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ANALYSIS OF PADDD: AN ENVIRONMENTAL ECONOMETRIC APPLICATION

Gláucio Costa de Menezes
Isabel Lausanne Fontgalland

An aerial photograph of a river winding through a dense, dark forest. The river is the central focus, reflecting the sky and the surrounding trees. The forest appears thick and continuous on both sides of the waterway.

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Presentation of the book

When you have such a new and broad research object in hand, it ends up interfering in new modeling movements in an intense way, directly or indirectly affecting the way of life of an immense variety of theories that surround us.

This process is driven by an old, relentless, and well-known logic of development "at any cost", based on originality. By this logic, successive frontiers of observation are identified, and explored, sometimes only temporarily, but in our case, it became research of approximately three years.

In 2000, Brazil's Federal Law No. 9.985 was enacted, which regulated Article 225 of the Constitution of the Federative Republic of Brazil of 1988, §1, items I, II, III and VII, and created the National System of Conservation Units and the Federal Conservation Units of Integral Protection, the latter being a type of protected area created by the Federal Public Power with the objective of preserving natural ecosystems from anthropic actions, allowing only indirect use of them, that is, that which does not involve consumption, collection, damage or destruction of natural resources. However, nature protection units have been affected by downgrading, redesigned and extinction events since the year 1900. These events, which also originate from acts of public authorities, are known as PADDD and intensified at the end of the first decade of the 21st century.

To get an idea of the amount of interference in nature conservation areas, located in Brazilian continental lands, and in their various biomes, according to the WWF organization (2019, online), in the period from 1900 to 2014, 67 PADDD (Protected areas downsizing, downgrading and degazetting) events were enacted and another 60 were proposed, totaling 127 actions that affected approximately 91,494 km² of area. These events called PADDD are acts of public power that aim to redelimit, downgrade or declassify protected areas. These acts are created through laws or decrees, considering that protected areas have a legal origin, and as stated in our legal system, a law can only be modified by another equal or superior law.

Using data inferred from websites related to the monitoring of Full Protection Conservation Units and the occurrences of PADDD events, as well as websites that provide data on the average income of municipalities, the number of employed population, the total value of salaries and other remunerations paid to people who exercise some type of occupation and their Gross Domestic Product (GDP), and using econometric tools such as the Multiple Linear Regression Model, we sought to answer the following problems: what are the economic and legal effects caused by PADDD events on the variation of the average income of the population, on the number of the employed population, on the total resources used to pay salaries and other remunerations of this employed population and on the Gross Domestic Product of the municipalities where the affected Brazilian federal Integral Protection Areas are located, in the period between 2000 and 2020, according to the Multiple Linear Regression Model? How can the multiple inputs of variables be measured in several occurrences of downgrading, redelimitation or declassification of conservation units?

The objective was to understand and quantify, using the Multiple Linear Regression Model, the economic and legal factors that influence the number of federal protected areas of the Full Protection type, taking into account variables such as: extension of the protected area, retraction of protected areas caused by PADDD events proposed and enacted between the years 2000 to 2020, territorial extension of the areas affected by PADDD events in their various primary causes and the variations in the average income of the population, the number of employed people, the total resources used to pay salaries and other remunerations of this economically occupied population and the nominal GDP, between the years 2000 to 2020, of the municipalities where these declassified, redelimited or downgraded conservation units are

located. Analyze the economic and legal effects caused by PADD events on the variation of the average income of the population, the number of employed populations, the total wages and other remuneration paid to the employed population and the nominal GDP of the municipalities where the Brazilian federal integral protection areas are located, in the period from 2000 to 2020, according to the Multiple Linear Regression Model.

In order to keep up with so many challenges in a country with continental borders, the year 2021 would be decisive for Brazil to take off, through systems of conservation units provided for in the Law of the National System of Conservation Units (SNUC) and other categories of officially protected areas such as Permanent Preservation Areas (APP's), Legal Reserves (LR's) and indigenous lands with native vegetation, at least 30% of the Amazon and 17% of each of the other biomes, protect being ensured and respected for the areas important for the Brazilian biodiversity collection and for ecosystem services, their demarcation, regularization and effective and equitable management.

Thus, to study the effects of these events known as PADD in Brazilian municipalities that have federal conservation units of integral protection inserted in their territorial limits, using variables such as the value of the average income of the population, the number of employed population, the total salaries and other remunerations paid to these people who have some type of paid occupation in these cities, as well as the value of their Gross Domestic Product, in the time span from 2000 to 2020, with the support of the Multiple Linear Regression Model, becomes important because the results achieved will contribute to a better direction of public policies that aim to promote events of this nature, since they will provide relevant information about the effects of this type of act on the economy of a municipality, so that the benefits and harms of these strategies can be analyzed in a comparative way.

Furthermore, the research proposed here is of scientific and social relevance and can serve as a basis for advances in environmental protection and in guaranteeing society's rights to a balanced environment, as well as for other studies in the areas of Environmental Law and Natural Resource Management.

Gláucio Costa de Menezes
Isabel Lausanne Fontgalland

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*"Sometimes we feel that what we do is nothing but a drop of water in the sea. But the sea would be smaller if it lacked a drop."
(Saint Terese of Calcuta).*

1 INTRODUCTION

1.1 *Contextualization of the problem*

The environment has always been a great source of raw material for humanity, whether this matter is of plant, animal, or mineral origin. The vast majority of needs are met through factor-factor and factor-product correlations, which indicate in their genesis the nature of economic development.

However, numerous scientific works, especially those produced by scholars of the economic sciences, demonstrate that some resources made available by nature are finite, and it should therefore be sought to develop strategic measures so that their use occurs in the most rational way possible. Among these strategies is, since the 1970s, the creation and dissemination of so-called "protected areas", whose main scope is the preservation of the environment for future generations.

Although, in this work, the terms "protected areas" and "conservation units" are used as synonyms, these present certain nuances that individualize them. The main one is the fact that "conservation unit" has a more legal connotation, given that the concept of this term is described in Federal Law No. 9,985/2000, which established the National System of Conservation Units in Brazil, which defines it as a preservation strategy legally established by the Government.

In turn, the term "protected area" can be more related to the natural sciences, being widely used by environmentalists and environmental scholars. For the IUCN (2017, online), the term protected area would be a strategy for the preservation of biodiversity instituted, considering legal means. However, it would aim not to PPAlly adequate guarantees of protection, but to achieve the long-term conservation of natural resources with their ecosystem services and associated cultural values. Ecosystem services, which are the definition above, can be considered, based on the best literature on the subject, as being the benefits that nature makes available to society, which is vital for the continuity of productive activities. According to the Ministry of the Environment (2022, online), examples of these services are food, water, climate regulation, cultural heritage, and cultural and historical identity.

Following the global trend, which is to develop effective public policies in the conservation and preservation of the environment, the Brazilian legal system underwent a process of improvement that culminated in the promulgation of the Constitution of the Federative Republic of Brazil, in October 1988, and the emergence of the aforementioned National System of Conservation Units (SNUC), in the year 2000, composed of numerous nature protection units, legally constituted and under the coordination of the federal, state and municipal governments. In 2021, these Conservation Units totaled 2,598, that is, they protect Aproximately 18% of the Brazilian continental territory.

Therefore, due to the need to undertake economic growth and development strategies, the

country had to cede space within the areas of environmental preservation, due to certain primary factors that triggered strategic actions of government agencies, through public policies for the development of the economy. As an example, there is the expansion of road infrastructure and hydroelectric systems, so that they could more satisfactorily serve the population and sectors of the economy.

These expansions ended up interfering in the Brazilian terrestrial biomes intensely, directly or indirectly affecting the way of life of an immense variety of living beings that inhabit them, whether these species are endemic or not. This process is driven by an ancient, relentless, and well-known logic of "at any cost" development based on immediacy. By this logic, successive frontiers of natural resources are identified, occupied, devastated, and exploited, sometimes only temporarily.

