texto discute los fundamentos conceptuales de la profesionalización del Estado y de la gestión estratégica de personas, contextualiza el diseño metodológico del programa y examina sus principales componentes, con énfasis en la formación institucional, la asignación orientada por competencias y el acompañamiento mediante mentoría durante los primeros meses de ejercicio. Los resultados indican impactos positivos en la adaptación, el compromiso y el sentido de pertenencia de los servidores, además del fortalecimiento de la integración organizacional y de la cultura institucional. El capítulo concluye que la integración cualificada de nuevos servidores constituye una estrategia relevante para el fortalecimiento de la capacidad estatal, presentando el Programa de Embarque como una experiencia susceptible de institucionalización y replicación en otros contextos de la administración pública.

Palabras clave: Innovación Pública. Gestión Estratégica de Personas. Integración Institucional. Onboarding en el Sector Público. Capacidad Estatal.

1 INTRODUCTION

The State's ability to plan, coordinate and implement public policies consistently is directly related to the quality of its technical staff. In a scenario marked by greater administrative complexity, digital transformation, and growing social demand for results, it is becoming increasingly evident that entry into the public service is not limited to approval in a competitive examination or formal tenure. The way in which the civil servant is received, oriented, and integrated into the organization decisively influences his performance, engagement, and permanence over time.

In this context, the experience of the Boarding Program of the State Secretariat of Planning of Piauí (SEPLAN/PI) offers a relevant example of innovation in people management in the public sector. Developed in 2025, the program was designed to welcome the first Government Analysts of the newly instituted Government Management Career, created by Law No. 8,202/2023. By opting for a structured integration journey, SEPLAN broke with traditional and fragmented welcoming practices, betting on an intentional, formative model aligned with institutional planning.

This chapter presents and analyzes this experience from an institutional perspective, focusing on the conceptual foundations that guided the program, its methodological design, and the main lessons generated. The text assumes an analytical-descriptive character, typical of book chapters, seeking to contribute to the debate on the professionalization of the State and innovation in public management.

2 PROFESSIONALIZATION OF THE STATE AND STRATEGIC MANAGEMENT OF PEOPLE

The literature on contemporary public administration has highlighted the professionalization of bureaucracy as a central element for strengthening state capacity. Abrucio and Loureiro (2018) point out that structured careers, associated with permanent training and development processes, are essential to ensure administrative continuity, decision-making coherence and quality in the formulation of public policies.

In this scenario, people management ceases to occupy a merely operational position and becomes part of the strategic core of public organizations. Chiavenato (2014) observes that competency-oriented management allows aligning institutional objectives with professional development, promoting greater efficiency and meaning to work. In the public

sector, this alignment gains specific contours, as it must be associated with the observance of legal principles, republican values and commitment to the collective interest.

Fischer (2019) reinforces that, in bodies responsible for transversal and strategic functions — such as planning, budgeting, and government monitoring — people management needs to dialogue directly with institutional planning. Well-structured initial integration programs reduce the adaptation time of civil servants, strengthen organizational identity, and expand the agency's delivery capacity.

3 INSTITUTIONAL INTEGRATION AND ONBOARDING PROCESSES IN THE PUBLIC SECTOR

The concept of onboarding refers to the set of practices aimed at the planned socialization of new members in an organization. Bauer and Erdogan (2012) demonstrate that structured integration experiences have a positive impact on engagement, learning and professional performance, in addition to reducing uncertainties common to the first months of exercise.

In the public sector, institutional integration plays an even more relevant role, as it involves not only the learning of routines and procedures, but also the internalization of legal norms, ethical values and responsibilities proper to the public service. Denhardt and Denhardt (2015) highlight that organizational socialization should be understood as part of the training of the civil servant as an agent of the public interest, guiding his performance beyond immediate results.

The literature points out four central dimensions for effective onboarding processes: role clarity, transmission of organizational culture, building relationships of trust and strengthening interpersonal connections (BAUER; ERDOGAN, 2012). These elements were present, in an articulated way, in the design of SEPLAN's Boarding Program.

4 INSTITUTIONAL CONTEXT AND DESIGN OF THE BOARDING PROGRAM

The creation of the Government Management Career in the State of Piauí represented an important advance in the process of administrative modernization. With the inauguration of the first Government Analysts assigned to SEPLAN, in 2025, the challenge of integrating professionals with diverse backgrounds to a secretariat with a strategic and transversal profile emerged.

The Boarding Program was conceived as a response to this challenge. More than an initial reception, it was structured as an intentional journey of integration and development, combining institutional training, behavioral profile analysis, competency-oriented staffing and systematic monitoring through mentoring.

The initial training, with a workload of 90 hours, addressed topics such as mission, vision and institutional values, strategic planning, organizational structure, ethics and integrity, diversity and operation of the main units of SEPLAN. This stage aimed to offer a systemic view of the organization, reduce information asymmetries and favor the construction of the institutional identity of the new employees.

5 MENTORING AND FOLLOW-UP IN THE FIRST MONTHS

One of the differentials of the Onboarding Program was the adoption of mentoring as a central monitoring strategy. Organized in cycles of 30, 60 and 90 days, the mentoring enabled a continuous process of listening, guidance and adjustment, respecting the different phases of adaptation experienced by the new employees.

According to Garvey, Stokes and Megginson (2018), mentoring contributes to situated learning, the sharing of tacit knowledge and the strengthening of organizational bonds. In SEPLAN's experience, systematic monitoring has made it possible to clarify expectations, support professional development and reduce insecurities common to the beginning of the public career.

In addition to the positive effects on incoming employees, mentoring also produced relevant institutional impacts, by stimulating the engagement of leaders and reinforcing an organizational culture based on cooperation and co-responsibility for people's development.

6 INSTITUTIONAL RESULTS AND LEARNINGS

The experience of the Onboarding Program showed significant results in the process of adaptation and integration of the new Government Analysts. A consistent evolution was observed in the perception of clarity of attributions, security in the performance of activities and institutional belonging over the first months of the year.

The staffing strategy guided by profile and skills analysis proved to be especially relevant. By aligning individual characteristics with the demands of the administrative units, SEPLAN reduced the need for subsequent relocations and favored greater satisfaction and initial engagement of the servers.

From an institutional point of view, the program strengthened the integration between directorates, consolidated people management as a strategic axis and contributed to the maturation of the organizational culture. Experience has shown that investing in the qualified arrival of civil servants generates impacts that go beyond the individual, directly reflecting on organizational capacity and the quality of government action.

7 POSSIBILITIES OF INSTITUTIONALIZATION AND REPLICATION

The lessons generated indicate that the Boarding Program has a high potential for institutionalization as a permanent people management policy. Incorporation into the People Development Plan, formalization through internal regulations and articulation with the State School of Government are ways that can ensure its continuity and sustainability.

The methodology adopted is also replicable in other bodies and careers of the state public administration. The flexibility of the training track, the mentoring model in cycles and the monitoring instruments allow adaptations according to the institutional context, without loss of conceptual consistency.

8 FINAL CONSIDERATIONS

The experience of the SEPLAN/PI Boarding Program shows that the integration of new civil servants can and should be treated as a strategy to strengthen the State. By structuring an intentional journey of welcoming, training and accompaniment, the secretariat has advanced beyond traditional practices, consolidating a model aligned with contemporary references in public management.

More than reporting an experience, this chapter demonstrates that well-designed people management policies produce lasting effects on organizational culture, institutional performance, and the quality of public policies. In this sense, the Boarding Program presents itself as a concrete reference for future initiatives of professionalization and innovation in public administration.

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**BEYOND THE DICHOTOMY: AN INTEGRATED ANALYSIS OF QUALITATIVE,
QUANTITATIVE, AND MIXED-METHOD APPROACHES IN EDUCATIONAL
RESEARCH**

**PARA ALÉM DA DICOTOMIA: UMA ANÁLISE INTEGRADA DAS
ABORDAGENS QUALITATIVA, QUANTITATIVA E MISTA NA PESQUISA
EDUCACIONAL**

**MÁS ALLÁ DE LA DICOTOMÍA: UN ANÁLISIS INTEGRADO DE ENFOQUES
CUALITATIVOS, CUANTITATIVOS Y MIXTOS EN LA INVESTIGACIÓN
EDUCATIVA**

 <https://doi.org/10.56238/sevened2025.036-156>

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ABSTRACT

This article aims to analyze the fundamental characteristics of qualitative, quantitative, and mixed methods approaches in scientific research, discussing the reasons that contribute to the recurring conceptual confusion between these perspectives in academia. It is a bibliographic research, descriptive-analytical in nature and with a qualitative approach, examining reference works in the area of scientific methodology. The results show that the three approaches have distinct, yet articulable, epistemological foundations, purposes, and procedures, and that conceptual confusion often stems from a lack of clarity regarding the distinction between technical procedures and methodological approaches. The study proposes analytical frameworks that systematize these articulations, highlighting that methodological choice should be guided by the research objectives and the problem investigated. It concludes that an integrated understanding of these approaches strengthens scientific rigor and supports more coherent methodological choices in the training of researchers.

Keywords: Qualitative Research. Quantitative Research. Mixed Methods. Scientific Methodology. Researcher Training.

RESUMO

O presente artigo visa analisar as características fundamentais das abordagens qualitativa, quantitativa e mista na pesquisa científica, discutindo as razões que contribuem para a recorrente confusão conceitual entre essas perspectivas no meio acadêmico. Trata-se de uma pesquisa bibliográfica, de natureza descritivo-analítica e abordagem qualitativa, que examina produções de referência na área da metodologia científica. Os resultados

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evidenciam que as três abordagens possuem fundamentos epistemológicos, finalidades e procedimentos distintos, porém articuláveis, e que a confusão conceitual decorre frequentemente da falta de clareza sobre a distinção entre procedimentos técnicos e abordagens metodológicas. O estudo propõe quadros analíticos que sistematizam essas articulações, destacando que a escolha metodológica deve ser guiada pelos objetivos da pesquisa e pelo problema investigado. Conclui-se que a compreensão integrada dessas abordagens fortalece o rigor científico e subsidia escolhas metodológicas mais coerentes na formação de pesquisadores.

Palavras-chave: Pesquisa Qualitativa. Pesquisa Quantitativa. Métodos Mistos. Metodologia Científica. Formação de Pesquisadores.

RESUMEN

Este artículo busca analizar las características fundamentales de los enfoques cualitativos, cuantitativos y mixtos en la investigación científica, analizando las razones que contribuyen a la recurrente confusión conceptual entre estas perspectivas en el ámbito académico. Se trata de una investigación bibliográfica, de naturaleza descriptiva-analítica y con un enfoque cualitativo, que examina obras de referencia en el área de la metodología científica. Los resultados muestran que los tres enfoques tienen fundamentos, propósitos y procedimientos epistemológicos distintos, pero articulables, y que la confusión conceptual a menudo se deriva de la falta de claridad en la distinción entre procedimientos técnicos y enfoques metodológicos. El estudio propone marcos analíticos que sistematizan estas articulaciones, destacando que la elección metodológica debe guiarse por los objetivos de la investigación y el problema investigado. Se concluye que una comprensión integrada de estos enfoques fortalece el rigor científico y apoya elecciones metodológicas más coherentes en la formación de investigadores.

Palabras clave: Investigación Cualitativa. Investigación Cuantitativa. Métodos Mixtos. Metodología Científica. Formación de Investigadores.

1 INTRODUCTION

Scientific research plays a central role in the production of knowledge, constituting a fundamental instrument for understanding, explaining and transforming reality. According to Lakatos and Marconi (2017), research is a formal procedure, with a method of reflective thinking, which requires scientific treatment and is organized to know reality or discover partial truths. In this context, the qualitative, quantitative, and mixed approaches stand out as the most recurrent in scientific production, each with its own epistemological foundations, specific objectives, and different forms of data collection, analysis, and interpretation. However, despite being widely used, it is observed in academic practice that students and even researchers show difficulties in adequately distinguishing these approaches, which can compromise the methodological coherence of scientific works.

This conceptual difficulty often occurs due to the inappropriate use of terms, the fragility in methodological training, and the superficial understanding of the bases that support each type of research. Gil (2019) points out that the choice of methodological approach should be directly linked to the objectives of the study and the type of problem investigated. However, it is common to find projects that mix concepts in the wrong way or that define the approach only by the type of data collection instrument, disregarding its theoretical foundations. A recurring mistake, for example, is to classify as mixed research studies that only present numbers and words side by side, without the planned methodological integration required by this approach (Creswell; Clark Plan, 2007).

In this context, studies are needed to systematize and clarify the differences between qualitative, quantitative and mixed research, especially in the context of initial and continuing education of researchers. Deepening the discussion about the specificities of each method, highlighting its theoretical bases, purposes, potentialities and limitations is a starting point.

Qualitative research, according to Minayo (2009), is concerned with the universe of meanings, values, beliefs and attitudes, seeking to understand the phenomena from the perspective of the subjects. Quantitative research, according to Fonseca (2002), is characterized by the use of quantification, both in the collection and treatment of data, employing statistical techniques to ensure greater objectivity and generalization of the results. Mixed research, in turn, combines the two approaches, allowing the integration between numerical and interpretative data, as advocated by Creswell and Plano Clark (2007), but requires an intentional and articulated methodological design, going beyond the simple juxtaposition of techniques.

In this sense, this article aims to analyze the fundamental characteristics of qualitative, quantitative and mixed research, as well as to discuss the reasons that contribute to the recurrent conceptual confusion between these approaches in the academic environment. The choice of the theme is justified by its relevance for the initial and continuing education of researchers, including undergraduate and graduate students and authors of course completion papers, since methodological clarity is an essential condition for scientific rigor and for the quality of academic productions. Thus, an analysis is proposed that goes beyond the qualitative-quantitative dichotomy, highlighting the possible articulations and the criteria for reasoned methodological choices.

The article presents, initially, a theoretical foundation that separately addresses the three methodological approaches. Next, the methodology used is described, characterized as bibliographic research. Subsequently, a comparative analysis is carried out based on the authors consulted, synthesizing the differences, similarities and contexts of application of each approach. Finally, the final considerations are presented, highlighting the contribution of the study to the strengthening of methodological understanding in the field of scientific research, with emphasis on overcoming common misconceptions in investigative practice.

2 THEORETICAL FOUNDATION

This section presents the conceptual bases of qualitative, quantitative and mixed research, based on renowned authors of scientific methodology, aiming to understand its characteristics, applications and theoretical foundations.

2.1 QUALITATIVE RESEARCH

Qualitative research is characterized by the search for a deep understanding of social phenomena, considering the meanings, motivations, values, beliefs and relationships established by the subjects in their life contexts. According to Minayo (2009), the qualitative approach works with the universe of meanings, motives, aspirations, beliefs, values and attitudes, which cannot be reduced to the operationalization of quantitative variables.

Bogdan and Biklen (1994) highlight that qualitative research has the following main characteristics: the natural environment as a direct source of data; the descriptive character; the researcher as the main collection instrument; the concern with the process and not just with the result; and the appreciation of the meaning attributed by the participants to their

experiences. Thus, the focus is not on the quantification of the data, but on the interpretation of the reality investigated.

As for the procedures, the qualitative research uses instruments such as interviews, participant observation, focus groups, documentary analysis and narratives, which enable an in-depth understanding of social phenomena. Gil (2019) emphasizes that this type of approach is particularly indicated when it is intended to investigate complex, subjective phenomena related to human interactions.

As examples of the application of qualitative research, studies in the area of education can be cited, such as investigations on pedagogical practices, teacher-student relationships, learning processes, school inclusion, among others. It is also widely used in the social sciences, psychology, social work, and health, especially in research that requires understanding the subjective dimension of the subjects.

Among the main authors of the qualitative approach, Minayo (2009), Bogdan and Biklen (1994), Chizzotti (2010), Lüdke and André (2013) and Gil (2019) stand out, whose contributions strengthen the theoretical-methodological bases of this research modality.

2.2 QUANTITATIVE RESEARCH

Quantitative research is characterized by the use of quantification both in data collection and analysis, seeking objectivity, measurement and generalization of results. According to Fonseca (2002), this type of research uses mathematical language to describe the causes of a phenomenon, the relationships between variables and the distribution of the population studied.

For Lakatos and Marconi (2017), the main purpose of quantitative research is to prove hypotheses, test theories and identify cause and effect relationships between variables, through the application of structured instruments and statistical analysis. The data is collected in a standardized way, allowing greater control and accuracy of the results.

Among the main characteristics of quantitative research are: objectivity, the neutrality of the researcher, the use of structured instruments (such as closed questionnaires, scales and tests), the possibility of generalizing the results and the use of statistical techniques for data analysis. Gil (2019) states that this approach is especially suitable when seeking to measure phenomena, identify patterns, and make inferences about large populations.

The stages of quantitative research usually involve: definition of the problem and hypotheses, literature review, definition of variables, choice of collection instruments,

application of instruments, tabulation of data, statistical analysis and interpretation of results. These steps ensure greater methodological rigor to the study.

Quantitative research is widely used in areas such as administration, economics, health, education, engineering, and exact sciences, and is appropriate for survey studies, experimental research, and correlational research.

2.3 MIXED METHODS

Mixed Methods Research, also known as Mixed Methods Research, is characterized by the integration of qualitative and quantitative approaches in the same study, enabling a broader and deeper understanding of the phenomenon investigated. According to Creswell and Plano Clark (2007), this type of research allows the combination of numerical and narrative data, favoring the triangulation of results and increasing the reliability of the analyses.

In the debate presented by Minayo and Sanches (1993), the complementarity between quantitative and qualitative methods is defended as essential for a more complete investigation in public health. While the quantitative approach operates at observable and measurable levels, such as epidemiological data and health indicators, the qualitative approach delves into the meanings, intentions, and subjective contexts of social actors. This distinction implies the possibility of methodological integration, in which each approach contributes with its specificities to the understanding of social reality.

Thus, mixed research emerges as a methodological strategy that overcomes the false dichotomy between methods, articulating statistical generalization with interpretative depth. As suggested in the article, the quantitative study can generate questions for qualitative investigation, and vice versa, promoting a more dialectical and multidimensional analysis. This integration enriches the investigation and reflects a more realistic and comprehensive view of health phenomena, aligning with the principle that both approaches are necessary (Minayo & Sanches, 1993).

For these authors, the main advantage of mixed research is the possibility of compensating for the limitations of one approach with the potential of the other. While quantitative research offers generalization and statistical precision, qualitative research provides interpretive depth and contextual understanding.

There are different mixed survey models. Among the main ones, the following stand out:

- a) Convergent model, in which qualitative and quantitative data are collected simultaneously and analyzed in an integrated manner;
- b) Explanatory sequential model, in which the quantitative stage occurs first, followed by the qualitative one to deepen the results;
- c) Exploratory sequential model, in which qualitative research precedes quantitative research, helping in the construction of instruments and hypotheses.

According to Sampieri, Collado and Lucio (2013), mixed research requires greater methodological mastery from the researcher, as it implies planning, executing and integrating two distinct approaches in a single research design. This modality has been widely used in educational, social, health and public policy evaluations.

Therefore, mixed research is configured as a robust and flexible approach, capable of expanding the possibilities of interpretation and strengthening the results of scientific investigation.

2.4 TYPES OF RESEARCH AND THEIR RELATIONSHIP WITH METHODOLOGICAL APPROACHES

In scientific methodology, it is essential to distinguish between the nature of the research (whether it is basic or applied), the technical procedures (how data is collected and analyzed) and the methodological approach (qualitative, quantitative or mixed). These dimensions are not mutually exclusive, but complementary, and can be combined in different ways according to the research problem and the objectives of the study (Lakatos; Marconi, 2017). This section explores these articulations, showing how the same type of research can be conducted under different approaches.

2.4.1 Basic and applied research: Articulations with the approaches

Basic research aims to generate new knowledge, without immediate concern for practical application, aiming at theoretical advancement and understanding of phenomena (Gil, 2019). Applied research, on the other hand, seeks to solve concrete problems, producing knowledge that can be used in specific contexts. Both can adopt any of the three methodological approaches.

Table 1

Examples of types of research according to purpose and methodological approach.

Purpose of the Research	Methodological Approach	Example
Basic Research	Qualitative	This study investigates, through interviews and discourse analysis, how the professional identities of teachers in initial training are constructed, focusing on the understanding of subjective and symbolic processes, with no intention of immediate intervention.
Basic Research	Quantitative	This study measures the correlation between hours of study and performance in standardized tests of high school students through questionnaires and statistical analysis, seeking to generalize patterns.
Basic Research	Mixed	Study that combines a (quantitative) survey to map student engagement profiles with focus groups (qualitative) to understand the motivations behind the different profiles, integrating the data to build a more robust theoretical typology.
Applied Research	Qualitative	Action research in a school to understand the local causes of school dropout, using participant observation and interviews with the community, aiming to propose a specific action plan.
Applied Research	Quantitative	Experimental study to test the effectiveness of a new educational software, comparing grades and retention rates between control and experimental groups.
Applied Research	Mixed	Evaluation of a government digital inclusion program that uses questionnaires to measure reach and satisfaction and qualitative case studies to understand impacts on the routine of families, integrating the results to recommend adjustments in the policy.

Source: Prepared from Gil (2019) with support from ChatGPT Business (2025).

2.4.2 Bibliographic and documentary research in the different approaches

Both bibliographic research (analysis of already published material) and documentary research (analysis of unpublished primary sources) are technical procedures that adapt to different approaches, depending on how the data are treated.

Qualitative bibliographic research: involves the interpretative and critical review of the literature, as a theoretical analysis of the concept of "curricular justice" in scientific articles, identifying nuances and constructing arguments (Gil, 2019).

Quantitative literature search: it is characterized by a systematic review with meta-analysis, where data from multiple primary studies are collected, coded, and submitted to statistical analysis to synthesize results and calculate effect sizes.

Mixed bibliographic research: it can integrate, for example, a meta-analysis (quantitative) with a thematic analysis of the discussions and limitations pointed out in the reviewed articles (qualitative), offering both a numerical and interpretative synthesis of the field.

Qualitative documentary research: hermeneutic analysis of teachers' class diaries or minutes of school councils, seeking to understand decision-making processes and organizational culture (Lakatos; Marconi, 2017).

Quantitative desk research: Coding and statistical analysis of data contained in medical records (e.g., frequency of diagnosis, length of hospital stay) or in educational administrative databases (e.g., pass rates by grade).

Mixed documentary research: a study that quantitatively analyzes the frequency of certain terms in a corpus of educational laws and, qualitatively, the context and argumentation in which these terms appear, to understand the evolution of political discourse.

2.4.3 Case study, survey and experimental research: Possible articulations

The most common technical procedures can also be planned under different methodological logics.

Qualitative case study: in-depth ethnographic investigation of a single school, using observation and interviews to understand its internal culture (Yin, 2015).

Quantitative case study: intensive statistical analysis of data from a single municipality (a "case") to model economic and educational factors, using regressions and other tests.

Mixed case study: research on an inclusion policy in a university that combines institutional data analysis (quantitative) with interviews with managers and students (qualitative), integrating the perspectives for a comprehensive evaluation.

Quantitative survey: the most traditional form, with closed questionnaires applied to a representative sample to generalize results (Fonseca, 2002).

Qualitative survey: less common, but possible, such as the application of questionnaires with extended open questions to a large group, whose answers are analyzed by content.

Mixed Survey: convergent model where the same group answers a questionnaire with scales (quantitative) and a set of open questions (qualitative), and the results are integrated for analysis.

Quantitative experimental research: the gold standard in the natural and health sciences, with control and experimental groups, randomization, and statistical analysis of results.

Qualitative experimental research: less common but possible design in social sciences, such as narrative or observational experiments where the focus is on understanding the processes and meanings attributed by participants to the experience.

Mixed experimental research: An experiment that measures objective outcomes (e.g., grades) and then conducts interviews with participants to understand their perceptions and experiences during the experiment (explanatory sequential model).

To illustrate how the same research theme can be conducted from different methodological perspectives, Chart 2 presents a concrete example related to the implementation of active methodologies in higher education, detailing how the formulation of the problem, the objectives, the procedures and the analysis vary according to the approach adopted.

Table 2

Implementation of active methodologies in higher education

Aspect	Qualitative Research	Quantitative Research	Mixed Research
Example title	"Teachers' perceptions about the challenges in the implementation of active methodologies in undergraduate courses"	"Impact of active methodologies on academic performance: an experimental study with university students"	"Implementation of active methodologies in higher education: a mixed analysis of perceptions and results"
General objective	Understand the experiences, challenges and meanings attributed by teachers to the adoption of active methodologies.	To measure the effect of the use of active methodologies on the final grades of university students.	Integrate quantitative data on academic performance with qualitative perceptions of professors and students about the implementation process.
Technical procedure	Field research with participant observation and semi-structured interviews.	Experimental research with control and experimental groups, application of pre and post-tests.	Field research (qualitative) + survey (quantitative) in a convergent model.
Instruments	Interview script, field diary, recordings.	Standardized questionnaires,	Mixed questionnaire (scales + open

Aspect	Qualitative Research	Quantitative Research	Mixed Research
		performance tests, Likert scales.	questions), interviews, document analysis.
Sample	15 professors from one institution (intentional sample).	200 students, randomized into two groups.	150 students (survey) + 10 teachers (interviews).
Data analysis	Thematic content analysis (Bardin).	Inferential statistics (t-test, ANOVA).	Descriptive statistical analysis + qualitative thematic analysis, with integration into the discussion.
Result example	Emerging categories: "institutional resistance", "inadequate training", "satisfaction with interaction".	Significant difference ($p < 0.05$) in the scores of the experimental group.	Triangulation: high student satisfaction (87%) related to the pedagogical flexibility perceived in the interviews.

Source: Prepared by the authors based on the theoretical references discussed.

The framework shows how the implementation of active methodologies in higher education can be approached from different methodological perspectives, each with specific objectives, procedures and forms of analysis. While the qualitative approach prioritizes the understanding of the experiences and meanings attributed by the actors involved, the quantitative approach focuses on measuring effects and testing causal relationships. The mixed approach, in turn, integrates these two dimensions, allowing not only to quantify results, but also to contextualize them based on the narratives and perceptions of the participants. This exemplification reinforces that the choice of approach should not be guided by the theme itself, but by the research questions and the types of understanding that are

intended to be achieved, as defended by Gil (2019) and Creswell and Plano Clark (2007). Thus, methodological clarity becomes fundamental for the coherence of the project and for the robustness of the results obtained.

2.4.4 Articulated synthesis: Differentiating technical procedures and methodological approaches

As demonstrated, the technical procedure defines the "how" the data is obtained, while the methodological approach defines the "how" it is treated and interprets these data. A case study is not inherently qualitative; A survey is not necessarily just quantitative. Chart 3 summarizes these possible articulations, with examples that illustrate the flexibility of research designs, showing that the same procedure can be conducted under different analytical logics, depending on the objectives and the treatment given to the data.

Table 3

Articulation between technical procedures and methodological approaches

Technical Procedure	Qualitative Approach (Example)	Quantitative Approach (Example)	Mixed Approach (Example)
Case Study	Ethnography of a school community.	Statistical analysis of municipal data (the municipality as a case).	Case of a policy: institutional data (QUANT) + interviews with beneficiaries (QUAL).
Survey	Questionnaire with open questions analyzed by content.	Questionnaire with Likert scales and statistical analysis.	Questionnaire with closed (QUANT) and open (QUAL) parts, integrated into the analysis.

Technical Procedure	Qualitative Approach (Example)	Quantitative Approach (Example)	Mixed Approach (Example)
Experimental Research	Observational experiment focused on interaction and perception.	Randomized controlled trials with outcome analysis.	Experiment with objective measures (QUANT) and post-test focus groups (QUAL).
Bibliographic Research	Theoretical-conceptual analysis of the literature.	Systematic review with meta-analysis.	Meta-analysis (QUANT) + critical analysis of the discussions in the articles (QUAL).
Desk Research	Discourse analysis of minutes or diaries.	Statistical analysis of historical series in archives.	Frequency analysis of terms (QUANT) and contextual analysis of their use (QUAL) in documents.

Source: Prepared by the authors, based on the authors cited. Note: The examples illustrate possibilities of articulation; The final definition depends on the objectives, treatment and integration of the data.

In addition to the relationship between procedures and approaches, it is also important to consider the nature of the research (basic or applied). Chart 4 integrates these three dimensions: approach, nature, and procedures.

Table 4

Relationship between research approach, nature and procedures

Approach	Nature of the Research	Possible Technical Procedures	Key features
Qualitative	Basic	Bibliographic research; documentary research; case study; ethnographic research; Field research	Emphasis on meanings, subjectivities, social contexts and interpretation of phenomena.
Qualitative	Applied	Case study; action research; participant research; Field research	Resolution of social, educational and institutional problems through an in-depth understanding of reality.
Quantitative	Basic	Bibliographic research; survey; experimental research; Correlational research	Use of numerical data, measurement of variables, statistical tests and generalization of results.
Quantitative	Applied	Survey; experimental research; Evaluative research	Focus on decision-making, evaluation of results, diagnosis and objective interventions.
Mixed	Basic	Combined literature search; case study with statistical data; Exploratory and descriptive research	Integration of qualitative and quantitative data to broaden the understanding of phenomena.

Approach	Nature of the Research	Possible Technical Procedures	Key features
Mixed	Applied	Case study with survey; evaluative research; educational research; Health Research	Complementarity between numbers and interpretations, strengthening analysis and decision-making.

Source: Prepared by the authors, based on Gil (2019), Lakatos and Marconi (2017), Creswell and Plano Clark (2007), Sampieri, Collado and Lucio (2013).

The qualitative, quantitative and mixed approaches are not to be confused with the nature or procedures of research, but are articulated in a complementary way, enabling different methodological combinations according to the objectives and the problem investigated. Thus, the same research can be, for example, basic or applied, bibliographic, documentary or case study, and also assume a qualitative, quantitative or mixed approach.

The methodological choice must be made in layers: first, the problem is defined and whether the nature is basic or applied; then, the most appropriate technical procedure to access the data is selected; and, finally, the approach (qualitative, quantitative or mixed) that will guide the analysis and interpretation is determined, ensuring internal coherence and scientific rigor to the research project.

2.5 COMPARATIVE ILLUSTRATIVE STUDY OF METHODOLOGICAL APPROACHES

To elucidate the epistemological and procedural distinctions between the qualitative, quantitative, and mixed approaches, this section presents an example applied to the same relevant educational problem: the factors that influence the permanence and learning of students in high school, with a focus on specific populations such as quilombola students. The comparative analysis demonstrates how the formulation of the problem, the objectives, the collection and the analysis of data are reconfigured according to the logic of each approach, as discussed by Creswell and Plano Clark (2013) and Sampieri, Collado and Lucio (2013).

All research must indisputably have a central research problem; We exemplify this one, to better clarify the reader: what are the factors that influence the permanence and

learning of students in the 1st grade of IFTO High School, with emphasis on populations in situations of social vulnerability, such as quilombola students? The choice of this theme is justified by its social and educational relevance, allowing us to illustrate how different approaches can shed light on different dimensions of the same complex phenomenon.

2.5.1 Quantitative Approach Research

Continuing, we have an example focusing on statistical associations, as it is a quantitative research. A good title option would be: factors associated with dropout and failure of students in the 1st grade of IFTO High School: a quantitative study. Thus, the general objective can be: to analyze, through quantitative data, the factors statistically associated with student dropout and failure.

The specific research problem would be: which socioeconomic, pedagogical and infrastructure variables (income, transportation, attendance, performance) present a significant correlation with dropout and failure rates? For data collection in a quantitative research, it is feasible to apply a structured questionnaire, with closed questions and scales (e.g., Likert), to a representative sample of approximately 200 students. Variables would include family income, commuting time, attendance, grades, internet access, and motivation.

For data analysis, the use of descriptive statistics (frequencies, means, standard deviations) and inferential statistics (correlations, chi-square, logistic regression) is recommended. The results are presented in tables and graphs, seeking to identify measurable patterns and relationships (Fonseca, 2002). Regarding the epistemological characterization, this approach, of a positivist nature, seeks objectivity, the generalization of the results to the population and the testing of predetermined hypotheses. Its strength lies in numerical precision and the identification of broad trends; their limitation, in the inability to grasp the meanings and contexts behind the numbers (Gil, 2019).

For a second example, focusing on a specific population, we would have the title: Factors associated with the permanence and learning of quilombola students in IFTO High School: a quantitative study, with the general objective of quantifying the relationship between living conditions, perception of discrimination and academic performance among quilombola students. The specific research problem would be: Is there a statistical association between the perception of racial discrimination (measured by scale), the conditions of transportation/income and the school performance of these students? The collection and analysis would be similar to the previous example, but with instruments adapted to capture

specific variables, such as perception of discrimination and access to retention policies, and the analysis would compare performance averages between groups (e.g., high vs. low index of perceived discrimination).

2.5.2 Qualitative Approach Research

On the other hand, the qualitative approach would focus on the perceptions and meanings attributed by the actors involved. An example would be entitled: perceptions of students and teachers about the factors that influence dropout and failure in the 1st grade of IFTO High School, with the general objective of understanding, from the perspectives of the actors involved, the meanings, challenges and dynamics that influence school (dis)continuity.

The specific research problem would be: how do students, teachers and managers interpret and experience the processes that lead to dropout and failure in the specific context of IFTO? Data collection would take place through semi-structured interviews, focus groups and participant observation with an intentional sample of 15 to 25 participants, where the focus is on depth, not on numerical representativeness.

Data analysis would be carried out through thematic content analysis (Bardin, 2016) or discourse analysis, involving transcription, coding, emergent categorization (e.g., "hostile school climate", "identity conflict", "lack of pedagogical support") and hermeneutic interpretation of the data (Minayo, 2009). The epistemological characterization here is interpretative or phenomenological based, prioritizing depth, contextualization, and understanding of social processes, without seeking statistical generalizations, but offering a dense and analytical description of the phenomenon in its natural context (Bogdan; Biklen, 1994).

Another example, focusing on the quilombola experience, could be entitled: Here inside and outside: narratives of quilombola students about the challenges of permanence and learning in IFTO High School, with the general objective of analyzing the identity narratives and social experiences of quilombola students in the institutional school environment. The specific research problem would be: how do identity trajectories, cultural encounters and disagreements, and experiences of (in)visibility impact the process of permanence and learning? The collection and analysis would use narrative interviews, oral history or discussion groups, with the analysis focused on the construction of meanings about race, belonging and education, going beyond material factors.

2.5.3 Mixed Approach Research (Qualitative + Quantitative)

Mixed research, on the other hand, is characterized by the planned and interpretative integration of qualitative and quantitative approaches in a single study, aiming at a more comprehensive understanding of what would be possible with a single approach (Creswell; Clark Plan, 2007). According to Sampieri, Collado and Lucio (2013), its main advantage is the methodological triangulation, which compensates for the limitations of one approach with the strengths of the other.

Among the main models, the explanatory sequential (QUANT → QUAL) stand out, where the quantitative phase identifies patterns and relationships and the qualitative phase deepens and explains these results; the exploratory sequential phase (QUAL → QUANT), in which the qualitative phase explores a little-known phenomenon and substantiates instruments or hypotheses for the subsequent quantitative phase; and the convergent (parallel), where the two phases are conducted simultaneously and the results are integrated into the final interpretation.

An applied example of the explanatory sequential model would be entitled: Factors that influence the dropout of students from the 1st grade of IFTO High School: a mixed-methods study, with the integrative research problem: How do the factors quantitatively most associated with the intention to drop out manifest themselves and are experienced in the daily lives of students? In the quantitative phase, a survey is applied with 200 students, whose statistical analysis reveals that 42% of students point to "problems with transport" as the main barrier to permanence, this being the most frequent variable.

In the qualitative phase, semi-structured interviews are conducted with 15 students who indicated transportation as a critical problem, and the narratives reveal that the obstacle goes beyond the distance metric, involving insecurity on the way, constant vehicle delays, overcrowding, and the resulting physical and mental fatigue.

Integration and triangulation, the central stage of the mixed research, qualifies and contextualizes the quantitative data: the number "42%" answers "what" and "how much", while the interviews answer "how" and "why" this fact is decisive. The integrated interpretation concludes that transportation-related evasion is not a mere logistical problem, but a psychosocial phenomenon that undermines motivation, increases absenteeism, and generates a feeling of helplessness. This dialogical articulation between the numerical and the narrative is what effectively characterizes the research as mixed.

It is a common mistake, even in academic papers, to consider a survey as mixed due to the simple joint presence of numbers and words. Mixed research requires: intentional planning of the two components in the research design; specific and rigorous data collection for each approach; own analysis for each data set; and explicit stage of integration in interpretation, where one piece of data illuminates, complements, expands or questions the other.

A qualitative survey that only enumerates frequencies in its categories (e.g., "80% of respondents mentioned lack of faculty support") is making use of an internal descriptive quantification, but is not conducting a mixed survey. The absence of an integrated design, valid quantitative instruments and statistical analysis prevents this classification. The example above of transportation illustrates precisely the difference between measuring a prevalence (42%) and integrating this measure with contextual meanings to generate a more robust conclusion.

Another example, following the sequential exploratory model with a quilombola focus, could be entitled: Factors of permanence and learning of quilombola students of IFTO: an exploratory mixed-methods study, with the general objective of developing and validating a quantitative instrument based on a preliminary qualitative understanding of the dimensions relevant to quilombola permanence.

The specific research problem would be: which constructs and dimensions, qualitatively identified as central to quilombola students, can be measured and validated on an expanded scale? The design would first involve a qualitative phase with interviews and focus groups to explore the theme, identifying categories such as "institutional discrimination", "identity strengthening" and "community support"; then, a development phase to build a questionnaire with scales based on these categories; and, finally, a quantitative phase with the application of the questionnaire to a larger sample to validate the constructs and test their relationships.

The presentation of these examples makes it clear that mixed research is not the simple juxtaposition of numbers and words. As Creswell and Plano Clark (2007) state, it requires an intentional integrated design, with clear phases and a final interpretation that dialogues with both types of data. It is a common mistake, as pointed out in the literature, to classify as mixed a qualitative research that only mentions descriptive frequencies (e.g., "10 of the 15 interviewees reported...").

Table 5 summarizes the key differences between the approaches in the context of the problem presented

Table 5

Comparison of Approaches in the Study of School Permanence

Aspect	Quantitative Approach	Qualitative Approach	Mixed Approach
Central Question	"What?" and "How much?" (Prevalence, association)	"How?" and "Why?" (Meaning, process)	Combines "What/How much?" with "How/Why?"
Epistemological Logic	Positivist, objectivist	Interpretive, constructivist	Pragmatic, integrative
Typical Design	Survey, experimental	Case study, ethnography	Sequential (explanatory/exploratory), Convergent
Main Result	Generalization, hypothesis testing	Contextual understanding, grounded theory	Extended explanation, triangulation
Example in IFTO	Correlation between income and dropout	Meaning of dropout for the student	Explain how low income leads to dropout

Source: Prepared by the authors based on the theoretical frameworks discussed (Gil, 2019; Lakatos & Marconi, 2017).

Therefore, the choice between these approaches should be guided not by fads, but by a rigorous reflection on which set of questions and which type of understanding best meets the objectives of the research, thus ensuring the methodological rigor essential to quality scientific production, especially in complex areas such as Education.

Table 6

Classification of the types of research according to the nature, objectives and technical procedures

As to Nature	Regarding the Objectives	Regarding Technical Procedures
Basic Research	Exploratory	Case Study
(Generates knowledge)	Descriptive	Participant Research
	Explanatory	Ex-Post-Facto Research
Applied Research		Desk Research
(Generates products/processes)		Bibliographic Research
		Experimental Research
		Operations Research

Source: Prepared by the authors based on the theoretical frameworks discussed (Gil, 2019; Lakatos & Marconi, 2017).

This table systematizes how these categories are articulated and highlights the flexibility and complementarity of the research designs, reinforcing that the methodological choice must be coherent with the problem and the objectives of the investigation.

3 METHODOLOGY

The present study is characterized as a bibliographic research, with a qualitative approach and a descriptive-analytical nature, whose objective is to understand, discuss and systematize the different methodological approaches of scientific research, qualitative, quantitative and mixed, based on the analysis of consolidated academic productions in the area.

Bibliographic research was adopted because it enables the survey, reading, analysis and interpretation of already published works, such as books, scientific articles, theses and dissertations, allowing the researcher to come into direct contact with the knowledge produced on a given topic, as highlighted by Gil (2019) and Lakatos and Marconi (2017). This type of research is especially suitable when seeking to understand concepts, theoretical foundations, methodological classifications, and different epistemological perspectives.

The qualitative approach was chosen due to the interpretative character of the study, since the focus of the investigation is not on the measurement of numerical data, but on the understanding of the meanings, conceptions, characteristics and purposes attributed to the research approaches by the different authors analyzed. In this sense, the analysis favors the critical interpretation of the texts, conceptual categories and theoretical arguments, according to the assumptions of qualitative research defended by Minayo (2009).

As for the descriptive-analytical nature, the study seeks, initially, to describe the main characteristics of the qualitative, quantitative and mixed approaches, and, later, to analyze them in a comparative way, evidencing their differences, approximations, limits and potentialities. The analytical dimension allows the concepts to be presented, as well as to interpret them in the light of the specialized literature and reviewed empirical studies.

The selection of bibliographic material was based on criteria of thematic relevance, scientific rigor and recurrence of citation in the area of research methodology, prioritizing classic and contemporary authors widely used in the academic environment, such as Gil (2019), Minayo (2009), Creswell and Plano Clark (2007), Gatti (2012) and Sampieri, Collado and Lucio (2013). In addition, scientific articles published in indexed journals, especially in the areas of education, social sciences, and health, which explicitly presented the use of qualitative, quantitative, or mixed approaches were included.

The searches were carried out in academic databases and institutional repositories, such as SciELO, Google Scholar and repositories of public universities, using descriptors such as: research methodology, qualitative research, quantitative research, mixed research and mixed methods. After the initial survey, the titles, abstracts and, later, the full texts were read, selecting only the studies that presented direct adherence to the objectives of this research.

The data analysis was developed through interpretative and comparative reading of the selected works, seeking to identify how each author conceives the research approaches, which theoretical foundations are mobilized, which methodological procedures are valued and how these approaches are applied in empirical studies. Then, the main elements were organized into analytical categories, such as: research objectives, type of data, collection instruments, forms of analysis and purposes of the study.

In addition, the empirical studies analyzed were classified according to the approach adopted (qualitative, quantitative or mixed), allowing the construction of a comparative

synthesis table, which systematizes the main methodological elements observed in each type of research.

4 DATA ANALYSIS AND DISCUSSION

The discussion of the data obtained from the selection and examination of scientific articles that used the qualitative, quantitative and mixed approaches is presented. The analysis was conducted in an interpretative and comparative way, in the light of the theoretical references presented in the Theoretical Foundation, seeking to identify how these approaches have been effectively applied in scientific production and how their main methodological characteristics are confirmed in practice.

4.1 ANALYSIS OF STUDIES WITH A QUALITATIVE APPROACH

The studies analyzed, based on the qualitative approach, have as a central characteristic the search for an in-depth understanding of the phenomena in their natural contexts, considering the meanings, perceptions, social relations and processes experienced by the subjects. According to Minayo (2014), qualitative research works with the universe of senses, values, beliefs and attitudes, aspects that cannot be reduced to numerical data. This definition is confirmed in the studies examined, which prioritize the interpretation of social reality based on human experiences.

In the work 'The methodological construction of research in education', Gatti (2010) highlights that qualitative research plays a central role in educational investigations, especially because it allows the understanding of pedagogical practices, institutional relations and subjectivities involved in the educational process. For the author, unlike positivist approaches, qualitative research recognizes the complexity of the educational field and values the interaction between researcher and research subjects, an aspect also evidenced in the studies analyzed.

Similarly, Lüdke and André (2013) highlight that qualitative research in education values the natural environment as a direct source of data and the interaction between researcher and participants, fundamental aspects for understanding educational processes in their complexity.

Another recurrent element in qualitative studies is the use of flexible data collection instruments, such as semi-structured interviews, participant observation, document analysis, and focus groups. According to Bogdan and Biklen (1994), these instruments allow the

researcher to capture reality in a more sensitive and contextualized way, since the natural environment is the main source of data. In the studies examined, this centrality of the context and the valorization of the detailed description of the investigated phenomena are clearly perceived.

In the article published in the journal *Ciência & Saúde Coletiva*, Nagai and Queiroz (2011) use the qualitative approach to understand phenomena related to the insertion of complementary and alternative medicine in the basic network of health services. The study shows that this methodology is not restricted to the educational field, but is also widely used in the health sciences and social sciences. Through the analysis of the participants' narratives, the authors were able to apprehend social, subjective and institutional dimensions of the investigated phenomenon, aspects that would hardly be captured through exclusively quantitative methods.

When comparing the conceptions of Minayo (2014), Gatti (2010) and Bogdan and Biklen (1994), a theoretical convergence is observed regarding the understanding of qualitative research as an interpretative process, in which the researcher actively acts in the construction of knowledge. All authors argue that this type of research does not seek statistical generalizations, but rather a deep understanding of the phenomena in their complexity, which is confirmed in the studies analyzed.

In general, the analysis of the works shows that qualitative research is especially indicated when the objective of the study is to understand social, educational, cultural or institutional processes in depth. As Gil (2019) points out, this approach is appropriate when one wants to explore little-known realities, investigate perceptions, behaviors, and interactions, or understand meanings attributed by the subjects. Thus, the studies analyzed confirm, in practice, the theoretical foundations discussed in the grounds of this article.

4.2 ANALYSIS OF STUDIES WITH A QUANTITATIVE APPROACH

Studies classified as quantitative are generally characterized by the predominant use of structured data collection instruments, such as closed questionnaires, scales, standardized tests, and objective forms, as well as by the application of statistical procedures for analyzing the results. This approach focuses mainly on the measurement of variables, the identification of patterns, trends, and relationships between phenomena, in addition to the possibility of generalizing the results to larger populations, as highlighted by Gil (2019) and Lakatos and Marconi (2017).

In the studies analyzed with this approach, it is observed that the research objectives were directly related to the quantification of behaviors, opinions, levels of satisfaction, academic or organizational performance. This type of design confirms the conception presented by Fonseca (2002), when he states that quantitative research is based on objectivity, on the standardization of instruments and on the search for measurable and replicable results.

Another recurrent aspect in quantitative studies is the clear definition of the sample and the variables investigated, as well as the control, albeit partial, of external influences. The data, after being collected, are organized in spreadsheets, tables and graphs, and are submitted to descriptive and, in some cases, inferential statistical analyses, such as correlation, regression and significance tests. This procedural rigor reinforces the idea that quantitative research seeks to minimize the subjectivity of the researcher in the analysis of the results.

The methodological literature, such as that presented by Sampieri, Collado and Lucio (2013), highlights that quantitative research is especially appropriate when the researcher wants to test hypotheses, verify relationships between variables or evaluate the impact of certain interventions. The studies analyzed confirm this theoretical orientation, as they present formal structures for data collection, analysis and interpretation, aligned with previously defined statistical models.

However, it is also observed that, although quantitative research offers numerical precision and the possibility of generalization, it has limitations in terms of a deep understanding of the meanings, motivations and subjective experiences of the participants. This limitation is widely discussed by Gil (2019), when he states that the objectivity of numbers is not always sufficient to explain the complexity of social and educational phenomena.

In general, the quantitative studies analyzed confirm that this approach is indicated when it comes to measurement, control of variables, objectivity, and the possibility of comparison between groups. The results reinforce the theoretical foundations of this approach presented in the Theoretical Foundation, evidencing its relevance for investigations that demand statistical precision, but also pointing out the need for articulation with other approaches when the objective of the research requires greater interpretative depth.

4.3 ANALYSIS OF MIXED APPROACH STUDIES

The studies classified as belonging to the mixed approach show the systematic integration between quantitative and qualitative data, both in the collection process and in the analysis and interpretation of the results. Contrary to what is often assumed in the academic environment, mixed research is not characterized only by the simultaneous presence of numbers and speeches, but by the methodological articulation planned between the two approaches, as highlighted by Creswell and Plano Clark (2007).

The literature points out that mixed methods can take on different designs, among which the sequential models (explanatory and exploratory) and the convergent model stand out. In the explanatory sequential model, for example, first the quantitative collection and analysis takes place and, later, the qualitative stage is used to deepen or explain the numerical results. In the convergent model, the two approaches are applied simultaneously, and the results are integrated in the interpretative phase.

In the studies analyzed, it is observed that those that are really configured as mixed studies present, in an explicit way, the planning of the two approaches, the clear definition of the steps, the justification for the use of methodological integration and the explanation of how the data were articulated in the final analysis. This rigor confirms the conception of Sampieri, Collado and Lucio (2013), according to which mixed research requires greater methodological mastery, precisely because it operates in two distinct epistemological fields.

However, it was also found that there is significant conceptual confusion regarding the definition of mixed research. Many studies use the term "mixed" only because they present some numerical data together with descriptive information, without there being, in fact, structured methodological integration. This practice reinforces the misconception pointed out in the literature that not all research that uses quantitative and qualitative data can be automatically classified as mixed.

According to Creswell and Plano Clark (2007), for a study to be effectively considered mixed, it must comply, at least: (a) the collection of quantitative and qualitative data; (b) the analysis of both types of data; (c) the explicit integration between these data at some point in the research; and (d) the theoretical and methodological justification for the adoption of this approach. The absence of any of these stages compromises the characterization of the research as mixed.

Thus, the analysis of the studies shows that the mixed approach, when correctly applied, significantly expands the explanatory potential of the research, by allowing the

combination of the objectivity of the numerical data with the interpretative depth of the qualitative analyses. On the other hand, it also reveals that the lack of conceptual clarity and methodological rigor is still one of the main challenges for the proper use of mixed methods in the scientific field.

4.4 COMPARATIVE SYNTHESIS OF APPROACHES IN THE ANALYZED STUDIES

The analysis of the studies shows that the qualitative, quantitative and mixed approaches have distinct but complementary applicabilities. While qualitative studies prioritize the understanding of the meanings, perceptions, and experiences of subjects in their social contexts, quantitative studies focus on the objective measurement of variables and the possibility of generalizing the results. Mixed studies, on the other hand, articulate these two dimensions, expanding the interpretative and explanatory possibilities of the phenomena investigated.

It is observed, therefore, that the studies analyzed confirm, in practice, the theoretical bases discussed throughout this article. It is evident that the choice of the methodological approach should not occur arbitrarily, but in line with the objectives of the research, the problem investigated and the type of data necessary for the analysis, as defended by Gil (2019), Minayo (2014) and Creswell and Plano Clark (2007). Thus, each method responds to different investigative demands.

This synthesis reinforces the importance of the researcher mastering the conceptual, epistemological and operational differences between the approaches, avoiding methodological mistakes and ensuring greater scientific rigor to academic productions. Clarity in the choice of method contributes directly to the internal coherence of the scientific work and to the validity of the results obtained.

The analysis of the literature reveals that the qualitative, quantitative and mixed approaches have different purposes, although they can be used in a complementary way. Qualitative research stands out for its ability to understand complex, subjective and contextualized phenomena, prioritizing the interpretation of meanings, values and social practices. Its flexible methods allow for a deeper understanding of the realities investigated.

On the other hand, quantitative research is based on the objective measurement of reality, using instruments capable of producing numerical data that can be statistically analyzed. Its focus is on verifying hypotheses, identifying patterns, and generalizing results, and is widely used in studies that require precision, control, and replicability.

Mixed research, in turn, is configured as an integrative proposal, bringing together the potentialities of qualitative and quantitative approaches. The literature points out that this methodology enables data triangulation, greater analytical richness, and reduction of biases, especially when a single type of data is not sufficient to explain a given phenomenon. Models such as the explanatory sequential, the exploratory sequential and the convergent are often cited as structured forms of articulation of this approach.

When comparing the three methodologies, it is observed that the conceptual confusion between students and researchers is mainly due to the lack of clarity regarding the objectives, characteristics and purposes of each method. It is often mistakenly believed that qualitative and quantitative are hierarchical or exclusionary approaches, when, in reality, they represent different epistemological perspectives for different research problems. The mixed approach, in turn, raises doubts due to the complexity of its application and the requirement for greater methodological mastery.

Thus, the analysis shows that an adequate understanding of the three approaches directly contributes to the coherent methodological choice in academic research, avoiding misunderstandings and strengthening scientific production. The conceptual and technical mastery of these methodologies expands the investigative possibilities and qualifies the results of the research.

5 FINAL CONSIDERATIONS

The present study showed that the qualitative, quantitative and mixed approaches have their own characteristics, distinct epistemological foundations and specific purposes in the field of scientific research. The literature analyzed demonstrates that the conceptual confusions often found in the academic environment are largely due to the superficial understanding of the particularities of each method and the mistaken belief that they are opposite, hierarchical or automatically complementary.

Qualitative research stands out for privileging the deep understanding of social, cultural and subjective phenomena, while quantitative research focuses on the objective measurement of data, the testing of hypotheses and the statistical generalization of results. The mixed methodology, on the other hand, integrates, in a planned and systematic way, elements from both perspectives, with the objective of broadening the understanding of the phenomena investigated, giving greater interpretative robustness to the results.

In this sense, it is essential to highlight that the mere presence of numerical data in a survey is not enough to characterize it as mixed. As stated by Creswell and Plano Clark (2007) and Sampieri, Collado and Lucio (2013), a research can only be considered of a mixed nature when there is intentional, planned and methodologically articulated integration between quantitative and qualitative data, in specific phases of the study (explanatory sequential, exploratory sequential or convergent), from collection to analysis and interpretation of the results.

In many essentially qualitative studies, numerical data may appear with a merely descriptive function, as a way of characterizing the participants, frequency of phenomena or initial organization of the data, without this altering their epistemological nature. In these cases, the numbers do not fulfill an explanatory, inferential or hypothesis testing function, which prevents their classification as mixed research. Thus, the punctual use of numbers in qualitative research does not imply, by itself, the adoption of the mixed methodology.

On the other hand, in mixed research, quantitative data are used for specific purposes, such as expanding the explanation of qualitative results, validating findings, comparing groups, identifying patterns, or producing generalizations that complement interpretative analyses. Likewise, qualitative data play an essential role in understanding the meanings, contexts and experiences underlying the numerical results, configuring a relationship of effective methodological complementarity.

By clarifying these differences, this article contributes to the improvement of the methodological understanding of students and researchers, supporting more coherent choices in the planning and execution of scientific research. It is recommended that future studies deepen this discussion through concrete empirical examples, especially in the field of education, in order to strengthen methodological training and avoid recurrent mistakes in the classification of research approaches.

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CAFFEINE AND PERFORMANCE IN ENDURANCE SPORTS: A SYSTEMATIC REVIEW OF THE LITERATURE

CAFEÍNA E DESEMPENHO EM ESPORTES DE RESISTÊNCIA: UMA REVISÃO SISTEMÁTICA DA LITERATURA

CAFEÍNA Y RENDIMIENTO EN DEPORTES DE RESISTENCIA: UNA REVISIÓN SISTEMÁTICA DE LA LITERATURA

 <https://doi.org/10.56238/sevened2025.036-157>

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ABSTRACT

Introduction: Caffeine is one of the most studied and widely used ergogenic substances by endurance athletes, with consistent evidence of improved physical performance. Objective: To conduct a systematic review of the literature on the effects of caffeine supplementation on the performance of athletes in endurance sports, analyzing dosages, timing of administration, mechanisms of action, and possible adverse effects.

Methods: A systematic search was performed in PubMed, Scopus, Web of Science, and SPORTDiscus databases, using the descriptors 'caffeine', 'endurance', 'performance', 'supplementation', and 'athletes'. Randomized clinical trials published between 2010 and 2024 involving endurance athletes were included.

Results: 47 studies met the inclusion criteria. Caffeine supplementation (3-6 mg/kg) significantly improved performance in endurance events ($p < 0.05$), with an average increase of 2-4% in time to exhaustion and a 1-3% reduction in race time. Mechanisms include adenosine receptor antagonism, increased fatty acid mobilization, reduced perception of effort, and improved muscle contractility. Adverse effects were reported at doses above 9 mg/kg.

Conclusion: Caffeine is an effective and safe ergogenic aid for endurance athletes when used at doses of 3-6 mg/kg, administered 45-60 minutes before exercise. Future studies should investigate individual variability in caffeine response and supplementation periodization strategies.

Keywords: Caffeine. Athletic Performance. Endurance Sports. Nutritional Supplementation. Ergogenic Aids. Exercise Physiology.

RESUMO

Introdução: A cafeína é uma das substâncias ergogênicas mais estudadas e amplamente utilizadas por atletas de resistência, com evidências consistentes de melhora no desempenho físico. Objetivo: Realizar uma revisão sistemática da literatura sobre os efeitos da suplementação de cafeína no desempenho de atletas em esportes de resistência,

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analizando dosagens, timing de administração, mecanismos de ação e possíveis efeitos adversos.

Métodos: Foi realizada uma busca sistemática nas bases de dados PubMed, Scopus, Web of Science e SPORTDiscus, utilizando os descritores 'caffeine', 'endurance', 'performance', 'supplementation' e 'athletes'. Foram incluídos ensaios clínicos randomizados publicados entre 2010 e 2024, envolvendo atletas de resistência.

Resultados: Foram identificados 47 estudos que atenderam aos critérios de inclusão. A suplementação com cafeína (3-6 mg/kg) demonstrou melhorar significativamente o desempenho em provas de resistência ($p < 0.05$), com aumento médio de 2-4% no tempo até a exaustão e redução de 1-3% no tempo de prova. Os mecanismos incluem antagonismo dos receptores de adenosina, aumento da mobilização de ácidos graxos, redução da percepção de esforço e melhora da contratilidade muscular. Efeitos adversos foram relatados em doses superiores a 9 mg/kg.

Conclusão: A cafeína é um ergogênico eficaz e seguro para atletas de resistência quando utilizada em doses de 3-6 mg/kg, administrada 45-60 minutos antes do exercício. Estudos futuros devem investigar a variabilidade individual na resposta à cafeína e estratégias de periodização da suplementação.

Palavras-chave: Cafeína. Desempenho Atlético. Esportes de Resistência. Suplementação Nutricional. Ergogênicos. Fisiologia do Exercício.

RESUMEN

Introducción: La cafeína es una de las sustancias ergogénicas más estudiadas y ampliamente utilizadas por atletas de resistencia, con evidencia consistente de mejora del rendimiento físico.

Objetivo: Realizar una revisión sistemática de la literatura sobre los efectos de la suplementación con cafeína en el rendimiento de atletas de resistencia, analizando dosis, momento de administración, mecanismos de acción y posibles efectos adversos.

Métodos: Se realizó una búsqueda sistemática en las bases de datos PubMed, Scopus, Web of Science y SPORTDiscus, utilizando los descriptores “caffeine”, “endurance”, “performance”, “supplementation” y “athletes”. Se incluyeron ensayos clínicos aleatorizados publicados entre 2010 y 2024, que involucraron atletas de resistencia.

Resultados: Se identificaron 47 estudios que cumplieron con los criterios de inclusión. La suplementación con cafeína (3–6 mg/kg) mejoró significativamente el rendimiento en pruebas de resistencia ($p < 0.05$), con un aumento promedio del 2–4% en el tiempo hasta el agotamiento y una reducción del 1–3% en el tiempo de prueba. Los mecanismos incluyen el antagonismo de los receptores de adenosina, el aumento de la movilización de ácidos grasos, la reducción de la percepción del esfuerzo y la mejora de la contractilidad muscular. Se reportaron efectos adversos con dosis superiores a 9 mg/kg.

Conclusión: La cafeína es un ergogénico eficaz y seguro para atletas de resistencia cuando se utiliza en dosis de 3–6 mg/kg, administrada 45–60 minutos antes del ejercicio. Estudios futuros deben investigar la variabilidad individual en la respuesta a la cafeína y las estrategias de periodización de la suplementación.

Palabras clave: Cafeína. Rendimiento Deportivo. Deportes de Resistencia. Suplementación Nutricional. Ergogénicos. Fisiología del Ejercicio.

1 INTRODUCTION

The search for nutritional strategies that optimize athletic performance has been a constant in sports science. Among the various ergogenic substances available, caffeine stands out as one of the most studied and widely used by athletes of different modalities, especially in endurance sports¹. Caffeine (1,3,7-trimethylxanthine) is a naturally occurring alkaloid found in a variety of plants, including coffee beans, tea leaves, cocoa, and guarana, and is consumed worldwide in beverages and supplements².

Historically, caffeine was included in the list of prohibited substances by the World Anti-Doping Agency (WADA) until 2004, when it was removed due to the difficulty in establishing clear boundaries between therapeutic use and doping³. Since then, its use has become even more prevalent among athletes, with studies indicating that up to 74% of elite athletes consume caffeine before or during competitions⁴.

Endurance sports, characterized by prolonged activities of moderate to high intensity, such as cycling, long-distance running, triathlon and swimming, impose significant metabolic demands on the body⁵. In this context, caffeine has demonstrated beneficial effects through multiple physiological mechanisms, including antagonism of adenosine receptors in the central nervous system, increased mobilization of free fatty acids, improved muscle contractility, and reduced subjective perception of exertion⁶⁻⁷.

Despite the extensive body of evidence on the ergogenic effects of caffeine, there are still important issues to be elucidated, such as optimal dosage, timing of administration, individual variability in response, the effects of habituation to chronic consumption, and possible interactions with other nutritional strategies⁸. In addition, the form of administration (capsules, coffee, gummies, gels) may influence the bioavailability and, consequently, the ergogenic effects⁹.

In view of this scenario, it is essential to carry out systematic reviews that synthesize the most recent scientific evidence on caffeine supplementation in endurance athletes, providing subsidies for the clinical practice of sports nutritionists, sports physicians and physical education professionals. Therefore, the aim of this study is to perform a systematic review of the literature on the effects of caffeine supplementation on the performance of athletes in endurance sports, analyzing dosages, timing of administration, mechanisms of action, and possible adverse effects.

2 METHODS

2.1 SEARCH STRATEGY

This systematic review was conducted following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)¹⁰ guidelines. The search was carried out in the electronic databases PubMed/MEDLINE, Scopus, Web of Science and SPORTDiscus, covering the period from January 2010 to December 2024. The search strategy used the following descriptors in English and their combinations: 'caffeine' OR '1,3,7-trimethylxanthine' AND 'endurance' OR 'aerobic' OR 'resistance exercise' AND 'performance' OR 'athletic performance' AND 'supplementation' OR 'ergogenic aid' AND 'athletes' OR 'trained individuals'.

2.2 ELIGIBILITY CRITERIA

We included randomized, double-blind, placebo-controlled trials published in English, Portuguese, or Spanish that investigated the effects of caffeine supplementation on the performance of athletes or individuals trained in endurance sports. The specific inclusion criteria were: (1) participants aged ≥ 18 years; (2) recreational, amateur or professional athletes; (3) intervention with caffeine in any form of administration; (4) evaluation of at least one outcome related to physical performance (time to exhaustion, race time, average power, oxygen consumption, subjective perception of exertion). Animal studies, narrative reviews, case studies, congress abstracts, and studies that combined caffeine with other ergogenic substances without a control group isolated for caffeine were excluded.

2.3 SELECTION OF STUDIES AND DATA EXTRACTION

Two independent reviewers performed the initial screening of titles and abstracts, followed by the complete reading of potentially eligible articles. Disagreements were resolved by consensus or by consulting a third reviewer. The extracted data included: participants' characteristics (age, gender, level of training), supplementation protocol (dose, timing, form of administration), type of exercise, performance outcomes, reported adverse effects, and main conclusions.

2.4 EVALUATION OF METHODOLOGICAL QUALITY

The methodological quality of the included studies was assessed using the PEDro (Physiotherapy Evidence Database) scale, which scores studies from 0 to 10 based on

criteria such as randomisation, blinding, intention-to-treat analysis and statistical adequacy¹¹. Studies with a score ≥ 6 were considered to be of high methodological quality.

3 RESULTS

3.1 SELECTION OF STUDIES

The initial search identified 1,247 records in the databases. After removing duplicates (n=312), 935 titles and abstracts were screened, of which 128 articles were selected for full reading. Of these, 47 studies met the inclusion criteria and were included in this systematic review. The main reasons for exclusion were: no placebo control group (n=34), combination of caffeine with other substances without an isolated group (n=21), non-athletic population (n=15), and non-performance outcomes (n=11).

3.2 STUDY CHARACTERISTICS

The 47 included studies involved a total of 1,089 participants (mean age: 26.4 ± 4.2 years), 78% of whom were male. The sports modalities investigated included cycling (n=21), running (n=15), triathlon (n=6), swimming (n=3) and rowing (n=2). The majority of studies (n=39, 83%) used anhydrous caffeine capsules, while 8 studies used coffee, gels or chewing gum. The dose of caffeine ranged from 2 to 9 mg/kg body weight, with most studies (n=32, 68%) using doses between 3-6 mg/kg. The timing of administration ranged from 30 to 90 minutes before exercise, with a predominance of 45-60 minutes (n=35, 74%).

3.3 EFFECTS ON PERFORMANCE

Caffeine supplementation demonstrated significant ergogenic effects in 42 of the 47 included studies (89.4%). The main findings were:

- Time to exhaustion: Mean increase of 2.8% (95% CI: 1.9-3.7%, $p < 0.001$) in time-to-exhaustion tests at intensities between 70-85% of VO_2max (n=18 studies).
- Race time: Average reduction of 1.7% (95% CI: 1.1-2.3%, $p < 0.001$) in time to complete fixed distances in cycling and running (n=24 studies).
- Average power: 3.1% increase (95% CI: 2.2-4.0%, $p < 0.001$) in average power during time trial tests (n=15 studies).
- Subjective perception of effort: Significant reduction ($p < 0.05$) in the Borg scale in 28 studies (59.6%).

- VO_2max : There was no significant change in maximal oxygen uptake ($p>0.05$), suggesting that ergogenic effects are not mediated by changes in maximal aerobic capacity.

3.4 DOSE-RESPONSE RELATIONSHIP

The analysis of the dose-response relationship revealed that doses of 3-6 mg/kg produced the greatest ergogenic effects with the lowest incidence of adverse effects. Doses below 3 mg/kg ($n=6$ studies) have shown inconsistent effects, with only 50% of studies reporting significant improvement in performance. Doses greater than 6 mg/kg ($n=9$ studies) did not provide significant additional benefit and were associated with a higher incidence of adverse effects, including tremor, anxiety, tachycardia, and gastrointestinal disturbances.

3.5 MECHANISMS OF ACTION

Studies have identified multiple mechanisms by which caffeine exerts its ergogenic effects:

1. Antagonism of adenosine A1 and A2A receptors in the central nervous system, reducing the feeling of fatigue and increasing alertness¹²⁻¹³.
2. Increased mobilization of free fatty acids from adipose tissue, potentially sparing muscle glycogen during prolonged exercise¹⁴.
3. Improvement of muscle contractility by increasing calcium release from the sarcoplasmic reticulum¹⁵.
4. Reduction of the subjective perception of exertion, allowing athletes to maintain higher intensities for prolonged periods¹⁶.
5. Effects on the autonomic nervous system, with increased sympathetic activity and release of catecholamines¹⁷.

3.6 INDIVIDUAL VARIABILITY

Eight studies specifically investigated individual variability in caffeine response. The main factors identified were:

- Genetic polymorphisms: Variations in the CYP1A2 gene, responsible for caffeine metabolism, influence the ergogenic response. Fast metabolizers (genotype AA) showed greater benefits compared to slow metabolizers (AC/CC genotypes)¹⁸⁻¹⁹.

- Habituation: Habitual caffeine consumers (>300 mg/day) demonstrated attenuated ergogenic response in 4 studies, although 3 studies found no significant differences^{20–21}.
- Gender: Three studies have suggested that women may be more sensitive to the effects of caffeine, possibly due to differences in body composition and hormone metabolism.

3.7 ADVERSE EFFECTS

Adverse effects were reported in 23 studies (48.9%), being more frequent at doses above 6 mg/kg. The most common effects included:

- Gastrointestinal disturbances (nausea, abdominal discomfort): 18.7% of participants
 - Anxiety and nervousness: 12.3%
 - Tremors: 9.8%
 - Tachycardia: 8.2%
 - Post-exercise insomnia: 15.4% (when administered <6 hours before sleep)
- No serious adverse events were reported. Most effects were classified as mild to moderate and did not result in discontinuation of study participation.

3.8 METHODOLOGICAL QUALITY

The mean PEDro score was 7.2 ± 1.3 (range: 5-10), indicating good overall methodological quality of the included studies. Forty studies (85.1%) obtained a score ≥ 6 , being classified as high quality. The main strengths were adequate randomization (100% of studies), blinding of participants and raters (95.7%), and appropriate statistical analysis (91.5%). The most common limitations were the absence of intention-to-treat analysis (31.9% of the studies) and lack of blinding of the therapists (25.5%).

4 DISCUSSION

This systematic review synthesized the evidence from 47 randomized controlled trials on the effects of caffeine supplementation on the performance of athletes in endurance sports. The results consistently demonstrate that caffeine, when administered at doses of 3-6 mg/kg approximately 45-60 minutes before exercise, produces significant ergogenic effects, with a 2-4% improvement in time to exhaustion and a 1-3% reduction in race time. These findings are particularly relevant in the competitive context, where 1-2% differences in performance can determine wins or losses²³.

The mechanisms by which caffeine exerts its ergogenic effects are multifactorial and complex. Antagonism of adenosine receptors in the central nervous system is considered the primary mechanism, reducing the perception of fatigue and increasing alertness^{12–13}. Functional neuroimaging studies have shown that caffeine increases the activation of brain areas related to motor control and motivation during exercise²⁴. In addition, caffeine promotes the mobilization of free fatty acids, which could theoretically spare muscle glycogen during prolonged exercise¹⁴. However, recent studies question the practical relevance of this mechanism, suggesting that the core effects are predominant²⁵.

The dose-response relationship observed in this review indicates that doses of 3-6 mg/kg represent the ideal balance between efficacy and safety. Lower doses may be insufficient to produce consistent ergogenic effects, while doses higher than 6 mg/kg provide no additional benefit and significantly increase the risk of adverse effects. These findings are consistent with the recommendations of the International Society of Sports Nutrition (ISSN), which suggests doses of 3-6 mg/kg as optimal for endurance athletes²⁶.

Individual variability in caffeine response is an important aspect that deserves attention. Polymorphisms in the CYP1A2 gene significantly influence caffeine metabolism and, consequently, its ergogenic efficacy^{18–19}. Fast metabolizers (genotype AA) show greater benefit, while slow metabolizers (AC/CC genotypes) may even experience negative effects on performance at high doses. This genetic information can be useful for personalizing supplementation strategies, although genetic testing is not yet widely accessible in sports practice.

The issue of habituation to chronic caffeine consumption remains controversial. While some studies suggest that habitual consumers develop tolerance to ergogenic effects²⁰, others have not found significant differences between habitual and nonhabitual consumers²¹. One potential strategy would be the periodization of caffeine consumption, with reduction or abstinence in periods of basic training and strategic use in important competitions. However, this approach requires more scientific investigation before it is widely recommended.

The safety profile of caffeine at ergogenic doses (3-6 mg/kg) has been shown to be favorable, with generally mild and transient adverse effects. However, healthcare professionals should be aware of specific contraindications, including cardiac arrhythmias, uncontrolled hypertension, anxiety disorders, and pregnancy. In addition, the timing of administration should consider the potential impact on sleep quality, especially when training or competitions take place in the afternoon or evening²⁷.

This review has some limitations that should be considered. First, heterogeneity in exercise protocols, populations studied, and forms of caffeine administration made it difficult to perform quantitative meta-analyses for some outcomes. Second, most studies predominantly included male participants, limiting the generalizability of findings to female athletes. Third, few studies have investigated the effects of caffeine in adverse environmental conditions (heat, altitude), which are relevant to many endurance competitions. Finally, most studies evaluated acute effects of supplementation, with a lack of data on long-term strategies and periodization.

5 PRACTICAL APPLICATIONS

Based on the reviewed evidence, the following practical recommendations can be established for endurance athletes and healthcare professionals:

1. Recommended dose: 3-6 mg/kg body weight, administered 45-60 minutes before exercise or competition.
2. Method of administration: Anhydrous caffeine capsules have shown greater consistency in effects, although coffee, gels, and gummies are also effective.
3. Individual test: Athletes should test supplementation during training before use in competitions, to assess tolerance and individual response.
4. Genetic consideration: When available, CYP1A2 genotyping can assist in personalization of the supplementation strategy.
5. Timing: Avoid administration <6 hours before the usual sleep schedule to minimize impacts on sleep quality.
6. Hydration: Maintain adequate hydration, as caffeine has a slight diuretic effect.
7. Monitoring: Professionals should monitor for possible adverse effects and adjust dosages as needed.
8. Education: Athletes should be educated about caffeine sources, dosages, and potential risks of overconsumption.

6 CONCLUSION

Caffeine is an effective and safe ergogenic for endurance athletes when used in doses of 3-6 mg/kg, administered 45-60 minutes before exercise. Ergogenic effects are primarily mediated by antagonism of adenosine receptors in the central nervous system, resulting in reduced perception of fatigue and improved physical performance. The magnitude of the

effects (2-4% improvement) is clinically relevant in the competitive context. Individual variability in response, influenced by genetic factors and habituation, requires a personalized approach. Adverse effects are generally mild and transient at recommended doses. Future studies should investigate periodization strategies, effects on female athletes, interactions with other nutritional strategies, and applicability in adverse environmental conditions. Healthcare professionals should consider caffeine supplementation as part of a comprehensive nutritional strategy for performance optimization in endurance sports.

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PREMATURE LOSS OF PRIMARY TEETH DUE TO DENTOALVEOLAR TRAUMA AND THE IMPORTANCE OF SPACE MAINTAINERS AS PREVENTIVE TREATMENT

PERDA PRECOCE DE DENTES DECÍDUOS DEVIDA A TRAUMA DENTOALVEOLAR E A IMPORTÂNCIA DOS MANTENEDORES DE ESPAÇO COMO TRATAMENTO PREVENTIVO

PERDIDA PREMATURA DE DIENTES TEMPORALES POR TRAUMATISMOS DENTOALVEOLAR Y LA IMPORTANCIA DEL MANTENEDOR DE ESPACIO COMO TRATAMIENTO PREVENTIVO

 <https://doi.org/10.56238/sevened2025.036-158>

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ABSTRACT

Introduction: Dentoalveolar trauma refers to injuries affecting both hard and soft tissues, caused by various social, cultural, and even socioeconomic factors. The characteristics of these traumas in children are relatively uncommon due to pediatric physiology and anatomy. Dental treatment for pediatric patients must be carefully planned based on the child's age and the complexity of the specific case.

Methods: This research employed a mixed-methods approach, as it incorporated both quantitative and qualitative data. It followed a descriptive research design with a non-probability convenience sampling method. The sample consisted of 57 eighth-level dental students from San Gregorio de Portoviejo University. A literature review was conducted using scientific articles published in databases such as PubMed, Web of Science, Latindex, and SciELO.

Results: Of the 57 students surveyed, 32 were male and 25 were female. The study aimed to identify the most frequently observed type of malocclusion in their clinical practice. The results, ranked from most to least frequent based on the number of responses, were as follows: "Class I malocclusion" with 20 votes, "Class II Division 2 malocclusion" with 19 votes, "Class II Division 1 malocclusion" with [insert number] votes, and "Class III malocclusion" with 19 votes.

Conclusions: Primary dentition plays a crucial role in functions such as mastication, space maintenance for permanent teeth, and stimulation of maxillary growth.

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Keywords: Trauma. Occlusion. Space Maintainer.

RESUMO

Introdução: O trauma dentoalveolar refere-se a lesões que afetam tanto os tecidos duros quanto os tecidos moles, sendo causado por diversos fatores sociais, culturais e até socioeconômicos. As características desses traumas em crianças são relativamente incomuns devido à fisiologia e à anatomia pediátricas. O tratamento odontológico em pacientes pediátricos deve ser cuidadosamente planejado com base na idade da criança e na complexidade do caso específico.

Métodos: Esta pesquisa utilizou uma abordagem de métodos mistos, incorporando dados quantitativos e qualitativos. Adotou-se um delineamento de pesquisa descritiva, com amostragem não probabilística por conveniência. A amostra foi composta por 57 estudantes do oitavo nível do curso de Odontologia da Universidade San Gregorio de Portoviejo. Foi realizada uma revisão de literatura utilizando artigos científicos publicados em bases de dados como PubMed, Web of Science, Latindex e SciELO.

Resultados: Dos 57 estudantes entrevistados, 32 eram do sexo masculino e 25 do sexo feminino. O estudo teve como objetivo identificar o tipo de má oclusão mais frequentemente observado na prática clínica dos participantes. Os resultados, classificados do mais ao menos frequente com base no número de respostas, foram os seguintes: “Má oclusão Classe I”, com 20 votos; “Má oclusão Classe II Divisão 2”, com 19 votos; “Má oclusão Classe II Divisão 1”, com [inserir número] votos; e “Má oclusão Classe III”, com 19 votos.

Conclusões: A dentição decídua desempenha um papel fundamental em funções como a mastigação, a manutenção do espaço para os dentes permanentes e a estimulação do crescimento maxilar.

Palavras-chave: Trauma. Oclusão. Mantenedor de Espaço.

RESUMEN

Introducción: Los traumatismos dentoalveolares son lesiones de los tejidos duros y blandos provocados por diversos factores sociales, culturales, e incluso socioeconómicos. Las características de estos traumatismos en niños son poco comunes debido a la fisiología y anatomía pediátrica. El tratamiento odontológico que se debe aplicar a un paciente pediátrico debe establecerse bajo una planificación en base a la edad y a la complejidad del caso que presente.

Método: Está investigación tuvo un enfoque mixto, debido a que se basa en datos de naturaleza cuantitativa y cualitativa, con un tipo de investigación descriptiva, de estudio no probabilístico por conveniencia. La muestra estuvo conformada por 57 estudiantes de octavo nivel de la Universidad San Gregorio de Portoviejo. Se realizó una revisión bibliográfica de artículos científicos publicados en bases de datos como PubMed, Web of Science, Latindex, y SciELO.

Resultados: De la encuesta realizada a 57 estudiantes 32 de ellos pertenecen al género masculino y los 25 restantes al género femenino. se busca identificar cual es el tipo de maloclusión que se presenta con mayor frecuencia en sus clínicas odontológicas, obteniendo como resultados de mayor a menor con base en los votos adquiridos: con 20 votos

"maloclusión clase I", con 19 votos "maloclusión clase II división 2", con votos "maloclusión clase II división 1" y, con votos "maloclusión clase III".

Conclusiones: La dentición temporal desempeña funciones importantes, como la masticación, el mantenimiento del espacio para los dientes permanentes y el estímulo del crecimiento de los maxilares.

Palabras clave: Trauma. Oclusión. Mantenedor.

1 INTRODUCTION

Dentoalveolar trauma is injury to the hard and soft tissues caused by various social, cultural, and even socioeconomic factors. The characteristics of trauma in children are uncommon due to pediatric physiology and anatomy. The loss of the tooth as a result of Dentoalveolar trauma brings with it the inclination of the adjacent teeth, causing the loss of the necessary physiological space ^(1,2).

The dental treatment that should be applied to a pediatric patient must be established under a plan based on the age and complexity of the case presented, for this reason the international association of pediatric dentistry defines a series of possible conditions to develop in the deciduous dentition, however, the premature loss of teeth is established as the main consequence of the origin and progression of dental caries, because it acquires the ability to establish an imbalance process in relation to the remineralization and demineralization of the hard tissues of the tooth ⁽³⁾.

Orthodontic appliances such as space maintainers are used preventively to prevent the tilting of adjacent teeth, causing little physiological space needed in the child's oral cavity. This type of appliance is available in two fixed and removable presentations, each of which has its indications that will depend on the time that the pediatric extraction has elapsed and the healing of the soft tissue lesions ⁽⁴⁾.

Internationally, a study carried out in Europe found that 15% of pediatric patients aged 3 to 5 years and school-age children (6 to 12 years) have suffered dental trauma ⁽⁵⁾, while a study from Saudi Arabia found that 57.9% of patients presented for tooth loss were due to dental avulsions. ⁽⁶⁾

In Latin America, dentoalveolar trauma in children has become a problem in oral health, and in a study carried out in Cuba, 24% of school-age children have had some dental trauma to the anterior teeth ⁽⁷⁾. Therefore, in the clinical case carried out by Coureaux also in Cuba, the placement of a removable aesthetic space maintainer in a 7-year-old pediatric patient who lost his tooth 21 ⁽⁸⁾ is detailed.

Ecuador In a study of the prevalence of dental trauma, it was found that, in a sample of 26 pediatric patients, 8.1% have lost their teeth due to blows caused by accidents or falls ⁽⁹⁾.

The objective of this study was to determine the efficacy of space maintainers as a treatment for premature loss of primary teeth.

2 MATERIALS AND METHODS

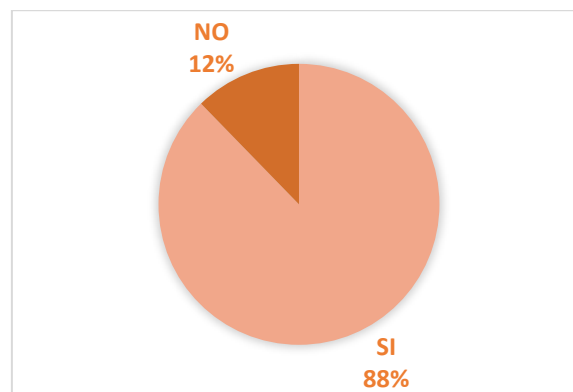
This research had a mixed approach, because it is based on quantitative and qualitative data, with a type of descriptive research, of non-probabilistic study for convenience. The sample was made up of 57 eighth-level students of the Dentistry career of the San Gregorio University of Portoviejo. The instrument used was a survey. A bibliographic review of scientific articles published in databases such as PubMed, Web of Science, Latindex, and SciELO was carried out.

3 RESULTS

From the survey of 57 students, the first question applied aimed to know if the student believed that the use of a space maintainer is useful to preserve the mediail diameter of a piece lost prematurely, in which 88% answered "yes" and 12% "no". (Figure 1).

Figure 1

Do you think that the use of a space maintainer is useful to preserve the mesiodistal diameter of a piece lost prematurely?

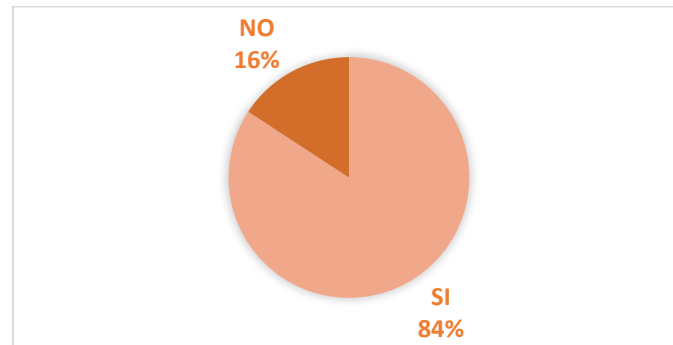


Source: Own elaboration

To determine the use or not of a space maintainer, it was necessary to know if the students believed that the absence of a temporary tooth had the ability to influence the development of a malocclusion, obtaining as results that 84% answered "yes" and 16% "no". (Figure 2).

Figure 2

Do you think that the absence of a temporary tooth influences the development of malocclusion?

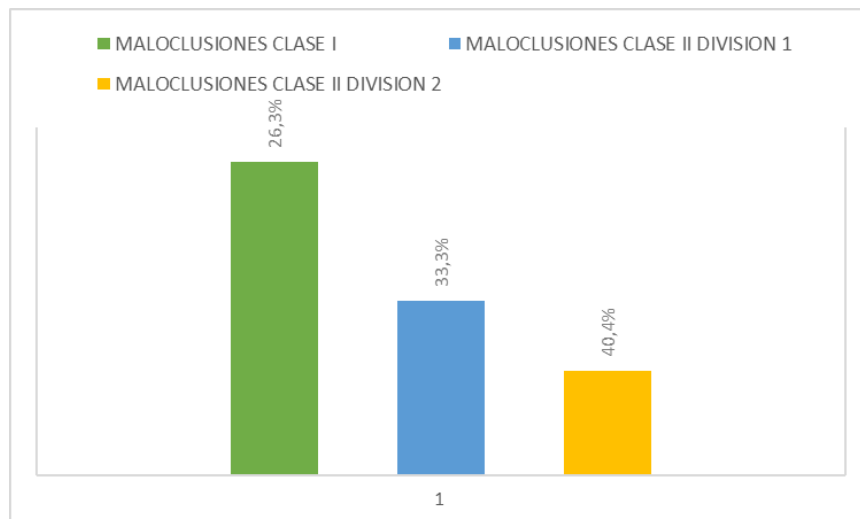


Source: The authors.

From question 2, we seek to identify which is the type of malocclusion that occurs most frequently in their dental clinics, obtaining results from highest to lowest based on the votes acquired: with 20 votes "class I malocclusion", with 19 votes "class II division 2 malocclusion", with votes "class II division 1" and, with "class III malocclusion" votes (Figure 3).

Figure 3

What is the type of malocclusion most frequently presented by pediatric patients?



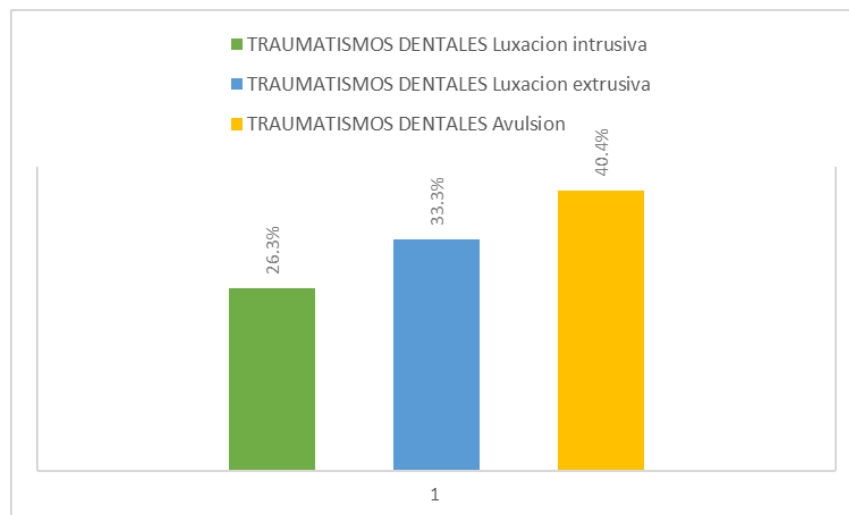
Source: The authors.