To get an idea of the amount of interference in the areas of nature preservation, located in the Brazilian continental lands, and in their various biomes, according to the WWF organization (2019, online), in the period from 1900 to 2014, 67 events of relimitation, reclassification, and extinction of conservation units (Protected areas downsizing, downgrading and degazetting) were promulgated and another 60 were proposed, totaling 127 actions that affected Aproximately 91,494 km² of area. These events, called PADDD, are acts of public power that aim to relimit, demean, or declassify protected areas. These acts are created through laws or decrees, considering that the protected areas have a legal origin and, as stated in our legal system, a law can only be modified by another equal or superior law.

Through the data Cerrado on websites related to the monitoring of Conservation Units of Integral Protection and the occurrences of PADDD events, as well as on sites that provide data on the average income of the municipalities, the quantity of the employed population, the total value of wages and other remuneration paid to people who exercise some type of occupation and the Gross Domestic Product (GDP) of these, and using econometric tools such as the Multiple Linear Regression Model, this study aimed to answer the following questions: (1) what are the economic and legal effects caused by the events of flexibilization and extinction of protected areas in the municipalities integrated into the environmental conservation program of Brazil? and (2) how can the multiple inputs of variables in various occurrences of demotion, relimitation, or declassification of protected areas be measured?

Studying the effects of these events known as PADDD, in the Brazilian municipalities integrated into the environmental conservation program of Brazil, becomes important because the results achieved will contribute to a better direction of public policies that aim to promulgate events of this nature since they will provide them with relevant information about the effects of this type of activity on the economy of a municipality so that the benefits and harms of these strategies can be comparatively analyzed.

Moreover, the research proposed here is of scientific and social relevance and may serve as a basis for advances in environmental protection and the guarantee of society's rights to a balanced environment, as well as for other studies in the areas of Environmental Law and Natural Resources Management.

It is also important to mention the fact that this research is unique in the methodology used and the object of study, and there is no other work of this nature currently in the literature specialized in environmental issues. Thus, the information collected in the research phase of this dissertation contributes to the production of several scientific articles published in journals, both national and international, becoming chapters of digital books of renowned publishing companies.

2 STATE OF THE ART

2.1 Protected areas in Brazil

2.1.1 The emergence of a concept

The concept of a Conservation Unit (CU) is valuable information to understand the true target of this institute, legally created to ensure the protection and preservation of extensive green areas. Corroborating this thought, Vallejo (2009, p. 1) conceptualized CU as being "natural areas protected by the public power and/or by the private initiative, destined to the conservation of biodiversity and other purposes".

Marreti et al. (2012, p. 339) emphasize the importance of studying a concept about CU by rounding up two types of protected areas: those protected areas *lato sensu*, which do not have explicit objectives of nature conservation, but contribute significantly to this end; and the protected areas *stricto sensu*, which have this objective as their main and explicit. It is possible to understand that *lato-sensu-protected areas are more comprehensive and include stricto-sensu-protected areas*, which are more specific. The correct translation of 'protected area' (English) – as well as 'protected area' (Spanish) or 'aire protégée' (French) – in Brazil is 'Conservation Unit'. However, this is usually associated with the 'protected areas stricto-sensu', considering its objective of nature conservation.

From the legal point of view, in Brazil, Federal Law No. 9,985 was promulgated on July 18, 2000, which came to regulate article 225 – paragraph 1, items I, II, III, and VII – of the Federal Constitution of 1988 and establish the National System of Nature Conservation Units. In Article 2, the item I, CU was defined as the:

"territorial space and its environmental resources, including jurisdictional waters, with relevant natural characteristics, legally established by the Government, with conservation objectives and defined limits, under a special administration regime, to which adequate guarantees of protection PPAly (BRASIL, 2000)".

This is a legal concept of CU, and it is widely used by environmental law operators, as well as by the government agencies responsible for creating these protected areas through laws and decrees, as allowed by the country's legal system.

To expand the legal concept mentioned above, Pimentel, Souza, and Magro (2009, p. 15) suggest an integrative view of the concept of CU, based on the law of the National System of Conservation Units, which would have as principles the ethical values in the face of the conservation of nature and society as the basis for the necessary union between the biological sciences, human and social. Finally, there is the fundamental importance of preserving biodiversity. For these authors, CUs can be defined as:

Space that covers the territorial, political, ecological, social, and symbolic dimensions, holder of relevant biological and/or human characteristics, legally instituted by the public power, to maintain local biodiversity based on environmental ethics and environmental education, for a conscious relationship of the use of natural resources, where the conservation of nature is exercised as a citizen's right, under a participatory administration that guarantees the permanence of biodiversity, to which the appropriate guarantees of protection are applied, for future generations (PIMENTEL, SOUZA and MAGRO, 2009, p. 15).

The IUCN (2017, online), contrary to the legal concept of CU, defines a protected area as being "a clearly defined, recognized, dedicated and managed geographical space, through legal or other effective means, to achieve the long-term conservation of nature with ecosystem services and associated cultural values." In this concept, the expression "long-term conservation of nature with ecosystem services and associated cultural values" appears, denoting that it is more related and is more commonly used by scientists, organizations and environmental entities.

In addition to analyzing the best definition of what constitutes a CU, it is also necessary to know what are its most relevant characteristics. According to Marreti et al. (2012, p. 341), such essential elements would be: i) natural relevance; ii) official act of the public authority; iii) territorial delimitation; and (iv) special management arrangements. Of these elements, only the first (natural relevance) is related to natural aspects of green areas that may become Conservation Units. The other three elements relate to the legal aspects.

2.1.2 The genesis of Protected Areas

Brazil has a large number of protected areas, in different modalities, recognized by environmental legislation, such as Permanent Preservation Areas (PPA), Legal Reserves (LR), and Conservation Units (CU), and the creation of these areas is a way to prevent the Amazon Forest from being devastated or declared under the legal protection of the Brazilian State, that is, to create a Conservation Unit. The creation of these areas can be considered relevant in the control of the

territory since it establishes limits and dynamics of specific use and occupation, and this control is the criteria of use that normally PPAly to them, often attributed due to the valorization of the natural resources in them or, still, by the need to protect biomes, ecosystems and rare or endangered species (MEDEIROS, 2005, p. 41).

The historical records indicate that both the Portuguese crown and the imperial government undertook some initiatives aimed at the protection, management, or control of certain natural resources, the first device is aimed at the protection of areas or resources in Brazilian lands, which have their registration still in the colonial period, with the priority objective being to ensure control over the management of certain resources, such as wood or water, as was already practiced in some parts of Europe (MEDEIROS, 2005, p. 43).

Table 1 - Historical and legal evolution of protected areas in Brazil

YEAR	FACT	RESULT	AUTHOR
1605	Creation of the "Pau Brasil Regiment"	- It is one of the first Brazilian forest protection laws; - It established strict limits to the practice of exploitation of Brazilwood in the colony.	MEDEIROS (2005, np).
1797	Promulgation of the Royal Charter	- It aimed to curb the unauthorized cutting by the crown of certain species of trees whose wood, considered noble (cedar, mahogany, among others), represented an important resource for the metropolis.	MEDEIROS (2005, np).
1911	Publication of the "Forest Map of Brazil"	The first comprehensive study was done in our country with a detailed description of the different biomes and their conservation states; It had the express intention of subsidizing the Brazilian authorities for the creation of a set of National Parks. It was created by the Brazilian scientist Luís Felipe Gonzaga de Campos.	Medeiros (2005, np) apud COSTA (2003, np).

Continues

YEAR	FACT	RESULT	AUTHOR
1934	Promulgation of Federal Decree No. 23,793 – 1st Brazilian Forest Code	Brought the first notion of Permanent Protection Area (PPA).	MARENZI; Longaretti (2018, np).
1934	Promulgation of the Constitution of the Federative Republic of Brazil of 1934	- For the first time, the protection of nature was a fundamental principle to which the Union and the States should compete; Nature began to have a new value, that is, it came to be considered an admirable national heritage to be preserved. With this, its protection acquires a new meaning and status, consisting of a task or duty to be fulfilled and supervised by the Public Power.	
1965	Promulgation of Federal Law No. 4,771 – Second Forest Code	- The legal figure "Permanent Preservation Area" was created; - His goals followed the same line as his predecessor's. - It extinguished the four typologies of protected areas previously provided for in the 1934 version, replacing them with four new ones: National Park and National Forest, the Permanent Preservation Areas (PPA), and the Legal Reserve (LR).	
1967	Promulgation of Federal Decree-Law No. 289	- Created the Brazilian Institute of Forest Development (IBDF), a federal agency linked to the Ministry of Agriculture, and its priority competence is to enforce the Forest Code, the law for the protection of fauna, all legislation about renewable natural resources, in addition to administering all protected areas in the country; - The objective was to implement, manage and supervise the protected areas in full expansion in Brazil.	MENEZES (2021, np).

Continues

YEAR	FACT	RESULT	AUTHOR
1973	Promulgation of Decree No. 73,030	<p align="center">-</p> <p>Creates the Special Secretariat for the Environment (SEMA), linked to the Ministry of the Interior, which began to share with IBDF the responsibility for the management and supervision of the Brazilian policy for protected areas;</p> <p>Creation of four more protected areas: Ecological Stations (ESEC), Environmental Protection Areas (APA), Ecological Reserves (RESEC), and Areas of Relevant Ecological Interest (ARIE).</p>	MEDEIROS (2005, np).
1980	Creation of Environmental Protection Areas (APA)	<p>- The first category of the protected area of national law to allow the allocation of private lands - and the consequent permanence of resident populations, and to seek the conciliation of the activities and economic interests of these populations with the conservation of natural elements;</p> <p>- It introduced into the national system the first traces of a trend that is currently present in many of the rights of countries: inhabited protected areas and with a clear concern for local economic development.</p>	LEITE (2015, NP).
1988	Promulgation of the Federal Constitution of 1988	- Dedicates a specific chapter to deal with the environment, Chapter VII, and its art. 225 considers it a right of all Brazilians to have an environment ecologically balanced.	MENEZES (2023, np)
1996	Creation of Private Natural Heritage Reserves (RPPNs)	- New typology that allowed the recognition of a protected area in the private domain, which stimulated and allowed the voluntary creation of protected areas by society.	MEDEIROS (2005, np).

Continues

YEAR	FACT	RESULT	AUTHOR
2000	Promulgation of Federal Law 9.985	<ul style="list-style-type: none"> - Creation of the National System of Nature Conservation Units – SNUC; - This system was an instrument that not only incorporated at once part of the protected areas, provided for by Brazilian legislation until then but also opened space for new categories to be created or incorporated from original experiences developed in the country, being undeniable the progress that was made in Brazil with the theme of nature protection with its institution. 	MEDEIROS (2005, np).
2012	Promulgation of Federal Law No. 12,651 – New Forest Code.	<ul style="list-style-type: none"> - Repealed Federal Law No. 4,771/1965; Since then, there have been some changes regarding the conditions for the limits of the Permanent Preservation Areas. 	MENEZES (2021, np).

Source: Prepared by Menezes; Fontgalland (2022, np)

For Vallejo (2009), the creation of CUs, currently, constitutes one of the main forms of government intervention, aiming at reducing biodiversity losses, in the face of environmental degradation imposed by society (deterritorialization of species of flora and fauna). However, this process has been accompanied by conflicts and impacts resulting from the deterritorialization of social groups (traditional or not) in various parts of the world.

2.1.3 *The Protected Areas and their main functions*

Protected areas play important roles, both for society and for the environment. Several forms of public policies should be fostered as a legal strategy for the protection and preservation of nature.

For Soares (2021, p. 18 apud Scharlemann *et al.*, 2010, np; Soares Filho *et al.*, 2010, np), protected areas maintain a variety of processes and functions that directly benefit humans and these ecological processes carried out by these areas act in the regulation of aspects of climate, soil, and water, as well as contribute to the reduction of threats to species of fauna and flora and the reduction of CO2 emissions, due to the degradation of natural ecosystems.

Smith (2021, p. 19 apud Stolton; Sue *et al.* 2015, NP) states that other services provided by protected areas refer to the purification of water and soil, given that some freshwater plants collaborate for the removal of pollutants in regions of groundwater reservoirs because they can

remove from water, nutrients, and toxic substances, thus improving water cycling processes and avoiding soil contamination.

For Bertzky *et al.* (2012, np cited by Soares 2021, p. 19), about provision services, some categories of protected areas, such as extractive reserves, are created to conserve natural resources, such as food, drinking water, wood, and medicinal plants. However, there are exceptions, as CUs can be created where the reconciliation between protection and production occurs, allowing the collection and use of natural goods by local communities.

With the social benefits resulting from the creation of protected areas, Soares (2021, p. 19) brings to light the teachings of Dias (2019, np), for whom protected areas play an important role in alleviating poverty and encouraging the economic development of the surrounding communities, as the relationship with the areas bordering the CU's gain greater attention and positive contributions. An example of this is what hPPAens in the Tarrafes do Rio Cacheu Natural Park and the Cantanhez National Park, located in Guinea Bissau, a West African country. These parks use mangrove areas as an essential resource for communities living along the coast and constitute a valuable heritage of biodiversity. These areas maintain the subsistence of the populations, being fishing, salt extraction, harvesting of mollusks and crustaceans, and the cultivation of mangrove rice the main activities developed by the local population.

2.1.4 Brief description of the Brazilian Federal Conservation Units of Integral Protection in the period from 2000 to 2020

According to article 2 of Federal Law No. 9,985/2000, in its item VI, Integral Protection Conservation Units (UCPI) are defined as those where the maintenance of ecosystems occurs free of changes caused by human interference, admitting only the indirect use of their natural attributes. For Félix and Fontgalland (2021, p. 79), the main difference between the UCPI and the Sustainable Use Conservation Units (UCUS) is crystallized in the degree of alteration allowed within these areas, given that in this one a certain level of use of its resources (UCUS) is allowed and in that one, no use is allowed (UCPI). However, as much as one has a structured legal system, there is no guarantee that the main purpose of these areas is the maintenance of protection status.

The PAs can also be distributed according to the public entity responsible for their management. This fact is observed in Article 3 of Federal Law 9,985/2000, which states, in its *caput*, that the SNUC is constituted by a set of federal, state, and municipal conservation units.

For Drummond, Franco, and Silva (2010, p. 350), the objectives and guidelines defined by the SNUC Law demonstrate that the four main concerns contemplated were: (1) the conservation of

biodiversity in its three fundamental levels (genetic, species, and ecosystem diversity); (2) the sustainable use of natural resources; (3) the participation of society and (4) the equitable distribution of the benefits gained through the creation, implementation, and management of Protected Areas. These points are in line with the objectives of the Convention on Biological Diversity (CBD), because – in addition to ordering the categories created at different times, by different governmental bodies and with different objectives – the SNUC Law reaffirms and gives greater solidity to the Brazilian position of adherence to the CBD. This demonstrates that, from the normative point of view, Brazil's effort in favor of the CUs is well balanced, both in terms of national laws and the international commitments assumed by the country.

The creation of nature preservation and conservation areas, under the coordination of the federal government, was increasing as new federal environmental laws were emerging.

In 2020, there were 336 nature preservation areas, equivalent to 19.5% of the national territory. Of these, 151 areas were under the governance of the federal government and were of the Integral Protection type, corresponding to an area of Aproximately 505,962.14 km².

The Federal Conservation Units (CUFs) are quantitatively divided into the following categories: Ecological Station (ESEC); Natural Monuments (MONAT); National Park (PARNA); Biological Reserve (REBIO) and Wildlife Refuge (RVS) (Table 1).