Respondents were asked what is the most frequent cause of dental trauma in their patients for which they have lost a temporary tooth, obtaining as results that 26.3% of the respondents presented pediatric extraction due to an intrusive dislocation, while 33.3% was

due to extrusive dislocation, therefore, 40.4% was due to avulsion of the temporary tooth. (Figure 4).

Figure 4

What is the most common cause of Dentoalveolar trauma for which your patients have told you that they have lost their tooth?

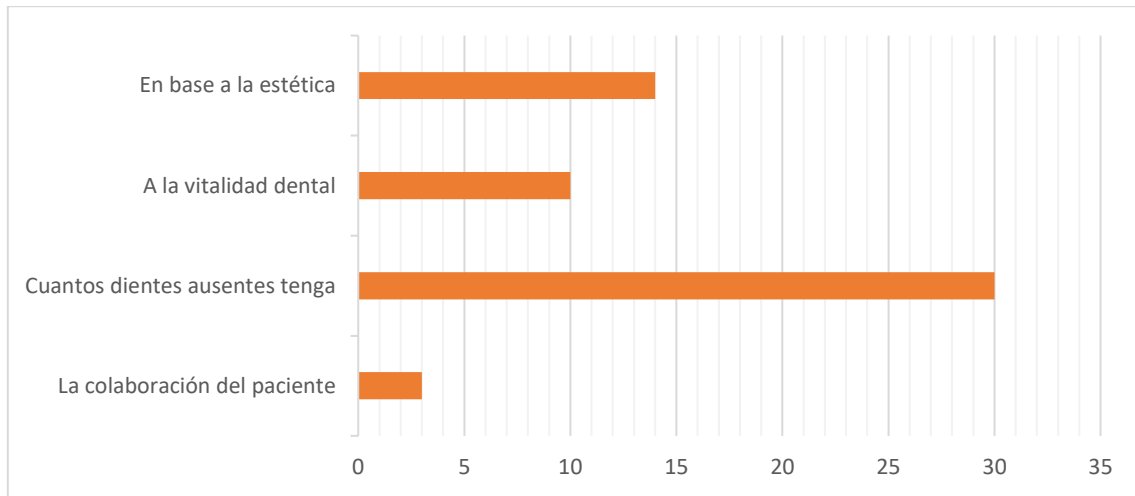


Source: The authors.

To determine the therapeutic use of a space maintainer, it is necessary to take into account various characteristics mentioned by the surveyed students, among these, 3 of them affirm that "the patient's collaboration" is important, another 10 "dental vitality", another 14 "aesthetics" and, the last 30 "how many missing teeth they have" (figure 5). From the characteristics taken into account, the most commonly used maintainer in dental clinics is determined, two mention the "palatine bar", another 2 the "arch of nance", another 8 the "hawley plate with pontics", another 11 the "crown and ansa" and, the last 34 say "bench and ansa" (figure 6). Once the corresponding space maintainer has been chosen for the case presented, the time in which it will be used must be determined, 8 of the interviewees mention that the time is determined by the "corono-root classification", another 11 students mention that the "collaboration of the patient", another 19 "Nola stages" and, the last 19 the "age of the patient" (Figure 7).

Figure 5

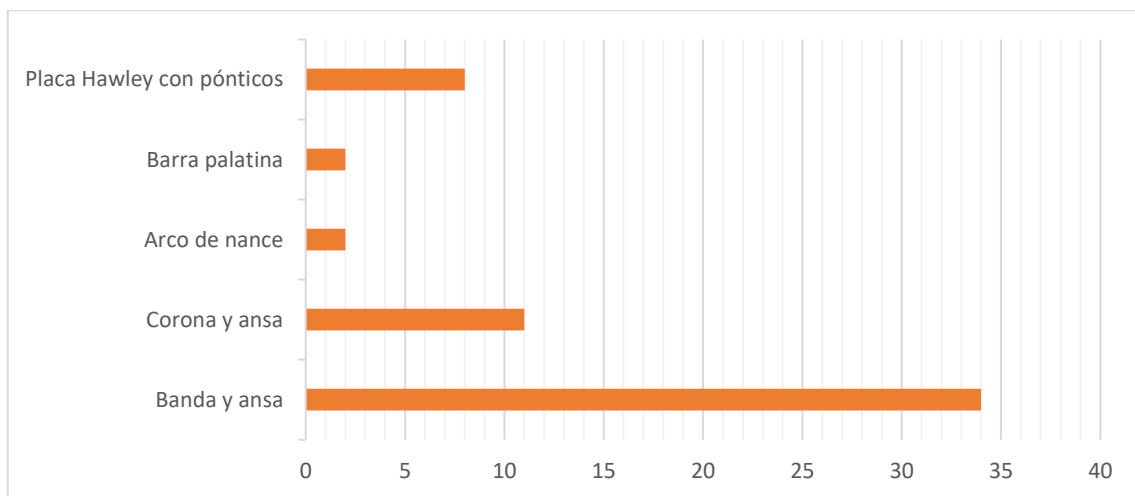
Based on what characteristics do you make your choice of space maintainer types?



Source: The authors.

Figure 6

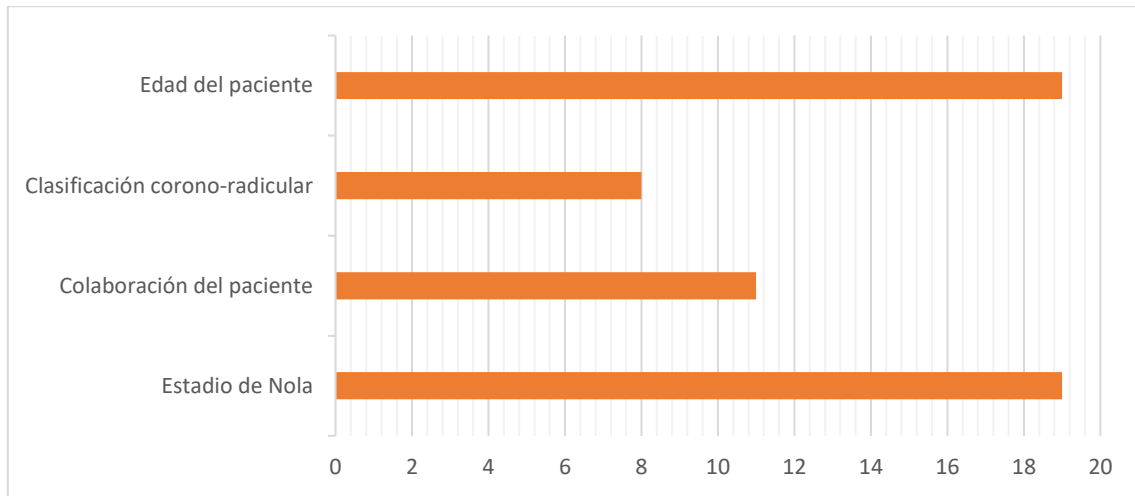
Which of these space maintainers is the most commonly used?



Source: The authors.

Figure 7

What determines the time for space maintainer utilization?

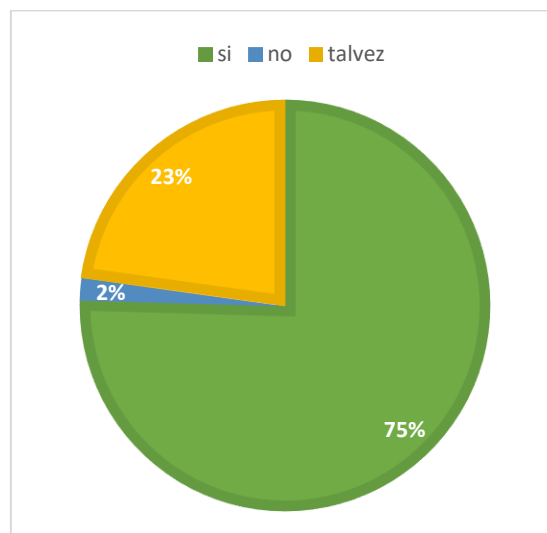


Source: The authors.

Finally, the last question seeks to know the considerations of the space maintainer from the perspective of the students, mentioning if they believe that they serve to preserve the space of one or two permanent pieces, obtaining as results that 75% of the respondents answered yes, 23% that maybe and only 2% that no. (Figure 8).

Figure 8

Do you consider that the space maintainer is used to preserve the space of one or two permanent pieces?



4 DISCUSSION

Occlusion is established as the result of an interaction of environmental and genetic factors, among these variables that have the greatest influence is the primary dentition and the attack of factors that have the ability to destroy it such as dentoalveolar trauma that causes loss of the tooth, being thus, in a study carried out by Rivero N. ⁽¹⁰⁾ mentions that the prevalence of space maintainer placement in patients aged 3 to 9 years with premature loss of primary teeth varies between 70.90%, on the other hand, Lambruschini V. ⁽¹¹⁾ comments in his article that maintaining the temporary teeth in the mouth under physiologically normal conditions is essential to establish a correct occlusion of adult teeth, so in this work we sought to highlight the importance of space maintainer to avoid the inclination of the teeth.

Loo J. et al ⁽¹²⁾ detail in their clinical case that aesthetic rehabilitation through orthodontic appliances or fixed space maintainers, in addition to preventing the messialization of adjacent teeth, restores the confidence in smiling to children who have lost previous teeth, which is why 14 of the 57 students surveyed mentioned that they choose the type of space maintainer according to aesthetics of the patient.

The use of the space maintainer after premature tooth loss is not usually of great importance for parents or guardians, so in a study carried out by Espín M ⁽¹³⁾ he comments that the tooth with the greatest loss in preschool infants is the second lower left molar and in turn indicates that only 30% of cases have space maintainers. In this context, in the article presented by Castellazi R. ⁽¹⁴⁾ mentions that in a randomized study of children between 6 and 9 years of age they presented changes in occlusion due to the lack of space maintainer, affecting the growth of the jaw with 42.6% in the male sex.

One of the main challenges in addressing premature loss of primary teeth due to dentoalveolar trauma is the lack of early diagnosis and adequate follow-up, especially in areas with limited access to pediatric dental care. In addition, many studies on the use of space maintainers feature observational designs with small or non-representative samples, which limits the generalizability of the results. The variability in clinical protocols and the lack of standardization of criteria for the placement of space maintainers also make it difficult to evaluate their long-term effectiveness.

It is essential that the dentist performs a comprehensive evaluation after a dentoalveolar trauma in the primary dentition, identifying any risk of premature loss that may compromise future occlusion. It is recommended to place space maintainers in a timely manner, individualizing each case according to the missing tooth, the estimated time of

eruption of the permanent successor, and the patient's cooperation. It is also essential to educate parents about the importance of monitoring and maintaining the space maintainer to avoid complications such as loss of space or tooth displacement.

5 CONCLUSION

Premature loss of primary teeth as a result of dentoalveolar trauma can adversely affect the proper development of occlusion and maxillofacial growth. The results of this research show that malocclusions are frequently present in dental clinical practice, with class I being the most common, which reinforces the need for a preventive approach from childhood. In this context, the timely and appropriate use of space maintainers is established as a fundamental tool to preserve space in the dental arch, prevent unwanted displacements and avoid future orthodontic complications.

FUNDING

The authors did not receive funding for the development of this research.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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**EVALUATION OF IN VITRO CULTURE MEDIA FOR THE MULTIPLICATION OF
AVOCADO (PERSEA AMERICANA) ROOTSTOCKS CV. HASS, FREE OF
PHYTOPHTHORA CINNAMOMI, IN THE DEPARTMENT OF TOLIMA**

**AVALIAÇÃO DE MEIOS DE CULTIVO IN VITRO PARA A MULTIPLICAÇÃO DE
PORTA-ENXERTOS DE ABACATEIRO (PERSEA AMERICANA) CV. HASS,
LIVRES DE PHYTOPHTHORA CINNAMOMI, NO DEPARTAMENTO DE TOLIMA**

**EVALUACIÓN DE MEDIOS DE CULTIVO IN VITRO, PARA LA
MULTIPLICACIÓN DE PORTAINJERTOS DE AGUACATE (PERSEA
AMERICANA) CV. HASS, LIBRES DE PHYTOPHTHORA CINNAMOMI EN EL
DEPARTAMENTO DEL TOLIMA**

 <https://doi.org/10.56238/sevened2025.036-159>

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Alonso Fernández³**

ABSTRACT

Avocado (*Persea americana* Mill) has become a crop of vital economic importance for Colombia; however, its productivity faces serious limitations due to the incidence of *Phytophthora cinnamomi* and the genetic variability resulting from seed propagation. The present study aimed to evaluate protocols for the in vitro establishment and multiplication of avocado rootstocks of the Criollo variety, ensuring pathogen-free plant material for the Department of Tolima. The methodology used nodal segments from mother plants previously analyzed by ELISA testing. Two disinfection protocols (P1 and P2) and three culture media (Murashige and Skoog – 50% MS, WPM, and Yasuda) were compared, evaluating contamination, oxidation, and viability variables. The results showed that Protocol 1 presented a significantly lower contamination rate (57.8%) compared with Protocol 2 (79.5%). Although oxidation was successfully controlled (7.31% overall) through the use of antioxidants and activated charcoal, microbial contamination remained the main challenge. It is concluded that the 50% MS medium combined with Protocol 1 provides the highest viability rate for the establishment stage, laying the groundwork for future phases of large-scale clonal multiplication.

Keywords: Plant Micropropagation. *Persea Americana*. *Phytophthora cinnamomi*. In Vitro Culture. Rootstocks. Explant Disinfection.

RESUMO

O abacate (*Persea americana* Mill) tem se consolidado como uma cultura de grande importância econômica para a Colômbia; entretanto, sua produtividade enfrenta sérias limitações devido à incidência de *Phytophthora cinnamomi* e à variabilidade genética decorrente da propagação por sementes. A presente pesquisa teve como objetivo avaliar protocolos para o estabelecimento e a multiplicação in vitro de porta-enxertos de abacate da variedade Crioula, garantindo material livre de patógenos para o Departamento de Tolima. A

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metodologia empregou segmentos nodais de plantas-matrizes previamente analisadas por teste ELISA. Foram comparados dois protocolos de desinfecção (P1 e P2) e três meios de cultivo (Murashige e Skoog – MS a 50%, WPM e Yasuda), avaliando-se as variáveis contaminação, oxidação e viabilidade. Os resultados demonstraram que o Protocolo 1 apresentou percentual de contaminação significativamente menor (57,8%) em comparação ao Protocolo 2 (79,5%). Embora a oxidação tenha sido controlada com sucesso (7,31% no geral) por meio do uso de antioxidantes e carvão ativado, a contaminação microbiana permaneceu como o principal desafio. Conclui-se que o meio MS a 50% combinado com o Protocolo 1 oferece a maior taxa de viabilidade para a fase de estabelecimento, estabelecendo as bases para futuras etapas de multiplicação clonal em larga escala.

Palavras-chave: Micropropagação Vegetal. Persea Americana. *Phytophthora cinnamomi*. Cultivo in Vitro. Porta-enxertos. Desinfecção de Explantes.

RESUMEN

El aguacate (Persea americana Mill) se ha posicionado como un cultivo de vital importancia económica para Colombia; sin embargo, su productividad enfrenta serias limitaciones debido a la incidencia de *Phytophthora cinnamomi* y la variabilidad genética derivada de la propagación por semilla. La presente investigación tuvo como objetivo evaluar protocolos para el establecimiento y multiplicación in vitro de portainjertos de aguacate variedad Criollo, garantizando material libre de patógenos para el departamento del Tolima. La metodología empleó segmentos nodales de plantas madre previamente analizadas mediante test de ELISA. Se compararon dos protocolos de desinfección (P1 y P2) y tres medios de cultivo (Murashige y Skoog - MS al 50%, WPM y Yasuda), evaluando variables de contaminación, oxidación y viabilidad. Los resultados mostraron que el Protocolo 1 presentó un porcentaje de contaminación significativamente menor (57,8%) en comparación con el Protocolo 2 (79,5%). Aunque la oxidación fue controlada exitosamente (7,31% general) mediante el uso de antioxidantes y carbón activado, la contaminación microbiana persistió como el principal desafío. Se concluye que el medio MS al 50% combinado con el Protocolo 1 ofrece la mayor tasa de viabilidad para la etapa de establecimiento, sentando las bases para futuras fases de multiplicación clonal masiva.

Palabras clave: Micropropagación Vegetal. Persea Americana. *Phytophthora cinnamomi*. Cultivo in Vitro. Portainjertos. Desinfección de Explantes.

1 INTRODUCTION

The avocado (*Persea americana* Mill) belongs to the Lauraceae family, which comprises about 2200 species, within this family are cinnamon (*Cinnamomum verum*), laurel (*Laurus nobilis*) and sassafras (*Sassafras albidum*). It is a species native to Mexico and Central America and is currently one of the most economically important fruit crops in the tropics/subtropics worldwide. (Bost et al, 2013; Pérez et al, 2015).

In avocado cultivation, the most common practice is to graft the avocado with shoots from a mature tree. The beneficial characters of shoots and roots are integrated by the selection of a rootstock and cuttings with optimal productivity. In the case of the selection of the crop from which the sprout is to be obtained, the vigor of the plant, productivity and quality of the fruit must be taken into account. Rootstocks are selected for their size, salinity tolerance, adaptation to alkaline soils, and resistance to pests and diseases (Hiti-Bandaralage et al, 2017).

Colombia is currently ranked as the third avocado producing country; however, the crop presents productivity and competitiveness problems due to low technological development, as well as deficiencies in marketing channels, lack of plant health guarantees, genetic variability of propagation material, and field losses associated with plant material from poor quality seeds (Restrepo et al, 2018).

2 JUSTIFICATION

The avocado fruit has a high nutrient content, high levels of monounsaturated lipids, proteins, vitamins and beneficial phytochemicals, which make the avocado an important part in the fight against malnutrition and hunger problems in developing countries. In addition to this, due to its oil production, it also plays an important role in the cosmetic and pharmaceutical industry (Chanderbali, 2013).

Colombia has planted 73,986 hectares of avocado with a production of 403,184 tons, ranking as the third producing country and the second in terms of harvested area. The areas of the country where it is most cultivated are Tolima, Antioquia, Caldas, Santander, Bolívar, Cesar, Valle del Cauca, Risaralda, and Quindío, which represent 86% of the country's total planted area (González, 2018). Of the avocado varieties, currently the one with the greatest economic importance in the country is the Hass avocado, as it has increased its exports by more than 413% in less than three years. The second national producer is the Department of Tolima with more than 11,000 tons harvested and has 148 hectares of avocado farms

registered for export (Suarez, 2019). However, one of the problems presented by producers is the incidence of the disease caused by *Phytophthora cinnamomi*, which has caused losses that accumulate millions of dollars and severely affect the growth, production and international trade of avocados (Litz et al, 2007).

There are two types of rootstock or rootstock in avocado cultivation: rootstock from seed and clonal rootstock. Due to the high level of heterozygosity which creates inconsistency in genetic stability, the use of rootstock from seed is less preferable than clonal rootstock. On the other hand, clonal propagation of avocado rootstocks has been it has become the bottleneck of production, as the method currently used for clonal propagation of rootstocks is costly and time-consuming (Ibarra et al, 2016; Hiti-Bandaralage et al, 2017).

Plant tissue culture has the potential to be an effective and efficient alternative for the clonal production of avocado rootstocks, since it allows the clonal propagation under controlled conditions, of a large number of plants in a short period of time and with little labor, and also guarantees genetic health and stability (Kumar and Loh, 2012). The micropropagation process in avocados has focused mainly on the massive propagation of rootstocks with tolerance to soil-borne diseases and salinity conditions; as well as to revitalize adult material (Ibarra et al, 2016).

Woody plants are generally recalcitrant to tissue culture conditions (Benmahioul et al, 2012) and avocado is no exception to this trend. Several authors have carried out tissue culture techniques for avocado micropropagation; however, factors such as: the explant, conditions of the mother plant, time of collection of the plant material, the cultivar, the composition of the culture medium, concentration of growth regulators, affect the success of micropropagation (Zirari and Lionakis, 1994; Wessels, 1996; Barringer et al, 1996; Dalsaso and Guevara, 1998; Rodríguez et al, 1999; Premkumar et al, 2002; Barceló-Muñoz & Pliego-Alfaro, 2003; Nhut et al, 2008; Zulfiqar et al, 2009; Hiti-Bandaralage et al, 2015; Ibarra et al 2016; Restrepo et al, 2018).

Taking into account the above, the objective of this research is the evaluation of different culture media and growth regulators for the establishment and induction of Sprouts on Avocado Rootstocks Var. Criollo free of *Phytophthora cinnamomi*, so that Hass avocado producers in the Department can use it as a pattern.

3 OBJECTIVES

3.1 GENERAL OBJECTIVE

To evaluate different culture media for the in vitro multiplication of rootstocks of Avocado (*Persea Americana*) cv. Hass, free of *Phytophthora cinnamomi* in the Department of Tolima.

3.2 SPECIFIC OBJECTIVES

- Evaluate disinfection protocols for aseptic establishment in avocado cultivar explants.
- Define the culture medium that allows the adequate in vitro multiplication of avocado explants.
- To identify native rootstocks potentially resistant to *Phytophthora cinnamomi*, in the Department of Tolima.

4 MATERIALS AND METHODS

The research was carried out in the plant biotechnology laboratory of the Agricultural Center "La Granja", National Learning Service in Espinal, Tolima. For the evaluation, nodal segments of native avocado rootstocks obtained from the nursery were used. Prior to obtaining the explants, Elisa tests were carried out for *Phytophthora* sp. in the mother plants, in order to guarantee plant health for this pathogen.

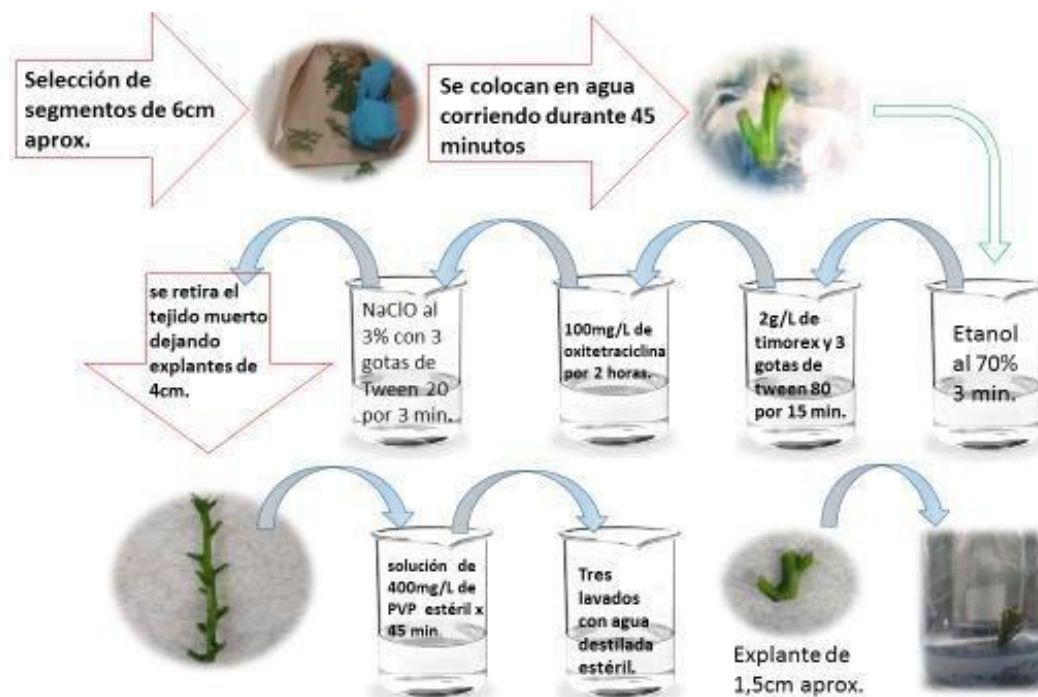
4.1 DISINFECTION PROTOCOLS

Two protocols were carried out to disinfect the explants, adapted from Hiti-Bandaralage et al. (2015), Ibarra et al. (2016), Restrepo et al. (2018). In the first protocol (P1) the segments of approximately 6cm are placed in running water for 45 minutes. Then, in a laminar flow chamber, they are immersed in 70% ethanol for three minutes and rinsed three times with sterile distilled water. The fragments are placed in a solution with 2 g/L of timorex and 3 drops of tween 80 in stirring for 15 minutes, then immersed in 100 mg/l of oxytetracycline for 2 hours. Rinse again three times with sterile distilled water for 5 minutes each and place in magnetic agitation for 3 minutes in 3% sodium hypochlorite solution with 3 drops of Tween 20, then five washes are made with sterile distilled water, the dead tissue is removed leaving explants of 4cm. These are placed in agitation for 45 minutes in a sterile solution of 400mg/l of sterile PVP (polyvinylpyrrolidone). Finally, they are rinsed three times in sterile distilled water and dissected of plant material, removing the oxidized portions at both

ends of the microcutting, leaving approximately 1.5cm of the explant for planting in the culture medium (Figure 1).

Figure 1

Protocol 1 for the disinfection of the explants. The red lines correspond to passages with contaminants, green for transitions and blue for passages and clean areas carried out in the laminar flow chamber

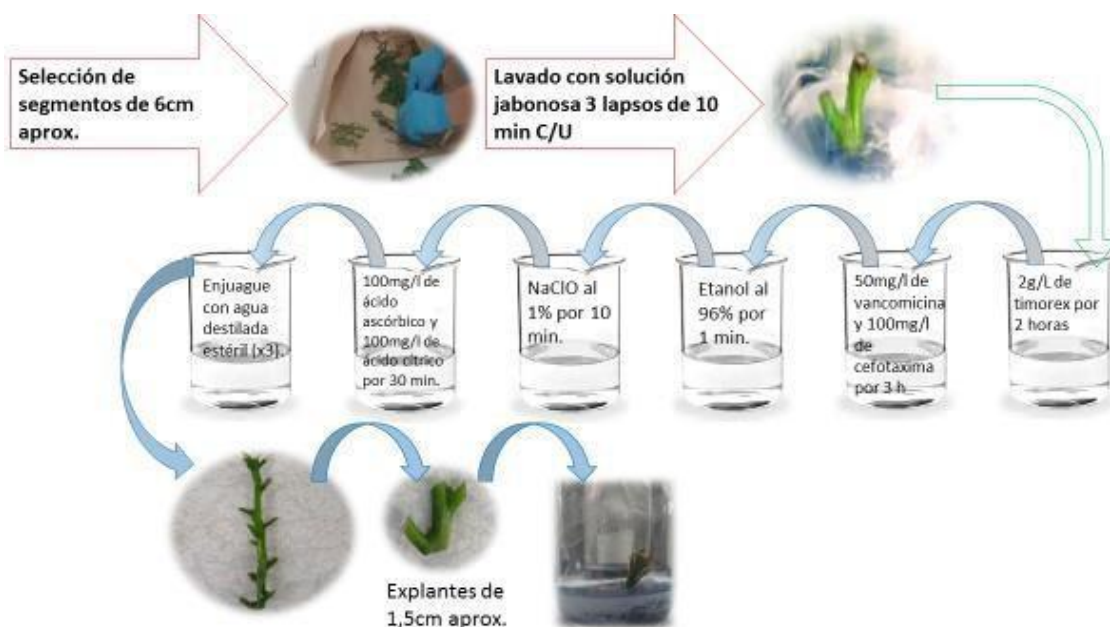


Source: Authors.

In the second disinfection protocol (P2), the nodal segments of approx. 6cm are washed in soapy solution for three periods of 10 minutes each and 3 rinses are performed with sterile water. In the laminar flow chamber they are kept in a solution of 2ml/l of timorex for two hours, followed by a solution of 50mg/l of vancomycin and 100mg/l of cefotaxime for 3 hours, washed with sterile water, then immersed in 96% ethanol for one minute and 1% sodium hypochlorite for 10 minutes. rinses with sterile water. Subsequently, the dead tissue is removed, leaving explants of 4cm in length. The material is left in a solution of 100mg/l of ascorbic acid and 100mg/l of citric acid for 30 minutes, three washes are carried out with sterile distilled water. Finally, fragments of 1.5cm are obtained for sowing in a culture medium (Figure 2).

Figure 2

Protocol 2 for the disinfection of the explants. The red lines correspond to passages with contaminants, green for transitions and blue for passages and clean areas carried out in the laminar flow chamber



Source: Authors.

4.2 IN VITRO ESTABLISHMENT

For in vitro establishment, the culture media MS (Murashige and Skoog, 1962) with 50% macroelements, WPM (Lloyd & McCown, 1980) and Yasuda (Yasuda et al., 1985), supplemented with vitamins and 30 g.L⁻¹ sucrose, were used. Additionally, the implementation of activated charcoal and permanence in darkness for 15 days for the three media was evaluated, as shown in Table 1. The pH was adjusted to 5.75 in all media, they are then sterilized at 1.2 kg cm⁻² pressure at 121 °C for 15 min. Once the

Experimental units are incubated at a temperature of 26 ± 2 °C under a photoperiod of 16 light hours depending on the treatment, for two weeks. The variables that were evaluated 15 days after planting were bacterial contamination, fungal contamination, oxidation and viability of the explants. Table 1 shows the treatments used to control the oxidation of plant tissue.

Table 1

Treatments used to prevent oxidation of explants

Treatment	Protocol	di	Photoperiod	Coal	Activate
	sinfection			d (g/l)	
S0	P1		Photoperiod 12 hours of light	0	
S1	P1		Photoperiod 12 hours of light	2	
S2	P1		Darkness 15 days	0	
S3	P1		Darkness 15 days	2	
S4	Q2		Photoperiod 12 hours of light	0	
S5	Q2		Photoperiod 12 hours of light	2	
S6	Q2		Darkness 15 days	0	
S7	Q2		Darkness 15 days	2	

4.3 OUTBREAK INDUCTION

After fourteen days of in vitro establishment, viable segments were seeded in 50% MyS media, Yasuda and WPM with growth regulators at different concentrations: IBA (indolebutyric acid), BAP (6-Benzylaminopurine) and GA3 (gibberellic acid) for budbreak induction (Table). Added with 30 g/l of sucrose, the pH was adjusted to 5.7 in all media, then sterilized at 1.2 kg cm⁻² pressure at 121 °C for 15 min. Once seeding is completed, the experimental units are incubated at a temperature of 26 ± 2 °C under a photoperiod of 16 light hours. The number of shoots per explant, shoot length and number of leaves at 30, 60 and 90 days after subculture were evaluated. To maintain adequate nutrient supplementation and growth regulators, the plants were transferred to fresh medium every four weeks, a fine cut was made in the base in each subculture to ensure the continuous absorption of nutrients.

Table 2

Growth hormone treatments for the in vitro multiplication stage

TREATMENT	BAP (mg. L-1)	GA3 (mg. L-1)	IBA (mg. L-1)
S0	0	0	0
S1	0.1	0,1	0
S2	0,5	0,1	0
S3	1	0,5	0
S4	0,5	0	0,1
S5	1,5	0,2	0
S6	2	0	0,5
S7	0,5	0	0,5

S8	0,2	0,2	0
S9	0,5	0,5	0

4.4 STATISTICAL ANALYSIS

For the establishment stage, the qualitative variables evaluated are: contamination, oxidation and viability of the explants at 15 days after planting in the three culture media of this stage and two disinfection protocols, with fifty replications, which were established under a completely randomized design under homogeneous conditions. The variables were analyzed using contingency tables and correspondence analysis for qualitative data. In the shoot induction stage, the following variables will be evaluated: number of shoots, shoot length, and number of leaves at two and three months after the establishment of the explants. An analysis of variance will be performed with the previously transformed data and the differences between the means of treatments are compared using the Tukey test at a 5% probability. Data from both stages will be analyzed using the InfoStat 2008 statistical package (DiRienzo et al, 2008).

4.5 ROOTSTOCK IDENTIFICATION

Creole rootstocks for the Hass avocado were identified in some of the avocado-producing municipalities in the Department of Tolima, which have possible resistance to *Phytophthora cinnamomi*. This identification was made by Elisa test.

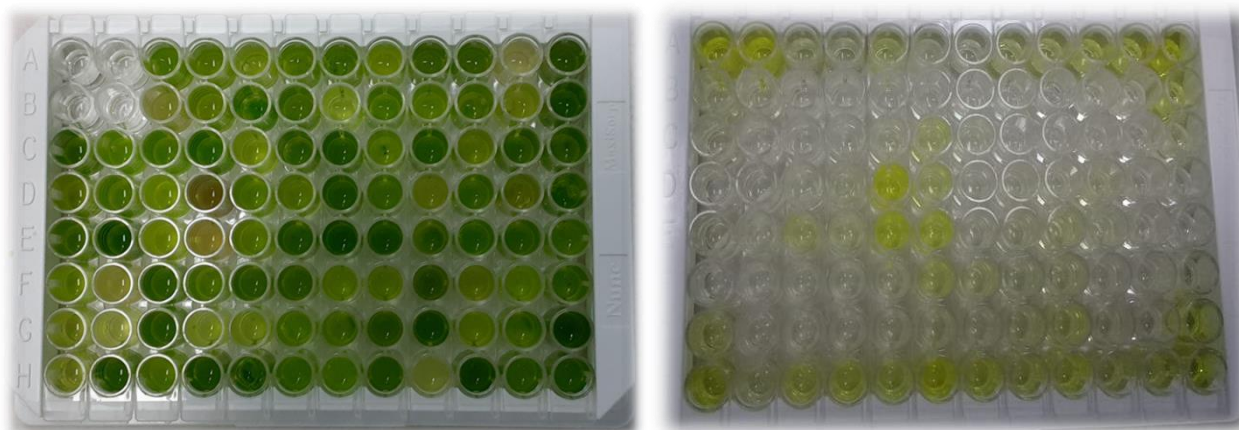
5 RESULTS

5.1 IDENTIFICATION OF FREE ROOTSTOCKS OF PHYTOPHTHORA SP.

Var avocado mother plants were chosen. Criollo that serve as rootstocks, to which an Elisa test was performed with the *Phytophthora* Pathoscreen kit for the identification of *Phytophthora* and in this way multiply the plants free of it.

Figure 3

ELISA test on avocado mother plants for the identification of Phytophthora spp



5.2 IN VITRO ESTABLISHMENT

5.2.1 Pollution

The establishment of explants in tissue culture is associated with problems of fungal and bacterial contamination. Measures to reduce contamination include the selection of healthy and stress-free mother plants, as well as the application of fungicides and bactericides to the explants (Barceló and Muñoz, 2003; Hiti-bandaralage, 2017).

At 15 days after planting, the percentage of contamination was 68.74, with bacterial contamination being higher than 40.34% (Table 2), similar results were found by Cooper (1987), with 70% contamination in the Duke variety 7, Dalssaso and Guevara (1988) also obtained a high percentage of bacterial and fungal contamination in the Fuerte variety and Zulfiqar et al. (2009) observed 72% contamination in the Fuerte variety. Of the protocols evaluated, the one with the lowest percentage of contamination was protocol 1 with 57.8% ($p < 0.01$), in turn the culture medium with the highest contamination was Yasuda in both disinfection protocols and the medium with the lowest percentage of contamination was MyS using protocol 1 with a significance of < 0.05 (Table 2) (Figure 3). which differs from what was found by Ibarra et al. (2016) where Yasuda was the medium with the lowest percentage of contamination (Figure 4).

In woody plants, higher percentages of contamination can occur because they grow in the soil for several years under environmental conditions, so they can be infected by microorganisms both exogenously and endogenously, which often makes in vitro control difficult. This requires establishing one or more sterilization agents that can remove bacteria and fungi from the explant (Ahmad et al, 2003). The disinfection protocols implemented in

this study were adapted from Hiti-Bandaralage et al. (2015), Ibarra et al. (2016), Restrepo et al. (2018), who obtained low percentages of contamination; however, the results obtained in the current research can be due to factors such as the plant health of the mother plant from which the explants were obtained (endogenous contamination), as well as by the manipulation at the time of planting.

Figure 3 shows that protocol 2 is associated with bacterial and fungal contamination; in turn, the MyS culture medium is associated with less bacterial contamination. Correspondence analysis explains 52% of the variables.

Table 2

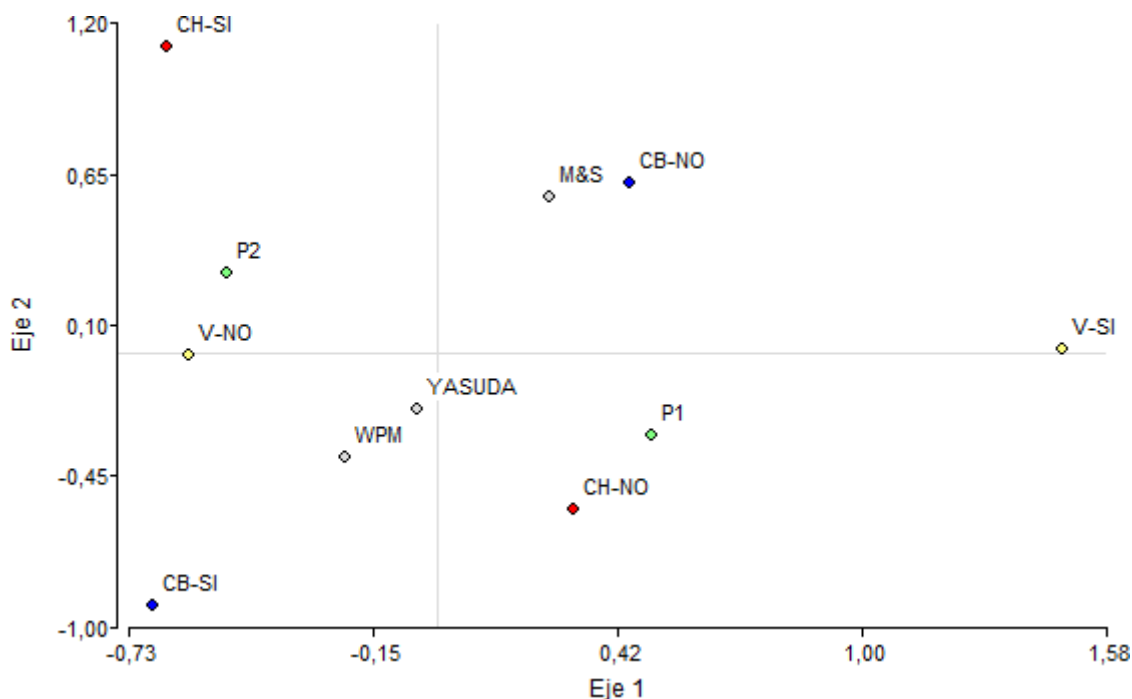
Percentages of contamination, oxidation and viability with the two disinfection protocols and three culture media two weeks after planting

Protocol/me dium	Pollution	C. Fungi	C. Bacterial	Oxidation	Feasibility
P1					
50%MyS	39*	35**	20**	2**	47,5
Yasuda	87*	20**	41,58*	12,63**	40**
WPM	61*	15**	54	10**	30**
Total P1	57,80**	23,39**	38,47**	8,14**	39,15**
Q2					
50%MyS	73**	43,5	38,5**	6,50**	19,5**
Yasuda	74**	42*	47	8**	17,5**
WPM	67**	45	41*	5**	17**
Total P2	79,50**	43,50**	42,17**	6,50**	18**

*(p<0.05) **(p<0.01) obtained in the contingency tables. Source: Authors.

Figure 3

Correspondence analysis for the association of the variables: disinfection protocol 1 (P1), disinfection protocol 2 (P2), bacterial contamination (CB), fungal contamination (CH), viability (V), WPM culture medium, Yasuda and MyS. (NO) negative, (YES) positive



Source: Retrieved from the Infostat 2008 statistical program.

5.2.2 Oxidation

In the process of conditioning the explant for in vitro establishment, plant tissues cut primarily from woody plants excrete phenolic compounds that can be oxidized by polyphenoloxidases, peroxidases, or by air. Oxidized phenolic compounds (quinones) have a browning around the cutting surface of the tissue, these quinones have an inhibitory effect on the enzymatic activity of the plant, which ultimately results in tissue death (Bath and Chandel, 1991). Taking into account the above, there are reports in the literature of various pretreatments of the explant to prevent this oxidation (Hiti-bandaralage et al, 2017).

In general, the percentage of oxidation with the different treatments used was low 7.31% (Table 3), being the lowest with treatment 5, in which ascorbic acid, citric acid and activated carbon were used, as reported by Cortes-Rodríguez et al. (2011). However, the other treatments showed significant results to prevent tissue browning, with the use of polyvinylpyrrolidone as reported by Ibarra et al. (2016) and keeping the tissue in darkness in the growth chamber for 15 days reported by Restrepo et al. (2018).

Figure 4 shows that all variables are associated with zero oxidation, with the use of photoperiod and protocol 2 being more associated with citric acid and ascorbic acid as antioxidant agents.

Table 3

Percentage of oxidation obtained with the different treatments with antioxidant agents

Treatment	Oxidation percentage
S0	2,67**
S1	17,36**
S2	2**
S3	10,96**
S4	4**
S5	1,33**
S6	15,33**
S7	5,33**

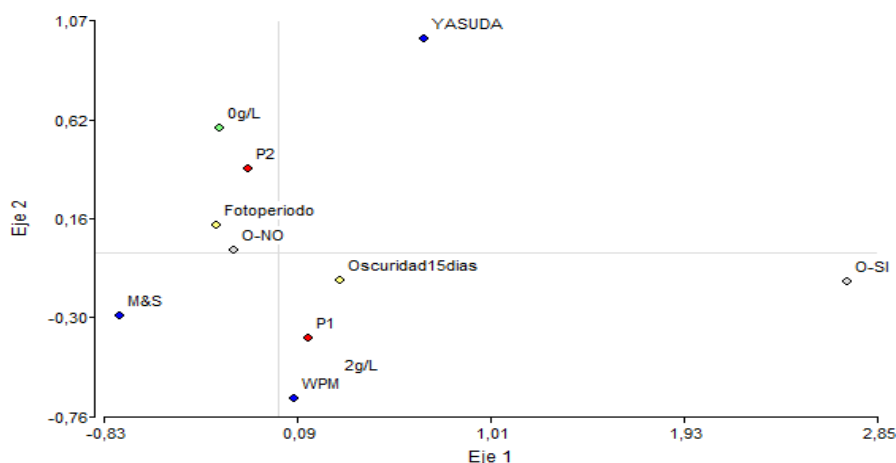
*($p < 0.05$) **($p < 0.01$) obtained in the contingency tables. Source: Authors.

5.2.3 Feasibility

The viability of the explants was 28.49%, being higher for protocol 1 and for the 50% MyS culture medium, and lower for the WPM culture medium. This viability is affected by oxidation and contamination processes, as they cause tissue death (Table 2) (Figure 3).