Table 1 - Calculation of Federal Conservation Units by Category in Brazil in 2020

Category	Quantity	Official Area (km ²)	% of Area concerning Area Total de CUs	% of the Official Area about the Brazil area
Full Protection				
Ecological Station	32	74.832,66	4,503	0,879
Natural Monument	5	116.865,88	7,032	1,372
National park	74	267.880,73	16,119	3,146
Biosphere Reserve	31	43.393,46	2,611	0,510
Wildlife Refuge	9	2.989,41	0,180	0,035
Full Full Protection (Federal)	151	505.962,14	30,446	5,942

Note: The official extensions mentioned in the legal instruments for the creation or alteration of the area of the Brazilian PAs were considered, and no overlaps with protected areas (CUs, TIs, TQs) were discounted. The maritime areas are contemplated.

Source: Instituto Socioambiental – Sistema de Áreas Protegidas (SisArp).

The largest number of Federal Conservation Units of Integral Protection is of the National Park type (PARNA), with 74 parks, which cover an area of 267,880.73 km², corresponding to Approximately 16% of the total area of the conservation units and 3.11% of the entire national territory. Next, the Ecological Station (ESEC) is the most numerous Integral Protection area, composed of 32 units, which cover an area of 74,832.66 km², representing Approximately 4.5% of the total area of all the CUs and 0.88% of the national territory (Table 1).

Between 2000 and 2020, 59 CUs were created, which protect a total territorial area of 309,548.33 km², accounting for 3.49% of the Brazilian territory and 115,763.88 km² of marine protected area, that is, 3.18% of the total marine area existing in the country.

Table 2 – Calculation of Federal Conservation Units created between 2000 and 2020 divided by category in Brazil

Category	Quantity	Official Area (km ²)	% of Area concerning Area Total de CUs	% of the Official Area about the Brazil area
Full Protection				
Ecological Station	10	40.780,38	13,17	0,47
Natural Monument	08	115.313,22	37,26	1,35
National park	30	142.336,20	45,98	1,67
Biosphere Reserve	07	8.134,70	2,63	0,00
Wildlife Refuge	08	2.983,83	0,96	0,00
Full Full Protection (Federal)	59	309.548,33	100	3,49

Source: Prepared by the author according to data from the Ministry of the Environment - Panel of Brazilian Conservation Units (2020).

From Table 2, it can be seen that the largest number of UCFPI's created in the period between 2000 and 2020 were National Parks (PARNA) with 30 protection areas, which cover an PPAroximate area of 142,336.20 km², equivalent to 45.98% of the total protected areas and 1.67% of the Brazilian territory. Next were the Ecological Stations (ESEC), with 10 CU's, which were responsible for covering an area of 40,780.38 km², accounting for 13.17% of the total protected areas and Approximately 0.47% of the Brazilian territory. In the same period, 8 Natural Monuments (MONAT) were created, which protect an average of 115,313.22 km², which represents 37.26% of the total protected areas created, corresponding to 1.35% of the national territory.

The classification of PICUs into management categories and the definition of each are represented in Table 3.

Table 3 - Legal definition of the management categories of the Integral Protection Conservation Units

Legal basis (Federal Law n° 9.985/2000)	Definition	Legal basis (Federal Law n° 9.985/2000)
Ecological Station	- Aims to preserve nature and conduct scientific research	Art. 9, caput
Biological Reserve	- It aims at the integral preservation of the biota and other natural attributes existing in its limits, without direct human interference or environmental modifications, except for the recovery measures of its altered ecosystems and the management actions necessary to recover and preserve the natural balance, biological diversity, and natural ecological processes.	Art.10, caput
National park	- Its basic objective is the preservation of natural ecosystems of great ecological relevance and scenic beauty, enabling the realization of scientific research and the development of environmental education and interpretation activities, recreation in contact with nature, and ecological tourism.	Art.11, caput
Natural Monument	- Its basic objective is to preserve rare natural sites, singular or of great scenic beauty.	Art.12, caput
Wildlife Refuge	- It aims to protect natural environments where conditions are ensured for the existence or reproduction of species or communities of local flora and resident or migratory fauna.	Art.13, caput

Source: Menezes; Fontgalland (2022, np) based on Federal Law No. 9,985/2000.

Table 3 shows the main differences between the categories of PICUs, as well as the following questions: What are the objectives beyond conservation? What nature conservations have been used? Who owns the land? Can there be or not the presence of residents? Among others.

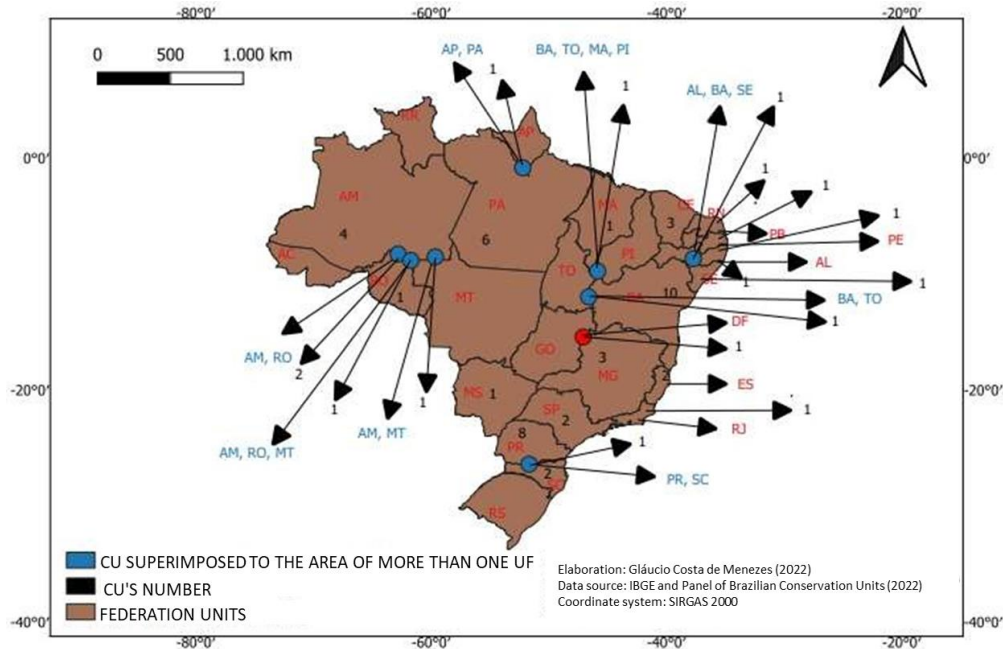
Table 4 - Comparative table between the categories of integral protection units

Category	Board of Directors	Definition	The creation process is normally initiated by	Mining Permit	Permission for private use	Main objectives beyond conservation	Ordinary management tools	Land tenure	Presence of Residents?
Ecological Station	Consultative	Depends on prior PPAroval of the managing body	Government	No	Yes	Research and Education	Management plan PPAroved and published by the managing body	Public	
Biological Reserve	Consultative	Depends on prior PPAroval of the managing body	Government	No	Yes	Research and Education	Not necessarily, only if the private use is not considered compatible with the purpose of the CU	Public	
National park	Consultative	Depends on prior PPAroval of the managing body	Government	No	Yes	Research and Education	Not necessarily, only if the private use is not considered compatible with the purpose of the CU	Public	
Natural Monument	Consultative	Depends on prior PPAroval of the managing body	Government	No	Not necessarily, only if the private use is not considered compatible with the purpose of the CU	Conservation especially of scenic beauty, research, and education	Not necessarily, only if the private use is not considered compatible with the purpose of the CU	Public and private	Yes
Wildlife Reserve	Consultative	Depends on prior PPAroval of the managing body	Government	No	Not necessarily, only if the private use is not considered compatible with the purpose of the CU	Research and Education	Not necessarily, only if the private use is not considered compatible with the purpose of the CU	Public and private	Yes

Source: Prepared by the author adapted from Murer; Futada (2020) – Conservation Units. Available at: <<https://uc.socioambiental.org/>>. Access on: 26 ago. 2022.

The PAs, created in the period from 2000 to 2020, can be distributed among the federative units of the country (Map 1).

Map 1 – Map of distribution of the Federal Areas of Integral Protection created, covering the years 2000 to 2020, by Federation Unit



Source: Authors

Table 5 shows the territorial extensions of these protected areas, as well as the percentages with the total area of the Federation Unit, in which its area is superimposed.

Table 5 - Calculation of Conservation Units of full federal protection in Brazil between 2000 and 2020, by a unit of the federation

UF	Qty CU's Full Protection	Territorial Extension (km ²)	% of the total area
BA	10	73.539,89	23,08
PR	08	1.707,16	0,54
PA	06	56.407,88	17,80
AM	04	27.351,13	8,59
CE	03	331,89	0,10
MG	03	2.063,18	0,64
AM, RO	02	19.623,06	6,26
ES	02	351,93	0,16
SC	02	697,27	0,22
SP	02	741,52	0,23
AL	01	61,31	0,00
AL, BA, SE	01	267,36	0,00
AM, MT	01	19.565,85	6,14
AM, RO, MT	01	9.613,11	3,06
AP, PA	01	38.352,66	12,03
BA, TO	01	7.070,85	2,31
BA, TO, MA, PI	01	7.497,66	2,35
DF	01	34,12	0,00

Continues

UF	Qty CU's Full Protection	Territorial Extension (km ²)	% of the total area
MA	01	1.599,52	0,56
MS	01	769,75	0,24
PB	01	47.191,78	14,81
PE	01	622,95	0,19
PR, SC	01	65,73	0,00
RJ	01	19,36	0,00
RN	01	85,18	0,00
RO	01	2.834,99	0,88
SE	01	80,25	0,00
TOTAL	59	318.547,34	100

Source: Prepared by the author according to data from the Ministry of the Environment - Panel of Brazilian Conservation Units (2020)

The states of Bahia and Paraná are the representatives of the federation that created more exclusive UCFPI's between the years 2000 to 2020, being 10 and 8, respectively, the quantitative. On the other hand, 10 Federation Units exclusively created only one preservation area in the same period. As for the extension in square kilometers (km²) of the protected area, the State of Bahia has 73,539.89 km² of legally preserved area, equivalent to 23.08% of the total protected areas, followed by the State of Pará, which, with its 6 UCFPIs, created from the year 2000, protect a territorial area of Aproximately 56,407.88 km² (17.80% of the total protected areas). The State of Paraíba has only one UCFPI, which was created between 2000 and 2020, but the protected area can be considered quite extensive, given that about 47,191.78 km² of the territory (14.81% of the total protected areas) are legally preserved (Table 5).

Table 5 shows the number of UCFPIs created in the period from 2000 to 2020 that are superimposed on the territory of more than one State of the Federation, as in the case of the CU that is in the territory of the States of Maranhão, Tocantins, Piauí and Bahia, a region known as MATOPIBA (MA + TO + PI + BA). Such CU protects an area of 7,497.66 km²; the same as 2.35% of the total protected areas.

In the period between the years 2000 and 2020, as shown in Table 6, it was possible to verify that the years in which more UCFPI was created were the years 2002 and 2006, with 9 Units each; which corresponds to about 49,359.29 km² and 43,823.47 km², that is, 14.16% and 12.57% of the total area of protected areas, respectively.

Regarding the year of creation of the UCFPI, it is possible to verify the following distribution in Table 6:

Table 6 - Calculation of Conservation Units of full federal protection in Brazil between 2000 and 2020, distributed by year of creation

Year	Qty CUs Full Protection	Territorial Extension (km ²)	% of the total area
2000	01	769,75	0,26
2001	07	12.307,75	3,53
2002	09	49.359,29	14,16
2003	01	508,92	0,14
2004	01	569,18	0,16
2005	07	43.480,87	12,47
2006	09	43.823,47	12,57
2007	02	241,61	0,00
2008	02	25.896,68	7,52
2009	01	267,36	0,00
2010	05	754,20	0,21
2011	00	0	0
2012	02	426,96	0,12
2013	01	13,60	0,00
2014	03	37.473,95	10,75
2015	00	00	0,00
2016	03	13.230,54	3,85
2017	01	790,85	0,22
2018	04	118.632,85	34,04
TOTAL	59	348.547,83	100

Source: Prepared by the author according to data from the Ministry of the Environment - Panel of Brazilian Conservation Units (2020)

However, in terms of legally protected territorial extension, 2018 was the year that most contributed in this sense, considering that in that year 4 UCFPI were created. These had the scope of preserving a green area of Approximately 118,632.85 km² (34.04% of the total area of protected areas); however, in 2013, only 1 UCFPI was created and its length was only 13.6 km². However, these PAs have been suffering from numerous legally constituted events of relimitation, recategorization, and reclassification, known internationally as PADDD, which even cause the extinction of these nature protection areas.

2.2 Events of Flexibilization and Extinction of protected areas

2.2.1 Legal Concept and Framework

According to Mascia and Pailer (2011, p. 2), demotion or declassification would be a decrease in restrictions on the number, magnitude, or extent of human activities within a natural protection area, that is, there is a legal authorization to increase the use of this area for human activities. Rebounding, resizing, reclassifying or *downsizing* would be a decrease in the size of a protected area as a result of the excision of land or sea area, through a change of legal limit. Finally, declassification, extinction, or *downgrading* can be considered a loss of legal protection of an entire preservation area.

For Borges (2019, p. 119), the process of declassification of a protected area would be an

event where its legal status as a protected area would be completely lost. In the case of the network, it would be the revision of the geographical limits of a CU, as defined in its decree of creation, which may imply the increase, decrease, or maintenance of an area with the change of form. Finally, the process of reclassification or recategorization is the event in which a CU undergoes a change in category or type, which may imply a decrease or increase in the legal restriction for human activities.

As the very legal definition contained in Article 2 of Federal Law No. 9,985/2000 demonstrates, the CUs receive the same definition of protected area in this article, considering that one is inserted within the definition of the other and are areas with territorial space and environmental resources, with relevant natural characteristics, legally instituted by the Government.

According to Borges (2019, p. 120), the legal framework that supports the acts of public power, defined above as PADDD, is provided by the SNUC Law (Brasil, 2000, online), mainly in three paragraphs of article 22, in Chapter IV of Federal Law No. 9,985/2000. In this, the following guidelines are inscribed regarding the revision of limits and categories of CUs in Brazil:

§5 The conservation units of the Sustainable Use group may be transformed totally or partially into units of the Integral Protection group, by a normative instrument of the same hierarchical level as the one that created the unit, provided that the consultation procedures established in paragraph 2 of this article are obeyed;

§6 The expansion of the limits of a conservation unit, without modification of its original limits, except for the proposed addition, may be done by a normative instrument of the same hierarchical level as the one that created the unit, provided that the consultation procedures established in paragraph 2 of this article are obeyed;

§7 The disallocation or reduction of the limits of a unit of conservation can only be done using a specific law [...] (BRAZIL, 2000, online).

Thus, for the transformation of a UCUS to occur, either totally or partially into a UPI, it is necessary that the promulgation of a normative instrument of the same hierarchical level as the one that created the modified unit occurs. The expansion of the limits of a CU, without modification of its limits still contained in its law of creation, except for the proposed additions, can only be done through the promulgation of a normative instrument of the same hierarchical level as the one that created the Unit. In addition, they must be preceded by public consultation and technical studies, as determined in paragraph 2, in Article 22 of Law 9,985/2000. In the case of the disallocation or reduction of the limits of a CU, they should only occur after the promulgation of a specific law that determines the occurrence of such an event of flexibilization and/or extinction. It is an example of these Public Acts, which created events of the type of flexibilization and extinction and affected several CUs, the National Logistics Plan (PNL), and the Ten-Year Energy Plan 2026 (PDE).

For Mariñas (2013, p. 38), one of the main components within the analysis of gradation

(change of category), reduction or cutting – or official ignorance (*desgazettement*) of protected areas (PADDD) – is undoubtedly the regulatory component.

According to Soares (2021, p. 26), even with the development of studies that identify the occurrence of CU loss, that demonstrate that these are not isolated cases and that they happen in various regions of the world, such studies do not quantify the impacts that can occur from the loss of these areas, not to mention that the practical results and their consequences can only be quantified after the effective loss of protected areas, which would take time. Thus, simulations of the loss of CUs can be an important tool for the development of prognostics of the effects on the environment, thus indicating future scenarios and their consequences.