Figure 4

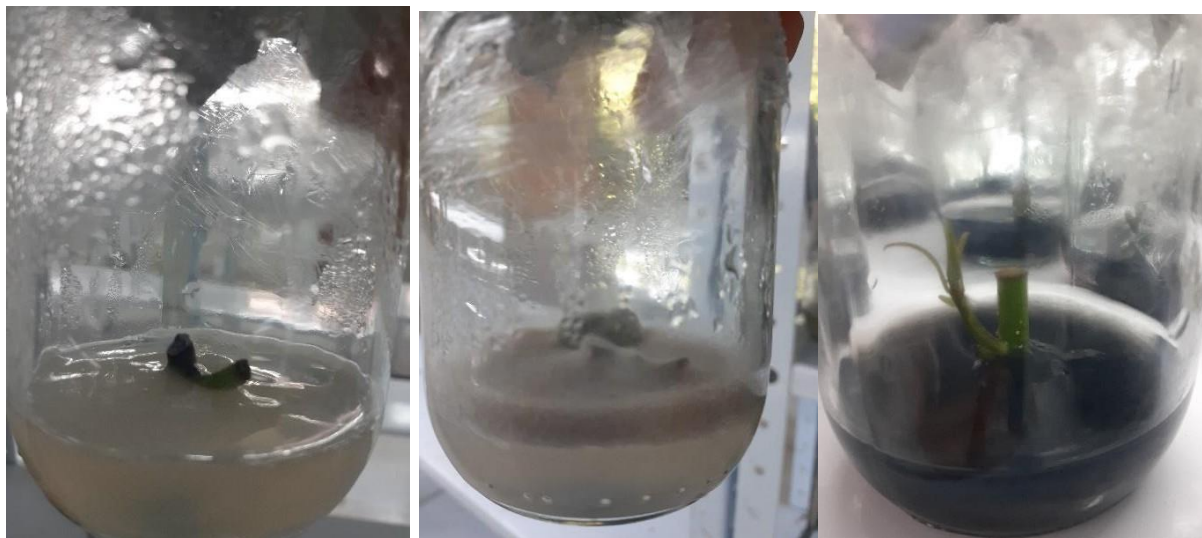
Correspondence analysis for the association of the variables: disinfection protocol 1 (P1), disinfection protocol 2 (P2), Oxidation (O), WPM culture medium, Yasuda and MyS. Activated charcoal 2g/l and activated charcoal 0g/l, Photoperiod in quarter growth and darkness in quarter growth for 15 days, (NO) negative, (IF) positive



Source: Retrieved from the Infostat 2008 statistical program.

Figure 5

a) *bacterial contamination*, b) *fungal contamination*, c) *viable explant in culture medium*



Source: Authors.

6 CONCLUSIONS

Disinfection protocol 1 was the one with the highest percentage of viability. The three culture media in the establishment stage allowed the development of the explants; however, the 50% MyS culture medium had the highest viability. The percentage of contamination was high while oxidation was very low, this indicates that the different treatments to prevent oxidation were efficient, presenting a slight improvement with the treatment in which ascorbic acid and citric acid were used. On the other hand, the high incidence of contamination may be due to various factors such as the plant health of the mother plants, handling at the time of sowing and the disinfection protocols used. Because it is an ongoing project, it is expected to obtain results from the use of different growth hormones in the multiplication stage.

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**MICROSENSORS AND MICROACTUATORS IN IOT SYSTEMS WITH ESP32
FOR MONITORING AND CONTROL**

**MICROSSENSORES E MICROATUADORES EM SISTEMAS IOT COM ESP32
PARA MONITORIZAÇÃO E CONTROLO**

**MICROSENSORES Y MICROACTUADORES EN SISTEMAS IOT CON ESP32
PARA MONITOREO Y CONTROL**

 <https://doi.org/10.56238/sevened2025.036-160>

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ABSTRACT

The rapid advancement of the Internet of Things (IoT) has driven the need for intelligent systems capable of combining miniaturization, energy efficiency, and high computational performance. In this context, this article analyzes the integration of microsenors and microactuators, largely based on MEMS (Micro-Electro-Mechanical Systems) technology with the ESP32 microcontroller. The ESP32 platform stands out as a suitable solution for low-cost IoT applications due to its dual-core architecture, processing flexibility, and multiple connectivity options, such as Wi-Fi, Bluetooth, and LoRa, enabling the development of compact, efficient, and connected systems.

Keywords: Microsensors. Microactuators. IoT Systems. Monitoring.

RESUMO

O avanço acelerado da Internet das Coisas (IoT) tem impulsionado a necessidade de sistemas inteligentes capazes de aliar miniaturização, eficiência energética e elevado desempenho computacional. Neste contexto, este artigo analisa a integração de

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microsensores e microatuadores, em grande parte baseados na tecnologia MEMS (Micro-Electro-Mechanical Systems), com o microcontrolador ESP32. A plataforma ESP32 destaca-se como uma solução adequada para aplicações IoT de baixo custo, devido à sua arquitetura dual-core, à flexibilidade de processamento e às múltiplas opções de conectividade, como Wi-Fi, Bluetooth e LoRa, possibilitando o desenvolvimento de sistemas compactos, eficientes e conectados.

Palavras-chave: Microsensores. Microatuadores. Sistemas IoT. Monitoramento.

RESUMEN

El rápido avance del Internet de las Cosas (IoT) ha impulsado la necesidad de sistemas inteligentes capaces de combinar miniaturización, eficiencia energética y alto rendimiento computacional. En este contexto, este artículo analiza la integración de microsensores y microactuadores, en su mayoría basados en la tecnología MEMS (Micro-Electro-Mechanical Systems), con el microcontrolador ESP32. La plataforma ESP32 se destaca como una solución adecuada para aplicaciones IoT de bajo costo, gracias a su arquitectura de doble núcleo, su flexibilidad de procesamiento y sus múltiples opciones de conectividad, como Wi-Fi, Bluetooth y LoRa, lo que permite el desarrollo de sistemas compactos, eficientes y conectados.

Palabras clave: Microsensores. Microactuadores. Sistemas IoT. Monitoreo.

1 INTRODUCTION

The Internet of Things (IoT) has emerged as one of the main technological paradigms of contemporary digital transformation, characterized by the interconnection of intelligent physical objects endowed with sensing, processing, and real-time data communication capabilities. This approach has promoted profound changes across multiple domains, including advanced manufacturing within Industry 4.0, smart cities, precision agriculture, environmental monitoring, and connected healthcare systems, enabling increased automation, operational efficiency, and data-driven decision support (Abdulhussain, 2025; Jing, 2023; Gazis, 2025).

From an architectural perspective, IoT systems are composed of multiple functional layers in which the interaction between the physical environment and the digital domain is primarily enabled by interface devices such as microsensors and microactuators (Senturia, 2000). These components are critical to the success and scalability of IoT applications, since data acquisition quality and actuation accuracy directly affect overall system performance (Witczak, 2024).

Microsensors play a fundamental role in the acquisition of physical, chemical, and biological variables, such as temperature, pressure, vibration, humidity, and gas composition, providing essential information for continuous and distributed monitoring. Microactuators, in turn, are responsible for active intervention in the environment, enabling control actions, adjustments, and automated responses, and are widely employed in positioning systems, micromirrors, acoustic devices, and biomedical applications (Amara, 2025; Ahmad, 2024; Islam, 2025).

The growing demand for compact, energy-efficient, and low-cost IoT devices has significantly driven advances in Micro-Electro-Mechanical Systems (MEMS) technologies. The miniaturization enabled by these systems allows the integration of sensors and actuators at micrometer scales while maintaining high sensitivity, low power consumption, and high reliability (Cheng, 2025). Recent studies highlight that advances in functional materials, fabrication techniques, and transduction structures have enhanced MEMS device performance, making them increasingly suitable for large-scale IoT deployments and operation in challenging environments (Fang, X., 2025; Jung, Y., 2025; Wan, Z., 2025; Ferreira, 2024).

Furthermore, recent research indicates that the combined use of MEMS-based microsensors and microactuators fosters the development of intelligent systems with a higher

degree of autonomy, enabling the implementation of advanced control strategies and predictive maintenance. In particular, applications involving vibration, temperature, and environmental variable monitoring have directly benefited from the integration of these devices into low-power IoT platforms (Kolok, 2025; Gazis, 2025).

In parallel with the advancement of MEMS devices, there has been significant evolution in embedded processing platforms used in IoT systems. System-on-a-Chip (SoC) microcontrollers have increasingly incorporated advanced wireless connectivity, processing capabilities, and power management features, thereby reducing both hardware and embedded software complexity (Hercog, 2023). Within this context, the ESP32 platform stands out for offering low-power Wi-Fi and Bluetooth connectivity, adequate computational performance, and widespread adoption in both academic and industrial applications.

Moreover, the integration of the ESP32 with long-range, low-power communication technologies such as LoRa significantly expands the application scope of IoT systems, enabling the monitoring and control of distributed devices over large geographical areas. Recent studies demonstrate that this combination is particularly effective in scenarios such as precision agriculture, predictive maintenance, and remote environmental monitoring, where communication reliability and energy efficiency are critical requirements (Le, 2021; Kolok, 2025; Gazis, 2025).

Within this context, this article proposes an analysis of the integration of MEMS-based microsensors and microactuators with the ESP32 platform, evaluating aspects such as technical feasibility, robustness, and energy efficiency of the proposed solution. The objective is to demonstrate that this approach represents a promising alternative for the development of practical monitoring and control systems within the Internet of Things framework, in alignment with recent trends reported in scientific literature.

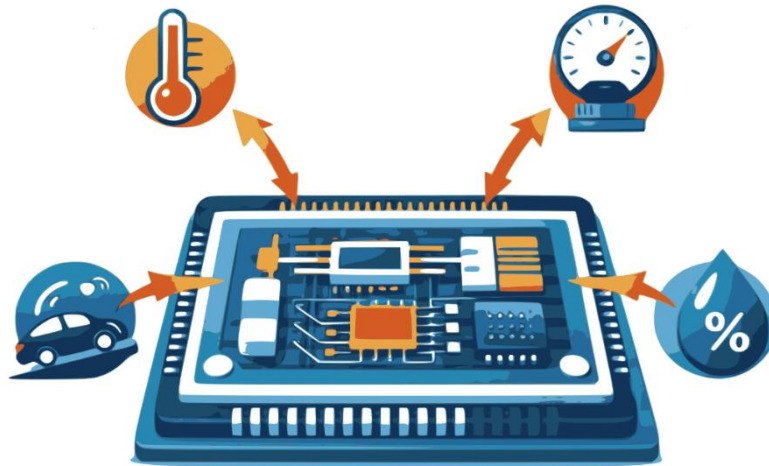
2 THE MINIATURIZATION OF COMPONENTS

The convergence of component miniaturization and the increasing ubiquity of the Internet of Things (IoT) has driven the development of intelligent systems capable of autonomously perceiving, processing information, and interacting with the environment. In this context, microsensors and microactuators play a central role as interface elements between the physical world and the digital domain, enabling data acquisition and the execution of control actions. Frequently based on Micro-Electro-Mechanical Systems (MEMS) technology, Figure 1, these devices allow the efficient integration of sensing and

actuation functions into compact, energy-efficient systems suitable for large-scale distributed applications.

Figure 1

MEMS (Micro-Electro-Mechanical Systems)



Source: Produced by the author, 2025.

MEMS are miniaturized systems that integrate mechanical components, sensors, actuators, and electronic circuits onto a single substrate, typically fabricated in silicon using processes derived from microelectronics. This integration enables the sensing and actuation of physical quantities such as pressure, acceleration, temperature, sound, and electric or magnetic fields with high precision and low power consumption. Owing to their small size, low cost in mass production, and high reliability, MEMS have become essential in a wide range of modern applications, including mobile devices, automotive systems, medical equipment, industrial instrumentation, and IoT solutions, contributing significantly to system miniaturization and the increasing intelligence of advanced technological systems.

(I) Microsensors and MEMS Technology

Microsensors are transducer devices responsible for converting physical quantities—such as temperature, pressure, acceleration, or humidity—into electrical signals that can be measured and processed. These components form the foundation of sensing in modern systems and play an essential role in applications that require continuous and accurate monitoring. MEMS technology is widely used in the fabrication of most contemporary microsensors, as it enables the integration of mechanical structures, sensing elements, and

electronic circuits for signal conditioning and processing onto a single silicon substrate, with dimensions ranging from micrometers to millimeters. Table 1 presents a comparison of commonly used microsensors in IoT projects, highlighting their typical applications and associated operating principles.

Table 1
Comparison of Common Microsensors in IoT Systems

Sensor	Measured Quantity	Operating Principle	Typical Applications
DHT22	Temperature and Humidity	Capacitive (Humidity), Thermistor (Temperature)	Environmental Monitoring, Smart Greenhouses
BMP280	Barometric Pressure and Temperature	Piezoresistive	Weather Stations, Indoor Navigation (Altitude)
MPU-6050	Acceleration and Angular Velocity	Piezoresistive (Accelerometer), Gyroscope (Coriolis Effect)	Predictive Maintenance (Vibration), Robotics, Drones
MQ-X	Gas Concentration (e.g., CO, Methane)	Semiconductor (Resistance Variation)	Air Quality Monitoring, Industrial Safety

Source: Produced by the author, 2025.

The operating principles of MEMS-based microsensors may vary depending on the physical quantity to be measured and the intended application. Among the most common mechanisms is the piezoresistive principle, widely employed in pressure sensors and accelerometers, in which the electrical resistance of a material changes when subjected to mechanical deformation. Another frequently used principle is the capacitive mechanism, typical of accelerometers and humidity sensors, which is based on variations in capacitance between electrodes caused by mechanical displacement or the presence of a variable dielectric medium. In addition, thermal sensors exploit phenomena related to heat transfer or voltage variation with temperature and are commonly used in flow sensors and thermocouples.

The miniaturization enabled by MEMS technology provides benefits that extend beyond simple reductions in size and cost. Miniaturized sensors generally exhibit higher sensitivity, faster response times, and lower power consumption—features that are fundamental for embedded and distributed systems. These advantages make MEMS-based

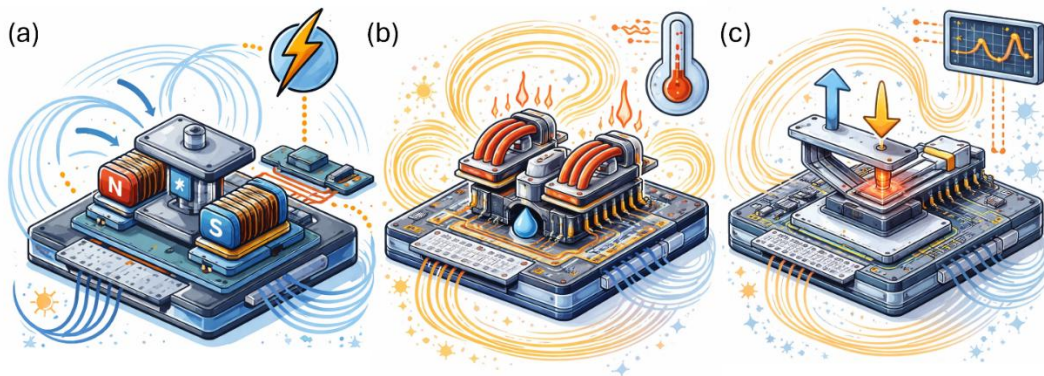
microsensors particularly well suited for Internet of Things (IoT) applications, in which large numbers of devices must operate efficiently, reliably, and with extended energy autonomy.

(II) Microatuadores e o Controle de Sistemas

Microactuators are components responsible for converting electrical control signals generated by the embedded system into physical or mechanical actions in the environment. They play a fundamental role in microelectromechanical systems, enabling digital decisions to produce tangible effects in the physical world. These principles are illustrated in a didactic manner in Figure 2.

Figure 2

Microactuators: (a) Electromagnetic, (b) Electrothermal, and (c) Piezoelectric



Source: Produced by the author, 2025.

Like sensors, many actuators benefit from MEMS technology, which enables the fabrication of devices with high precision, reduced dimensions, and low power consumption. These characteristics make microactuators particularly suitable for embedded applications and miniaturized systems. Among the main types of microactuators are electromagnetic actuators, which use the Lorentz force to generate motion and are widely employed in micro-relays and microvalves. Electrothermal actuators are also prominent; they are based on the thermal expansion of materials, such as thermal bimorphs, and are commonly used in microvalves and optical shutters.

Another important class of microactuators is piezoelectric microactuators, which exploit the inverse piezoelectric effect to generate high-precision and high-force movements. These devices are essential in fine positioning systems, micropumps, and applications that require precise displacement control. In control systems, the microactuator is the element

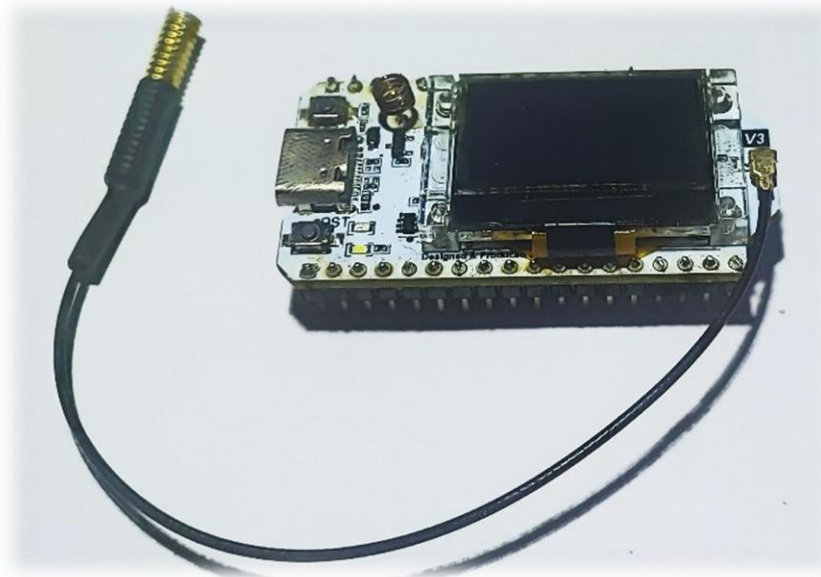
responsible for closing the feedback loop: the microsensor measures the variable of interest, the controller processes this information, and the microactuator acts on the environment, adjusting the system until the desired operating point is achieved.

(III) Runtime Optimizations

The ESP32, developed by Espressif Systems, is a System-on-a-Chip (SoC) that has become one of the leading platforms for the development of Internet of Things (IoT) prototypes and products, combining low cost, high performance, and considerable versatility. Its technical characteristics make it particularly well suited for integration with microsensors and microactuators. From a processing standpoint, the ESP32 features a microcontroller capable of executing concurrent tasks, allowing, for instance, sensor data acquisition to be handled by one core while wireless communication is managed by another core. This capability is commonly observed in applications such as the Heltec Automation LoRa 32 V3, as illustrated in Figure 03.

Figure 3

Heltec Automation LoRa 32 V3



Source: Produced by the author, 2025.

In terms of connectivity, the ESP32 integrates Wi-Fi modules compliant with the 802.11 b/g/n standards and Bluetooth Low Energy (BLE), which are essential for communication with cloud services and mobile devices. In addition, it can operate with LoRa technologies across

frequency bands ranging approximately from 433 to 510 MHz and from 863 to 928 MHz, significantly extending its range for long-distance and low-power applications.

Regarding interfaces, the ESP32 provides a wide variety of peripheral options, including GPIOs, I²C, SPI, UART, ADC, and DAC, which facilitates direct connection to most commercially available microsensors and microactuators, thereby reducing the need for complex external circuitry.

The combination of processing capability, multiple connectivity options, and low power consumption makes the ESP32 a robust solution for monitoring and control systems. These characteristics enable advanced applications such as predictive maintenance, industrial automation, and real-time environmental monitoring.

(IV) Environmental Monitoring and Control System

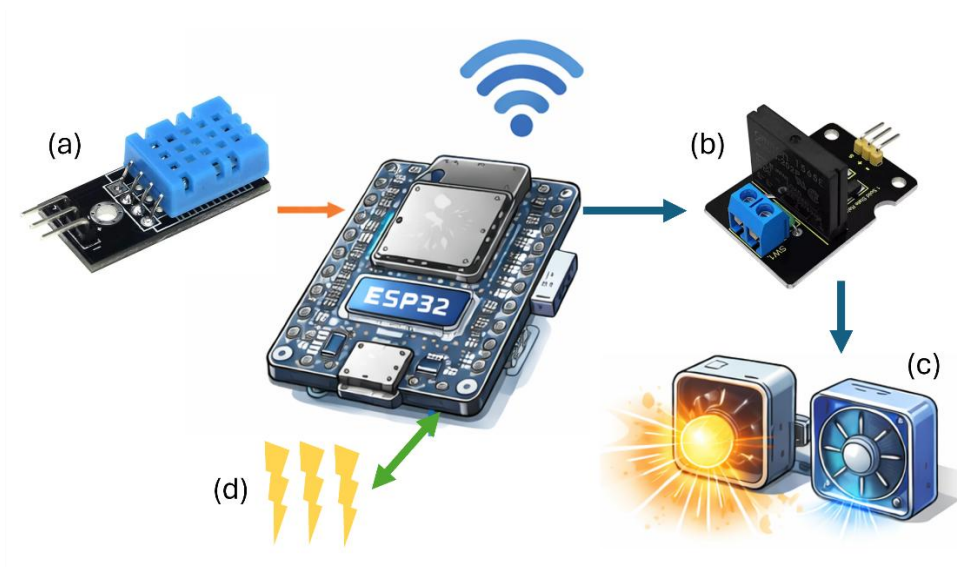
The system adopts a hardware architecture composed of a central controller, sensors, and actuators, designed for environmental monitoring and control applications. The controller used is the ESP32, which is responsible for data processing, execution of the control logic, and Wi-Fi connectivity, enabling system integration with external monitoring platforms.

As a microsensor, the digital temperature and humidity sensor DHT22, also known as the AM2302, is employed. This sensor was selected due to its good accuracy, low cost, and ease of interfacing with microcontrollers, providing reliable measurements of the environmental variables required for greenhouse control.

The system's microactuator is a solid-state relay (SSR) module, which operates as an electromagnetic microactuator. It is responsible for switching heating devices, such as a lamp, and cooling devices, such as a fan, on or off, allowing environmental variables to be adjusted according to the conditions measured by the sensor. Figure 4 illustrates the architecture of this Environmental Monitoring and Control System for a smart greenhouse.

Figure 4

Architecture of the Intelligent System: (a) DHT22 microsensor, (b) solid-state relay (SSR), (c) heating device (lamp) and cooling device (fan), and (d) power supply and communication via USB Type-C cable.



Source: Produced by the author, 2025.

The system architecture is based on the continuous acquisition of temperature and humidity data by the DHT22 sensor, the processing of this information by the ESP32, and direct actuation on the environment through the relay. In addition, the collected data are transmitted via Wi-Fi to a cloud platform, such as ThingSpeak or Firebase, enabling remote monitoring and historical data storage, as demonstrated in several recent studies on IoT systems.

The control logic implemented in the ESP32 firmware is based on a simple ON/OFF control strategy, primarily focused on temperature regulation. In this model, heating or cooling is activated when the measured variable exceeds predefined threshold limits. If an additional water flow system is integrated with the fan, this control logic can be extended to regulate humidity as well, thereby expanding the functionality of the environmental control system.

3 CONCLUSION

The architecture presented throughout this study clearly demonstrate the effectiveness of integrating microsensors, microactuators, and the ESP32 platform for the implementation of IoT-based monitoring and control systems. The synergy between the miniaturization enabled by MEMS technology and the ESP32's processing capability, connectivity options, and low power consumption yields a solution that is not only robust and scalable, but also economically viable for a broad range of applications, including environmental control, industrial automation, and predictive maintenance.

The practical case study of an environmental control system applied to a smart greenhouse further reinforces these findings. By employing a temperature and humidity microsensor (DHT22) in conjunction with a relay-based microactuator, the proposed architecture successfully closes the control loop, enabling real-time data acquisition, timely decision-making, and rapid actuation on the physical environment. This configuration demonstrates how relatively simple control strategies, such as ON/OFF control, can be effectively implemented using low-cost hardware while still achieving reliable and responsive system behavior.

Beyond the specific application presented, the proposed architecture highlights the flexibility and adaptability of the ESP32–MEMS combination, which can be readily extended to more complex control schemes, additional sensing modalities, and distributed system topologies. The integration with cloud platforms for remote monitoring and data storage further enhances the system's usability and scalability, supporting data-driven analysis and long-term performance assessment.

In conclusion, the integration of the ESP32 with MEMS-based microsensors and microactuators constitutes a solid and promising foundation for the development of next-generation IoT systems. Future work may focus on further optimizing energy consumption, implementing advanced control algorithms, and incorporating Edge Computing concepts to enable local data processing, reduced latency, and increased system autonomy, thereby addressing emerging challenges in large-scale and mission-critical IoT deployments.

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KNOWLEDGE, EXPERIENCES, AND EXPERIENCES: NARRATIVES OF BLACK WOMEN IN THE FACE OF DOMESTIC VIOLENCE

SABERES, VIVÊNCIAS E EXPERIÊNCIAS: NARRATIVAS DE MULHERES NEGRAS NO ENFRENTAMENTO À VIOLÊNCIA DOMÉSTICA

CONOCIMIENTOS, EXPERIENCIAS Y CONVERSACIONES MUNDIALES: NARRATIVAS DE MUJERES NEGRAS FRENTE A LA VIOLENCIA DOMÉSTICA

 <https://doi.org/10.56238/sevened2025.036-161>

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ABSTRACT

This article investigates the narratives of Black women facing domestic violence, which emerge as important sources of tacit knowledge and resistance practices. From an intersectional perspective of gender and race, this article investigates the experiences of victims living in Northeastern communities. Furthermore, the research question focuses on the following: what knowledge, experiences, and practices are mobilized through the narratives of Black women in confronting domestic violence? The specific objectives are: i) to identify and understand the knowledge and practices of Black women; ii) to describe the personal, social, historical, cultural, and educational contexts of these women victims of domestic violence; iii) to identify the different forms of violence to which they are subjected in their own homes, considering the intersectionality of gender and race, according to Carneiro (2003) and Ribeiro (2017). The research corresponds to a qualitative bibliographical and documentary research. Finally, we conclude that the narratives of Black women victims of domestic violence reveal a rich array of knowledge, experiences, and experiences grounded in non- school knowledge, community care practices, and oral literature.

Keywords: Black Women. Domestic Violence. Black Feminism. Non-School Knowledge.

RESUMO

O presente artigo investiga as narrativas de mulheres negras que enfrentam violência doméstica emergem como importantes fontes de saberes tácitos e práticas de resistência, este estudo investiga, sob uma perspectiva interseccional de gênero e raça, as vivências e experiências de vítimas residentes nas comunidades nordestinas. Ademais, o problema de pesquisa centra-se na seguinte questão: quais saberes, vivências e experiências são mobilizados, através das narrativas de mulheres negras, no enfrentamento à violência doméstica? Os objetivos específicos configuram-se em: i) identificar e conhecer os saberes e fazeres das mulheres pretas; ii) descrever o contexto pessoal, social, histórico, cultural e educacional dessas mulheres vítimas de violência doméstica; iii) identificar as diferentes formas de violência às quais estão submetidas em seu próprio lar, considerando a interseccionalidade de gênero e raça, segundo Carneiro (2003) e Ribeiro (2017). Com a investigação corresponde a uma pesquisa bibliográfica documental de matriz qualitativa. Por fim, conclui-se que as narrativas de mulheres negras vítimas de violência doméstica, revelam

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um rico leque de saberes, vivências e experiências fundamentadas em saberes não escolares, práticas de cuidado comunitário e oralituras.

Palavras-chave: Mulheres Negras. Violência Doméstica. Feminismo Negro. Saberes Não Escolares.

RESUMEN

Este artículo investiga cómo las narrativas de mujeres negras que enfrentan violencia doméstica emergen como fuentes importantes de conocimiento tácito y prácticas de resistencia. Este estudio investiga, desde una perspectiva interseccional de género y raza, las experiencias de las víctimas que residen en comunidades del noreste. Además, el problema de investigación se centra en la siguiente pregunta: ¿qué conocimientos, experiencias y prácticas se movilizan, a través de las narrativas de las mujeres negras, al enfrentar la violencia doméstica? Los objetivos específicos son: i) identificar y comprender los conocimientos y prácticas de las mujeres negras; ii) describir el contexto personal, social, histórico, cultural y educativo de estas mujeres víctimas de violencia doméstica; iii) identificar las diferentes formas de violencia a las que son sometidas en sus propios hogares, considerando la interseccionalidad de género y raza, según Carneiro (2003) y Ribeiro (2017). La investigación corresponde a una investigación cualitativa bibliográfica y documental. Finalmente, se concluye que las narrativas de mujeres negras víctimas de violencia doméstica revelan una rica gama de conocimientos, experiencias y vivencias basadas en conocimientos no formales, prácticas de cuidado comunitario y tradiciones orales.

Palabras clave: Mujeres Negras. Violencia Doméstica. Feminismo Negro. Conocimiento No Formal.

1 INTRODUCTION

Considering that the narratives of black women who face domestic violence emerge as important sources of tacit knowledge and practices of resistance, this article investigates, from an intersectional perspective of gender and race, the experiences of victims living in Northeastern communities. In this sense, the Brazilian panorama marked by epistemicide dominates, while racist and sexist discourses historically shape the social position of black women (Gonzales, 1983; Davis, 2018).

The Maria da Penha Law (Brazil, 2006) and the Femicide Law (Brazil, 2015) represent institutional advances, however, without incorporating the multiple forms of violence that cross the body and subjectivity of these women, they keep invisible the non-school knowledge shaped in collectives and conversation circles.

Law No. 13,104, which came into force on March 9, 2015, amending article 121 of the Penal Code to include the criminal type as a qualifying circumstance for the crime of homicide, with a penalty of imprisonment of 12 to 30 years, soon after its approval, this law was included in the list of heinous crimes such as: rape, genocide and robbery. The law is an achievement of feminist movements to give visibility to this crime that victimizes a woman every two hours in the country and enables the improvement of public policies to prevent this extreme form of violence against women (Brasil, 2015).

The culture and gender hierarchies present in patriarchal societies, in addition to structural violence, are determining factors of femicide. The frequency of femicides is higher when there are social inequities, armed conflicts, migration, gender discrimination, and the exercise of hegemonic and aggressive masculinity (Silva; Seabra; Junior; 2016).

Thus, researching violence, its causes, and how to combat it is hard work and a very complex challenge, not least because it is a phenomenon of multiple origins and various nuances and perceptions of laws, policies, and cultures involved in the act of violence and its consequences, especially when this violence is against women.

Considering that the patriarchal structure is sexist in nature, based on the domination and power of men over women, that is, a world of the male gender par excellence. In patriarchal society, there is a homeland that is recorded as if it were (and in fact was) the amplified family itself, whose male figures stood out. This domination or sexist conception generated social results that were not always positive (Silva; Seabra; Junior; 2016).

In line with Ricoeur (2012), narrative construction assumes a central role in revealing not only trajectories of pain, but also strategies for reencountering one's own body, enhancing

the becoming-woman proposed by Deleuze and Guattari (1995) as a tool for deconstructing the hegemonic narrative. In this way, it seeks to problematize how ancestral knowledge, orality and community practices are articulated in the production of attitudes towards domestic violence.

In light of this problem, the general objective of this study is to analyze the narratives of black women who face domestic violence emerge as important sources of tacit knowledge and practices of resistance. In view of the above, the research problem focuses on the following question: what knowledge, experiences and experiences are mobilized, through the narratives of black women, in confronting domestic violence?

The specific objectives are configured as: i) to identify and know the knowledge and practices of black women; ii) describe the personal, social, historical, cultural and educational context of these women victims of domestic violence; iii) identify the different forms of violence to which they are subjected in their own home, considering the intersectionality of gender and race, according to Carneiro (2003) and Ribeiro (2017).

The article aims to fill gaps in the literature by articulating theory and life history, enhancing the production of critical knowledge for the formulation of more effective public policies, aligned with black feminist epistemologies (Gomes, 2019; Pereira; Carneiro, 2019).

In view of these premises, the structure of this article is divided into five main sections, strictly following the ABNT standards. The first section comprises the theoretical framework, in which basic concepts such as non-formal education (Trilla, 2011), body-writing (Maluf, 1999) and narrativity (Benjamin, 2001; Cardoso, 2007).

This is followed by a description of the qualitative and bibliographic methodology adopted, complemented by visits to the Specialized Women's Police Stations, to the Maria da Penha Patrol of the Military Police. In the analysis section, the narratives collected in the periodicals are presented and interpreted, illustrated by the ethnographic scene of a black feminism meeting in the Brazilian Northeast. as described by Strathern (2016).

Finally, the final considerations summarize the main findings and indicate paths for future research and for the strengthening of public policies. In addition, in accordance with CNS Resolution No. 510/2016, there is no need for evaluation by the CEP, given the documentary and low-risk nature of the research.

2 METHODOLOGY

In line with Creswell (2014), a qualitative approach of a theoretical nature was adopted, based on bibliographic research and documentary analysis of laws, official reports and scientific articles, which defines this path as one based on multiple meanings and historical-social perspective.

Considering that scientific research is present in every field of science, in the field of education we find several published or in progress. It is a process of investigation to solve, answer or deepen a question in the study of a phenomenon.

According to Bastos and Keller (1995, p. 53) define: "Scientific research is a methodical investigation of a given subject with the objective of clarifying aspects under study". For Gil (2002, p. 17) "Research is required when there is not enough information to answer the problem, or when the available information is in such a state of disorder that it cannot be adequately related to the problem".

Bibliographic research is mainly inserted in the academic environment and has the purpose of improving and updating knowledge, through a scientific investigation of works already published.

In this context, bibliographic research is a fundamental skill in undergraduate courses, since it constitutes the first step for all academic activities. A laboratory or field research necessarily implies preliminary bibliographic research. Seminars, panels, debates, critical summaries, monographs do not dispense with bibliographic research.

It is mandatory in exploratory research, in the delimitation of the theme of a work or research, in the development of the subject, in citations, in the presentation of conclusions. Therefore, if it is true that not all students will carry out laboratory or field research, it is no less true that all, without exception, in order to prepare the various works requested, must undertake bibliographic research (Andrade, 2010, p. 25).

The instruments that are used in the bibliographic research are: books, scientific articles, theses, dissertations, yearbooks, magazines, laws and other types of written sources that have already been published.

Bibliographic research, according to Fonseca (2002), is carried out "based on the survey of theoretical references already analyzed, and published by written and electronic means, such as books, scientific articles, web site pages". Thus, any scientific work begins with a bibliographic research, which allows the researcher to know what has already been studied on the subject.

There are, however, scientific studies that are based solely on bibliographic research, looking for published theoretical references with the objective of collecting information or prior knowledge about the problem to which the answer is sought (Fonseca, 2002, p. 32).

In this way, sources were explored, such as visits to the social networks of the Specialized Women's Police Stations, the Maria da Penha Patrol of the Military Police, complemented by institutional documents (Association of Women Against Violence, 2018; Brazilian Yearbook of Public Security, 2021). This triangulation of data sought to confront official narratives with community knowledge, as recommended by Wolcott (2010 apud Creswell, 2014), giving greater validity to the study.

Questions guided the collection of information: How do the individual narratives of black women articulate with collective articulations in non-school spaces? How do these reports show tacit knowledge of coping with violence? The initial stage consisted of systematic bibliographic mapping in databases such as Scielo, Capes and Google Scholar, using descriptors such as "black women", "domestic violence", "black feminism" and "non-school knowledge".

Subsequently, qualitative content analysis was carried out, according to Bardin (2011), to identify emerging thematic categories, such as body writing and community care. In addition, texts by classic and contemporary authors were consulted, ensuring the required temporal and conceptual diversity (Adorno, 1997; Benjamin, 2001; Gonzales, 1983; Davis, 2018; Ricoeur, 2012).

3 RESULTS AND DISCUSSIONS

This section presents the theoretical and conceptual basis that supports the study. It defines the context of the research, explains the key concepts related to the topic and demonstrates the relevance of the study through the discussion of previous theories and research. As in the Maria da Penha Patrol of the Military Police of Maranhão (PMMA), which acts in the execution of the Maria da Penha Law through standard operating procedures and projects for prevention and care for women in situations of violence.

This law defines various types of violence (physical, psychological, sexual, patrimonial) and the PMMA aims to protect victims and punish aggressors, based on Law No. 11,340/2006, which also provides mechanisms for the protection of women's rights (Brasil, 2006).

Since 2017, the Maria da Penha Patrol has provided 42 thousand services throughout Maranhão. Of these procedures, 580 are arrests for non-compliance with protective measures. The group has its own personnel, vehicles and a partnership with justice agencies. It was created by State Decree No. 31,763, of May 20, 2016. The group is an organ of the Military Police of Maranhão and is part of the Community Security Command, which are linked to the State Secretariat of Public Security (SSP).

The Maria da Penha Patrol works in the care and monitoring of women in vulnerable situations, victims of domestic and family violence, holder of emergency protective measures, granted by the competent authority, supervising compliance with it. To fulfill this mission, it carries out ostensible and preventive policing, with daily assistance through visits, rounds and telephone contacts.

Welcome, security and guarantee of dignity to women who are victims of violence. The work of the Maria da Penha Patrol is consolidated as one of the most important tools for the combat, prevention and control of crimes against women. Maranhão has 13 groups of these, strategically implemented in regional offices that reach more than 40 municipalities and surrounding areas.

The most extreme manifestation of violence against women is that which culminates in death. Deaths resulting from the practice of gender violence are currently called femicide.

In addition, the overwhelming majority of these crimes are committed by men, especially by partners or ex-partners, and result from situations of abuse in the home, threats or intimidation, sexual violence, or situations in which women have less power or fewer resources than men. However, before scrutinizing the minors of femicide itself, it is necessary to start with an analysis and understanding of the very conception of gender violence (Redondo; Pimentel; Correia, 2012; Alarcão, 2006).

Furthermore, considering that violence has always been associated with the human experience, and that the individual is part of the suprasystems of community and society, this is a phenomenon with cultural and historical roots, legitimized by traditions and accompanied by the complicit silence of the witnesses in the community and the victims (Krug et al., 2002; Lisbon; Vicente; Barroso, 2005).

It is worth noting that the family's behavior in the face of violence as a crisis can be predicted through the study of previous patterns, and it is common to find, during the elaboration of the history of this family, previous situations in which the aggressor witnessed

conjugal violence or being himself, or someone from the phratry, a victim of mistreatment or sexual abuse (Minuchin, 1982; Rolland, 2000; Alarcão, 2006).

Women are the most common victim, one in three women in the world have been beaten, forced to have sex, or abused in one way or another in their lives, and the aggressor is usually someone close to the woman, and 40% to 70% of homicides in which the victim is female are the culprit is her husband or boyfriend (Krug et al., 2002).

In this lamiré, it is possible to recognize that the struggle of the various feminist movements to make public the violence suffered by women, in order to recognize it as a problem that involves society in general, still encounters an obstacle in the face of family power, which manages to silence such a situation (Bandeira, 2014).

In this context, the assumption that violence against women is a type of violence apprehended during the primary processes of socialization and displaced to the sphere of society in secondary moments of socialization and in the sociability of adult life. This, therefore, is not characterized as a pathology or as an individual deviation, but rather as "social permission" granted and agreed with men in society (Soares, 1999).

Thus, from this perspective, the concept of non-school knowledge takes center stage in the understanding of learning constituted throughout life, in daily relationships and in community practices. According to Trilla (2011, p. 19), "non-formal education is any organized, systematic, educational activity, carried out outside the framework of the official system".

Furthermore, Pedreño (2017, p. 280) argues that this tacit knowledge "transforms us, shapes our lives and shapes them, in the sense of producing attitude and conduct". In this context, Nilma Lino Gomes (2019) highlights the black educator movement as a locus for the construction of critical epistemologies, while Sueli Carneiro (2003) demonstrates, in "Enegrecer o feminismo", how colonial violence shaped imaginaries about the black body, eroticizing and objectifying it.

In addition, Angela Davis (2018) in "Woman, race and class" points out the interconnection between oppressions, showing that knowledge of resistance is produced in multiple spaces, from congada circles to meetings of feminist collectives, according to Hooks (2018).

In line with Anderson (2007 apud Cardoso, 2007), narration is not reduced to a simple historical reconstruction, but acts as a device for the co-construction of meaning. Walter

Benjamin (2001, p. 37) warns that "the narrator holds in himself the accumulation of experience, and transmits an experience to the other".

Thus, *oralituras*, a term expanded by Martins (2003), allude to the sociocultural phenomenon in which body, memory and writing are intertwined, creating body-writing that resists epistemological erasure.

On the other hand, Deleuze and Guattari (1995) propose the concept of becoming-woman, which allows us to glimpse trajectories of escape from the gender binary and racial subalternity, materializing as a tool for re-signification of everyday experience. Upon This analysis, it is worth highlighting the conceptual contribution of intersectionality, defended by black feminism and authors such as Djamila Ribeiro (2017), to understand the simultaneity of gender, race, class, and sexuality oppressions.

Furthermore, Salisbury (2019) and Lopes (2014) corroborate this view by pointing out that the experience of black women in Brazil cannot be dissociated from community care practices, food preparation, and ancestral knowledge transmitted through generations.

In addition, Ricoeur (2012) offers an important framework for understanding the intertwining between time and narrative, showing how subjective experiences are rewritten day after day, projecting themselves into the future and reappearing in the present, tensioning the notions of the past and becoming.

On the other hand, research such as Gregori (1989) and Fonseca and Lucas (2006) describe the psychological and social consequences of domestic violence, pointing out gaps in the traditional approach, which often makes the racial profile invisible.

Bianchini, Bazzo and Chakian (2022) emphasize that the Maria da Penha Law (BRASIL, 2006) and the Femicide Law (Brasil, 2015) need to incorporate specific policies for black women, otherwise they will reinforce structural inequalities.

In this sense, the articulation between black feminist epistemologies and public policies emerges as a path to the full recognition of the knowledge and practices of resistance of these women, becoming an instrument of emancipation and promotion of human rights.

The narratives and experiences found in the bibliographic research revealed ancestral knowledge shared in groups of children and in the collective preparation of typical Afro-Brazilian foods, configuring care practices that, according to Nilma Lino Gomes (2019), constitute epistemologies of resistance.

Through this analysis, it was observed that sitting on mats and cushions, described in a scene similar to the June 2017 meeting, becomes a rite of passage, as Martins (2003)

highlights, to give visibility to the body-writing, a word that synthesizes experiences of discrimination and community affection. These narratives are loaded with metaphors, such as "my treasure is my body" (Participant, 62 years old), which explain subjective processes of resignification.

On the other hand, reports on types of violence — physical, psychological, patrimonial and sexual — were pointed out in an interconnected way, confirming the intersectional approach of Davis (2018).

One woman reported having been prevented from working, constituting patrimonial violence, while another mentioned recurrent racist insults: "black monkey" and "hard hair", echoing the colonial eroticization described by Carneiro (2003).

These words reflect the naturalization of racist and sexist discourses, corroborated by Gonzales (1983), which permeate public and private institutions, determining social roles, according to Carvalho et al. (2016).

Another emerging dimension refers to the strengthening through participation in black women's collectives, in which there was reconstruction of self-esteem and political empowerment.

This is close to Gomes' (2019) idea of the "black educator movement", revealing that knowledge acquired in non-formal spaces enhances complaints and referrals to protection networks, such as the Maria da Penha Patrol. This process of empowerment resonates with the concept of becoming-woman of Deleuze and Guattari (1995), evidencing trajectories of rupture with cycles of violence.

In addition, the narratives about coping strategies point to practices of articulation with public agencies, the use of solidarity networks and the use of social networks as a tool for collective denunciation. Pinto and Amazonas (2006, p. 34) state that the social visibility of contemporary women challenges subservient models, which materializes in the use of the internet to expose violent behaviors and mobilize support.

In this context, the production of oral narratives presents itself as an important technology of resistance, according to Costa (2015) and Cardoso (2007), enabling the voice of each woman to be heard and recognized.

4 CONCLUSION

In view of the above, it is concluded that the narratives of black women victims of domestic violence in the Brazilian northeast reveal a rich range of knowledge, experiences and experiences based on non-school knowledge, community care practices and orality.

These elements, accompanied by processes of resignification of the body-writing, shape strategies of resistance that go beyond traditional institutional approaches.

In this sense, the importance of public policies aligned with black feminist epistemologies is evident, as suggested by Bianchini, Bazzo and Chakian (2022), to promote effective actions to confront gender and race violence. In addition, the articulation of ancestral knowledge and everyday experiences shows that non-formal education plays a vital role in the construction of attitude and coping behavior (Pedreño, 2017; Trilla, 2011).

It was also observed that, even in the face of hegemonic discourses of racial and gender subjugation, black women have repertoires of resistance that are manifested through collective and individual narratives, acting as devices of empowerment and denunciation.

Nevertheless, the results reinforce the need for critical reflection on the gaps in current laws, such as the Maria da Penha Law (Brazil, 2006) and the Femicide Law (Brazil, 2015), which need to incorporate racial perspectives into their prevention and protection strategies.

From this perspective, policies to strengthen the SUS, psychosocial care, and include the knowledge of black women should be prioritized, as advocated by Davis (2018) and Ribeiro (2017).

Finally, the absence of structured interviews and the need to deepen concrete actions of support networks are pointed out as limitations of this study. Therefore, new empirical studies that integrate participatory methodologies, action research, and evaluation of public programs are recommended. At the same time, the relevance of incorporating the voice of black women at all levels of public policy formulation is reinforced, ensuring that their reports and knowledge feed practices to confront domestic violence in an integral and intersectional way.

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POPULATION, FAMILIES, AND RACIAL INEQUALITIES IN MEXICO
POPULAÇÃO, FAMÍLIAS E DESIGUALDADES RACIAIS NO MÉXICO
POBLACIÓN, FAMILIAS Y DESIGUALDADES RACIALES EN MÉXICO

 <https://doi.org/10.56238/sevened2025.036-162>

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ABSTRACT

This article analyzes demographic and socioeconomic aspects that differ between these excluded populations - indigenous and Afro-descendants, in contrast to the rest of the population. Mexico is a multi-ethnic country with a diverse population composed of European descendants, Afro-descendants, and Indigenous groups, the result of thirty thousand years of an evolving nation until the colonial invasion (1519 to 1521), followed by the colonial period (1521 to 1821), the trafficking and slavery of one hundred and fifty thousand African people, the independence wars (1810 to 1821), a Revolution (1910 to 1920) and the consolidation of the constitutional state, which includes eugenics by the Western assimilation of original peoples and African-descendants through education. This study compares three population groups according to their specific demographic variations in civil status, age at marriage, number of children, family structure, and level of education. The objective is to understand how these racialized groups differ in family behavior and the intersections between demographic and household characteristics. The quantitative methodology includes demographic methods to describe the patterns and differences between ethnically racialized groups and to explain how population reproduce racism conforming to structural and family inequalities. The results show that the demographic transition is less accelerated among indigenous and Afro-descendants, related to their lower level of education and other socio-economic vulnerabilities, but also to fertility and family structure and composition, leading to the need for support for the racialized women and elderly in the next decades, and multi-generational families. Conclusions show the need for specific affirmative policies oriented to support families of Indigenous and Afro-descendants.

Keywords: Indigenous. Afro-Descendant. Family. Ethnic-Racial Inequalities.

RESUMO

Este artigo analisa aspectos demográficos e socioeconômicos que diferem entre essas populações excluídas — indígenas e afrodescendentes — em contraste com o restante da população. O México é um país multiétnico, com uma população diversa composta por descendentes de europeus, afrodescendentes e povos indígenas, resultado de trinta mil anos de formação de uma nação em constante evolução até a invasão colonial (1519 a 1521), seguida pelo período colonial (1521 a 1821), pelo tráfico e pela escravização de cento e cinquenta mil pessoas africanas, pelas guerras de independência (1810 a 1821), por uma Revolução (1910 a 1920) e pela consolidação do Estado constitucional, que incluiu a eugenia

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por meio da assimilação ocidental dos povos originários e dos afrodescendentes via educação. Este estudo compara três grupos populacionais de acordo com variações demográficas específicas no estado civil, idade ao casamento, número de filhos, estrutura familiar e nível de escolaridade. O objetivo é compreender como esses grupos racializados diferem no comportamento familiar e as interseções entre características demográficas e domiciliares. A metodologia quantitativa inclui métodos demográficos para descrever os padrões e as diferenças entre grupos etnicamente racializados e para explicar como a população reproduz o racismo em conformidade com desigualdades estruturais e familiares. Os resultados mostram que a transição demográfica é menos acelerada entre indígenas e afrodescendentes, relacionada ao menor nível de escolaridade e a outras vulnerabilidades socioeconômicas, mas também à fecundidade e à estrutura e composição familiar, levando à necessidade de apoio às mulheres e aos idosos racializados nas próximas décadas, bem como às famílias multigeracionais. As conclusões apontam para a necessidade de políticas afirmativas específicas voltadas ao apoio às famílias indígenas e afrodescendentes.

Palavras-chave: Indígenas. Afrodescendentes. Família. Desigualdades Étnico-Raciais.

RESUMEN

Este artículo analiza aspectos demográficos y socioeconómicos que difieren entre estas poblaciones excluidas —indígenas y afrodescendientes— en contraste con el resto de la población. México es un país multiétnico, con una población diversa compuesta por descendientes de europeos, afrodescendientes y pueblos indígenas, resultado de treinta mil años de conformación de una nación en constante evolución hasta la invasión colonial (1519 a 1521), seguida del periodo colonial (1521 a 1821), el tráfico y la esclavización de ciento cincuenta mil personas africanas, las guerras de independencia (1810 a 1821), una Revolución (1910 a 1920) y la consolidación del Estado constitucional, que incluyó la eugenesia mediante la asimilación occidental de los pueblos originarios y de los afrodescendientes a través de la educación. Este estudio compara tres grupos poblacionales de acuerdo con variaciones demográficas específicas en el estado civil, la edad al matrimonio, el número de hijos, la estructura familiar y el nivel educativo. El objetivo es comprender cómo estos grupos racializados difieren en el comportamiento familiar y las intersecciones entre las características demográficas y del hogar. La metodología cuantitativa incluye métodos demográficos para describir los patrones y las diferencias entre grupos étnico-racializados y para explicar cómo la población reproduce el racismo conforme a desigualdades estructurales y familiares. Los resultados muestran que la transición demográfica es menos acelerada entre los pueblos indígenas y los afrodescendientes, relacionada con su menor nivel educativo y otras vulnerabilidades socioeconómicas, pero también con la fecundidad y la estructura y composición familiar, lo que conduce a la necesidad de apoyo a las mujeres y a las personas mayores racializadas en las próximas décadas, así como a las familias multigeneracionales. Las conclusiones evidencian la necesidad de políticas afirmativas específicas orientadas al apoyo de las familias indígenas y afrodescendientes.

Palabras clave: Indígenas. Afrodescendientes. Familia. Desigualdades Étnico-Raciales.

1 INTRODUCTION

In Latin America, Indigenous and Afro-descendant families play a fundamental role in preserving the culture, traditions, and identity of their communities. Indigenous communities belong to more than five hundred ethnic languages and groups (World Bank, 2015), organized into extended kinship systems that include not only parents and children, but also uncles, aunts, grandparents, and community members. The traditional education system is based on oral transmission of knowledge and customs through community ties and networks. They live based on a subsistence economy of traditional agriculture, fishing, and crafts, combined with informal trade and community tourism. Therefore, in Mexico, people self-define themselves Indigenous as people sharing norms, values and culture in households and communities, independent of whether they speak the language. Indigenous identity and population measures rely on self-declaration, considering whether individuals speak an original language and if they self-identify with original values and customs.

2 LANGUAGE AND SELF-ADSCRIPTION

In Mexico, there are 68 Indigenous groups, each speaking their own native language, which together have 364 variants. (INPI, 2019).

In 2020 there were 23.2 million self-declared Indigenous people or 19% of the total population (INEGI, 2022). Mexico is the country with the largest Indigenous population on the American continent. However, only 7.4 million people aged five and older speak an Indigenous language, and 11.8 million live in a household where the head speaks an Indigenous language. Of the Indigenous language speakers, 2.7% are monolingual, and the majority are older women. Integrationist or assimilation policies have managed to reduce the number of Indigenous language speakers. (INALI, 2009; Nolasco, 2021; INEGI, 2022; INEGI 2024; CONAZA, 2023).

The percentage of the Indigenous-speaking population fell from 6.6% in 2010 to 6.1% in 2020. It is worth remembering that in 1930 it was 16%. Indigenous languages are disappearing due to prevalent discrimination (Nolasco, 2021) from colonization, slavery, and continued with eugenics — a Modern pseudoscience that legitimated social Darwinism, the idea of the European supremacy over all other ethnic groups (Ansley, 1997). At the end of the 18th century, the independency of American colonies continued discrimination by eugenics. The legacy of Africans slavery -- justified with Christianity beliefs, was replaced

with the legitimacy of pseudoscience -- Social Darwinism, Modern biology, and genetics. Eugenics was massively financed and implemented by the Western powers around the world as obligatory discipline in the curricula from basic school until post-graduation, as well as among all the scientific, intellectual, and political framework, as well as in social, reproductive, health, family, and migration policies. In Mexico, the integrationist policy legitimized the Western cultural assimilation, forcing the adoption of Spanish as the only official national language and promoting the *mestizo* identity instead of Indigenous identity. All ethnic groups were forced to abandon their languages and to deny their values and customs, continuing historical-colonial discrimination and population decline. The aspiration of *mestizaje* means whitening population through interethnic marriage, legitimizing racism against Non-European people, values, beliefs and practices. (Ansley, 1997; Gomes, 2024).

Mexican ruling elites and dominant classes are mostly of European origin or *mestizos*, while the Indigenous population are those who recognize themselves as descendants of the original population living in Mesoamerica more than 500 years ago, before the Conquest, preserving their language, values, beliefs, and customs, and a sense of belonging with their land and families (Sandrín, 2016; Nolasco, 2021). Despite after 1970 Mexico adopted multicultural legislation and policies, following international agreements, “the elders do not teach the language to subsequent generations to avoid discrimination.” (Nolasco, 2021).

Afro-descendants arrived in Latin America at the beginning of colonization, with the colonizers, and then became widespread through African slavery, to substitute the Indigenous labor force, decimated by colonization. (Darién, 1995). Modern slavery trafficked millions of Africans to Brazil, Colombia, Mexico, Ecuador, Peru, Central America, and the Caribbean. Colonization and slavery resulted in the displacement and disruption of original families and cultures. Nevertheless, certain communities and individuals maintained ancestral traditions, including music, dance, cuisine, and religions. African families reproduce through matrilineal ties and networks of mutual support, working mostly in informal works and cultural economy, even facing structural racism, stigmatization, and vulnerable social conditions. Afro-descendants are particularly exposed to social and racial violence, and some groups like *quilombolas* (descendants of escaped slaves) fight for land ownership, and, like the Indigenous, they were also displaced from the territories where they have lived for centuries (Gomes, 2024; Lezama 2023; Valdivieso, 2016 Velasco et al, 2014; Gandelman, 2011; Bello and Rangel, 2002; Navarrete, 2004).

In 2020, Afro-Mexicans total 2.6 million or 2% of the Mexican population (INEGI, 2024). Structural racism has predominated with slavery and continued through eugenics, which recognized only Indigenous and Euro-descendants as composing “The Mexican Cosmic Race” (Stern, 2000). Black people are invisible since their arrival until 2020 when, for the first time, they achieved social recognition in Mexico. Despite its official invisibility, their integration into the *mestizo* culture preserved African cultural heritage, whose influences are in dances (*jarocho*, dance of the devils), music, and cuisine, mixed with Indigenous groups living with strong community and cultural cohesion. (Velázquez, 2015; Villafuerte, 2011).

The municipalities where Afro-Mexicans are mostly located in the Costa Chica region, behind the mountains of Guerrero and Oaxaca, where predominated the miscegenation with Indigenous groups; therefore, they do not possess the strong racial or cultural group identity with their African ancestors, like Indigenous people do. (INEGI, 2022)

Forced to adopt Western culture after the Conquest and the legacy of colonization, slavery, Catholic religion, racial miscegenation, Spanish education, and Modern eugenics, Indigenous and Afro-descendants have been racialized and discriminated in all the social and political spheres of the society. Contemporary globalization and migration add new threats to their cultural preservation (Velasco et al, 2014).

In Mexico, structural racism hidden behind jokes, nicknames like “Negro” or “Indio Ladino,” and segregates Indigenous people and Black people from childhood, at school, institutions, in social positions, and in public spaces. The multicultural approach continues the discrimination against miscegenation, hiding the presence of Afro-Mexicans in the population (Gomes, 2024; Navarrete, 2004).

Despite their less visible communities, there are recent advances in legal recognition of African slavery and African descendants in Mexican, who were legitimized as ethnic groups with specific rights since 2019 in the Constitution and in the National Program for Afro-descendants (2021), focused on health and education, as well as with including this ethnic category in the census (Valdivieso, 2016).

Despite colonization, slavery and racism, Indigenous and Afro-descendant families are pillars of Latin American cultural diversity. Numerous Indigenous live in extended families, whit other members residing together within the same household. And Indigenous and afro-descendant women play a key role in cultural transmission and the domestic economy and cultural preservation. Afro-descendant families maintain traditions (music, cooking, religion) and are frequently headed by women, with heavy economic burdens (Gandelman et al,

2011). Despite marginalization, both groups are resilient preserving their community and family values and practices.

3 VALUES, LAND, REPRODUCTION, AND HEALTH.

The collective ownership of the land implies the recognition of ancestral rights and reflects their historical massive participation in the Wars of Independence for the end of slavery and in the Revolution of 1910 for agrarian reform (León-Portilla, 2010). The connection that Indigenous peoples have with the land involves economic, social, identity, and religious elements. Afro-descendants in rural areas also conceive access to land not only as a guarantee of subsistence but also as continued cultural identification. For both, Indigenous people and Afro-descendants, land property, reproduction, family, and health are related to traces of ancestral values, beliefs and customs, as well as to Indigenous languages, all of this interwoven with Indigenous identity and sense of community. (Velasco et al, 2014; Gandelman, 2011; Bello and Rangel, 2002)).

Human reproduction is part of broader processes of social and cultural reproduction; of structures and networks of social relations, framing differences in the exercise of power, reproductive, sexual and family practices of individuals and their groups (Salles and Tuirán, 2001). The Indigenous youth have little autonomy and maintain strong family and social ties (Szasz and Lerner, 2010).

Beliefs and values about reproduction influence family size and contraceptive use, which differ among *mestizos* and Indigenous groups (Navarrete, 2004). Being indigenous reduces the probability of using some form of contraceptive by 45% compared to non-indigenous young women, and the most significant explaining variables are a) completing primary or secondary school, b) having the ideal number of children equal to or higher than four, and c) believing that women's role is to continue studying or working (No-family) (Ssandrín, 2010; Hicks, 1974).

Indigenous women have difficulty accessing basic sexual and reproductive health services, which has a significant impact on the average number of live births per woman: 3.3, compared to 2.2 for non-Indigenous women (UNFPA, 2021). Between 1999 and 2009, the fertility of non-Indigenous women decreased from 3.5 to 2.4 children per woman, while that of Indigenous women fell from 4.1 to 3.2 children per woman, with significant differences between the various Indigenous groups. (Sandrín, 2010; Sandrín, 2016).

Moreover, fertility among Indigenous adolescents aged 15 to 19 is higher than among non-Indigenous women, at 83 and 62 births per thousand adolescent women, respectively. Sixty-five percent of Indigenous adolescents are not in school. (Nolasco, 2021).

Barriers to accessing Western health services are distance, poverty, language and discrimination. In Mexico, only 15.4% of the Indigenous population has access to health services, in contrast to the national population, which has 16.3%. (Bello and Rangel, 2002). Moreover, due to male migration, 23.4% of indigenous households have a woman as a head. (Nolasco, 2021).

Reproduction, fertility, family formation and expansion are related to education level and socioeconomic inequalities, which are analyzed in the next section.

4 EDUCATION, WORK AND POVERTY

The most important challenges for Indigenous and Afro-Mexicans are socio-economic disadvantages — poverty and migration — that threaten indigenous autonomy and cultural preservation. (Gandelman, 2011; INPI, 2019). Even after decades of integration policies, Indigenous people continue discriminated against at school and in other social positions, mainly because of their language, clothing, and behavior.

Both groups live mostly in social exclusion – in poverty, geographical isolation, with lack of access to basic services (health, education), displacement due to territorial conflicts, elite control, capital-intensive agriculture, occupation and dispossession of their lands due to megaprojects like mines exploitation, agribusiness, infrastructure, as well as a secular decline in rural productivity and employment, aggravated by economic and land property reforms), financial sector liberalization and privatization, as well as migration. From the perspective of world systems, all these phenomena occur in interrelation with national and local contexts and have become increasingly frequent throughout the world in recent decades (Wallerstein, 2004; Gandelman et al, 2011; Sánchez, 2003).

Both groups have lower levels of education and income compared to their counterparts (Bello and Rangel, 2002). In Mexico, their income is unaffected by either increases or declines in national poverty rates and being indigenous increases by 30% the probability of being poor (Hall and Patrinos; 2006).

In Mexico, 31.1% of the Indigenous population has educational gaps, while the national percentage is 15.4%. 8.4 million Indigenous people live in poverty and 3.4 million live in extreme poverty. Indigenous women who migrated to cities have an average 6.2 years

of schooling, compared to the 9.1 years of schooling for women in the country. They work primarily in the informal sector, without social benefits, and survive from day to day, with an income that is also day by day in nature. (Nolasco, 2021).

Half of labor and income gaps between the Indigenous and non-Indigenous is related with the low educational attainment, and the other half by discrimination (Parker et al, 2005).

Parker et al. (2005) found that language barriers are related to the lower performance of Indigenous children, particularly among monolingual Indigenous, whereas bilingual children perform almost equivalent to their non-Indigenous counterparts in Mexico.

The low educational level of the mother, father's profession, and child labor reproduce among generations, since these are the main determinants affecting Indigenous children's enrollment at school and, subsequently, their labor discrimination and income disadvantages. (Román, 2013).

Qualitative studies indicate that that Indigenous children have high school expectations. Although Indigenous students often maintain high aspirations despite their parents' limited education, low parental cultural capital restricts the transfer of knowledge and skills necessary to sustain educational engagement and progress. Consequently, these students exhibit lower academic performance, higher rates of grade repetition and dropout than non-Indigenous peers, and frequently enter the labor market early, typically in precarious employment. (Espinoza et al, 2014).

In Mexico, in 2015, the educational attainment of the Indigenous was lower than for Afro-descendant people and speaking an Indigenous language or identifying as Indigenous has a negative effect of a larger magnitude compared to being Afro-descendant. Moreover, contrary to expectations, there is no evidence that Afro-descendants had a lower status in the labor market through occupational status, and even more remarkably in schooling. (Torre-Cantalapiedra and Sánchez-Soto, 2019)

Due to the migration of a considerable number of men to urban areas or overseas, women serve as heads of 23.4% of indigenous households. (Nolasco, 2021). Although migration to the US divides families, remittances help maintain international family connections and networks; however, migration and cultural loss also put pressure on collective land holdings (*Ejidos*) (Velasco et al, 2014).

5 METHODOLOGY

This article analyzes demographic and socioeconomic aspects that differ between these excluded populations — indigenous and Afro-descendants — in contrast to the rest of the population, comparing these three racialized population groups in Mexico according to age and family structure, civil status, number of children, and level of education.

The article develops an understanding as to how these population groups differ and the intersections between demographic and social characteristics in racialized groups.

The methodology includes the estimation of demographic indicators, graphs, and maps to describe and analyze the patterns, distribution, and differences between ethnically racialized groups, comparing proportions, population pyramids, and spatial distribution of Indigenous, Afro-descendants (AD) and other groups (OG) in Mexico. Indigenous populations are classified as those who speak an Indigenous language (IL) or self-defined as Indigenous (ISD).

Results from statistical correlations and logistic regression models demonstrate the factors likely to be associated with each ethnically racialized population, compared to their counterparts, as well as the main characteristics related to inequalities between groups.

The source of information is the National Survey of Demographic Dynamic --ENADID, field-applied in 2023 and whose results were released in 2025 (ENADID, 2025).

The dependent variable has two categories, representing one ethnically racialized group in contrast with the rest of the population. The independent variables studied are age, sex, marital status, level of education, area of residence (rural vs urban), household structure, health service affiliation, migration, and labor activity.

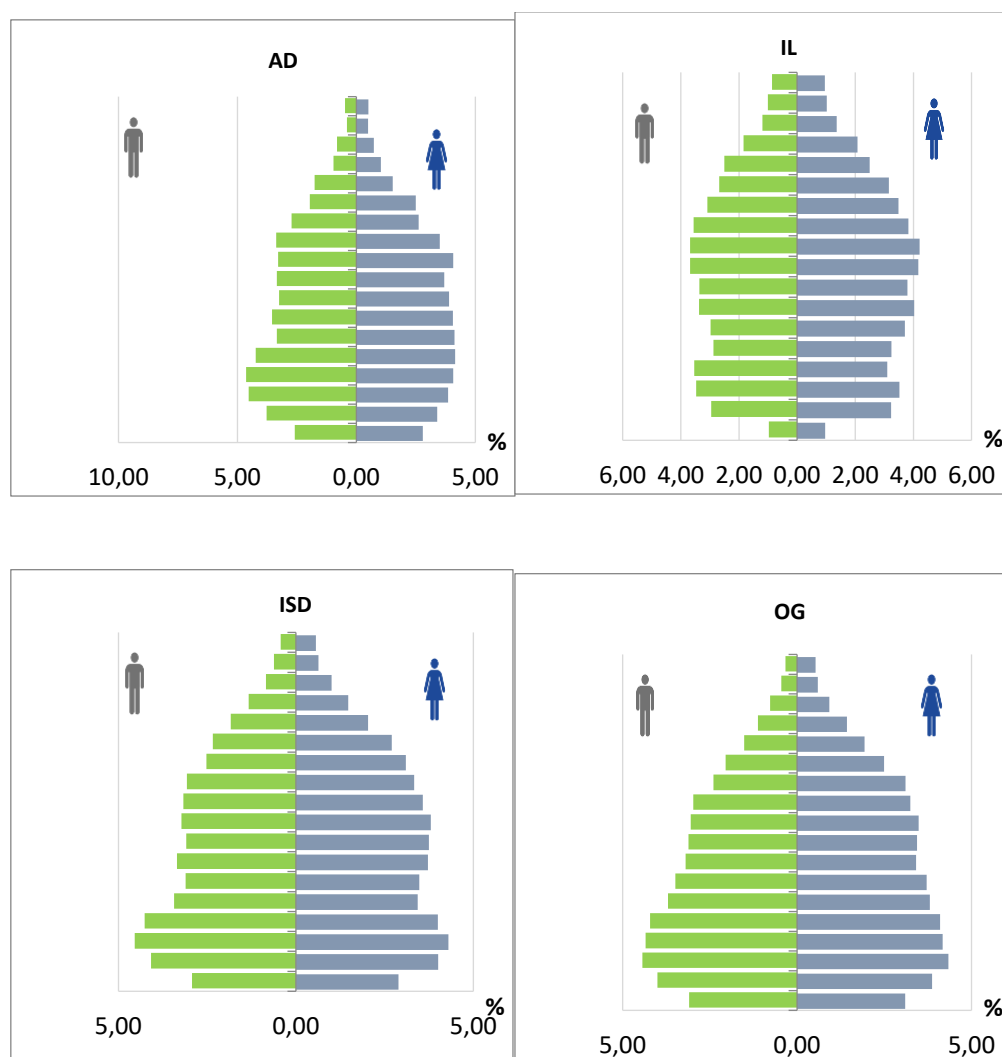
6 RESULTS

The Mexican population is mostly young and young-adult, with high proportions of them between 10 and 29 years old, and strong reductions in the number of children up to 9 years old, a result of the progressive reductions in the birth rates since the 1970s, which is observed in all racialized groups, although birth rates declined much later among Indigenous groups. The population is lower in this age group because Indigenous language data is collected for those over three groups. Indigenous (IL and ISD) have older population structures, compared to AD and OG. Their pyramids show a strong lack of male and female adults between the ages 25 and 44 and higher proportions of generations over 60 years old. This population structure is the result of long-term internal and international migration by Indigenous men and women from rural and Indigenous regions to Mexican urban centers and

the United States, leading to older Indigenous individuals remaining in both rural and urban areas. (Figure 1).

Figure 1

Population Pyramids of Ethnic-Racialized Groups in México, 2023



Source: Own estimations from the National Survey on Demographic Dynamics (ENADID, 2023)

Among AD and OG populations, the age groups 10-14, 15-19, and 20-24 years old are the most populated, followed by slight decreases until 60-64, and then sharp decreases in the older age groups. The only exception is Afro-descendant men, who have a lack of representation between 30 and 50 years old, like Indigenous groups.

Afro-Mexicans (AD) show strong differences by sex: the female population structure is younger than the other groups, while the male age structure is older, with a lack of adult men, like Indigenous groups. As Afro-Mexicans are concentrated in specific rural areas of the

country (the mountains and coasts of the States of Guerrero and Oaxaca), it would be due to the migration of Afro-descendant adult men to find work, while Afro-Mexican women stay living in their area of origin.

Data from the National Survey on Demographic Dynamics (ENADID, 2025) show similar trends.

Spatial distribution

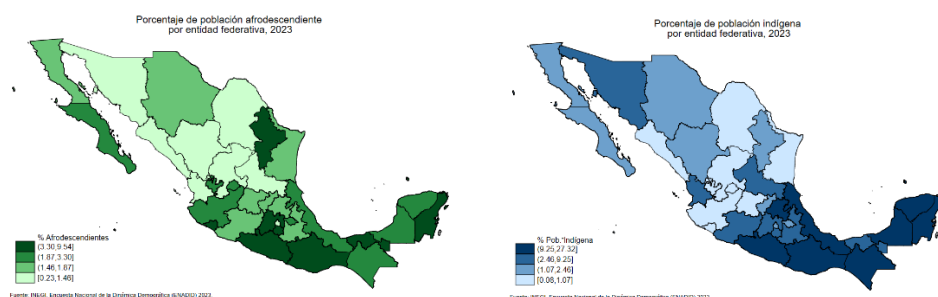
Afro-Mexicans reside mostly in Guerrero, Morelos, Colima, Oaxaca, México, Tabasco, Nuevo Leon, and Chiapas.

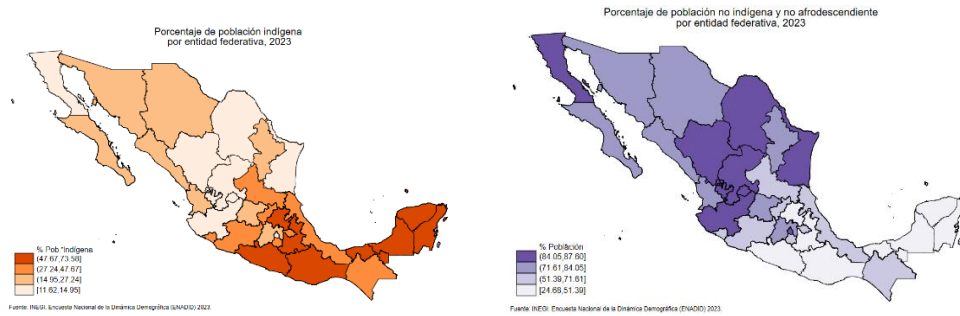
People who speak some Indigenous Language (IL) live mostly in the states of Oaxaca, Yucatán and Chiapas, followed by Quintana Roo, Guerrero, and Campeche, all of them on the Pacific or Atlantic coasts, as well as in Hidalgo, in the Central region, where they represent between 9% and 27% of the total population. These states have historically concentrated Indigenous populations.

Indigenous communities live mostly in the states of Oaxaca, Yucatán, Quintana Roo, Guerrero, Campeche, Hidalgo, Tabasco, and Puebla, mostly situated along the coast. Self-identified Indigenous people make up 48% to 74% of the population in these states, which is higher than those who speak an Indigenous language. All the other states have between 15% and 48% of the population who self-declare to be Indigenous, but self-declared mestizos and European-descendant people predominate. The elevated proportions of individuals self-identifying as Indigenous are associated with the recent addition of an option to indicate family and ethnic background in censuses and surveys. Educational policies oriented to development have erased their language from everyday use over the course of a century, forcing the use of Spanish, the denial of their indigenous identity and, instead, adopting the mestizo identity, in a process of inclusion by assimilation. (Figure 2).

Figure 2

Spatial Distribution of Ethnic-Racialized Groups in Mexico, 2023





Source: Own estimations from the National Survey on Demographic Dynamics (ENADID, 2023)

Other groups (OG) who do not identify as Indigenous or Afro-descendants are in the North and Central regions of the country, with over 80% residing in Baja California, Coahuila, Tamaulipas, Durango, Zacatecas, Aguascalientes, Jalisco, and Mexico City. In these more developed states, a sizable portion of the population may identify with values commonly associated with contemporary Western societies. In these advanced states, most people align with modern Western values.

6.1 FAMILY FORMATION AND EXPANSION

The marital status is similar in the AD and OG populations — in both groups' half of the adults are married, followed by single people — around 40% of men and 30% of women. 5–9% live separated and 2–3% are divorced. The rates of widowhood differ by gender: for men, it is 2.8% and 2.3%, while for women, it is 8.7% and 8.1%. This variation is associated with differences in life expectancy between men and women.

In contrast, the Indigenous (IL) population has higher proportions of marriage (68.1% for men and 60.2% for women), lower proportions of separated (3.3%) and divorced (0.5%) of both sexes (7.3% and 0.6% respectively), as well as lower proportions of single men (23.3%) and women (19.6%), but higher proportions of widowed men (4.8%) and women (12.2%), due to their higher mortality and lower life expectancy. This result confirms the culture of family preservation and almost universal marriage among IL, compared to all other groups.

The following Indigenous group (ISD) has a similar marriage pattern to the IL, but slightly lower proportions of married men (57%) and women (53.1%), as well as higher proportions of separated (5.2% for women and 8.9 % for men), divorced (1.1% and 1.7% respectively), and single (33.5% and 26.4% respectively), and lower percentages of widowhood (3.2% and 9.9% respectively). Although this group preserves marriage and family values compared to other racialized groups, these values are lower than in the IL group, who

also preserve their Indigenous Language. Although assimilation policies and Western cultural influences led to language loss, family and marriage values stayed stable.

Table 1

Marital Status of Ethnic-Racialized groups in Mexico, 2023

Marital Status	Afro descendant (AD)		Indigenous Language (IL)		Indigenous Self-declared (ISD)		Other groups (OG)	
	Men	Wome	Men	Women	Men	Women	Men	Wome
Married	53.1	49.9	68.1	60.2	57.0	53.1	50.8	49.0
Separated	4.9	9.5	3.3	7.3	5.2	8.9	5.0	7.7
Divorced	2.2	3.2	0.5	0.6	1.1	1.7	1.8	2.7
Widow	2.8	8.7	4.8	12.2	3.2	9.9	2.3	8.1
Single	37.0	28.6	23.3	19.6	33.5	26.4	40.2	32.5

Source: Own estimations from the National Survey on Demographic Dynamics (ENADID, 2023)

The age at first union is low among the IL population (21.4), followed by the ISD group (21.5), the OG population (22.4 years old), and the latest to marry is the AD group (22.6) — more than one year later than Indigenous groups. The Afro-descendant population marries at a similar average age to the self-declared Indigenous.

Table 2

Average age at the first union in Mexico, 2023

<i>Total population</i>	22.1
<i>Afro descendant population</i>	22.6
<i>Indigenous population, language</i>	21.4
<i>Indigenous population, self-declared</i>	21.5
<i>NINA, No Indigenous & no Afro descendant</i>	22.4
<i>Population with an inability</i>	22.6

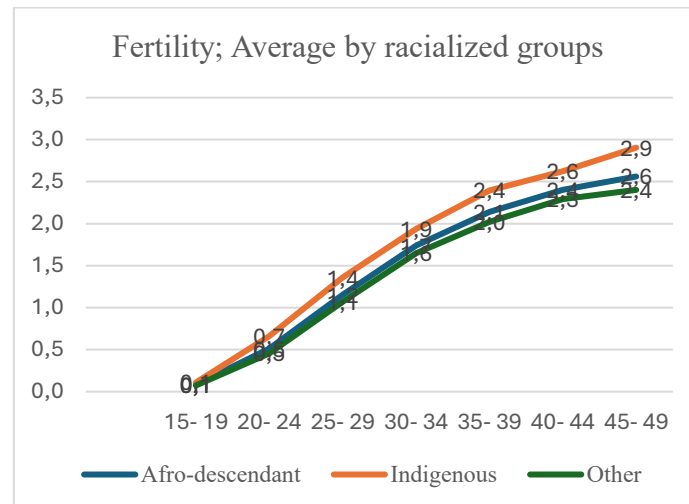
Source: Own estimations from the National Survey on Demographic Dynamics (ENADID, 2023)

In brief, Indigenous groups marry in higher proportions and earlier, particularly the IL population, while Afro-descendant people marry in lower proportions and much later than Indigenous and compared to other population groups.

Indigenous women tend to marry younger and at higher rates, resulting in longer exposure to sexual activity and pregnancy risk. As a result, they also have a higher number of children, compared to Afro-descendants and other population groups. (Figure 3)

Figure 3

Average Fertility by racialized groups, México, 2023



Source: Own estimations from the National Survey on Demographic Dynamics (ENADID, 2023)

6.2 HOUSEHOLD SIZE, STRUCTURE AND COMPOSITION

Indigenous households are larger (33.1% of them have up to five members) than Afro-descendant households (25.1% have up to five members). The smaller households are among the OG population, related to their lower marriage rates and higher separation, divorce and single rates, as well as their higher age at marriage and lower fertility. In contrast,

Indigenous populations have consistent indicators related to the persistence of strong family values — higher proportions of marriage, lower proportions of separation and divorce, a lower age of marriage and a higher fertility.

Indigenous households are, on average, larger (3.9 members) than Afro-descendant (AD) households (3.5 members) and Other Groups (OG) households (3.3 members). Indigenous and Afro-descendant households each have, on average, 2.2 members who either speak an Indigenous language or self-identify as Afro-descendant.

Table 4

Household size by ethnic-racial condition in Mexico, 2023

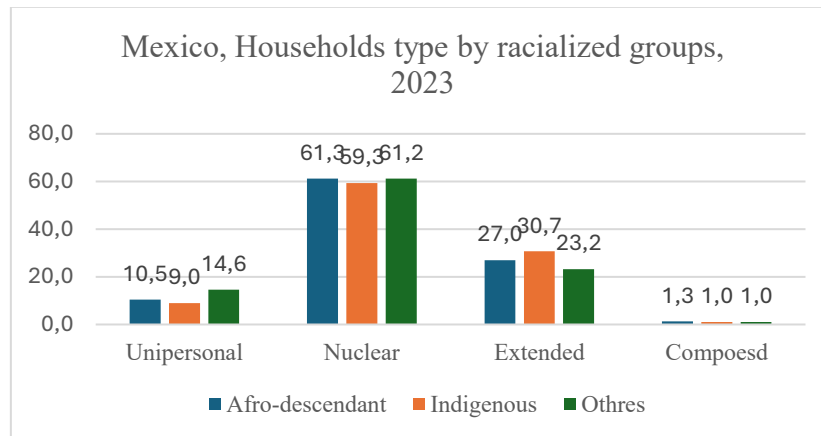
Size	Afro descendant (AD) Households		Indigenous Households		Other Groups (OG) Households	
	N	%	N	%	N	%
Total	1,442,497	100.0	3,291,684	100.0	34,124,263	100.0
1	150,986	10.5	294,946	9.0	4,983,030	14.6
2	295,054	20.5	631,474	19.2	7,531,023	22.1
3	314,213	21.8	625,146	19.0	7,128,349	20.9
4	319,488	22.1	650,495	19.8	7,094,829	20.8
5 +	362,756	25.1	1,089,623	33.1	7,387,032	21.6

Source: Own estimations from the National Survey of Demographic Dynamics (ENADID) 2023.

The predominant proportion of nuclear households is aligned with the preference for marry and having children for the three groups, with slightly proportions for Afro-descendants and Indigenous. The second more frequent type of household is the extended with another member of the family, confirming the preference for collective values in both groups, compared to the rest of the population. Moreover, Afro-descendant people have higher proportion of unipersonal household and lower proportion of extended hosehold, compared to Indigenous and the other group, a less shared network of family relationships, suggesting a kind of isolation as individuals.

Figure 4

Household structure by racialized groups, Mexico, 2023.



Source: Own estimations from the National Survey on Demographic Dynamics (ENADID, 2023)

As a result, the proportion of members declaring an ethnic-racial condition within their households or among all the members of their households is small — in all households, they represent less than 10 % of the total number of members in the family composition. Indigenous and Afro-descendant individuals comprise less than 5% of family members.

Table 5

Proportion of Afro descendant people in Afro-descendant households, Mexico, 2023

<i>Percent in the total number of members</i>	<i>N</i>	<i>%</i>
<i>Total</i>	1,442,497	100.0
<i>Less than 5%</i>	1,292,060	89.6
<i>5 - 9%</i>	147,011	10.2
<i>10 - 16%</i>	3,426	0.2
<i>Proportion of Indigenous people in Indigenous households, 2023</i>		
<i>Percent in relation to the total number of members</i>	<i>N</i>	<i>%</i>
<i>Total</i>	3,291,684	100.0
<i>Less than 5%</i>	2,941,838	89.4
<i>5 - 9%</i>	339,414	10.3

10 - 14%

10,432

0.3

Source: Own estimations from the National Survey on Demographic Dynamics (ENADID, 2023)

6.3 LEVEL OF EDUCATION

Indigenous people have the lowest level of education, 22.8 % of them do not complete the basic school education, 19.1 % complete the basic school education, 18.9 % the secondary school education, but 17.9 % have no education; only 11.1 % of them finish the higher secondary level education. In contrast, Other Groups (OG) achieved 33.4 % with higher secondary education and 36.2 % at university; and Afro-descendant people are in an intermediate position, with 19.5 % with complete secondary education, 21.1 % in higher secondary education and 19.7 % at university.

The proportion of people with no education is also higher among the Other Groups (OG), but this could also be related to their higher life expectancy, and the survival of the elderly generation who didn't have access to the universalization of the educational system, that happened 70 years ago.

Table 6

Level of education by Ethnic-Racialized groups in Mexico, 2023

	<i>Afro</i>	<i>Indigenous</i>	<i>Indigenous</i>	<i>Other</i>
<i>Level of education</i>	<i>descendant</i>	<i>language</i>	<i>self-</i>	<i>Group</i>
			<i>declared</i>	<i>s</i>
<i>No education</i>	8.7	17.9	11.0	16.4
<i>Incomplete primary</i>	13.7	22.8	18.9	3.7
<i>Complete primary</i>	11.7	19.1	14.9	2.7
<i>Incomplete secondary</i>	5.6	4.4	5.8	2.3
<i>Incomplete secondary</i>	19.5	18.9	21.3	5.3
<i>Higher secondary</i>	21.1	11.1	16.8	33.4
<i>Higher</i>	19.7	5.74	11.0	36.2

Source: Own estimations from the National Survey on Demographic Dynamics (ENADID, 2023)

6.4 MULTIVARIATE DEMOGRAPHIC AND SOCIOECONOMIC CONDITIONS

The logistic models contrast Indigenous and Afro-descendant populations to their counterparts, controlling family and other social variables. Both vulnerable groups — Indigenous and Afro-descendants— have a higher and significant probability to have a lower education level and to live in rural areas, compared to their counterparts. Additionally,

Indigenous people are likely to be women, living in extended households, while Afro-descendants are likely to be older and not affiliated to health services.

Table 7

Logistic Model. Socio demographic factors related to Indigenous and Afro-descendant People in Mexico, 2023

	Odds Ratio Indigenous Language		Odds Ratio Afro Descendant	
Gender (men)	0.1772924	**	0.0343524	
Age (<17)				
18- 29	-0.2084712		0.0700014	
30- 59	-0.0809361		0.1801266	*
60 +	0.0218807		0.3570382	**
Marital Status (Single)				
Married	0.1791051		0.0050568	
Separated, Divorced	0.1829592		-0.005845	
Widow	0.0717031		0.0310778	
Level of Education (No education)				
Basic school	0.0288725		-0.1401354	*
Secondary	0.3785551	**	-0.0943434	
Middle superior	0.446241	**	-0.3299054	***
Superior	0.828407	***	-0.4400946	***
Household structure (unipersonal)				
Nuclear	0.1963908		0.0977776	
Extended	0.3283216	*	0.1803625	
Area of residence (urban)	-0.597918	***	0.4850105	***
Migrants living in the household (no)	-0.2611708		0.1127791	
Affiliation to health service (no)	0.1327841		-0.1773506	**
Labor activity (not working)	-0.0592059		-0.0173633	
_cons	-1.187799	***	2.766557	***

Note: *** p<0.0001; ** p <0.05; * p<0.10

Source: Own elaboration based on National Survey of Demographic Dynamics (ENADID) 2023.

Despite the differences observed in descriptive data, marital status and migration were not sufficiently significant to explain the differences between each vulnerable group separately in contrast with others.

7 CONCLUSIONS

Both indigenous and Afro-descendant households have higher marriage and birth rates and start early unions and fertility than the rest of the mestizo and European-descendant

population, especially in rural areas, as well as early marriage and traditional gender roles, along with high but declining fertility rates and lower access to healthcare. These results confirm results from previous authors (Pino et al, 2020; Costa et al, 2022).

In certain Indigenous communities, teenage pregnancy aligns with cultural norms supporting fertility and marriage. But there are also cases related to violence against Indigenous and Afro-descendant adolescents. Extended families often reside together in villages, with multiple family units participating in local governance based on established customs and traditions. Women are often the guardians of languages and traditions, particularly in cooking, textiles, and handcrafts.

Indigenous people preserve their family culture with universal marriage and children, as well as the culture of sharing the household with other relatives. While Afro-Mexicans are likely to be older than other groups and share the households with other relatives. This results in strong challenges to health, because they are the oldest, and exposed to having a higher prevalence of chronic and degenerative illness but, at the same time, they suffer a strong lack of access to education and health services, as well as lower participation in the labor market and lower income levels, compared to the rest of the population.

Both groups present specific dynamics, influenced by socio-economic discrimination and cultural resilience. (Lezama, 2023; Costa et al, 2022).

As a conclusion, we could say that the predominant characteristics of Mexican Indigenous people are the socioeconomic exclusion and discrimination, as well as their resilience to preserve collective and family values, customs and practices, through the predominance of marriage and larger number of children, as well as the value of sharing the household with other relatives, facing collectively economic adversities and discrimination. While African-Mexicans are likely to be older than other groups, this results in strong challenges to health, because they are the oldest, and exposed to having a higher prevalence of chronic and degenerative illness but, at the same time, they suffer a strong lack of access to health services, more than other groups (Costa et al, 2022).

Ethnic and racial disparities within the population are evident in relation to existing structural and familial inequities. The ageing process is less accelerated among indigenous and Afro-descendants, related to their lower level of education and other socio-economic vulnerabilities, but also to their higher fertility and family structure and composition, leading to the need for support for the racialized women and elderly in the next decades, and multi-generational families.