According to Menezes and Fontgalland (2022, p. 10), in the 1960s and 1970s, the United States of America, the most economically powerful country in the world, was in the lead in terms of developing a domestic agenda of Environmental Protection materialized in singularly advanced legislation for the time. However, this fact no longer occurs, because, as of 2019, there was in that country the occurrence of several legal changes that modified, shrank, or shaken protected areas, such occurrences being known as events of a downgrade, reduce, declassify (*downgrade, downsizing, and degazettement*) of CU's. This can accelerate forest loss, fragmentation, and carbon emissions.

2.2.2 *Events of Flexibilization and extinction of CUs occurred in Brazil*

In Brazil, between 1900 and 2014, there were 67 PADDD events, which covered an area of 110,000 km² and became more frequent in the late 2000s. The main reasons for this were, according to studies, power generation, and rural settlements. Protected areas covering more than 70,000 km² were also considered by researchers as a risk of reduction or declassification (WWF - Brazil, 2019, p. 7).

According to Pack *et al.* (2016, p. 5), the first Brazilian event of the PADDD-type decree occurred in 1971, when President Emílio Médici signed Decree No. 68,873, which reduced the Araguaia National Park, without citing the reason for the legal change. This decree reduced the Araguaia National Park to only 33% of its original size.

In thirty years (1988-2018), according to the PADDD tracker platform, there have been 46 PADDD events in the Amazon alone, in addition to 29 more potential events of this nature that, if successful, would cover a total area of more than 190,000 km². In these cases, the average "useful lifespan" of the protected areas affected by PADDD is around eight years, ranging from their creation to the proposed PADDD. In many of the areas, the PADDD legal instrument is proposed in the same year of its creation (WWF-Brasil, 2019, p.12), while the "useful lifespan" of the PAs affected by

PADDD-type events – considering the time from the creation of the areas to their demotion, resizing or declassification – is, on average, 15 years.

PADDD events can be divided into two groups: those enacted and those proposed. Table 7 shows the numbers of PADDD promulgated between the years 1900 and 2014, keeping them separated by types of events and the primary causes that led to their promulgation, as well as the extent in km² of the affected areas.

Table 7 - PADDDs promulgated in Brazil between 1900 and 2014

PADDD's ENACTED		
	Number of events	The affected area (km²)
TYPES OF EVENTS		
Demote	09	16.713
Reduce	43	81.088
Extinguish	15	14.676
TOTAL PADDD	67	112.477
PRIMARY CAUSE		
Disputed legality	-	-
Hydroelectric infrastructure	26	16.775
Industrial agriculture	02	337
Land claim	10	46.759
Rural settlements	14	7.243
Unknown	09	26.288
TOTAL PADDD	61	97.402

Source: Prepared by the author according to data extracted from Pack et al. (2016, np).

Most of these events caused the reduction of the PAs affected, being registered 43 events of this nature were, which reached 81,088 km². Regarding the primary causes that led to the promulgation of the events, the expansion of the hydroelectric infrastructure registered 26 cases and reached a preserved area of 16,775 km². Then, as a primary cause, we have the expansion in the number of rural settlements, with 14 events recorded and an affected area of 7,243 km². The land claim also draws attention to the affected area, because with the enactment of 10 PADDD events, which had this type of primary cause, a preservation area of Aproximately 43,288 km² was reached. Other primary causes are the effects of the expansion of industrial (2) and unknown (9) agriculture. In all, these primary causes caused PADDD events affecting an area of 97,402 km² (Table 7).

Corroborating the data cited, Menezes and Fontgalland (2022, p. 13) state that, in recent years, numerous events of the "PADDD" type have been observed in Brazil. These contributed to the decrease in the quantity and extent of protected areas in the country, mainly to authorize the construction of dams for the production of hydroelectric power, affecting these events PADDD 4% of protected areas, with 48% of them enacted or proposed between 2010 and 2017, with the protected areas with the highest historical rates of deforestation being the most likely to be reduced or

desertified, representing an attempt to align protected area status with previous land use.

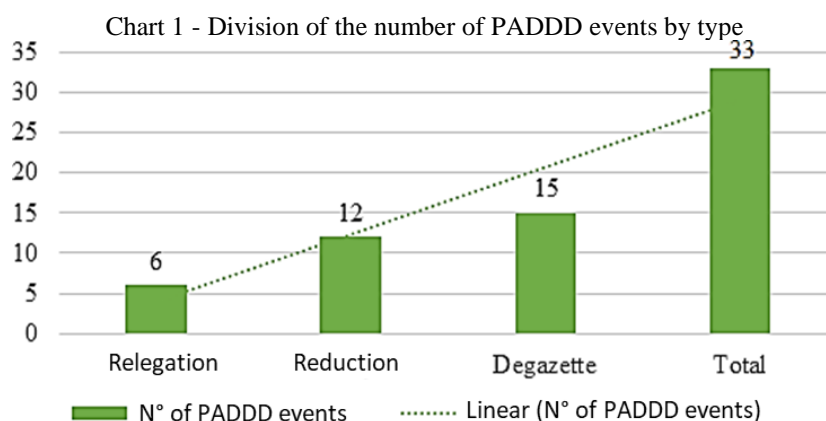
Regarding the PADDD's proposed in Brazil, between 1900 and 2014, they can be classified as active and inactive. Being active those that are occurring at the present moment and inactive those that are not yet in the execution phase. These proposed events can also be subdivided into absolute numbers by type of event and by the primary causes that gave rise to them.

Table 8 - PADDD's proposed in Brazil between 1900 and 2014

PADDD's ENACTED				
	ACTIVE		INACTIVE	
	Number of events	The affected area (Km ²)	Number of events	Affected area (km ²)
TYPES OF EVENTS				
Demote	09	11.573	06	1.970
Reduce	15	7.109	12	3.296
Extinguish	03	53.445	15	105.226
TOTAL PADDD	27	72.128	33	110.492
PRIMARY CAUSE				
Disputed legality	01	13.011	12	110.492
Infrastructure Hydroelectric	01	00	01	-
Industrial agriculture	01	23.694	-	93.244
Land claim	03	566	04	10.885
Rural settlements	09	27.906	08	2.763
Unknown	-	-	02	3.228
TOTAL PADDD	15	65.177	27	110.120

Source: Menezes; Fontgalland (2022, np) data extracted from Pack *et al.* (2016, NP)

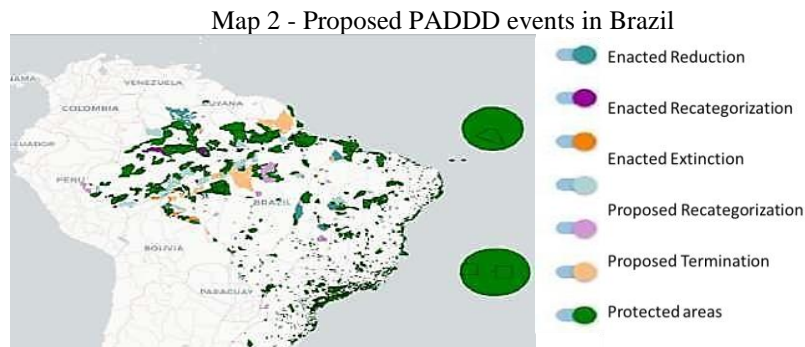
Analyzing Table 8, it is observed that there were 27 proposed and active PADDD events between 1900 and 2014, which affect a preserved area of 72,128 km². These events were of the type to lower (9), reduce (15) and extinguish (3).



Source: Prepared by the author (2022)

The proposed events of inactive PADDD totaled 33 occurrences divided into the types of drawdown (6), reduction (12), and degazete (extinction) (15), affecting an extensive green area of

Aproximately 110,492 km² (Graph 1).



Map 2 shows the distribution of protected areas in the Brazilian territory, as well as the distribution of proposals for downgrading, resizing, or declassification. It is also inferred that the proposals for reduction and extinction are the most common, however, the extinctions that have been enacted are, to date, the least numerous events.