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ALL “WORLD” IS BANTU YES SIR!

TODO “MUNDO” É BANTU SIM SENHOR!

TODO “MUNDO” ES BANTÚ ¡SÍ SEÑOR!

 <https://doi.org/10.56238/sevened2025.036-163>

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ABSTRACT

This article focuses on researching a segment of the Bantu peoples, originating from Central-Western Africa and later from East Africa, sub-Saharan regions below the Equator. This is because they were the first Black population absorbed by the Atlantic Diaspora. In Brazil, the Bantu people were distributed across various regions, mainly through the ports of the Southeast, particularly Rio de Janeiro, especially the Baixada Fluminense, given its predominantly Bantu composition. Therefore, the overall objective is to encourage global society to delve into the past and, through the African continent and the Atlantic Diaspora, understand itself, considering Darwinian theory asserts the emergence of "Homo sapiens" precisely in the lake region, a demographically Bantu area. This fact is reinforced by research on the presence of melanin in the inhabitants of that area, due to climatic conditions. So, by immersing ourselves in the past, this time in reverse order, or rather, from the Baixada Fluminense, Rio de Janeiro, Brazil, until we reach the place of origin of the intelligent being (the maker of things). From there, we analyze from this angle to understand why the statement is made: "The whole world is Bantu, yes sir." Clues point to facts that show that the traditions and cultural references of this people were fundamental in the construction of Brazilian identity. This set of traditional and cultural values remains alive in the daily lives of families, in Candomblé temples, in the streets, in the markets, in the samba school grounds (large, medium and small), and in the avenues of their official parades. All this, before, during and after Carnival or in other types of popular festivals, as well as in any other place of Afro-descendant human concentration, mainly through their language, dance and musicality. These expressions remain anonymous regarding their countries of origin. They are generalized in the classrooms of this region, as well as in other regions of Brazil, simply as black or African. Thus, Africa, geographically, socially, and politically, is treated as a region devoid of any solidarity, forgetting that it constitutes the "Cradle of Civilization." The methodology used was qualitative-quantitative, with a descriptive nature, since it began with the collection and measurement of demographic data of the specific African population, supported by its strata, which brought the religious culture of the Bantu peoples to Brazil. The scientific paradigm followed to make the methodological choices was pragmatic, which facilitated the identification and description of the religious culture of the Bantu peoples in the diaspora of enslaved Africans subjected to the South Atlantic slave trade. The expected results revolve around combating racism, recognizing and valuing the identity of the Bantu black person, due to being the pioneer in the descent of Homo sapiens, in the construction of Brazil, and the formation of the Brazilian language, among other influences.

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Keywords: Bantu. Baixada Fluminense. Rio de Janeiro. Brazil. World.

RESUMO

Este artigo tem como objeto de pesquisa parte dos povos denominados Bantu, oriundos da África Centro-Occidental, e posteriormente da África Oriental, regiões subsaarianas, abaixo da linha do Equador. Haja vista, ter sido a primeira vertente negra absorvida pela Diáspora Atlântica. No Brasil, o povo bantu foi distribuído por várias regiões, principalmente, pelos portos do sudeste, com destaque para o Rio de Janeiro, privilegiando a Baixada Fluminense, haja vista, a sua formação, majoritariamente banta. Dessa forma, o objetivo geral é provocar, a sociedade mundial mergulhar no passado para através do Continente Africano e a Diáspora Atlântica, conhecer a si mesma, haja vista, a teoria darwinista afirmar, o surgimento do “homo sapiens”, precisamente, na região dos lagos, área demograficamente banta. Fato este reforçado por pesquisas diopianas quanto a melanina existente nos seres habitantes daquela área, por conta das condições climáticas. Então, ao realizar essa imersão no passado, desta feita, em ordem inversa, melhor dizendo, da Baixada Fluminense, Rio de Janeiro, Brasil, até chegar ao local de surgimento do ser inteligente (fazedor de coisas). Daí então, analisar por este ângulo para entender o porquê da afirmativa: “Todo o Mundo é Bantu Sim Senhor”. Pistas apontam para fatos que levam às tradições e referências culturais desse povo, terem sido fundamentais na construção da identidade brasileira. Esse conjunto de valores tradicionais e culturais permanece vivo no dia a dia das famílias, nos terreiros de candomblé, nas ruas, nos mercados, nas quadras das grandes, médias e pequenas escolas de samba, e nas avenidas de desfiles oficiais delas. Tudo isso, antes, durante e depois do carnaval ou em outros tipos de festas populares, bem como em qualquer outro lugar de concentração humana afrodescendente, principalmente por meio de sua linguagem, dança e musicalidade. Estas expressões, permanecem anônimas quanto aos seus países de origem. São generalizadas nas salas de aulas dessa região, bem como, em outras regiões do Brasil, apenas como negras ou africanas. Assim, a África, geográfica social e politicamente, é tratada como uma região descompromissada de qualquer olhar de solidariedade, e esquecem de que esta constitui-se como o “Berço Da Civilização”. A metodologia utilizada foi quali-quantitativa, com natureza descritiva, uma vez que se iniciou com a coleta e mensuração de dados demográficos da população africana específica, apoiada por seus estratos, a qual, trouxe a cultura religiosa dos povos bantos para o Brasil. O paradigma científico seguido, para realizar as escolhas metodológicas, foi o pragmático, o que permitiu facilitar a identificação e descrição da cultura religiosa dos povos bantos, na diáspora dos africanos escravizados, submetidos ao tráfico do Atlântico Sul. Os resultados esperados giram em torno do combate ao racismo, reconhecimento e valorização da identidade do negro bantu, por conta de ser o pioneiro na descendência do homo sapiens, na participação na construção do Brasil, e formação da língua brasileira, entre outras influências.

Palavras-chave: Bantu. Baixada Fluminense. Rio de Janeiro. Brasil. Mundo.

RESUMEN

Este artículo se centra en la investigación de un segmento del pueblo bantú, originario de África Centro-Occidental y posteriormente de África Oriental, en las regiones subsafricanas situadas por debajo del ecuador. Esto se debe a que fueron la primera población negra absorbida por la diáspora atlántica. En Brasil, el pueblo bantú se distribuyó por diversas regiones, principalmente a través de los puertos del Sudeste, en particular Río de Janeiro, y en especial la Baixada Fluminense, dada su composición predominantemente bantú. Por lo tanto, el objetivo general es animar a la sociedad global a profundizar en el pasado y, a través

del continente africano y la diáspora atlántica, a comprenderse a sí misma, considerando que la teoría darwiniana afirma el surgimiento del "Homo sapiens" precisamente en la región de los lagos, una zona demográficamente bantú. Este hecho se ve reforzado por la investigación sobre la presencia de melanina en los habitantes de esa zona, debido a las condiciones climáticas. Así, al sumergirnos en el pasado, esta vez en orden inverso, o mejor dicho, desde la Baixada Fluminense, Río de Janeiro, Brasil, hasta llegar al lugar de origen del ser inteligente (el creador de las cosas), analizamos desde esta perspectiva para comprender por qué se afirma: «El mundo entero es bantú, sí señor». Las pistas apuntan a hechos que demuestran que las tradiciones y referencias culturales de este pueblo fueron fundamentales en la construcción de la identidad brasileña. Este conjunto de valores tradicionales y culturales se mantiene vivo en la vida cotidiana de las familias, en los templos de candomblé, en las calles, en los mercados, en los recintos de las escuelas de samba (grandes, medianas y pequeñas) y en las avenidas de sus desfiles oficiales. Todo esto, antes, durante y después del Carnaval o en otros tipos de fiestas populares, así como en cualquier otro lugar de concentración humana afrodescendiente, principalmente a través de su lengua, danza y musicalidad. Estas expresiones permanecen anónimas respecto a sus países de origen. En las aulas de esta región, así como en otras regiones de Brasil, se generalizan simplemente como negros o africanos. Así, África, geográfica, social y políticamente, se trata como una región carente de solidaridad, olvidando que constituye la "Cuna de la Civilización". La metodología empleada fue cualitativa-cuantitativa, de naturaleza descriptiva, ya que comenzó con la recopilación y medición de datos demográficos de la población africana específica, respaldada por sus estratos, que trajeron la cultura religiosa de los pueblos bantú a Brasil. El paradigma científico seguido para la toma de decisiones metodológicas fue pragmático, lo que facilitó la identificación y descripción de la cultura religiosa de los pueblos bantú en la diáspora de africanos esclavizados sometidos a la trata de esclavos del Atlántico Sur. Los resultados esperados giran en torno a la lucha contra el racismo, el reconocimiento y la valoración de la identidad de la persona negra bantú, por ser pionera en la descendencia del Homo sapiens, en la construcción de Brasil y en la formación de la lengua brasileña, entre otras influencias.

Palabras clave: Bantú. Baixada Fluminense. Río de Janeiro. Brasil. Mundo.

1 INTRODUCTION

The Atlantic Slave Deterritorialized about 12.7 million Africans, mostly Bantu, between the sixteenth and nineteenth centuries, impacting the formation of colonial societies. African workers were fundamental to the production of wealth, being responsible for different trades and economic activities, such as agriculture, navigation, land transport, domestic services and the different forms of production in the urban world, such as street commerce, stevedoring, among others (Bezerra, 2011). It is necessary to think that this process also meant an African diaspora, not only demographic, but also technological, since the knowledge of trades such as navigators, cooks, masons, blacksmiths, architects, among others, were widely practiced by Africans long before they were deterritorialized and sent to the Americas. Likewise, it is necessary to identify that African peoples also impacted the Brazilian cultural formation. Although not recognized by coloniality, the African peoples of Banta origin were the main responsible for the formation of most of the Brazilian cultural expressions, coming from Angola, such as: samba, capoeira, maracatu, jongo, tambores de mina, among others. Even in the cases of cultural expressions of Iberian origin, such as the folias de reis, the samba schools and carnival, the Bantu and their descendants resignified these expressions, transforming them into symbols of freedom, resistance and resilience of the black population that forms the majority of Brazilian society in contemporary times. Among the popular expressions of Brazilian culture, Candomblé stands out for preserving civilizing principles against colonials, that is, in a society marked by domination, slavery and the extermination of peoples and cultures through colonization, African peoples bequeathed a religiosity whose philosophies and existence offer other cosmogonic possibilities. Thus, other perspectives and epistemologies for Brazilian society are fundamental for thinking about contemporary social issues resulting from a process of slavery that inaugurated a necropolitics. Thus, this article's main function is to bring to light, through the products mentioned below, the preponderant role of the Bantu black in the construction of Brazil and the formation of the Brazilian language, in order to maintain the preservation of the Bantu culture as a strengthening of the identities of black youth in the territory, as well as to provide opportunities for educational training and professional preparation for the insertion of individuals from the popular classes in the productive market. (Adolfo, 2010), (Bezerra, 2011), (Costa e Silva, 2006), (Lopes, 2014), (Redinha, 1958), (Ribas, 1958), (Slenes, 2008), among others.

2 DEVELOPMENT

To think about Africa historically, it is necessary to go beyond the ideas of a continent of exotic nature and without history. African and Asian societies were seen as static societies by the Eurocentric system. The colonizers considered Africans as heirs of rudimentary customs, primitive societies, frozen in time since immemorial periods. This look at African cultures was not restricted to the nineteenth century, nor only to research guided by positivist sciences, influenced by social Darwinism. And not only to the works that followed the reading of historical materialism, and reached a good part of the twentieth century.

According to Alberto da Costa e Silva (2006, p. 57), Charles Darwin, in his book "The descent of man and sexual selection, published in 1871" explains that, in each major region of the world, the existing mammals are closely related to the extinct species of the same area. It is probable, therefore, that Africa was once inhabited by extinct apes closely connected with the gorilla and chimpanzees: and as these two species are now the most closely related to man, it is more probable that our primitive ancestors lived on the African continent than anywhere else. As Costa e Silva (2006, p. 57) warns, "Darwin's intuition seems to be confirmed by scientific findings, which increasingly point to sub-Saharan Africa as the region where man, the animal maker of instruments, emerged". Because of this, it should be noted that Africa south of the Sahara Desert, below the equator, in the central western part was and is nothing more, nothing less than a demographically Bantu region due to the peoples who live there speaking mostly languages belonging to the proto-Bantu linguistic trunk.

Darwin's theory (1871), which places Africa as the place of origin of man, is a confirmation that there are no arguments against evidence. not all the racism that already existed at that time could deny the place of Africa as the cradle of civilization. Considering that to this day it is considered the most probable hypothesis regarding the emergence of man. An Africa considered by Eurocentrism as an apathetic continent, with no prospects for evolution, inhabited by sub-races, descendants of Can, a religious theory, cited by Azzi (2008, p.29), is suddenly recognized as the cradle of civilization.

The Senegalese Sheik Anta Diop (2003, p. 73) reinforces it, shown in Figure 7, who states that the first men were Negroids, and that according to Gloger's law, animals in the general sense, warm-blooded, in hot and humid climates, developed melanin (black pigmentation). That is why the origin of humanity was black, the whitening took place due to climate change. Another result is to be able to prove that the territorial space pointed out by Charles Darwin as the cradle of civilization is exactly the same place where the Bantu people

come from, that is, Central Africa, the same one that, by irony of fate, had its people relegated to ostracism by the precursor of the study of the Brazilian black, Dr. Raimundo Nina Rodrigues (1896), who classified him as inferior to the Sudanese people who later arrived in the new colony of Portugal.

This is said, not least because the region indicated by Darwin, as the cradle of civilization, goes against the concepts of the Eurocentrism instituted, when already in the nineteenth century they defined the existence of two worlds, the rich to the north and the poor to the south. By explaining socioeconomic differences based on skin color, the capitalist nations of that time exempted themselves from their historical responsibility. In other words, they bequeathed to ethnic origin and not to imperialism, colonialism and exploitation, the backwardness and misery of a large part of the nations of the world.

Sub-Saharan Bantu peoples below the equator brought to Brazil from the Kingdom of Congo, a central-western region of Africa formed by numerous small kingdoms existing between the *Zaire* (or Congo) rivers, the *Kuango River* and the *Lucala River*. In "The Hoe and the Spear: Africa before the Portuguese", Alberto Costa e Silva (2006), says that according to Banta tradition, around the fourteenth century, when *Nimi Lukeni*, the king of the *Kikongo* married an important woman of the Ambundo people, the kingdom of *Kongo* was formed, and the king came to be called *Mani Kongo*, the Lord of the Congo. The capital of the Kingdom of Congo was in the Center-North of the domains, the city was called *Mbanza Kongo*. The city was all fortified, surrounded by a stone wall and was on top of a hill, surrounded by the cultivation areas as well as the villages. *Mbanza* was a large commercial center through which shipments of salt, fish, fabrics, ceramics and baskets, raffia and copper passed. This great city was the center of a kingdom that subdued the small kingdoms around it, which became vassal kingdoms. The basis of the economy was agriculture and farmers produced bananas, palm oil, coconuts, cola, millet, sorghum, yams, macunde, they also raised pigs, cattle and goats. The rivers were rich in fish and the savannahs were rich in game. They knew iron, which they used in the manufacture of weapons and copper in the manufacture of jewelry. From the valley of the Inquice or Nkisi River, to the east, the raffia cloths (Costa e Silva, 2006, pp. 521-522).

In the Kingdom of Angola, at the time of the Portuguese discovery, there were two kingdoms south of the Kingdom of Congo. They were *Ndongo* and *Matamba*. In 1555 a nomadic and ferocious people invaded Congo and southwest Africa, from Guinea to the center of the region today Angola. They were the *Jaca* or *Majaca*, also called *Simba* and

Manes in Guinea, *Gatas* or *Gallas* in Abyssinia (Ethiopia) and *Jingas* in Angola. The invaders destroyed everything and one of the chiefs, the *Ngola Jinga*, took possession of the two kingdoms (*Ndongo* and *Matamba*). He gave the kingdom of *Ndongo* to his son, the *Ngola Nbandi*, whose name has since come to designate the conquered kingdom (*Ngola*: Angola). It was the dynasty of the *Jingas* that was established in Angola, the former kingdom of *Ndongo*, also now called the kingdom of the *Jinga* or the *Jingas*. *Ngola Bandi*, son of *Ngola Jinga*, was a brave king who resisted the fierce expeditions of the Portuguese colonizers several times, victoriously counterattacking them (Vansina, 2011, p. 648).

In 1618 the vassals of *Jinga Nbandi*, eighth king of *Matamba*, tired of the tyranny of the old king, revolted and killed him. *Ngola Nbandi*, son of the old *Jinga Nbandi* and a slave (not to be confused with the first *Ngola Nbandi*), *took power*. Thanks to the conspiracy prepared, and to consolidate the two kingdoms of Angola, *Matamba* had his brother, stepmother and a nephew, the son of a sister, beheaded. This sister is the one who would be the future Queen *Jinga*, the famous D. Anna de Souza. She never forgave her brother for the affront she received (her son's death), although she pretended to have forgiven him and collaborated as Ambassador of the Kingdom of *Matamba* before the colonizers (Costa e Silva, 2006).

It was in one of these embassies that she consented to be baptized in the Catholic religion, receiving the name Anna de Souza. But, at the first opportunity, the Catholic Dona Anna took revenge on her brother, poisoning him on the small island of *Kuanza*, where he had taken refuge beaten by the Portuguese and completely abandoned by his vassals.

There is a passage about the haughtiness of Queen *Jinga*, when received in a palace, in peace negotiations with the Portuguese Viceroy, in Luanda, 1657. Detail: the viceroy sits on the throne to receive her, however, he does not offer *Jinga* a place of seat. Then she retaliates and unravels, and orders one of her maids to get on all fours, to serve as her seat. In this way, he levels himself at the level of the Viceroy, maintaining the horizontality of the dialogue and, at the same time, also demonstrating his power and fearlessness in the face of the attempt to intimidate the colonizing foreigner (Mello, 1945).

Nzinga Mbandi Ngola, queen of *Matamba* and Angola, lived from 1581 to 1663, and represents resistance to the occupation of African territory by the Portuguese who landed there for the slave trade. The Portuguese occupation of that region began in 1578 with the foundation of what is now Luanda, the capital of Angola. King *Ngola Kiluanji*, Nzinga's father, resisted the invasion of his territory for many years. He was succeeded by his son *Ngola*

Mbandi who, initially, also prevented the advance of the slave trade into the interior. Nzinga assisted her brother by negotiating the return of territories already occupied by the invaders. But later he did not agree with the submission to the Portuguese of several African chiefs, including his brother, and, ordering their deaths, he came to command resistance groups to the occupation of the lands of *Ngola* (Angola) and *Matamba* (Thornton, 1991).

Nzinga allied himself with *Jaga* warriors and began to act in quilombos, with spaces and war tactics similar to those used by his contemporary Zumbi dos Palmares in Brazilian lands. He achieved victories and relative peace until he died at the age of 82. In the last days of Queen Jinga, the Capuchin missionaries managed to return to Catholicism (1657) in which she remained until her death on December 17, 1663, at the age of 82, according to Father Antonio Caeta (Pacavira, 1985).

Unlike the African countries already mentioned, Mozambique, having exported, less enslaved to Brazil, did not present sufficient quantity and subsidies in a timely manner, to form another Bantu religious nation of calundu/candomblé. Historical estimates indicate that more than 500,000 slaves were taken from Mozambique during the diaspora period, with significant numbers destined for the islands of the Indian Ocean and, later, for Brazil, especially in the nineteenth century when Bantu calundu/candomblé was already formed by the nation of the Ambundos, speakers of the Kimbundu language, belonging to the country of Angola. and by the Bakongo nation, speaker of the Kikongo language, which previously, that is, before the partition of the African continent, at the Berlin conference, was the former kingdom of Congo, today one of the eighteen Angolan provinces called Zaire (Costa e Silva, 2006).

The slave trade from Mozambique had two main routes: Indian Ocean: Hundreds of thousands of people were trafficked to the Mascarene Islands (such as Réunion and Mauritius) and other regions of the Indian Ocean between the eighteenth and nineteenth centuries. Atlantic Ocean: Although with a smaller contingent, Mozambique became an important source of slaves for Brazil, in the final period of the slave trade, when trafficking from Angola and Costa da Mina suffered greater repression.

Exact figures are difficult to determine due to the clandestine nature of much of the trafficking, especially after the formal ban on the trade. However, historical databases such as the Slave Voyages project bring together thousands of voyage records to help quantify this forced movement. Between the first and fifth centuries, Bantu peoples migrated from

northern and western regions to this region. Swahili and, later, Arab trading ports existed on the Mozambican coast until the arrival of Europeans (Pelissier, 1988).

During the first and fifth centuries, migratory waves of Bantu-speaking peoples came from regions of West and North Africa through the Zambezi River valley and then gradually settled across the plateau and coastal areas of the country. These peoples established communities or agricultural societies based on the cultivation of cattle. In addition, they brought with them the technology for the extraction and production of iron utensils. Metal used by them in the manufacture of weapons in the conquest of neighboring peoples. The coastal trade of Mozambique was first dominated by Arabs and Persians, who had established settlements as far south as the Island of Mozambique. Swahili, Arab, and Persian trading settlements existed along the country's coast for several centuries. Several Swahili trading ports dotted the country's coast before the arrival of the Arabs, who traded with Madagascar and the Far East. Swahili and, later, Arab trading ports existed on the Mozambican coast until the arrival of Europeans (Cabaço, 2010; Mondlane, 1975).

Mozambique is endowed with rich and extensive natural resources. The country's economy is primarily based on agriculture, but the industrial sector, mainly in the manufacture of food, beverages, chemicals, aluminum, and oil, is growing. The country's tourism sector is also growing (Mosca, 2005; Gefffray, 1991).

The arrival of the Bantu peoples in this region more than a thousand years ago introduced important elements in the political, economic and social dynamics of the region, which had a great impact on the political-administrative organization of the Postcolonial States. The Bantu migrated to the region from southern Cameroon and the southeastern region of Nigeria, having populated the territories of Angola, South Africa, Botswana, Democratic Republic of Congo, Lesotho, Namibia, Mozambique, Tanzania, Zambia and Zimbabwe. Subsequent migrations and the slave trade led the Bantu peoples to settle in Madagascar, Mauritius and the Seychelles as well). Among the most common native languages are Macua, Tsonga, Ndau, Chuabo and Sena (Matusse, 2009).

The population of about 30 million people is predominantly made up of Bantu peoples. The religion with the largest number of adherents in Mozambique is Christianity (the Catholic denomination is the one with the largest number of adherents), but there is a significant presence of followers of Islam. The country is a member of the African Union, the *British Commonwealth*, the Community of Portuguese Speaking Countries (CPLP), the Latin Union,

the Organization of the Islamic Conference, the Southern African Development Community and the International Organization of the Francophonie.

As for Portuguese rule, since about 1500, Portuguese trading posts and fortresses have ended Arab commercial and military hegemony in the region, becoming regular ports of the new European sea route to the east. Vasco da Gama's voyage around the Cape of Good Hope in 1498 marked the Portuguese entry into the region's trade, politics, and culture. The Portuguese gained control of the Island of Mozambique and the port city of Sofala in the early 16th century, and by the 1530s, small groups of Portuguese traders and prospectors looking for gold had penetrated into the country's interior regions, where they set up the garrisons and trading posts of Sena and Tete on the Zambezi River, and attempted to gain exclusive control over the gold trade. The Portuguese tried to legitimize and consolidate their commercial position through the creation of the Crown Deadlines (a type of sesmaria), which were linked to the administration of Portugal. Although the deadlines were originally developed to be controlled by the Portuguese, due to miscegenation with the locals they eventually became Luso-African centers defended by large armies of African slaves known as cundas. Historically, there was slavery in Mozambique. Human beings were bought and sold by local tribal chiefs and by Arab, Portuguese and French traders. Many of the Mozambican slaves were supplied by tribal chiefs who raided neighboring warrior tribes and sold their captives to partners. (Cabaço, 2007).

Although Portuguese influence gradually expanded, its power was limited and exercised by individual colonists who were granted extensive autonomy. The Portuguese were able to wrest much of the coastal trade from the Arabs between the 1500s and 1700s, but with the capture of Fort Jesus of Mombasa (in present-day Kenya) by the Arabs in 1698, the trend shifted to the Arab side. As a result, Portuguese investment declined while Lisbon turned to more profitable trade with India and the Far East and the process of colonizing Brazil. During these wars, Arab tribes from present-day Oman recovered some of the trade from East Africa north of Mozambique. In the nineteenth century, other European powers, particularly the British (British South Africa Company) and the French (Madagascar), became increasingly involved in the region's trade and politics around the territories of Portuguese East Africa (Geffray, 1991).

During the Portuguese colonial rule, a large minority of people of Portuguese descent lived permanently in almost all regions of the country and Mozambicans with Portuguese blood, at the time of the country's independence, numbered about 360,000 people. Many of

them left the region after Mozambican independence in 1975. There are various estimates for the size of the Chinese community in Mozambique, seven thousand to twelve thousand people (Cabrita, 2000).

Mozambican literature achieved greater development in the colonial period, dealing with nationalist themes. The most important writers of this phase were Rui de Noronha and Noémia de Sousa. José Craveirinha began in literature in the 1940s, addressing themes of the social reality of Mozambicans in his poems, and provoked the rebellion. He is considered the most important Mozambican poet. José Craveirinha received it. It is believed that a significant part of Mozambican literary production is due to the poets of the so-called "European literature" (Seno, 2024). These poets like Mia Couto are those who, being ethnically Caucasian, center all, or almost all of the theme of their works on the daily problems of Mozambique, exerting a significant influence on the country's national identity, (Braúma, 2014)

Supporting the previous texts, the authors Adolfo (2010) and Lopes (2014), among others, corroborate the importance of investigating African cultural diversities that refer to linguistics, divinities, ancestry, the concept of life and death and reincarnation with an emphasis on the role of the child, it is also of paramount importance in the construction of the content to be included in Brazilian education. In the past, as for the formation of the Baixada Fluminense, it is found that today the following municipalities are: Queimados, São João de Meriti, Belford Roxo, Mesquita, Nilópolis and Duque de Caxias, as former districts of Nova Iguaçu. It is also known that the first wave of slaves coming to Brazil in 1565 came from the ports of West Central Africa. The first shipment of slaves that arrived in Rio de Janeiro dates from the middle of the same period, that is, shortly after the foundation of the City of São Sebastião do Rio de Janeiro (Figueiredo, 2004). Thus began the occupation of the Baixada Fluminense by this valiant people who brought in their *mutue* (head) and in their *muxima* (heart) their divinities and entities, developed here in a secret way, the so-called Calundus, who gave rise to the Bantu Candomblés (Ângelo, 2013). They brought their agricultural technology, here used in the cultivation of sugarcane, cotton, coffee, beans, rice, corn, cassava, etc., in addition to manual arts and many other wisdom (Bezerra, 2011).

As the African diaspora took place, unlike the African peoples, who later arrived and were directed to Salvador - BA (seventeenth and eighteenth centuries), the Bantu arrived from the sixteenth to the nineteenth century, were spread throughout the Brazilian territory, contributing with their agricultural technology, construction of railroads, construction of cities,

among other achievements. A fact that, together with the Indians and the Portuguese, elevated Brazil abroad to the condition of a Nation (Júnior, 1953), (Costa e Silva, 2006), (Freyre, 2003); (Netherlands).

Almost three million people entered the ports of southeastern Brazil, especially Rio de Janeiro, which is equivalent to approximately 21.5% of all Africans who arrived in the Americas as slaves. Of this amount, more than 80% came from the regions of predominance of Bantu culture in West Central Africa. Africans from this region were in majority quantity in the various spaces of slave life in Rio de Janeiro, both in the interior of the province and in the capital. It was common to see them on the streets as urban workers, but especially in the countryside, where the difficult daily life of sugarcane, coffee and other food crops was lived (Bezerra, 2011). (Lopes, 2012), among others. Therefore, it is also a regional and local issue. It is important to highlight the coincidence of the entry of the Bantu in Rio de Janeiro, in the same year of the foundation of the City, 1565. Based on the study initiated by the Baixada Fluminense, culminating in Darwin's theory (1871), there is no reason not to imagine that: **"THE BAIXADA FLUMINENSE IS BANTU, RIO DE JANEIRO IS BANTU, BRAZIL IS BANTU, "THE WHOLE WORLD IS BANTU, YES SIR!"**.

3 METHODOLOGY

The research is based on the use of the qualitative-quantitative methodology, with a descriptive nature, since it began with the collection and measurement of demographic data of the specific African population, supported by its strata, which brought the religious culture of the Bantu peoples to Brazil.

The scientific paradigm followed to make the methodological choices was the pragmatic one, which facilitated the identification and description of the religious culture of the Bantu peoples, in the diaspora of enslaved Africans, subjected to the South Atlantic slave trade. (Costa e Silva, 2006; Slave Voyages, 2017).

In addition to this contribution, a bibliographic review of authors such as: Adolfo (2010), Ângelo (2013), Bezerra (2011), Figueiredo (2004), Lopes (2014; 2012; 2011), Maia (1961), Mott (1997), Pereira (2011), Prandi (1991), Ramos (2001), Redinha (1958), Thompson (2001), Thornton (1991) and Vanzina (2004), among others. Among the expected results is the deconstruction of the negative labeling that marginalizes Candomblé and the *Bantu* nation due to its peculiar aesthetics.

In view of this, some sources were essential for the development of this research, including:

- Library of the University of São Paulo/SP. SIBI/USP – Ground Floor Cidade Universitária. Rua da Praça do relógio, 109, Butantã, São Paulo-SP. Zip Code: 05508-050. Phone: 3091-4195.
- Institute of Brazilian Archaeology - IAB. Belford Roxo, RJ, CEP 26193-575. Phone: (21) 3135-8117. E-mail: www.arqueologia-iab.com.br.

In its first stage, the research found the variables Bantuism and non-Bantuism with the support of descriptive quantitatives, since it was necessary to build a dialogue with historical demography, so that, as shown in Table.1, it was possible to name and quantify the African nations that predominated among the enslaved Africans who arrived in Rio de Janeiro during the Atlantic Slave Trade.

Table 1

African Regions	Numbers	%
Senegambia	756.000	6
Sierra Leone	389.000	3,1
Costa da Mina	337.000	2,7
Gold Coast	1.209.000	9,7
Bay of Benin	1.999.000	16
Bay of Biafra	1.595.000	12,7
West Central Africa	5.695.000	45,5
West Africa	543.000	4,3
Total	12.570.000	100

Source: Slavevoyages (2017). Trans-Atlantic Slave Trade Database. Retrieved from <www.slavevoyages.com>.

Thus, this same table leads to agreement with Bezerra (2011), when he states that of the almost three million enslaved people who entered the ports of southeastern Brazil, 80% were of Banta origin, that is, they came from West Central Africa *versus* Central Africa. Therefore, these variables have to do with the ethnicity and cultural traditions of the first Africans who lived and worked in the Recôncavo da Guanabara during the times of slavery and the Atlantic slave trade.

In the data analysis, the Mann-Whitney test was applied for comparison between two independent samples. Thus, the hypothesis to be tested is that: there is no association between the variables ("Bantu" and "non-Bantu" follow-up) at the level of significance ($\alpha =$

5%). These procedures were carried out to contemplate the general objective that is to investigate and prove the Bantu cultural and religious influence in the Baixada Fluminense, in addition to also covering the specific objectives that deal with training, inclusion in Brazilian education, with the help of the Bantu impact as a single theme in Carnival. For this, the following three were chosen, among many other influencing factors:

- a) The human demographic quantity of each group;
- b) The time lapse between them, as to the order of arrival (sixteenth, seventeenth and eighteenth centuries).
- c) The period of permanence in the territory (from the fifteenth to the nineteenth century, and after slavery).

These factors collaborated in all ways in favor of the Bantu, the result of which showed the majority of *Bantu men and women*, to the detriment of non-Bantu men and women (Africans from other linguistic regions of Africa), as shown in Table 2.

Table 2

Variables – Mann Whitney Test

Variable	Bantus	Non-Bantus	P-value
Male	273,04	230,50	0,012
Women	274,93	243,95	0,075

Source: 2022 survey data.

Table 1 shows that Bantu women, although not statistically relevant, are more numerous than non-Bantu women. This confirms Bantu hegemony in terms of population. However, the exclusivity of men in the Bantu orchestra and a greater demand for musicians demonstrate that there is a Bantu majority in the population of Nova Iguaçu. In this way, it is also possible to measure the cultural impacts of Bantu religiosity in the patrimonial and educational formation of Nova Iguaçu. Thus, the methodology contemplates all objectives, since by virtue of the theme, its variables transit, implicitly or explicitly, throughout the research carried out.

4 CONCLUSION

In terms of experiences, it is an article that invites Brazilian society to dive into the past in terms of diaspora, to get to know itself, and from there, to create new perspectives of Bantu artistic languages, or as an Afro-descendant Bantu, to redesign other expressions as they

have already done when creating the samba school, the maracatus (Nation and Baque Virado), among other artistic languages, as well as, at the same time that they are rarely called upon to make this connection with the past, they will fix in memory the preponderant role of their ancestors in the construction of Brazil and the formation of our Language, and then, with the certainty of their identity, they will strengthen themselves in the fight against racism. And in order to be able to move, not only Brazilian society, but the entire world society, to discover in three or more days, what has been hidden for almost five hundred years in the history of Brazil, the ideal would be to look for the largest amphitheater on the planet, Marquês de Sapucaí **to carry out a thematic plot through the 12 Samba Schools of the Special Group, The thematic plot: EVERYONE "WORLD" IS BANTU YES SIR!** Action that represents a worldwide strategy of visual communication in the fight against racism and appreciation of black identity. As a result, it is important to emphasize that these samba schools, now considered great exponentials of culture, have gigantic and overcrowded rehearsal courts, constituting vast fields of research and information through the rehearsals, guaranteeing valuable returns to the sponsoring brands and the research itself. In addition to court rehearsals, there are also technical rehearsals that take place on the Samba Walkway, external presentations, among other means of dissemination. However, if the 12 samba schools of the special group are not obtained, the amount equivalent to the remaining vacancies will be divided equally among the associations of the Gold Group, which accept the thematic theme in question, since they also parade in Marquês de Sapucaí, on Friday and Saturday of Carnival. And so, successively, being able to reach the Samba Schools of the Silver, Bronze and Evaluation Groups, of Intendente Magalhães, baptized as "carnival of the People", for those smaller schools, which parade there. Thus demonstrating the expansion of dialogue in this project.

Still within this context, it would also be important to hold a hybrid course of presentation and orientation on the subject, lasting 6 months, administered by a competent public or private body, in a previously authorized space, in order to train a reasonable number of participants from each Samba School belonging to the respective group, regarding the memory and heritage of the Bantu in the construction of Brazil and the formation of the Brazilian Language. And within this contest, guide the participating samba schools, didactically, during the production period, including the realization of workshops alluding to the unique theme, preferably in these communities or other interested spaces. In this act you will be discovering and training people, mainly of black origin, many of them who

already work in this field, however, informally, because they do not have certification in the various fields of Art, History and other comprehensive areas, such as: blacksmiths (welders), carpenters, prop makers, decorators, seamstresses, hatters, designers, tailors, carnival workers, dancers, musicians, actors, among many other skills that black culture has to offer.

In terms of plurality, this is a project whose title already expresses the great richness of artistic manifestations presented by the samba schools in an unprecedented way, exploring the Africa/Latin America connection, that is, Angola, Congo, Mozambique, Brazil, the World. These manifestations, complemented with the orientation course alluding to the theme created and applied by professors, on knowledge that reaffirms diversity, connecting orality with academia. In this way, it offers ways to understand the contemporary construction of Identities.

That said, Brazil, Angola, the Congos and Mozambique, with a vast baggage of diversities, frictions and conceptions, symbolize, perhaps, what is most consistent in the immeasurable area of integration disputes between Africa and South America. Thinking in this way, from the union of these cultures, much can and should still be learned. Unraveling some mysteries, and deciphering some taboos, is imperative. Even better, if it can appropriate knowledge such as this and many other learnings, to subsidize representations of greater expansion. Based on the reports of interviewees, the search for greater knowledge about the Bantu in Africa and Brazil will increase the number of followers, practitioners and sympathizers, in search of new knowledge. The theme in question, due to its diversity and non-habituality, brings a range of suggestive potentialities, which will imply many other academic works. Therefore, with the conviction that many obstacles on the Banta theme still need to be overcome, future research is suggested.

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A REAL-TIME PRODUCTION CONTROL SYSTEM

UM SISTEMA DE CONTROLE DE PRODUÇÃO EM TEMPO REAL

UN SISTEMA DE CONTROL DE PRODUCCIÓN EN TIEMPO REAL

 <https://doi.org/10.56238/sevened2025.036-164>

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ABSTRACT

This article presents the development and application of a real-time production control system, integrating hardware and software for continuous monitoring of industrial operations and costs. The proposal aims to promote greater operational efficiency and agility in decision-making. The main objective is to present a proposal for applying the concept of paperless manufacturing, here referred to as “right time,” in a production line of medical and hospital products, in order to identify and quantify the benefits generated by the proposed environment. The adopted methodology was action research, encompassing the system design, its technological architecture, and its application in a simulated manufacturing environment. The results demonstrate significant gains in operational visibility, waste reduction, and improvement in cost control. With the implementation of the developed improvement proposal, a reduction of 32% in document-filling time on the assembly line is estimated, in addition to a 5% decrease in annual paper consumption. Other observed benefits include improvements in internal communication, document control, workplace organization, and the execution of routine activities. Additionally, the study contributes to digital transformation in industry, aligning with the principles of Industry 4.0 and reinforcing the importance of digitalization as a strategic tool for the modernization of production processes.

Keywords: Process Optimization. Digital Transformation. Real-Time Production Control. Industry 4.0. Lean Manufacturing.

RESUMO

Este artigo apresenta o desenvolvimento e a aplicação de um sistema de controle de produção em tempo real, integrando hardware e software para o monitoramento contínuo das operações e dos custos industriais. A proposta visa promover maior eficiência operacional e agilidade na tomada de decisões. O objetivo principal é apresentar uma proposta de aplicação do conceito de manufatura paperless, aqui denominado tempo certo, em uma linha de produção de produtos médicos hospitalares, com o intuito de identificar e quantificar os benefícios gerados pelo ambiente proposto. A metodologia adotada foi a pesquisa-ação, abrangendo a concepção do sistema, sua arquitetura tecnológica e a

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aplicação em um ambiente fabril simulado. Os resultados demonstram ganhos significativos em visibilidade operacional, redução de desperdícios e melhoria no controle de custos. Com a implantação da proposta de melhoria desenvolvida, estima-se uma redução de 32% no tempo de preenchimento de documentos na linha de montagem, além de uma diminuição de 5% no consumo anual de papel. Outros benefícios observados incluem avanços na comunicação interna, no controle de documentos, na organização do ambiente de trabalho e na execução das atividades rotineiras. Adicionalmente, o estudo contribui para a transformação digital na indústria, alinhando-se aos princípios da Indústria 4.0 e reforçando a importância da digitalização como ferramenta estratégica para a modernização dos processos produtivos.

Palavras-chave: Otimização de Processos. Transformação Digital. Controle de Produção em Tempo Real. Indústria 4.0. Lean Manufacturing.

RESUMEN

Este artículo presenta el desarrollo y la aplicación de un sistema de control de producción en tiempo real, integrando hardware y software para el monitoreo continuo de las operaciones y de los costos industriales. La propuesta tiene como objetivo promover una mayor eficiencia operativa y agilidad en la toma de decisiones. El objetivo principal es presentar una propuesta de aplicación del concepto de manufactura sin papel, denominado aquí “tiempo correcto”, en una línea de producción de productos médicos hospitalarios, con el fin de identificar y cuantificar los beneficios generados por el entorno propuesto. La metodología adoptada fue la investigación-acción, abarcando el diseño del sistema, su arquitectura tecnológica y la aplicación en un entorno fabril simulado. Los resultados demuestran avances significativos en visibilidad operativa, reducción de desperdicios y mejora en el control de costos. Con la implementación de la propuesta de mejora desarrollada, se estima una reducción del 32% en el tiempo de llenado de documentos en la línea de montaje, además de una disminución del 5% en el consumo anual de papel. Otros beneficios observados incluyen mejoras en la comunicación interna, en el control de documentos, en la organización del entorno de trabajo y en la ejecución de las actividades rutinarias. Adicionalmente, el estudio contribuye a la transformación digital en la industria, alineándose con los principios de la Industria 4.0 y reforzando la importancia de la digitalización como herramienta estratégica para la modernización de los procesos productivos.

Palabras clave: Optimización de Procesos. Transformación Digital. Control de Producción en Tiempo Real. Industria 4.0. Lean Manufacturing.

1 INTRODUCTION

Digital transformation has driven significant changes in the way industries operate. In this context, real-time production control becomes essential to ensure competitiveness, efficiency, and quality. The concept of "right time" proposes that operations take place at the right time, with adequate resources and without waste. This article proposes a system that integrates hardware and software to monitor and control production in real time, promoting greater visibility and control over production processes.

The concept of Industry 4.0, which emerged in 2011, goes beyond the digitalization and automation of production processes. It encompasses the integration between information technologies and industrial automation, with the aim of reducing latency in managerial decision-making and facilitating access to reliable data from the industrial operation, maximizing business value (Becker et al., 2017).

The global market is increasingly competitive, demanding greater productivity and quality from organizations, reduced production time, and the ability to meet demands with shorter deadlines and more complex products. These products require traceability of both the process and the product, as a way to ensure reliability (Conceição et al., 2009).

To ensure this traceability, companies develop and regulate their manufacturing processes based on internal and external standards. These documents, defined as operational procedures, are fundamental for the standardization of processes and for the prevention of failures and waste, in addition to facilitating the understanding of activities (Freitas et al., 2012).

An approach that contributes to the standardization and integration of these procedures is Virtual Manufacturing, which allows the connection between all sectors involved in the planning, design, updating and documentation of information and specifications of the process and the manufacture of the product on a computational basis (Banerjee and Zetu, 2001; Conceição et al., 2009; Groover, 2011).

Digital Transformation (DT) is a process driven by digital technologies, whose impacts affect the mechanisms of value creation, strategy, and organizational structure (Vial, 2019). It transforms products, processes, structures, and organizational aspects (Matt, 2015). For Feroz et al. (2021), DT goes further, creating opportunities both for business competitiveness and for the remodeling of business performance and its environmental impact.

The concept of electronic documentation (paperless) emerged more than 30 years ago and aims to eliminate or reduce the use of paper in the administrative routine, using

technology to optimize processes, facilitate access to information, save resources and contribute to sustainability (Ortega, 2004). This practice can be applied to companies of all sizes and segments, promoting resource savings, agility, information security, and sustainability. According to Indolfo et al. (1995), documents are material records of information that prove facts and thoughts in a given time and space. Freitas and Guarechi (2011) highlight that electronic documents provide convenience, speed, security and reliability, in addition to reducing the volume of printed material, becoming instruments of great relevance for organizations.

Thus, the main objective of the present work is to present a proposal for the application of the concept of paperless manufacturing, here called right time, in a production line of hospital medical products, aiming to identify and quantify the benefits generated with the proposed environment.

2 INTEGRATED INFORMATION SYSTEM

Efficient data sharing between and within an organization's functional areas directly contributes to more effective business processes and businesses. Information systems designed to enable this sharing are known as integrated information systems. Companies receive resources — such as materials, people, or equipment — and turn them into goods and services for customers. For this transformation to occur efficiently, it is essential to have accurate and up-to-date information.