According to WWF – Brazil (2019, online), the main causes for the occurrence of PADDD in the country were:

- a) public infrastructure projects;
- b) land sought for housing in rural areas;
- c) areas of land claimed for residents;
- d) legal qualification for agricultural operations on an industrial or semi-industrial scale;
- e) subsistence activities.

The main indicators of PADDD-type event trends are public infrastructure as well as land use, whether for agriculture, deforestation, or mining (Table 9). The effectiveness of the creation of the protected area is also a trend of events of downgrade, resizing, or declassification of CU because the possession of the land and the consolidation of a protected area are influencing factors of the rates of occurrences of actions of this nature.

Table 9 - Table with PADDD trend mPPAing indicators

INFRASTRUCTURE	Transport	Proximity or overlap of a protected area with projects of development/expansion of roads, railways, waterways, airports, ports, and terminals.
	Power Generation	Proximity or overlap of protected areas with power generation, distribution, or transmission projects.
LAND USE	Agriculture	Occurrence of agricultural activities between or near CUs.
	Deforestation	Deforestation in or near the CUs.
	Mining	Mining claims in or near protected areas.
	Rural Cadastre	OverlPPAing of rural environmental records with preservation areas.
EFFECTIVENESS OF THE PROTECTION AREA	Land tenure	Land tenure status of the protected area.
	Consolidation of protected area	Existence of legal and administrative tools for the management of CUs and evaluation of the effectiveness of the management of CUs (RPPAAM).

Source: Menezes; Fontgalland (2022) from the date of the report "PADDD trends in the protected areas of the Brazilian Amazon - MPPAing the risk of downgrading, lowering and declassification of protected areas in the biome", produced by WWF - Brazil in the year 2019.

For Fontgalland and Menezes (2022, p. 14), the occurrence of events that modify or cause the extinction of CUs does not only entail harm, as they can be responsible for restoring the rights of displaced peoples and can also improve the conservation of properties, as in the case of events that are related to the planning and conservation of areas. However, there should be a hierarchy in the mitigation of the effects caused by such events, seeking, in the first place, to avoid or minimize as much as possible the impacts of these actions in protected areas and, if unavoidable, to compensate for the harmful effects of these actions, increasing protection elsewhere. To date, according to several authors, investments, research, and political support aimed at aborting, "PADDD" events must be accelerated, given the well-being of future generations, whose uncertainty about which natural resources will have access still looms.

Finally, Fontgalland and Menezes (2022, p. 14) further state that laws should influence decision-makers to deliberate proposals for "PADDD" events separately from other policies and obtain the PPAr approval of various parties, including the same, if not higher, level of government for protected areas legislation.

When the analysis period is delimited for the years covered between 2000 and 2020, it is verified, with the support of the Panel of Brazilian Conservation Units (2020), that 13 PADDD events occurred, as described in Table 10.

Table 10 - Table containing the PADD events that occurred in Brazil between the years 2000 and 2020

PADD EVENTS THAT OCCURRED IN BRAZIL BETWEEN THE YEARS 2000 AND 2020

Federal IP CU affected	Extension initial (km ²)	Year of Creation	SI	Municipalities where they are located	Biome	Event PADD	Year of Event	Gain/Loss (km ²)	Extension final (km ²)
Jericoacoara National Park	84	2002	CE	Jijoca de Jericoacoara (57,97%)	Caatinga	Redelimitation	2007	4,34	89
				Cruz (14,29%)					
				Camorim (1,24%)					
Mico Leão Preto Ecological Station	55	2002	SP	Euclides da Cunha (35,58%)	Atlantic Forest	Redelimitation	2002	12	67
				Teodoro Sampaio (33,61%)					
				Marabá Paulista (18,00%)					
				Presidente Epitácio (12,81%)					
Serra de Itajaí National Park	571	2004	SC	Indaial (32,27%)	Atlantic Forest	Rebounding	2004	3.176	574
				Apiúna (17,64%)					
				Blumenau (17,21%)					
				Botuverá (10,84%)					
				Guabiruba (9,17%)					
				Presidente Nereu (8,60%)					
				Vidal Ramos (2,19%)					
Gaspar (2,08%)									
Natural Monument of Pontões Capixabas	175.57	2002	ES	Pancas (86,86%)	Atlantic Forest	Recategorization	2008	0	175.67
				Águia Branca (13,14%)					
Chapada das Mesas National Park	1.600	2005	MA	Carolina (83,87%)	Cerrado	Redelimitation	2006	0	1.600
				Estreito (9,24%)					
				Riachão (6,89%)					
Cuniã Ecological Station	532	2001	RO	Porto Velho (91,04%)	Amazon	Redelimitation	2007	194	726
			AM	Canutama (8,96%)		Redelimitation	2008	638	1.897
						Redelimitation	2010	200	7.498
Parnaíba River Springs National Park	7.298	2002	MA	Alto Parnaíba (48,13%)	Cerrado	Redelimitation	2015	200	7.498
			PI	Barreiras do Piauí (20,52%)					
				Corrente (4,59%)					
				Gilbués (4,49%)					
				São Gonçalo do Gurgéia (4,77%)					
			TO	Mateiros (7,76%)					
São Félix do Tocantins (6,39%)									

Continues

PADDD EVENTS THAT OCCURRED IN BRAZIL BETWEEN THE YEARS 2000 AND 2020																																												
Federal IP CU affected	Extension initial (km ²)	Year of Creation	SI	Municipalities where they are located	Biome	Event PADDD	Year of Event	Gain/Loss (km ²)	Extension final (km ²)																																			
Parnaíba River Springs National Park	7.298	2002	TO	Lizarda (3,22%)	Cerrado	Redelimitation	2015	200	7.498																																			
			BA	Formosa do Rio Preto (0,14%)						National Park of the Jamanxim	9.100	2006	PA	Itaituba (70,43%)	Amazon	Redelimitation	2017	(-) 511.35	8.589	Trairão (29,57%)	Campos Amazônicos National Park	8.736	2006	AM	Nova Aripuanã (68,03%)	Amazon	Redelimitation	2012	878	9.613	Manicoré (18,63%)	Humaitá (0,01%)	RO	Machadinho D'Oeste (12,94%)	MT	Colniza (0,38%)	Mapinguari National Park	15.724	2008	AM	Lábrea (50,19%)	Amazon	Redelimitation	2010
National Park of the Jamanxim	9.100	2006	PA	Itaituba (70,43%)	Amazon	Redelimitation	2017	(-) 511.35	8.589																																			
				Trairão (29,57%)						Campos Amazônicos National Park	8.736	2006	AM	Nova Aripuanã (68,03%)	Amazon	Redelimitation	2012	878	9.613	Manicoré (18,63%)					Humaitá (0,01%)						RO	Machadinho D'Oeste (12,94%)	MT	Colniza (0,38%)	Mapinguari National Park	15.724				2008	AM			Lábrea (50,19%)
Campos Amazônicos National Park	8.736	2006	AM	Nova Aripuanã (68,03%)	Amazon	Redelimitation	2012	878	9.613																																			
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			RO	Machadinho D'Oeste (12,94%)																																								
MT	Colniza (0,38%)																																											
Mapinguari National Park	15.724	2008	AM	Lábrea (50,19%)	Amazon	Redelimitation	2010	1.809	17.533																																			
				Canutama (40,02%)			2012	(-) 84,70	17.449																																			
			RO	Porto Velho (9,79%)																																								

Source: Prepared by the author according to data from the Ministry of the Environment - Panel of Brazilian Conservation Units (2020).

Among the 13 events of the PADDD type, 12 were of relimitation of protected areas and only one of recategorization. They affected seven national parks, two ecological stations, and a natural monument. These, together, correspond to a preserved green area of Aproximately 4,387,597 ha. These Conservation Units have their territorial areas superimposed on those of 40 Brazilian municipalities that are distributed in 11 Federation Units.