For example, when receiving a purchase order, the sales team activates production, which schedules manufacturing. If raw materials are required, production notifies the purchasing department, which carries out the purchase. The logistics sector, in turn, receives and accounts for the materials, updates the records and forwards the inputs to production. This flow is only possible with the integration of information systems, which results in a more efficient organization and optimized processes (Monk and Wagner, 2006 1).

According to no et al. (2015 2), the integration of systems facilitates the flow of information and communication between organizational sectors. Rich and Dibbern (20123) add that this optimization allows identifying bottlenecks in data entry and implementing corrective measures. As a result, internal communication improves, productivity increases, and costs are reduced.

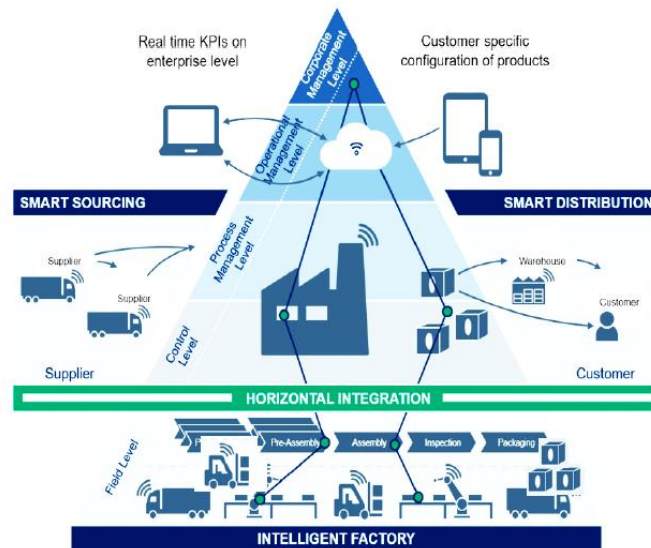
In manufacturing environments, where several departments and employees work simultaneously, the efficient circulation of information is essential. For this, integration between systems and data is necessary (Chao, 2016).

Two fundamental concepts in this context are Horizontal Integration and Vertical Integration. Horizontal Integration connects the sectors of the production chain, allowing quick responses and optimized use of resources — such as, for example, inventory connected to the supplier for automatic replenishment. Vertical Integration, on the other hand, connects all hierarchical levels of the company, from the operation to the board of directors, promoting agility in communication and assertiveness in decision-making (Albertin, 2021).

In this work, the proposal is based on Vertical Integration, allowing the exchange of information in real time between sectors, which generates value for the organization through faster and more accurate decisions. Figure 1 presents the Industry 4.0 pyramid and the concepts of integration and Smart Industry.

Figure 1

Industry 4.0 Pyramid Concepts of Integration and Smart Industry



Source: Pinterest (2022).

2.1 DIGITAL TRANSFORMATION

The term "digital" has been widely used since 2010, and the expression "digital transformation" (DT) has gained prominence in various media, such as newspapers, TV programs, books, and academic articles (Krimpmann, 2015; Andriole, 2020; Imran et al., 2021). Krimpmann (2015, p. 1209) defines DT as the "sum of technologies that transform

previously physical processes into processes that are partial or fully activated by technology". Thus, DT occurs when new structures — such as business models, practices, values, and beliefs — emerge from the consolidation of digital innovations.

Hinings, Gegenhuber and Greenwood (2018, p. 53) add that DT results from the combined effects of multiple digital innovations, creating new actors, structures and practices that challenge or replace existing organizational rules. Vial (2019, p. 3) defines DT as a process that aims to improve institutions through the combination of information, computing, communication and connectivity technologies, promoting new forms of collaboration and innovation.

The structural change promoted by DT requires cultural and behavioral transformations, and leadership is an essential factor in this process (Shaughnessy, 2018). Organizations look to TD to improve the quality of their products and services (Fachrunnisa et al., 2020), as well as to meet environmental sustainability demands (Feroz, Zo, and Chiravuri, 2021).

Digital technologies are reshaping the way sustainability is measured and controlled, especially in areas such as waste management, pollution control, and sustainable production. However, there are still gaps in the literature on how organizations should adapt to these disruptions (Feroz, Zo, and Chiravuri, 2021). Jones and Wynn (2021) note that while "digital" and "sustainability" are dominant trends, their intersection is still underexplored.

Lokuge et al. (2021) highlight that the environmental impact of digital technologies requires global coordination, aligned at the local, organizational, and individual levels, with a focus on awareness, incentives, and overcoming barriers. Sartal et al. (2020) reinforce that today's society recognizes the need for a new model of production and consumption, which considers environmental and social impacts.

In this context, digital technologies offer opportunities to develop sustainable business models or adapt existing ones with environmentally responsible practices. Incorporating sustainability into DT and organizational strategy is still a challenge that requires further study. Feroz and Chiravuri (2021) point out that the development of sustainable digital capabilities positively impacts organizational performance, customer loyalty, and brand value.

Finally, Hausberg et al. (2019) identify gaps in DT research, especially with regard to the sustainability and societal effects of digital technologies. The authors warn of the risks of digital exclusion, especially in economically vulnerable societies, reinforcing the need for a critical and inclusive approach to digital transformation.

2.2 PAPERLESS

According to Granieri (2016), the concept of paperless, that is, the elimination or reduction of the use of paper, is a policy adopted by organizations that, with the help of technology — such as software, applications, and online resources — allows the management and storage of documents in order to optimize processes and increase operational efficiency.

Arney, Jone and Wolf (2009) point out that, in addition to the technology offering new alternatives for reducing the use of paper, it also provides significant cost savings. However, this concept still faces resistance in some companies, due to the difficulty of adapting management and organizational culture, as well as the increase in the flow of information throughout the value chain, which intensifies paper consumption.

With the reduction of the obligation to physically print documents and the advancement of technologies, the market already offers affordable solutions for organizations that wish to adopt the paperless model (Granieri, 2016).

For an effective transition to the digital environment, strategic planning is necessary, which involves investments in high-capacity storage software, such as OCR (Optical Character Recognition), which converts scanned documents into searchable text, as well as applications and devices for creating and maintaining documents. Investments in team training and digital security are also essential (Chuck, 2014).

Johnson (2012) and Granieri (2016) suggest strategic goals for the adoption of paperless systems, such as: reduction of operation time, document traceability, improvement in report generation, optimization of processes and promotion of sustainable practices.

2.3 INFORMATION MANAGEMENT

Information management, as defined by Marcondes (2020), is essential for organizations, as it seeks to identify, organize, and maximize available informational resources. This is fundamental, since information is considered a strategic resource, capable of driving knowledge generation, innovation, and competitive advantage. Information management covers all stages of the information cycle — from collection to use — including the storage, organization, analysis, and distribution of data. For this, it is essential to use technological tools that facilitate access and sharing of information between users.

At the same time, the ISO 9000 standards establish guidelines for the creation and maintenance of a quality management system. These standards define quality principles

applicable to any organization that seeks sustained success through standardization and continuous improvement of its processes. Among them, ISO 9001 stands out, which specifies the requirements to demonstrate the ability to provide products and services that meet customer requirements and legal requirements. ISO 9004 offers guidelines to improve the performance of the quality management system, while ISO 19011 deals with guidelines for internal and external audits (ABNT, 2015).

Therefore, both information management and the adoption of ISO 9000 standards are determining factors for organizational success, contributing to process efficiency, continuous improvement and competitiveness in the market.

3 METHODOLOGY

The present research has a quantitative and qualitative approach and an explanatory character and was applied in a medical products company, manufacturer of dental implants, located in the interior of the state of São Paulo.

For this study, the action research procedure was used, which, as defined by Thiollent (1985) and Gil (2010), is a methodology of experimental verification in a participatory or cooperative way that provides the development and change of the environment/object studied.

Mello et al., (2012), Coughlan and Coughlan (2002) and Thiollent (2007) establish the following stages for the construction of an action research: Exploratory phase; Formulation of the problem; Construction of hypotheses; Hold seminars; Select samples; Collect data; Analyze data; Prepare an action plan; Implement and evaluate the results.

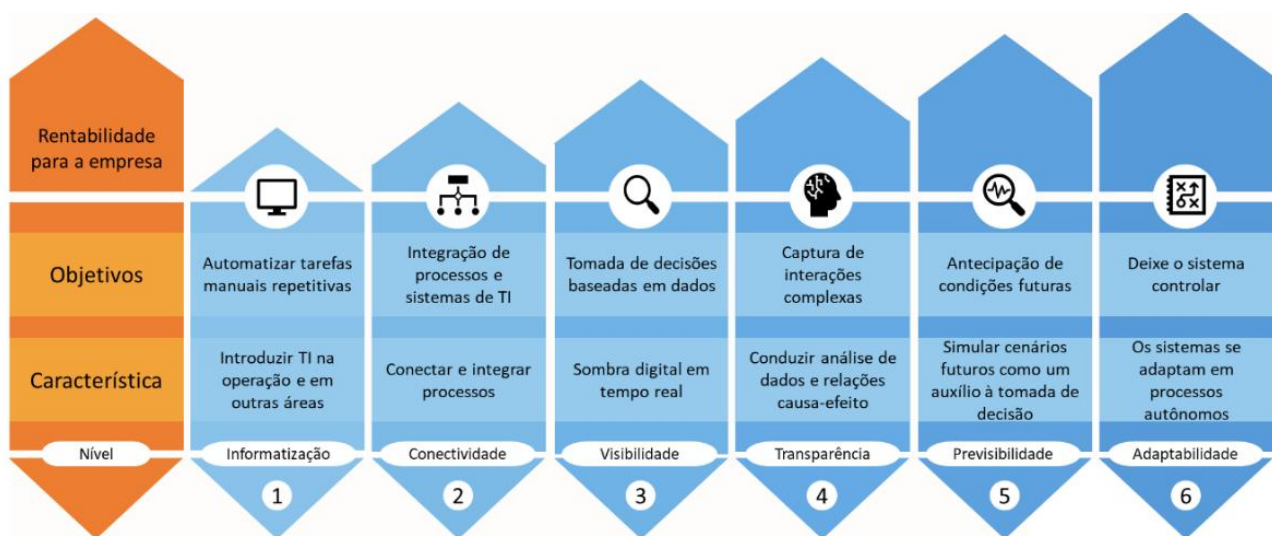
The methodology proposed by the German Academy of Sciences and Engineering (Acatech) allows companies to assess their maturity in relation to industry 4.0 and develop strategies to increase it, aiming to maximize the economic benefits of digital transformation (Becker et al., 2017). This maturity index helps organizations understand their progress in digital transformation and plan their next steps. Acatech describes six levels: a) computerization; b) connectivity; c) visibility; d) transparency; e) prediction capacity; and f) adaptability. Starting with basic automation at the compute level, organizations move on to systems integration at the connectivity level, followed by the ability to monitor operations in real time at the visibility level. Transparency is achieved through detailed understanding of the plant's state, while predictive ability allows you to predict future trends. The apex of maturity is reached at the level of adaptability, where organizations can quickly adjust their

operations and strategies according to changes in the business environment or unexpected problems, however, it has proven to be a challenging task (Beckeret al., 2017).

When it comes to the maturity of a process in relation to Industry 4.0, there are several models that represent the stages of a digital transformation. In the case studied in this article, the company is in a process of computerization, that is, the introduction of systems in an operation. Figure 2 shows the stages of evolution that a company must follow to ensure the digitalization of processes and belong to the Industry 4.0 level.

Figure 2

Stages of the development path of industry 4.0

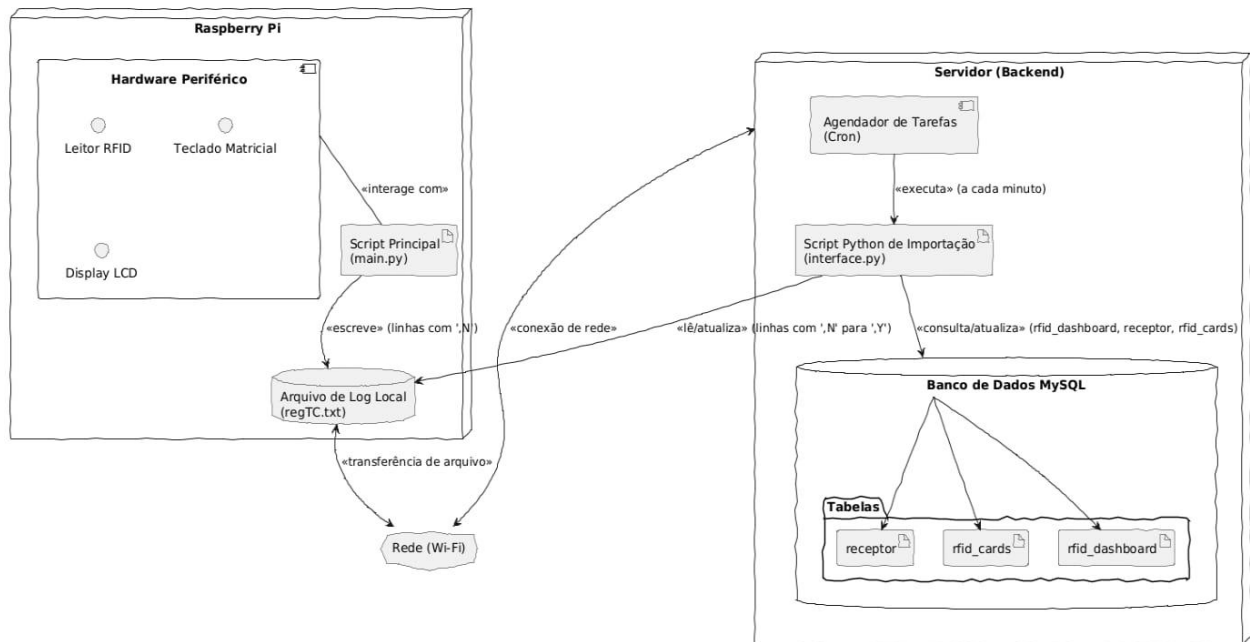


Source: Prepared by the author adapted from Schuh et al. (2020).

Figure 3 shows the flowchart that represents the operation of the system with Raspberry Pi, backend server integrated with its peripherals and MySQL database. It clearly shows the flow of data between the components and scripts involved.

Figure 3

Schematic drawing of the software architecture



Source: Prepared by the author (2025).

4 RESULTS AND DISCUSSION

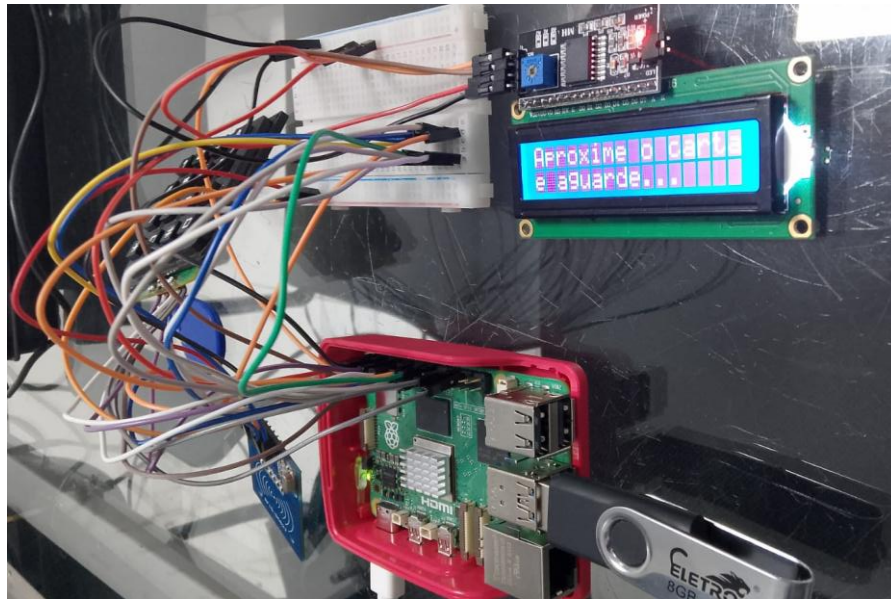
The project developed aims to apply RFID (Radio Frequency Identification) technology to optimize time and cost control in operational and academic environments. Using a Raspberry Pi board integrated with an LCD display and RFID sensors, it was possible to create a functional and accessible system for monitoring attendance and activities.

The message displayed on the display — "Bring the card close and wait..." — indicates the simplicity and efficiency of the identification process, which can be used to register the entry and exit of employees, students or event participants. The collected data is stored locally on an 8GB USB stick, ensuring security and portability.

The photographic record in figure 4 presents the prototyping of the product developed for real-time time and cost control.

Figure 4

Prototyping the Timing hardware



Source: Prepared by the author (2025).

The photographic record in figure 5 shows the device developed in an acrylic case to protect the electronic circuit and easy access to the card reader and for data input using the keyboard.

The device called "Tempo Certo" was tested in a medical device industry, with the aim of controlling production operations in real time. Before the implementation, an employee was responsible for manually collecting the data from the previous day to make the production notes and send the status of the manufacturing system to management. This process was time-consuming and subject to errors and delays.

With the application of the developed technology, based on RFID and embedded computing, the data began to be presented in real time. This allowed the employee to redirect their time to more value-added activities, such as performance analysis and continuous improvement of processes.

According to Wanderley, Holanda and Oliveira (2014), RFID "has been presenting itself as an important tool in the search for quality in the flow of information, presenting great potential for application in various segments". This wireless technology allows the automation of product identification, integrating the physical and technological sectors and providing real-time monitoring of stock levels and movements.

In addition, Salgado (2013) highlights that the integration between technology and logistics allows for a more accurate and efficient information chain, reducing errors and increasing the reliability of processes. Almeida (2010) reinforces that inventories represent about 2% of the net revenue of companies, and effective management is essential to avoid losses and improve operational performance.

Figure 5

Right Time in Operation



Source: Prepared by the author (2025).

Among the main results obtained with the project, the following stand out:

- Reduction of operating costs with manual processes of time and production control.
- Increased accuracy in the collection of time and movement data.
- Process automation, with less human interaction and greater reliability.
- Ease of integration with existing systems, thanks to the use of accessible and open-source components.
- Portability and scalability, allowing system replication in different environments with minimal adaptation.
- Technological engagement of students and entrepreneurs, who actively participated in the assembly and programming of the system.

Figure 6 features an open hand in the foreground, symbolizing human control over digital systems. Floating above the hand, various graphical and user interface elements represent a real-time data processing environment.

Visual composition conveys the idea of interaction between humans and technology, with a focus on monitoring, performance, and control of complex systems. It can be used to illustrate topics such as industry 4.0, intelligent automation, real-time data analysis or human-machine interfaces.

The application of this solution presented several dashboards to facilitate real-time decision-making for management. The results obtained indicate that the implementation of the improvement will allow a 32% reduction in the time to fill out documents on the assembly line of hospital medical products, in addition to a 5% decrease in the company's annual paper consumption. Other benefits include improvements in internal communication, document control, the work environment, and routine activities.

Figure 6

Presentation of results in real time



Source: Prepared by the author (2025).

This work demonstrates how emerging technologies, such as RFID and embedded computing, can be applied in a practical and efficient way to solve real problems, promoting innovation, productivity, and interdisciplinary learning.

5 FINAL THOUGHTS

The present research proposed the application of the concept of paperless manufacturing in a production line of medical products, with the objective of identifying and quantifying the benefits generated by this new environment.

Based on the research carried out, the concepts presented and the analysis of the reality of the company studied, quantitative and qualitative benefits resulting from the implementation of the proposal were identified and quantified.

The results obtained indicate that the implementation of the improvement will allow a 32% reduction in the time to fill out documents on the assembly line of hospital medical products, in addition to a 5% decrease in the company's annual paper consumption. Other benefits include improvements in internal communication, document control, the work environment, and routine activities.

In addition, the study contributes to the digital transformation in the industry, aligning with the principles of Industry 4.0.

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**AFRICAN KNOWLEDGE IN CIRCULATION: NOTES FROM RESEARCH ON
THE CIRCULATION OF PEOPLE, SYMBOLIC GOODS, AND IDEAS IN THE
CONTEMPORARY PRODUCTION OF KNOWLEDGE ABOUT AFRICA**

**SABERES AFRICANOS EM CIRCULAÇÃO: NOTAS DE UMA PESQUISA
SOBRE A CIRCULAÇÃO DE PESSOAS, BENS SIMBÓLICOS E IDEIAS NA
PRODUÇÃO CONTEMPORÂNEA DE SABERES SOBRE A ÁFRICA**

**CONOCIMIENTOS AFRICANOS EN CIRCULACIÓN: NOTAS DE UNA
INVESTIGACIÓN SOBRE LA CIRCULACIÓN DE PERSONAS, BIENES
SIMBÓLICOS E IDEAS EN LA PRODUCCIÓN CONTEMPORÂNEA DE
CONOCIMIENTOS SOBRE ÁFRICA**

 <https://doi.org/10.56238/sevened2025.036-165>

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ABSTRACT

This article, developed within the framework of a broader research project between Brazil and Germany (Barros, 2020), examines theoretical perspectives and methodological challenges involved in the study of knowledge production about Africa in the fields of Literature and the Social Sciences, emphasizing the international conditions that shape the circulation of individuals, ideas, and symbolic goods. Starting from the question of how the international trajectories of African students, writers, and researchers mold contemporary dynamics of knowledge production about Africa, the article articulates the circulation of people, works, and epistemological models within a framework marked by linguistic, political, and institutional asymmetries. The text adopts a descriptive and reflective approach structured around three interdependent axes: first, it explores the theoretical challenges inherent to defining the object when considering epistemic hierarchies and historical asymmetries that have shaped African Studies (Falola, 2007; Hountondji, 2010; Zeleza, 2016, 2020; Yanka, 2016). It then revisits the Bourdieusian contribution (2002) to the study of the international circulation of cultural goods, linking it to Claire Ducournau's (2017) research on the production of Francophone African literary consecration and to the generational dynamics examined by Abdoulaye Gueye (2001; 2006). Subsequently, it discusses the reconfiguration of African student mobilities, highlighting the case of students in the former Soviet bloc based on studies coordinated by Monique de Saint Martin, Grazia Scarfò Ghellab, and Kamal Mellakh (2015), revealing both the diversity of experiences and the varying effects of training in Eastern Europe. In conclusion, the article argues that analyzing the mobilities and circulations observed in these empirical studies—literary, scientific, or educational—offers a privileged avenue for understanding the reconfiguration of imaginaries, sensibilities, and modes of knowledge production about Africa on multiple scales, outlining a research agenda centered on Afro-diasporic trajectories as key operators in the global production of knowledge.

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Keywords: Africa. Knowledge Production. Social Sciences. Diaspora.

RESUMO

O presente texto, elaborado no âmbito de um projeto de pesquisa mais amplo entre Brasil e Alemanha (Barros, 2020), explora perspectivas teóricas e desafios metodológicos envolvidos no estudo da produção de conhecimento sobre a África nas áreas de Literatura e Ciências Sociais, enfatizando os condicionantes internacionais que regulam a circulação de indivíduos, ideias e bens simbólicos. Partindo da pergunta sobre como as trajetórias internacionais de estudantes, escritores e pesquisadores africanos moldam dinâmicas contemporâneas de produção de saberes sobre a África, o artigo articula a circulação de pessoas, obras e modelos epistemológicos em um quadro marcado por assimetrias linguísticas, políticas e institucionais. O texto propõe um registro descritivo e reflexivo, que se desdobra em três eixos considerados interdependentes: em um primeiro momento, explora os desafios teóricos inerentes à construção do objeto quando se consideram hierarquias epistêmicas e assimetrias históricas na moldagem dos estudos africanos (Falola, 2007; Hountondji, 2010; Zeleza, 2016, 2020; Yanka, 2016). Em seguida, retoma a contribuição bourdieusiana (2002) para o estudo da circulação internacional de bens culturais, articulando-a à pesquisa de Claire Ducournau (2017) sobre a fabricação da consagração literária francófona africana e às dinâmicas geracionais examinadas por Abdoulaye Gueye (2001; 2006). Posteriormente, discute as reconfigurações das mobilidades estudantis africanas, destacando o caso dos estudantes no ex-bloco soviético, com base nas pesquisas coordenadas por Monique de Saint Martin, Grazia Scarfò Ghellab e Kamal Mellakh (2015), evidenciando tanto a diversidade das experiências quanto os efeitos variáveis da formação no Leste europeu. Ao final, argumenta que a análise das mobilidades e circulações observadas nessas pesquisas empíricas, sejam elas literárias, científicas ou estudantis, constitui via privilegiada para apreender a reconfiguração do imaginário, das sensibilidades e dos modos de produção dos saberes sobre a África em múltiplas escalas, delineando um programa de investigação centrado nas trajetórias afro-diaspóricas como operadores-chave da produção global de conhecimento.

Palavras-chave: África. Produção de Conhecimento. Ciências Sociais. Diáspora.

RESUMEN

Este texto, elaborado en el marco de un proyecto de investigación más amplio entre Brasil y Alemania (Barros, 2020), explora perspectivas teóricas y desafíos metodológicos implicados en el estudio de la producción de conocimiento sobre África en las áreas de Literatura y Ciencias Sociales, destacando los condicionantes internacionales que regulan la circulación de individuos, ideas y bienes simbólicos. Partiendo de la pregunta sobre cómo las trayectorias internacionales de estudiantes, escritores e investigadores africanos moldean las dinámicas contemporáneas de producción de saberes sobre África, el artículo articula la circulación de personas, obras y modelos epistemológicos en un contexto marcado por asimetrías lingüísticas, políticas e institucionales. El texto propone un enfoque descriptivo y reflexivo que se despliega en tres ejes interdependientes: en primer lugar, examina los desafíos teóricos inherentes a la construcción del objeto cuando se consideran jerarquías epistémicas y asimetrías históricas en la configuración de los estudios africanos (Falola, 2007; Hountondji, 2010; Zeleza, 2016, 2020; Yanka, 2016). En seguida, retoma la contribución bourdieusiana (2002) al estudio de la circulación internacional de bienes culturales, articulándola con la investigación de Claire Ducournau (2017) sobre la fabricación de la consagración literaria africana francófona y con las dinámicas generacionales

analizadas por Abdoulaye Gueye (2001; 2006). Posteriormente, discute las reconfiguraciones de las movilidades estudiantiles africanas, destacando el caso de los estudiantes en el antiguo bloque soviético, a partir de las investigaciones coordinadas por Monique de Saint Martin, Grazia Scarfò Ghellab y Kamal Mellakh (2015), que evidencian tanto la diversidad de experiencias como los efectos variables de la formación en Europa del Este. Finalmente, el artículo sostiene que el análisis de las movilidades y circulaciones observadas en estos estudios empíricos —literarias, científicas o estudiantiles— constituye una vía privilegiada para comprender la reconfiguración del imaginario, de las sensibilidades y de los modos de producción de saberes sobre África en múltiples escalas, delineando un programa de investigación centrado en las trayectorias afro-diaspóricas como operadores clave de la producción global de conocimiento.

Palabras clave: África. Producción de Conocimiento. Ciencias Sociales. Diáspora.

1 INTRODUCTION

The objective of this text is to explore some of the theoretical perspectives and methodological challenges faced by researchers in the context of a research focused on the issue of the production of knowledge about Africa, Literature and Social Sciences contemporaneously. As part of a broader research project that aimed to reflect on the spheres of knowledge production about and for Africa, sewn together in a partnership between universities in Brazil and Germany³ (Barros, 2020), in this text we return to the issue of the international constraints on the circulation of individuals, ideas, and symbolic goods in the international space, trying to outline the contours of a fertile field of studies on student careers, African researchers, intellectuals and literati from the mid-twentieth century onwards.

At its starting point, the guiding question of the research was to understand how the international trajectories of African students, writers, and researchers contributed to shaping contemporary patterns of knowledge production about Africa and the African diasporas in the fields of literature and social sciences. In our perspective, this way of formulating the question would allow us to articulate three distinct and interdependent levels of analysis, combining the circulation of individuals, works and epistemological models. In other words, these modalities of international circulation would dynamize both the literary repertoires and the schemes of interpretation and production of knowledge about Africa, in a framework marked by linguistic, epistemological and institutional hierarchies.

For the present text, however, we intend to offer a more descriptive and reflective record of this ongoing research, striving to build useful tools for researchers and students who wish to venture into the study of a field as broad and challenging as the one that permeates the categories and uses of the international, transnational, globalization and/or globalization (Sapiro, 2021); Africa and African diasporas (Sansone, 2002; Silvério et al., 2020; Gueye, 2006; Zeleza, 2020) and, finally, of the specific forms of internationality in the field of Social Sciences (Gingras, 2002; Siméant, 2015). The focus here is therefore on the forms of articulation between these different axes of problems.

³ Briefly, the aforementioned project, *Producing knowledge about and for Africa in Germany and Brazil*, focused mainly on the careers of Anglophone and Francophone scholars from West Africa and African scholars from countries that have Portuguese as their official language. In the end, the project was interested in addressing the perspectives and motivations of African students and scholars about their priority destinations and exchanges and how this would have contributed to their later professional careers and the construction of African knowledge societies. In the alternative, the interest was also focused on professionals who had passed through Brazil, encompassing both those who returned and those who chose to remain in the national territory (Barros, 2020).

In the perspective adopted in this study, the exploration of the modes of circulation and the trajectories of individuals allows us to reflect in a very refined way on the theme of cultural mediation in asymmetrical conditions, bringing together the problems concerning the circulation of literary goods, epistemological models and which, in the end, refers to the circulation of agents beyond the geographical and institutional boundaries within which we traditionally think of the forms of consecration and literary, intellectual and scientific recognition. All the analytical efforts undertaken here to explore an investigative agenda derive from this attempt to delineate an analytical framework that allows circumscribing this terrain of inquiry, evidencing both its tensions and its potentialities, and indicating paths for future research that deal with African intellectual mobilities as central operators in the global production of knowledge.

Objectively, the text is structured in three axes of discussion considered interdependent. In the first, we raise some of the theoretical challenges implied in the study of the production of knowledge from/in Africa, literature and the social sciences when thinking about the weight of structures of domination over scientific, literary and artistic representations. Next, we return to this issue of the conditioning factors of the international circulation of symbolic goods from the seminal perspective of Pierre Bourdieu (Sapiro; Pacoutet, 2015) exploring a research on the processes of fabrication of the literary consecration of writers and works from sub-Saharan Africa in the French linguistic area (Ducournau, 2017). In the third part, we present some suggestive propositions from the research coordinated by Monique de Saint Martin, Grazia Scarfò Ghellab and Kamal Mellakh (2015) on the experience of African graduates in the USSR and in the countries of the Soviet bloc from the second half of the twentieth century onwards. internationally notable for their inseparably scientific, literary, and political investments (for an inspiring study, see: Ducournau, 2013; Zeleza, 2013).

2 THE CONSTRUCTION OF THE OBJECT AND SOME THEORETICAL CHALLENGES

In fact, the choice to analyze the experiences and trajectories of individuals from African countries, in the context in question, was not fortuitous. In addition to the research we have carried out on leading groups and international circulation (Neris, Seidl, 2015a; Neris, Seidl, 2015b; Neris, Seidl, 2015b; Neris, 2023) or on Nation, memory, and cultural policies in Africa (Barros, 2020; 2021), the historical context concomitant with the Cold War and the Afro-Asian decolonization process – roughly speaking, corresponding to the second half of

the twentieth century (Hobsbawn, 2015) – offers particularly interesting territory for this study, for several reasons.

Starting with the change in international migration patterns, previously dominated by population movements from colonized countries towards colonizing countries (South/North) and the explosion of the universalization of higher education in Africa, especially from 1945 onwards, with dynamics and trajectories that vary according to the country (Zezeza, 2016). Throughout the second half of the twentieth century, as Paul Tiyambe Zezeza (2020) demonstrates, African population migration grew in a higher percentage than any other region on the planet, even tending towards a diversification of destinations with a gradual and consistent increase in displacements on the South/South axis. In fact, this change in patterns has something to say, including about the ways of institutionalizing higher education in Africa and about the training of its leading groups (Niane, 1992; Garcia Jr., 2004).

Equally important was the remarkable expansion of African studies centers, institutes and programs through the molding of an institutional architecture, research and publications (institutes, centers, journals, periodicals) that produced a large number of works (impossible to be inventoried), which do not allow themselves to be crossed by the hierarchies and asymmetries characteristic of the production of knowledge in the international division of intellectual space (Zezeza, 2020). In Brazil, for example, this interest dates back at least to the 1950s, with the creation of the Center for African and Oriental Studies (CEAO) at the Federal University of Bahia, the Center for African Studies (CEA) at the University of São Paulo, which later contributed to the expansion and contemporary consolidation of this field of study in the national academic space (Sansone, 2002; Zamparoni, 2007). As complex, contradictory, processual and/or interdisciplinary as the shaping of African studies may have been, the fact is that these have been structured simultaneously at the national and transnational, local and global levels (Zezeza, 2006), while at the same time taking on different meanings in Africa and in the West (Hountondji, 2010).

We are, however, only at the tip of the iceberg of a current, relevant and decisive debate for the production of knowledge in Africa itself, with a series of epistemological implications and challenges. In fact, it is important to consider that the production of knowledge about Africa on the continent itself is permeated by a power structure that shapes the circuits of intellectual production, validation, circulation and consumption between languages and national contexts that occupy unequal positions (Falola, 2007; Hountondji, 2010; Yanka, 2016).

It is no coincidence that Paul Zeleza criticizes, for example, the way in which in the academic factories of North America and Western Europe African Studies "have historically been imprisoned by languages, epistemologies and discourses that are external to Africa, reducing this continent to no more than a laboratory for testing the supposedly universal models, theories and paradigms" (Zeleza, 2007). Paulin J. Hountondji questions, in turn, whether what we call African studies – which encompasses a diverse framework of disciplines in the Social Sciences (History, anthropology, sociology, economics, political science) – can legitimately be called African, especially when it is not "sourced from Africa or produced by Africans" (Hountondji, 2010). If, for Hountondji, the institutional field of knowledge production in Africa has not been able to formulate original problems, that is, "original sets of problems based on a solid appropriation of the international intellectual legacy and deeply rooted in the African experience" (Hountondji, 2010, p. 128), this does not necessarily mean that there should be a break with the tradition of Western knowledge. In a perspective that seems to us similar to that of the Ghanaian Kwame Anthony Appiah (1997), who studied the formations of African philosophers in the Western tradition, it is understood here that the construction of African knowledge must follow an essentially comparative and critical path, and cannot entirely dispense with the Western philosophical formation itself.

If these conditioning factors of cross-cultural transfers fall strongly on the domain of the social sciences and humanities, they impose themselves even more clearly in the universe of literary production, strongly linked to language and the cultural construction of national identities, even having repercussions on subfields of studies such as comparative literature or comparative studies (Fazzini, 2023). In this sense, Luca Fazzini's (2023) statement is correct that, when one thinks about the place in Africa in *world-literature*, one can see the hegemony/predominance of a restricted corpus of works, authors, and genres (notably the novel), belonging, above all, to the English and French linguistic universe (the Portuguese language occupying a clearly marginal position) and that obtaining global projection and recognition in the Euro-American academic and publishing circuits, they place themselves at the top of the hierarchy of legitimate scientific-literary objects.

The problem becomes even more complex, in fact, when it is conceived that the very definition of African literature(s) permeates/encompasses textualities that are completely marginalized in relation to transnational linguistic areas (English, French, Spanish, German, Portuguese, Arabic), forming, in practice, distinct and split circuits of production and circulation (Gnocchi, 2004). Sometimes excluded, sometimes confined, weakened and/or

dominated, African literatures then tend to depend heavily on the recognition of international bodies and mediators (with which they become an export product), consequently excluding a wide universe of languages, authors and forms of popular, oral, sometimes anonymous, languages and forms of knowledge produced by Africans and which generally do not enter the order of knowledge (Mudimbe, 2013) and in the canon and in the international literary market (in this regard, see: Fyfe; Krishnan, 2022, Hodapp; 2020)

Although with specificities, the production of knowledge about Africa, literature and social sciences presents similarities when taken from the conditioning factors of these asymmetric transnational cultural exchanges. In fact, it is always useful to remember that the schemes of perception and interpretation of colonial and postcolonial realities have always been fed and have been fed by enterprises of domination that permeate scientific, literary and artistic representations (Ducournau, 2010; Sapiro et al., 2015).

3 THE INTERNATIONAL CIRCULATION OF CULTURAL GOODS: CALIBRATING THE CONSTRUCTION OF LEVELS OF ANALYSIS

As we highlighted in a previous text on the translation of literary works, the contributions of Pierre Bourdieu (2002) and a series of authors inspired by his theoretical perspective are fundamental to the design of global research in the Social Sciences (Siméant, 2015). In a short text entitled "*The social conditions of the international circulation of ideas*", delivered on the occasion of a conference at the University of Freiburg in 1989, Pierre Bourdieu then questioned whether there was a spontaneously international intellectual life, when examining the circulation of intellectual works and the examples of import and export between France and Germany. For Bourdieu, in addition to intellectual life being "the place of nationalisms and imperialisms, preconceived ideas, very elementary summary representations", etc., in practice, "international exchanges are subjected to a certain number of structural factors that generate colossal misunderstandings" (Bourdieu, 2002, p. 6). Understanding some of the social mechanisms that operate in this process and that would represent an obstacle to the development of "a European program of scientific research regarding European scientific relations" (Bourdieu, 2002, p. 5) was the objective of this communication, whose main elements can be summarized below (Neris, Neris, 2016):

- For Pierre Bourdieu, the fact that texts do not circulate with their context, that is, that they do not import the field of production with and against which they were produced, means that, when they are introduced in a different field of production, they are

subjected to a reinterpretation as a function of the structure of the field of reception. As the meaning and function of a work in its field of origin are recurrently ignored, the meaning acquired by this or that work is determined to a large extent by the field of arrival;

- This resignification is operated by a series of social mechanisms, such as: selection operations (what is translated? what is published? who translates? who publishes?); marking and labeling operations carried out by publishers, authors, disciplines, etc.; and the operations of reading, through which categories of appreciation and problems that are the product of a different field of production are applied to the works.
- By reconstructing the finishing field, it is possible to better understand the effects of the games to which the translated authors and works are subjected. These involve everything from the reinforcement of dominant positions to ways of strengthening dominated positions, always involving a variety of combinations. It is through the reconstitution of these positions, for example, that it becomes possible to apprehend the affinities linked to identity (or homology) that favor the translation of authors with whom there is a convergence of interests, styles, parties and intellectual projects. "Thinkers of great elasticity are, in this sense, a full plate for these strategic uses", emphasized Pierre Bourdieu (2002, p. 9). In the same way, the characterization of distinct intellectual and social contexts allows us to understand how "fictitious oppositions between similar things and false similarities between different things" are sometimes constituted (Bourdieu, 2002, p. 10).
- In addition, this selection is accompanied by forms of annexation and marking through which certain readings and interpretations of the texts are consecrated, specific issues and problems are highlighted, sometimes residual for the author, while the interpretative authority of the translator and the commentator is consecrated. This labeling also involves the typographic structure of the work, the cover images, the distribution of the text with its emphases, succession of prefaces, etc., through which a series of transformations or even deformations of the original message are also operated.

This is, without a doubt, one of the few texts in which Pierre Bourdieu addresses more directly an object that is linked to the spaces of international power. There is no doubt, in fact, about the fact that the very use of the notion of field to address transnational and international

objects has been motivating debates about the conditions of importation, appropriation and redefinition of the concept (Sapiro, 2019). This was also one of the main theoretical questions faced by several authors who composed the work *Les champs littéraires africains* (2001) - a collection of texts organized by Romuald Fonkoua and Pierre Halen, with the collaboration of Katharina Städtler. In addition to the theoretical framework and the conditions of theoretical appropriation, researchers must also be aware of the variety of notions and the implications that the notions of circulation, transfers, exchanges, networks, connections, miscegenation, hybridizations, etc., carry for the object of study itself. In addition to not seeming appropriate to consider them as mere synonyms, it is appropriate to specify the definition of the terms, their uses, and limits (Sapiro, 2021), including here the understanding of the chosen metaphorical register (Lahire, 2006).

Although with reservations, the problem of the circulation of cultural goods internationally raises a series of levels and questions of analysis that deserve to be highlighted (Sapiro; Pacouret, 2015). Yes, because when it comes to studying international or transnational dynamics, it becomes clear that there is a need to define the unit of observation that is usually based on socially recognized and identifiable entities - cultures, societies, communities, nations, states, regimes (Sapiro, 2012).

Equally important, according to Sapiro and Pacouret (2015), is the choice of levels of analysis: at the macro level, attention should be paid to the structural asymmetries in international relations according to the position in the geopolitical, economic, and cultural power relations between countries (central, semi-peripheral, peripheral); at *the meso level* It is necessary to re-inscribe the analysis in the structure of national markets and the fields of cultural production of origin and reception (editorial, artistic, musical, cinematographic, literary, among others) and at the *micro level* arouses interest precisely the strategies and individual or institutional motivations of production, use and appropriation and mediation of imported cultural goods. It is important to emphasize, moreover, that "the center-periphery scheme" constitutes a powerful tool to describe the phenomena of asymmetry in the linguistic exchanges in question (Casanova, 2002)

Once the particular category of cultural asset has been selected - in this case, literature or scientific production in the social sciences - the corpus (author, school and/or genre) has been defined, it is necessary to identify the forms of materialization, the modes of production of publications and the symbolic capital linked to the prestige of both the authors, the mediators or importers. A decisive step is, therefore, to circumscribe this circulation between

spaces and cultures according to the place of publication of origin and the place of reception, and this choice may fall both on larger units such as countries, as well as on more particular cities and contexts (Sapiro; Pacouret, 2015). The use of international catalogs, as well as national publishers, compendiums, anthologies and bibliographic databases can be particularly useful in the attempt to map this circulation. No less important is the very definition of the linguistic area (nationality, geographical origin) which also produces not inconsiderable effects on the conditions of circulation of the works⁴.

The unequal distribution of this capital orders the literary linguistic field according to an opposition between the literary languages dominated by one part – languages that have recently been "nationalized" (i.e., made national languages relatively late), endowed with little literary capital, little international recognition, a small number of translators (national and international) or poorly known and remaining for a long time invisible in the great literary centers (such as Chinese and Japanese) – and on the other hand, the dominant languages, which, due to their specific prestige, their antiquity, and the number of texts declared universal written in their languages are endowed with an important volume of literary capital (Casanova, 2002, p. 9).

Some important studies can be mentioned as salutary examples of the use of these theoretical perspectives, especially works that deal with the material circulation of symbolic goods, with particular attention to the center-periphery relations between France and the countries of the African continent. The chosen approach is also opportune, since the international trend of valuing writers from the cultural peripheries in the literary, publishing, book salons, schools/or universities gained strength mainly after the 1980s (Sapiro, 2020).

In this sense, it is worth highlighting especially the work of Claire Ducournau, who was directly interested in the material and symbolic mechanisms that guaranteed the access and recognition of authors linked to the African continent, whose careers were marked and shaped by the institutions of French literary life (Ducournau, 2017). In line with the research program proposed by Pierre Bourdieu, Ducournau makes efforts to understand the logic of the work of writing, of publishing and seeing oneself recognized in a literary scene, in view of the structural constraints that condition the production and reception, the internal and external analyses of the works. Thus, through a prosopographical research with 151 writers from the

⁴ In addition to the theoretical issues, it would also be necessary to add here that the study of processes, institutions and actors that move on the international scene also requires from researchers not only the mastery of distinctive social and linguistic skills, but also the availability of resources to carry out empirical work in costly and sometimes adverse conditions. which is a not inconsiderable challenge in a professional and academic area such as ours that recruits mainly graduates from the lower classes and with less chance of having the required economic and linguistic capital (in this regard, see: Siméant, 2015).

French-speaking part of Sub-Saharan Africa who had gained recognition in the post-independence context, she was able to demonstrate how the creation of a "legitimate African literature" or even the emblem "African literary classic" was manufactured in France from two transnational waves: the first, in the 1980s, demarcated by the entry of Leopold Sédar Senghor into the French Academy and, later, in the 1990s, which depended heavily on some intermediaries for it to be recognized as properly literary. In addition to great intellectual figures, such as André Gide and Jean Paul Sartre, literary magazines (the recompositions of the publishing world, as a whole), then contributed to the molding of a kind of legitimate profile of the African writer, with all the implications on how and why some authors are published and others are not.

To a large extent, the outline of these processes converges with the generational dynamics of the black diaspora of African intellectuals in France studied by Abdoulaye Gueye (2001; 2006). Strongly influenced by the more general migratory movements and political dynamics in the African and French contexts, these *Les Intellectuels africains en France* are understood as belonging to different generations in Gueye's reading: the first generation, whose entry would have occurred between the 1950s and 1970s, would be very marked by the transitions of political regime, by the pioneering in the realization of higher studies in independent structures in Africa and massively influenced by Marxism, when not directly engaged in the Federation of Students of Black Africa in France (FEANF), created in the 1950s. Socialized under colonization, these individuals tended to build their identities and engagements around an autonomous Africa, elaborating different repertoires of justification for returning to the newly independent countries, in which they placed their hopes of participating in national construction (notably by engaging in political and/or diplomatic positions).

In a different way in relation to the previous generation, subsequent generations, in addition to having less insertion in the conventional instances of politics, attenuate their political discourses in the same proportion as they invest in other domains (economic, cultural, scientific). Born in the post-independence period and progressively distanced from the African continent, to which they no longer directed their expectations of return or to the reconstruction of Africa, the new generations began to present motivations more directed to concrete and clearly defined objectives, such as punctual sending of resources or materials to the countries of origin (Gueye, 2001). It is precisely among these generational strata that reach adulthood in the 1980s that the first literary productions of part of the literati studied by

Ducournau (2017, p. 299) are found, who, despite their greater concrete distance from the African territory, maintain an ambiguous relationship with an Africa conceived as an entity, discursive and referential in his "works produced outside the continent". In fact, despite the structural differences observed, perhaps this more recent experience of African students who activated different strategies of family reproduction - such as the constitution, for example, of diasporic families, which were dispersed across different countries and continents and in various professional domains - constitutes the manifestation of the acquisition of what Angela Xavier de Brito called the *habitus of migrant*⁵ (Brito, 2010).

In fact, a decisive part of the works of literature published between the 1960s and 2010 in the area in question are concentrated in a restricted number of countries, with a notorious preponderance of France, followed by Cameroon, Zaire/DRC, Senegal, etc. (Ducournau, 2017). Throughout this process, in fact, there was a notorious change in the genres preponderant in the scale of literary values, progressively passing from poetry, until then dominant in African literature, to the novel, which would better adjust to the logic of the market and to the expectations (including university ones) in relation to African literary productions in France. In a very similar way, this issue of the importance of external mediation also appears forcefully in Wend Griswold (2000) who used Nigerian novels to explore the impact of production systems on the content of the literary work. Through his work, it has been evidenced, for example, that British publishers are more likely to publish Nigerian novels if the themes concern the traditional, peasant, rural universe, even if a significant part of Nigerian novelists write books that address urban social problems.

4 STUDENT MOBILITIES IN THE GLOBAL SOUTH: NOTES FROM THE EXPERIENCES OF AFRICAN STUDENTS IN THE FORMER SOVIET BLOC

On this topic, as already pointed out, we shift the focus to a fertile field of study that has explored the redefinition of forms of academic mobility, appearing, alongside the traditional South/North displacements, a series of other multipolar and even invisible

⁵ "This last notion takes into account some of the aspects covered by the concept of *habitus*, as it is summarized by J.C. Kaufmann (2001): the *habitus of migrant* is a second nature, which is constructed through the succession of experiences lived during the processes of spatial mobility, during which people who move acquire new mental schemes and new moral and bodily dispositions. Or even, an implicit intelligence, situated between reflexivity, memory and the unconscious, buried in the most intimate of beings, which is sedimented in individuals and serves, in turn, as an instrument for the transmission of cultural acquisitions. But the *habitus of the migrant* also includes aspects described by the Bourdieusian concept of *habitus*, to the extent that, by dint of being repeated, these dispositions acquire a certain stability, become more or less socially structured - and, therefore, structuring" (Brito, 2010, P. 433)

migrations of students from countries on the African continent (Leclerc-Olive et Hily 2016; Saint Martin et al., 2015). The attempt to retain some lessons from the exploration of the experiences of African students who arrive in the former Soviet bloc is what motivates the project. We then selected the work coordinated by Monique de Saint Martin, Grazia Scarfo-Ghellab et Kamal Mellah (2015), which raises, from our perspective, important questions about the new mobilities between countries of the South, particularly those in Africa⁶. From our perspective, the exploration of the unprecedented experiences faced by students, activists and trainees who settled in a geographical, political, cultural and linguistic context as distinct as that of the USSR allows us to suggest, with great richness, an instigating agenda of research on the expectations, implications and biographical consequences of the international migrations of African graduates who return or settle outside the continent.

In *Étudier à l'Est* (Saint Martin et al., 2015) the authors attempted to combine three fundamental levels of analysis. First, some of the researchers try to outline the political, social and institutional frameworks within which cooperation agreements and government policies from State to State were operated. In this context, two major events that mark the Soviet rapprochement with African states stand out: in 1957, the Sixth World Festival of Youth and Students organized in the socialist bloc and which brought together representatives from 131 countries with 600 African participants; in addition, the foundation in Moscow of the University of the Friendship of the Peoples, which in 1961 was renamed Patrice Lumumba University, intended primarily for students from Asia, Africa and Latin America (Yengo; Saint Martin, 2017). On the second level, the book addresses the experiences, narratives, hopes and contradictions experienced by former African students, notably the first to confront this experience. The last part focuses on the contrasting experiences of the migratory path, but mainly with the conditions and itineraries of return, demarcating the effects and variable profitability of the passage through different worlds.

It is also worth highlighting the suggestive methodological strategies, based on in-depth interviews and the use of a corpus of very diverse sources, such as archives of the Russian Federation, Unesco, embassies of African countries, as well as literary testimonies written by former African students, such as the novel by the Guyanese Jan Carew, entitled *Moscow n'est pas ma Mecque* or *Tavarich Gay*, written by Souleyanta Ndiaye (Saint Martin

⁶ Although they were increased from the 1960s onwards, with the creation of several establishments in Eastern Europe aimed at welcoming African students, it should be noted that their contacts with the communist world were older (Yengo; Saint Martin, 2017).

et al., 2015). In this way, the authors were able to explore various facets of the Soviet experience, such as the weight of the discovery of otherness, the challenges of adapting and learning the language, hopes and disappointments, daily vicissitudes and undesirable events, relationships of complicity, friendship, but also surveillance and control, etc. The diversity of memories of former African students then refers to the very complexity of experiences and trajectory, combining convergent dynamics at the same time as singularities.

As is well known, while the international migrations of students were characterized until the 1950s by the omnipresence of currents going notably from colonized countries towards colonizing countries, from the mid-1950s onwards new mobilities emerged, such as that of students from African and Asian countries, recently independent, destined for socialist countries. This process is undoubtedly linked to the increasingly central place acquired by the international in the legitimization schemes of the ruling groups on the global stage (for an excellent reconstitution of this debate in Brazil, see: Seild, 2013). In the case of Africa, this increase in international student mobility has shifted northward (Gérard, 2008; Niane, 1992), as traditionally occurred, but with a strong increase in the south-south axis and within the continent itself, as has already been evidenced in several recent studies (Geisser, 2000; Mazzella, 2009; Tati, 2014).

It should also be emphasized that a significant part of these migrations are still part of the framework of cooperation agreements, which depend heavily on government policies and the strategies of the new African states in an international space divided into blocs. Concomitantly with the Afro-Asian decolonization movement, there was the progressive opening, carried out by the Union of Soviet Republics (USSR) and different socialist countries, of institutions, programs and incentives for the massive and systematic collection of Maghreb and sub-Saharan students (Saint Martin et al, 2015). The reasons for this opening, however, do not stem simply from an expansionist policy of the USSR in relation to the third world, but also from the demand of African countries that did not yet have universities and had an urgent need to train new elites (Gheorghiu, 2012).

The case of Portugal's former colonies can be taken as an illustrative example of this, since, with the end of Salazarism in 1984 and the massive departure of metropolitans and their descendants, the leaders of liberation movements in Angola, Mozambique and Guinea-Bissau had to "appeal to the offer of intellectual and political skills at an international level", with which a series of posts were opened for Brazilian exiles (Garcia Júnior, 2004, p. 249). Occupying first-level positions in public universities or even in the educational system of

countries such as Angola and Mozambique, these Brazilians then participated in the process of diversifying the forms of international cooperation with effects not yet fully understood (Garcia Júnior, 2004). Be that as it may, in parallel with the massive return of Brazilians in the context of progressive liberalization of the Brazilian public space, there was an increase in Russian, Bulgarian and German cooperation from the German Democratic Republic (GDR) in the Portuguese-speaking space of Africa.

Thus, through the creation of Soviet Houses of Science and Culture, Soviet Cultural Centers, the organization of libraries full of Soviet publications in other languages, or even the demand for the incorporation of Marxism-Leninism in the education systems of the countries economically and politically supported by the USSR, broad Soviet hegemony was consolidated in the space in question. All of this allows us to understand more clearly how African mobilities towards Eastern Europe have been increased on the continent, and are certainly "among the most important institutionalized student mobilities in the history of higher education and executive training" (Saint Martin et al, 2015; Katsakioris, 2015).

The data compiled by Katsakioris (2007) corroborate this centrality acquired by the Soviet Union as the main destination (from 611 between 1959-1960, the number of African students only increased to more than fifteen thousand in 1980 and reached about 30 thousand on the eve of the fall of the Berlin Wall), followed at a distance by Romania and the GDR. The available statistics regarding these student flows are full of gaps, however, requiring several precautions from researchers. When researching African students in Romania and the GDR, Mihaï Dinu Gheorghiu highlighted the state of disorganization of the archives, the geographical dispersion of the actors and the difficult communication between Europe and Africa as a powerful discourager for carrying out studies such as the one under discussion (Gheorghiu et al, 2015).

In any case, the compulsory research allows us to outline some of the striking traits of these African students, mostly men, recruited for studies in Eastern Europe. Although these should be selected from among the children of workers or peasants, according to Soviet guidelines, in practice, as Katsakioris, Demintseva and Mazov (2015) have found, the selection on the African side was carried out arbitrarily, without exactly meeting the criterion of modest social origin, which allowed students from middle social sectors to enter, of the elites and even of the offspring of the aristocracies of their countries of origin. In some situations, such as that of Minabe Diarra, of the Communist Party of Mali – who defended her thesis in 1972 at the Institute of Ethnography and Anthropology of the USSR Academy of

Sciences – these students did not even have a secondary education (Siim-Moskovitina, Dobronravin; 2015). Almost all of these students were supported by scholarships, either those provided by their home states or by Soviet political, social, or cultural organizations.

Although they were divided into different areas, including literature, philosophy, cinema, most of these students focused on training in engineering, medicine, pharmacy, agronomy, among others (Saint Martin et al, 2015). Generally, the disciplines in the field of Social Sciences were the object of optional teaching in universities – when they were not subsumed under the teaching of Marxist-Leninist philosophy – with only a small minority of foreigners who specialized in these disciplines. It is not surprising that few studies have been concentrated on the intellectual and/or political trajectories of elites of the humanities among the works gathered in the work (Kouvouama, Bowao; 2015). Be that as it may, it is precisely in the domain of the social sciences that the Soviet ideological influence was most clearly outlined, based on a methodological and theoretical basis necessarily informed by Marxist-Leninist ideology. Anna Siim-Moskovitina and Nikolay Dobronravin (2015) thus show part of the demands that were imposed on the production of theses and thesis summaries sustained in Leningrad or Moscow:

In these disciplines, Marxist-Leninist ideology was the formal basis of methodology. All students were required to quote Lenin, Marx, Engels, and the Soviet leaders of the time (from Khrushchev to Gorbachev) in their writings and speeches. This was even more true if they were preparing for a PhD in history or anthropology. When African doctoral students described and analyzed their own cultures and societies, all the phenomena described were interpreted within the framework of historical materialism. They had to severely criticize the "bourgeois and pro-capitalist" approaches of the West in the social sciences, as well as the reality of traditional societies (caste, arranged marriages, polygamy, etc.) and their "old-fashioned" and "archaic" way of life that "delays" the development of individuals.

When it comes to African Studies, Anna Siim-Moskovitina and Nikolay Dobronravin (2015) also note that these were poorly developed until the 1960s. An example of this, the Institute of African Studies, founded in 1959 and dependent on the Russian Academy of Sciences, began its first publications only in 1973, extending until 1990. This process of institutionalization, by the way, was contemporaneous with the increase in interest in the USSR in French, Portuguese, and English-speaking African literature among the more general and specialized Soviet public (Nikiforova, 2000). This is a process of African-Soviet rapprochement that arouses interest not only in relation to the patterns and conditions of

student circulation, but also opens up an agenda of research on the growing number of art and film festivals, the creation of conferences of African and Asian writers and the reception of African artists and intellectuals by the USSR (In this regard, see: Blum et al., 2021).

Finally, it should be noted that the experiences of return are varied and the very conditions of using the diploma as an asset depended strongly on the political dynamics of each African State of origin. It is necessary to guard against the view that the rate of return on stays abroad consequently generated given conditions for social ascension on return. Thus, for example, while the degrees obtained by students from countries that opted for the path of socialism (Benin, Congo, Mali, Angola, etc.) served as tickets for quick access to public and prominent functions, in countries still strongly linked to colonial metropolises, such as Morocco or Ivory Coast, the diplomas acquired in the socialist bloc were often declassified and labeled as mediocre in the face of the excellence of the studies carried out in the bloc capitalist. The exploration of the diversity of return itineraries of these students and the problematic cases of recognition of the diploma obtained in the USSR, requiring a series of reconversions or professional reorientations, reveal that the value of the diploma was not at all mechanical and univocal (Saint Martin et al, 2015). The example of Bulgaria and the varying effects of international mobility in the field of social sciences and humanities can be taken as particularly suggestive.

5 THE CIRCULATION OF AFRICAN WORKS, GRADUATES AND TEACHERS: SOME PROVISIONAL CONCLUSIONS

At the end of the text, the reader may rightly ask himself: what is the common point in the empirical and theoretical considerations made so far about the production of knowledge about Africa, Literature and Social Sciences. At first glance, it may not seem like much, but the scientific curiosity outlined here in relation to the conditioning factors of the production of knowledge, the circulation of cultural goods and literary productions to/from/for Africa has led us to highlight precisely the experiences of migration, travel and displacement of concrete individuals that end up playing a fundamental role in the reconfigurations of the imaginary and sensibilities in relation to the continent. Valid for the African literary scene (in this regard, see: Mazauric; Sow, 2013), the importance of these mobilities is also decisive when it comes to thinking about the academic space itself and the circulation of research models, knowledge, and practices (Niane, 2011) in an increasingly complex, diverse, and competitive structure of the global market for scientific skills (Dia, Ngwe, 2018).

Obviously, the selection of student or teacher mobility is aligned with the very intention of reflecting on the epistemological conditioning factors of knowledge production in Africa and by Africans (Hountondji, 2010), also opening space to reflect on the contribution of researchers from the continent to research in the humanities and social sciences in Africa (Gueye, 2011). But these reflections are equally useful when one thinks, for example, of the trend identified by Paul Zeleza (2006) in departments of Euro-American literature in which, under the influence of the dominant versions of postcolonial theory, at the same time that generous niches have been opened in multicultural studies programs for African writers, there is a tendency to canonize a literary production based on the West or on themes set in it, filtered by the stereotyped focus on transnational and migrant subjectivities and textualities. In fact, much remains to be done in order to objectify the relations of domination that permeate the schemes of interpretation of colonial and postcolonial realities in literature, the arts and the social sciences (Sapiro; Ducournau, 2010),

Despite the existence of peculiarities/singularities in the conditioning factors of the circulation of scientific and literary works (Sapiro, 2012), there are many dimensions of international circulation and the experiences of various individuals that raise convergent problems at various points. In any case, what we want to emphasize is that the exploration of African migrations, of African diasporas, which articulate ancient and innovative dynamics, archaic or contemporary forms - it would be necessary to recall with Zeleza (2020, p. 921) the existence of differences and similarities between the "trans-Indian oceanic diasporas, the trans-Mediterranean diasporas and the transatlantic diasporas" - offers unique opportunities to apprehend the reconfiguration of the imaginary, of sensibilities and, certainly, of the modes of production of knowledge as well as of the goods and works of culture. What we sketch here were the outlines of the construction of a dynamic object, which continues to challenge researchers.

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NEWTON'S LAWS AND THEIR TEACHING IN HIGH SCHOOL: AN INVESTIGATIVE APPROACH

LEIS DE NEWTON E SEU ENSINO NO ENSINO MÉDIO: UMA PROPOSTA INVESTIGATIVA

LAS LEYES DE NEWTON Y SU ENSEÑANZA EN LA EDUCACIÓN SECUNDARIA: UNA PROPUESTA INVESTIGATIVA

 <https://doi.org/10.56238/sevened2025.036-170>

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ABSTRACT

The persistence of traditional practices in Physics teaching, characterized by excessive mathematical formalism and a content-transmission-centered approach, still hinders students' construction of meaning in secondary education. In the case of Newton's Laws, such an approach tends to privilege the mechanical application of formulas to the detriment of conceptual understanding and the problematization of phenomena. This article aims to discuss theoretical and didactic foundations for teaching Newton's Laws and to present an inquiry-based proposal aligned with the Brazilian National Common Curricular Base (BNCC), aimed at overcoming such formalism. This is a theoretical-bibliographic study grounded in constructivist frameworks and contributions from inquiry-based science education, articulating assumptions of the Science, Technology, Society and Environment (STSE) approach, elements from the History and Philosophy of Science (HPS), and the use of Digital Information and Communication Technologies (DICT). The proposal is structured around the investigation of contextualized problem situations that mobilize prior knowledge, teacher mediation for the formulation of students' hypotheses, and the conceptual systematization of the three laws of motion. As potential outcomes, this proposal fosters an inquiry-based approach that promotes the construction of meaning regarding the relationships among force, mass, and motion, expanding evidence-based argumentation and strengthening students' scientific autonomy. It is concluded that this teaching proposal contributes to overcoming formalism in the teaching of Newton's Laws, requiring pedagogical intentionality, formative assessment, and teacher education consistent with current curricular guidelines.

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Keywords: Physics Education. Newton's Laws. High School. Inquiry-based Approach. Problem Situation.

RESUMO

A persistência de práticas tradicionais no ensino de Física, marcadas pelo formalismo matemático excessivo e pela centralidade na transmissão de conteúdos, ainda dificulta a construção de significados pelos estudantes no Ensino Médio. No caso das Leis de Newton, tal abordagem tende a privilegiar a aplicação mecânica de fórmulas em detrimento da compreensão conceitual e da problematização dos fenômenos. Este artigo tem como objetivo discutir fundamentos teóricos e didáticos para o ensino das Leis de Newton e apresentar uma proposta investigativa alinhada à Base Nacional Comum Curricular (BNCC), voltada à superação desse formalismo. Trata-se de um estudo de natureza teórico-bibliográfica, fundamentado em referenciais construtivistas e em contribuições do ensino por investigação, articulando pressupostos da abordagem Ciência, Tecnologia, Sociedade e Ambiente (CTSA), elementos da História e Filosofia da Ciência (HFC) e o uso de Tecnologias Digitais da Informação e Comunicação (TDICs). A proposta organiza-se a partir da investigação de situações-problema contextualizadas que mobilizam conhecimentos prévios, mediação docente para a formulação de hipóteses discentes e sistematização conceitual das três leis do movimento. Essa proposta possibilita, como possíveis resultados, uma abordagem investigativa que favorece a construção de significados das relações entre força, massa e movimento, ampliando a argumentação baseada em evidências e fortalecendo a autonomia científica dos estudantes. Conclui-se que essa proposta de ensino contribui para a superação do formalismo no ensino das Leis de Newton, exigindo para tanto, intencionalidade pedagógica, avaliação formativa e formação docente consistente com as diretrizes curriculares vigentes.

Palavras-chave: Ensino de Física. Leis de Newton. Ensino Médio. Abordagem Investigativa. Situação-problema.

RESUMEN

La persistencia de prácticas tradicionales en la enseñanza de la Física, caracterizadas por un excesivo formalismo matemático y por la centralidad en la transmisión de contenidos, aún dificulta la construcción de significados por parte de los estudiantes en la educación secundaria. En el caso de las Leyes de Newton, dicho enfoque tiende a privilegiar la aplicación mecánica de fórmulas en detrimento de la comprensión conceptual y la problematización de los fenómenos. Este artículo tiene como objetivo discutir fundamentos teóricos y didáticos para la enseñanza de las Leyes de Newton y presentar una propuesta investigativa alineada con la Base Nacional Común Curricular (BNCC) de Brasil, orientada a la superación de dicho formalismo. Se trata de un estudio de naturaleza teórico-bibliográfica, fundamentado en referentes constructivistas y en aportes de la enseñanza por indagación, articulando presupuestos del enfoque Ciencia, Tecnología, Sociedad y Ambiente (CTSA), elementos de la Historia y Filosofía de la Ciencia (HFC) y el uso de Tecnologías Digitales de la Información y la Comunicación (TDIC). La propuesta se organiza a partir de la investigación de situaciones-problema contextualizadas que movilizan conocimientos previos, la mediación docente para la formulación de hipótesis por parte de los estudiantes y la sistematización conceptual de las tres leyes del movimiento. Como posibles resultados, esta propuesta favorece un enfoque investigativo que promueve la construcción de significados en las relaciones entre fuerza, masa y movimiento, ampliando la argumentación

basada en evidencias y fortaleciendo la autonomía científica del estudiantado. Se concluye que esta propuesta de enseñanza contribuye a la superación del formalismo en la enseñanza de las Leyes de Newton, exigiendo intencionalidad pedagógica, evaluación formativa y formación docente coherente con las directrices curriculares vigentes.

Palabras clave: Enseñanza de la Física. Leyes de Newton. Educación Secundaria. Enfoque Investigativo. Situación-problema.

1 INTRODUCTION

School education, throughout its institutionalization process, began to reflect the sociocultural contexts in which it is inserted. However, it still preserves traditional practices centered on the mechanical and decontextualized transmission of contents, characterized by low student participation and little appreciation of prior knowledge (Vygotsky, 1987; Durkheim, 1922). This model, criticized by Rubem Alves (2010) for limiting students' creativity and engagement, is described by Freire (1968) as banking education, marked by vertical pedagogical relations, absence of dialogue and weakening of problematization as a formative principle.

In the field of Physics Teaching, such characteristics are often manifested in the excessive emphasis on mathematical formalism and in the centrality of algorithmic resolution of exercises, to the detriment of conceptual understanding and the construction of meanings. Research in the area has defended methodologies aligned with contemporary demands, valuing active participation, investigation and the development of critical thinking (Nardi, 2001; Moran, 2000).

This change in perspective dialogues with the growing need to promote learning that transcends the mere application of formulas and favors the interpretation of everyday natural and technological phenomena. From a normative point of view, the Law of Guidelines and Bases of National Education (LDB) and the National Common Curriculum Base (BNCC) guide an education focused on the integral development of students, emphasizing contextualized, inclusive practices based on evidence-based argumentation (Brasil, 1996; 2018).

In the field of Natural Sciences, the BNCC highlights the investigation of phenomena, the understanding of the relationships between Science, Technology, Society and Environment (CTSA) and the construction of competencies that articulate conceptual knowledge and citizen action.

In this scenario, the teaching of Newton's Laws in High School assumes a structuring role in the organization of Mechanics, as it makes it possible to understand forces, movements and interactions present in everyday situations and in technological applications. However, when approached predominantly under formalist logic, this content tends to be reduced to the mechanical application of mathematical relations, making it difficult to understand the concepts that underlie such relations.

Overcoming this limitation implies recognizing the student as an active subject of the

learning process and promoting practices that favor problematization and the construction of meanings.

In view of this scenario, this article starts from the following research question: Which didactic paths can contribute to overcoming formalism and decontextualized traditional practices in the teaching of Newton's Laws in High School, favoring the construction of meanings by students?

In line with this issue, the objective of this article is to discuss theoretical and didactic foundations for the teaching of Newton's Laws in High School and to present a proposal for didactic organization oriented to overcoming formalism and promoting conceptual learning.

From this outline, the article is organized in the presentation of the theoretical foundations that support the proposal, in the description of its principles and structuring stages and in the discussion of its implications for the conceptual learning of Newton's Laws in High School.

2 THEORETICAL FRAMEWORK

2.1 CONSTRUCTIVISM AND CONSTRUCTION OF MEANINGS IN THE TEACHING OF PHYSICS

The criticism of transmissive approaches in the teaching of Science is supported by the constructivist bases that understand learning as an active process of construction of meanings. Ausubel (1985) argues that learning becomes meaningful when new information is related in a substantive and non-arbitrary way to the student's previous knowledge. Such a perspective shifts the focus from memorization to cognitive organization and conceptual anchoring.

Vygotsky (1987) expands this understanding by highlighting the role of social mediation and language in the formation of scientific concepts, situating the Zone of Proximal Development (ZPD) as a privileged space for cognitive advancement. Learning, in this horizon, does not occur in isolation, but through guided interaction, in which the teacher assumes a decisive role in the organization of situations that enable the progressive internalization of concepts.

Piaget (1998), in turn, contributes by emphasizing the processes of assimilation and accommodation, understanding cognitive development as a continuous movement of imbalance and rebalancing. Cognitive conflict, in this context, constitutes a structuring element of the construction of knowledge. Learning Physics, therefore, is not reduced to the

reproduction of mathematical procedures, but involves conceptual reorganization and establishment of relationships between different representations and experiences.

This understanding dialogues with contemporary curricular guidelines that defend the integral formation of the student and the articulation between scientific knowledge and application contexts (Brasil, 2018). The construction of meanings, in this sense, becomes a structuring axis for the teaching of classical contents of Mechanics, such as Newton's Laws, often reduced to algorithmic application.

2.2 TEACHING BY INVESTIGATION AND PROBLEM SITUATIONS

In the context of Physics teaching, teaching by investigation is pointed out as a consistent alternative to practices focused on exposure and mechanical resolution of exercises. Gil-Pérez (1993) and Cachapuz (2005) defend didactic models based on problem-situations that mobilize previous knowledge, stimulate mediation for the formulation of hypotheses and lead to the progressive systematization of scientific knowledge.

The problem-situation is not configured as a mere applied exercise, but as a structured context that provokes questions, makes alternative conceptions explicit and creates conditions for its conceptual reconstruction. In this process, teacher mediation is essential to articulate the hypotheses formulated by the students to the consolidated scientific models, avoiding both authoritarian imposition and the absence of epistemological direction.

This approach can integrate, through dialogic, elements of the History and Philosophy of Science (HFC), evidencing the historical and provisional nature of scientific models, as well as articulate relationships between STSA. The insertion of Digital Information and Communication Technologies (DICTs) expands possibilities of visualization, simulation and analysis of phenomena, as long as it is guided by clear pedagogical objectives.

By shifting the focus from memorization to investigation, teaching by inquiry favors the development of evidence-based argumentation and intellectual autonomy, aspects consistent with the competencies provided for in the BNCC for the Natural Sciences (Brasil, 2018).

2.3 FORMATIVE ASSESSMENT AND PEDAGOGICAL MEDIATION

Consistent with the investigative perspective, the evaluation assumes a formative and procedural character, overcoming the exclusive emphasis on the verification of final results. Campos and Nigro (1999) argue that evaluation should be integrated into the teaching process, allowing the monitoring of the students' conceptual evolution and guiding more

precise pedagogical interventions.

Pozo (2009) expands this understanding by proposing multidimensional and continuous assessments, such as qualitative records, concept maps and contextualized activities, capable of evidencing advances, difficulties and cognitive strategies mobilized by the students. Evaluating, in this horizon, implies understanding how the student thinks and how he reorganizes his ideas in the face of new conceptual challenges.

Such an approach becomes particularly relevant in the teaching of Newton's Laws, content that often reveals persistent Aristotelian alternative conceptions related to force, motion, and interaction. Pedagogical mediation, articulated with formative evaluative strategies, contributes to making these obstacles explicit and to promoting their conceptual overcoming.

2.4 DIDACTIC TRANSPOSITION AND IMPLICATIONS FOR THE TEACHING OF NEWTON'S LAWS

Didactic transposition, understood as a process of reorganization of scientific knowledge into school knowledge (Delizoicov; Angotti; Pernambuco, 2002), is a central dimension in the discussion about the teaching of Newton's Laws. The challenge lies not only in simplifying content, but in selecting, reorganizing and contextualizing concepts in a way that preserves their scientific coherence and explanatory power.

In the case of Mechanics, the risk of formalism is manifested when laws are presented exclusively as mathematical relations, detached from their conceptual foundations and their conditions of validity. Prioritizing conceptual understanding implies making explicit that Newton's Laws apply to macroscopic systems in inertial frames (non-accelerated frames) and that outside these limits, these laws require other theoretical formulations, such as Relativity and Quantum Mechanics. This explanation favors a more consistent view of the nature of scientific models.

Materials produced by the Group for the Reelaboration of Physics Teaching (GREF, 1993) and the National Book and Didactic Material Program (PNLD) 2024 exemplify didactic reorganization efforts aligned with curricular guidelines, by integrating everyday situations, CTSA relationships, HFC elements, TDICs, conceptual problematization and investigative teaching. These initiatives reinforce the need to overcome the centrality of algorithmic manipulation and to promote inclusive practices that consider different rhythms and modes of learning.

In this sense, the framework presented here supports the defense of a teaching of Newton's Laws oriented to the construction of meanings, to intentional mediation and to the investigation and problematization of phenomena in line with the current curricular guidelines and with critical scientific training.

3 METHODOLOGY

This article is characterized as a theoretical-bibliographic research, with a qualitative approach and propositional character. Bibliographic research, as defined by Gil (2010), is developed from material already prepared, especially books, scientific articles and official documents, enabling the critical and systematic analysis of concepts and categories pertinent to the problem investigated. In this sense, the study organizes and interprets contributions from the field of Physics Teaching and Science Teaching, articulating them to the elaboration of a didactic proposal aimed at the teaching of Newton's Laws in High School.

The qualitative approach is based on the understanding of processes, meanings and theoretical constructions, prioritizing interpretation and conceptual analysis to the detriment of data quantification (Lüdke; André, 2013). Bogdan and Biklen (1994) point out that qualitative research is concerned with understanding the phenomenon in its context, seeking to interpret meanings attributed to practices and concepts. Although the present study does not involve the collection of empirical data, it shares this orientation by critically analyzing theoretical references and their implications for the didactic organization.

The methodological path was structured in two complementary movements. The first consisted of the selection and analysis of literature related to the axes that support the investigated problem: constructivist contributions to meaningful learning; fundamentals of teaching by inquiry; formative evaluation and pedagogical mediation; didactic transposition; and national curriculum guidelines, with emphasis on the National Common Curriculum Base. The analysis sought to identify theoretical convergences, conceptual tensions and gaps related to the formalistic treatment of Newton's Laws in High School.

The second movement focused on the systematization of a proposal for didactic organization based on the analyzed references. The proposal was structured based on contextualized problem situations, mobilization of previous knowledge, mediation in the formulation of hypotheses and subsequent conceptual systematization of the three laws of motion. Possibilities of articulation with CTSA relations, HFC elements, use of TDICs and formative assessment strategies integrated into the teaching process were also considered.

As this is a theoretical and purposeful study, there was no empirical application in a school context or participation of research subjects, dispensing with ethical procedures related to research with human beings. As a limitation, it is noteworthy that the proposal presented was not submitted, within the scope of this article, to empirical validation in the classroom, configuring itself as a theoretically grounded didactic organization and open to further investigation in future investigations.

4 RESULTS AND DISCUSSIONS

The analysis of the theoretical references mobilized throughout this study allowed us to organize a didactic proposal for the teaching of Newton's Laws in High School based on three articulating axes: mobilization of previous knowledge, problematization through contextualized situations and conceptual systematization mediated by the teacher. As it is a theoretical-bibliographic and propositional study, the results presented here refer to the systematization of this didactic organization and the discussion of its pedagogical implications in the light of the literature in the area.

4.1 ORGANIZATION OF THE DIDACTIC PROPOSAL

The didactic proposal is organized in sequential and articulated stages, designed to favor the conceptual reconstruction of Newton's Laws from contextualized problem-situations. Each stage involves three fundamental moments: survey of previous knowledge, problematization in groups and teacher mediation oriented to conceptual systematization.

The starting point consists of mapping the students' initial conceptions about movement, force and interaction. This survey can be carried out through a brief diagnostic pre-test, open-ended questions projected in class, or guided reading of a short text that explores intuitive notions about why objects move or stop. The objective is not to evaluate performance, but to make explicit previous ideas often associated with the conception that movement requires continuous strength to maintain itself.

4.1.1 Newton's First Law: Inertia and Frames of Reference

To introduce the First Law, the following problem-situation is proposed: what happens to standing passengers when a bus starts or brakes abruptly? Before any formalization, students are organized into small groups and are invited to discuss and record explanatory hypotheses. It is common to emerge interpretations based on the idea that the body "is thrown

backwards" or "pushed forward" by a mysterious force associated with the movement of the vehicle.

At this point, the teacher assumes the role of mediator, asking the groups to explain their justifications and confront arguments. The collective discussion shows that, when the bus accelerates, the passenger's body tends to maintain the previous state of rest, going backwards; when he brakes, he tends to maintain the state of movement, going forward. From this confrontation of ideas, the principle of inertia is introduced, explaining that a body remains at rest or in uniform rectilinear motion (MRU) if the net force on it is zero.

As a historical and epistemological expansion (HFC), it is suggested the guided reading of excerpts from *Galileo's (1999) Dialogues on the two greatest systems of the world*, in which experiments with inclined planes and the notion of conservation of motion in the absence of resistance are discussed. The analysis of these excerpts makes it possible to highlight the rupture with Aristotelian physics, which associated movement with the continuous action of a force, conceptually preparing the ground for the Newtonian formulation of the principle of inertia. This moment contributes to the students' understanding that scientific concepts result from historical processes of debate and overcoming previous models.

After the discussion, conceptual systematization is carried out: inertia is presented as a property related to the mass of the body, understood as a measure of resistance to the variation of the state of motion (GREF, 1993). Situations such as the use of seat belts, airbags and the movement of satellites in orbit are analyzed to consolidate the understanding of the principle in different contexts, such as the analysis of CTSA relationships. At this point, the limits of validity of Newton's Laws are also explained, highlighting that they apply to macroscopic systems, in inertial frames and at speeds much lower than the speed of light.

4.1.2 Newton's Second Law: Relationship between force, mass and acceleration

To address the Second Law, the investigative logic is resumed. The proposed new problem-situation involves two identical supermarket carts, but one empty and the other loaded with bottles of water, both initially at rest. The question is: what is needed to set them in motion? In which of them is it more difficult to move it, applied to the same force? What happens if we apply the same force to both?

Students discuss in groups and record their hypotheses. They often recognize that the loaded cart requires "more effort," but they do not always articulate this perception with the

quantitative notion of mass as a measure of inertia. Teacher mediation leads to the analysis that the variation of movement depends on the net force applied and the mass of the body, and it is also up to the teacher to relate this situation to the conceptual elements discussed in the First Law (inertia and mass) (GREF, 1993).

Formalization occurs gradually. It is based on the idea that the net force is associated with the variation of movement over time (acceleration). In High School, for constant mass, this relationship is expressed by:

$$F_r = m \cdot a \quad (1)$$

It is explained that:

represents the net force (N), mass (kg), and acceleration (m/s²). The focus is not only on calculation, but on interpretation: all acceleration results from the action of a net force and, for the same force, bodies of greater mass have less acceleration. F_r, m, a

To consolidate this understanding, a contextualized example is analyzed: a 1200 kg car that travels at 20 m/s and suffers a braking force of 6000 N. The application of equation (1) leads to a (de)acceleration of -5 m/s^2 . The physical meaning of the result is discussed: the velocity decreases by 5 m/s every second while the force acts (hence the negative sign). This moment is decisive to prevent the equation from being perceived as a mere algorithmic tool, emphasizing its explanatory power. Later, having explained the third law, one can return to this example and detail it by discussing Newton's three laws in this same situation.

Situations involving acceleration and braking of vehicles, sports practices or displacement of loads expand the analysis and favor the articulation of this law in contexts such as the analysis of CTSA relations.

4.1.3 Newton's Third Law: Interactions and pairs of forces

The Third Law is introduced from a problem-situation involving an athlete kicking a suspended sandbag. The question is: if the athlete applies force to the bag and puts it in motion, why does he feel pain on impact and is "pushed back"? Group discussion allows for the explicit of alternative conceptions, such as the idea that only the object "receives" the force.

Teacher mediation leads to the understanding that forces are interactions between bodies. By exerting force on the sac (, the athlete simultaneously receives a force of the same intensity and direction (, but in the opposite direction (hence the negative sign). This relationship can be expressed by: $\vec{F}_{AS})\vec{F}_{SA})$

$$\vec{F}_{AS} = -\vec{F}_{SA} \quad (2)$$

Examples such as rocket propulsion, jumping, and vessel displacement reinforce the interactional character of the forces and broaden conceptual understanding in different contexts, such as the analysis of CTSA relationships.

To deepen the study of Newton's Laws, it is also possible to problematize whether the First Law constitutes a particular case of the Second. Although relation $\vec{F}_R = m\vec{a}$ (1) suggests that the absence of acceleration implies a net force of zero, this interpretation is conceptually insufficient. The Second Law expresses a classical deterministic model that describes everyday macroscopic phenomena, but does not exhaust the foundations of Newtonian mechanics nor does it apply to relativistic or quantum domains (Nussenzweig, 1997).

It is inferred, therefore, that Newton's First Law is not a particular case of the Second. Its essential function, although it is compatible with the condition of $a = 0 \text{ m/s}^2$, implied in $F_r = 0 \text{ N}$, is to establish the existence of inertial frames, a necessary condition for the validity of Newton's three Laws and of the entire formalism of classical mechanics.

4.1.4 Integration of digital resources and formative assessment

Throughout all stages, it is recommended to use interactive simulations, such as those provided by Physics Education Technology (PhET), to explore vectors of force, balance and motion. Simulations should be accompanied by guiding questions that require qualitative interpretation before mathematical formalization.

The evaluation occurs in a procedural way, through written records of hypotheses, debates, collective syntheses and resolution of contextualized problems. This monitoring allows the teacher to identify conceptual advances and persistent difficulties, adjusting pedagogical interventions.

4.2 DISCUSSION OF THE RESULTS IN THE LIGHT OF THE LITERATURE

The systematized didactic organization shows convergence with the constructivist bases discussed in the theoretical framework. The mobilization of previous knowledge and the confrontation of hypotheses dialogue with the perspective of meaningful learning, as new information is anchored in existing cognitive structures. Cognitive conflict, triggered by problem situations, favors conceptual reorganization, as pointed out by classic studies in the area.

The centrality of teacher mediation proves to be a decisive element to avoid both formalistic imposition and the absence of conceptual rigor. By articulating student hypotheses to consolidated scientific models, the professor preserves the epistemological coherence of the content, without reducing the student to a mere executor of algorithmic procedures.

The results of the systematization indicate that the investigative approach contributes to shift the focus from the calculation to the physical interpretation of the relationships between force, mass and motion. By integrating everyday situations, limits of validity of laws and discussion of inertial references, the understanding of the nature of scientific models is expanded, overcoming simplifying views often present in textbooks.

The articulation with CTSA relations and with digital resources strengthens the contextualization and expands the formative reach of the content, in line with the competencies provided for the Natural Sciences. In addition, the incorporation of formative assessment throughout the process allows for the monitoring of the conceptual evolution of the students, favoring more precise pedagogical interventions.

In general, the results discussed indicate that the overcoming of formalism in the teaching of Newton's Laws does not depend on the elimination of mathematics, but on its reintegration into a process of construction of meanings. When inserted in an investigative, mediated and contextualized path, laws cease to be formulas to be applied mechanically and constitute explanatory instruments to understand phenomena of the physical world.

Thus, the proposal presented reaffirms that the teaching of Newton's Laws, guided by problematization, intentional mediation and formative evaluation, can consistently contribute to the critical scientific education of high school students, in line with the current curricular guidelines and with the contemporary demands of Physics Teaching.

5 CONCLUSION

This article aimed to discuss theoretical and didactic foundations for the teaching of Newton's Laws in High School and to present a proposal for didactic organization oriented to overcoming formalism and promoting conceptual learning.

In response to the research question, it is argued that the overcoming of traditional decontextualized practices and excessive mathematical formalism passes through didactic paths that replace the student at the center of the learning process, articulating prior knowledge, problematization and intentional teacher mediation, in order to transform the laws of motion into explanatory instruments to interpret real situations and not just formulas to be applied mechanically.

The results of this study, of a theoretical-bibliographic and propositional nature, consist of the systematization of a didactic proposal anchored in contextualized problem situations for Newton's First, Second and Third Law, with explicit stages of diagnostic survey, group discussion, formulation of hypotheses, confrontation of ideas and conceptual systematization.

The incorporation of CTSA relations, elements of HFC, as well as the guided use of DICTs, expands the possibilities of visualization and argumentation, preserving conceptual rigor. It is a viable proposal for application in High School, as it is based on everyday situations, accessible didactic resources and strategies that can be integrated into the teacher's regular planning, without requiring complex structural changes in the curriculum.

From a formative point of view, the proposal reinforces that the teaching of Newton's Laws gains consistency when supported by formative and procedural evaluation, capable of making persistent alternative conceptions visible and guiding pedagogical interventions along the way. In line with the BNCC and the current curricular guidelines, the organization presented contributes to a Physics Teaching more aligned with contemporary demands, by favoring evidence-based argumentation, critical reading of everyday phenomena and a more rigorous understanding of the modeling character of physical laws.

As a limitation, as it is a theoretical and purposeful study, the proposal was not applied empirically in the scope of this article. Future investigations, through intervention research or case studies, may analyze its implementation in different school contexts, examining its effects on conceptual learning and on the overcoming of alternative conceptions. Even so, it is argued that the didactic reorganization presented offers consistent foundations to face the formalism in the teaching of Newton's Laws, strengthening a more critical and meaningful scientific education in High School.

ACKNOWLEDGMENTS

The authors would like to thank the State University of Rio Grande do Norte (UERN) and the Federal Rural University of the Semi-Arid (UFERSA), institutions to which the authors are linked as civil servants, for their institutional support to the development of this research. Finally, they acknowledge the National Council for Scientific and Technological Development (CNPq) for granting a doctoral scholarship to the first author and the CNPq Knowledge Dissemination Support Scholarship - Level 1C, for the second and fourth authors.

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