The events promoted the reduction of 596.05 km² and the increase of 4,270.53 km², resulting in a final gain of 3,674.48 km². Therefore, the total preserved area increased from 43,875.97 km² to Aproximately 47,550.45 km² (Table 10).

2.3 The Brazilian Biomes and the Conservation Units of Integral Protection

In the international community, the evolution of the concept of conservation has taken the form of the deliberate creation of new PAs in formations, in the shape of ecosystems or even in biomes, previously despised by the aesthetic values, until then predominant. Deserts and mangroves are two illustrative examples. In Brazil, since the end of the 1960s, at least, scientists such as Alceo Magnanini and part of the technicians of the Brazilian Institute of Forest Development (IBDF) were already concerned about the absence or scarce presence of stretches of the varied Brazilian landscapes in our CU's system – mangroves, caatinga, cerrado, Pantanal and the various Amazonian landscapes. The Plan of the System of Conservation Units of Brazil, of 1979, was based on extensive studies motivated by the objective of providing our CU's system with a variety congruent with the diversity of the Brazilian biomes (DRUMMOND; FRANK; Smith, 2010, p. 27).

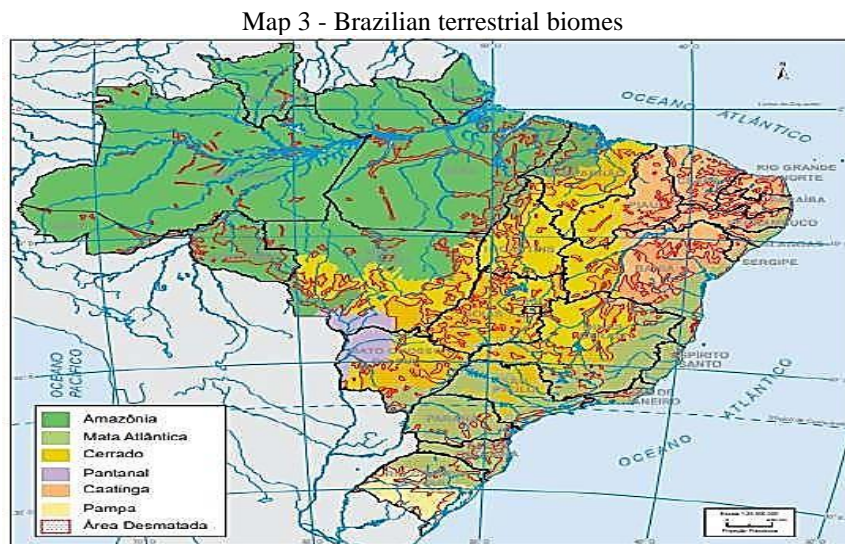
Federal Law 9.985/2000 deals with the objectives of the SNUC in article 4. Among these, there are two that are strongly related to the Brazilian biomes, being them item I, which claims to be the objective of the law, in the sense of contributing to the maintenance of biological diversity and genetic resources in the national territory and the jurisdictional waters; and item III, which says that it is a set of legal provisions, which aims to contribute to the preservation and restoration of the diversity of natural ecosystems. Article 5 defines the guidelines that govern the SNUC, which, in its item I, describes that the conservation units must contain significant and ecologically viable samples of the different populations, habitats, and ecosystems of the national territory and jurisdictional waters, safeguarding the existing biological heritage. Thus, it is perceived that the UCFPIs are one of the mechanisms available in our legal system to ensure the preservation of the various existing biomes, both in our territory and in our jurisdictional waters.

The formulation of the concept of biome took place at the beginning of the last century, as part of Dynamic Ecology, about succession studies, forming climax and bioecology, in the context

of the search for an PPAroach to the plant-animal set. In this process, the formulation was reached that the biome, or plant-animal formation, is the basic unit of the community and would be composed of a harmonious relationship between both. Another finding was that in the biosphere, organisms form communities related to their environment through the exchange of energy and matter and in this way; a more comprehensive type of community that, recognized by its physiognomy, would be a biome. In Brazil, with the dissemination of the concept of biodiversity and aiming to highlight the biological and genetic richness, the biome has always been associated with the concept of conservation and its visualization has been sought by the aggregation of ecosystems by proximity and regionalization (IBGE, 2019, p. 149).

According to the National Commission of the IBGE, a biome is defined as a set composed of plant and animal life, consisting of the junction of several types of vegetation that are close and that can be identified at the regional level, which have very similar geology and climate conditions. In addition, from the historical point of view, they suffered the effects of the same processes of landscape formation, which resulted in a diversity of flora and fauna of their own.

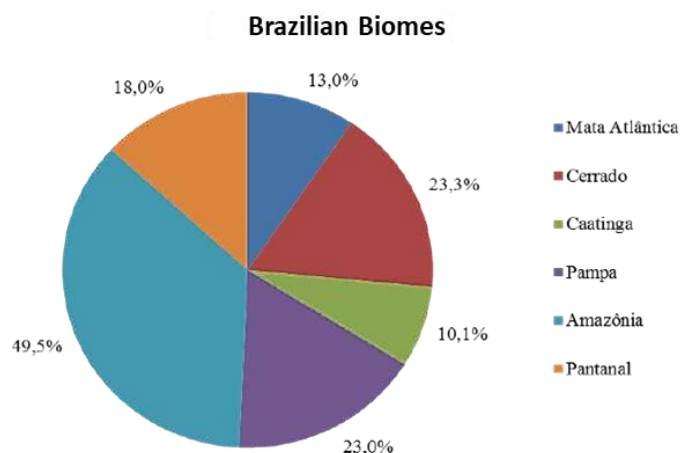
Map 3 shows the map of the Brazilian terrestrial biomes distributed throughout the country's territorial extension.



Source: IBGE (2022, online). Available in: < <https://cnae.ibge.gov.br/images/7a12/mapas/Brasil/BIOMES.pdf>>. Access on: Aug 22, 2022.

Regarding the extension of the biomes, in comparison to the Brazilian territory, it was found that 49.5% of the continental territory is inserted in the Amazon biome, 23.3% in the Cerrado biome, and 13% in the Atlantic Forest biome, which means that almost 86% of the continental lands of the country are inserted in at least one of these three biomes. Aproximately 14% of the territory is inserted in the caatinga, pampa, and Pantanal biomes (2).

Chard 2 - Chard of the area occupied by biome with the territorial area of Brazil



Source: Adapted from IBGE, (2019). Available in: <<https://biblioteca.ibge.gov.br/visualizacao/livros/liv101676.pdf>>. Accessed on: Aug 26. 2022.

The Federation Units have different percentages and territorial extensions of the Brazilian terrestrial biomes, as described in Table 11.

Table 11 - Quantitative areas occupied by Biomes and Coastal-Marine System, according to the Major Regions and the Federation Units

Major Regions and SI	Area (km ²)	Area (km ²)						
		Amazon	Scrubland	Atlantic Forest	Caatinga	Pampa	Swamp	Coastal System-Marine
Brazil	8.510.821	4.212.742	1.983.017	1.107.419	862.818	193.836	150.988	194.837
North	3.851.281	3.586.999	264.282	-	-	-	-	46.565
Rondônia	237.765	235.212	2.553	-	-	-	-	-
Acre	164.124	164.124	-	-	-	-	-	-
Amazonas	1.559.168	1.559.168	-	-	-	-	-	-
Roraima	224.274	224.274	-	-	-	-	-	-
Pará	1.245.759	1.237.085	8.675	-	-	-	-	34.110
Amapá	142.471	142.471	-	-	-	-	-	12.456
Tocantins	277.720	24.666	253.055	-	-	-	-	-
Northeast	1.551.991	114.047	451.710	156.030	830.205	-	-	42.482
Maranhão	329.642	114.047	215.595	-	-	-	-	25.743
Piauí	251.617	-	132.721	-	118.896	-	-	533
Ceará	148.895	-	-	-	148.896	-	-	3.939
Rio Grande do Norte	52.810	-	-	2.036	50.773	-	-	2.278
Paraíba	56.467	-	-	4.095	52.373	-	-	353
Pernambuco	98.068	-	-	15.522	82.546	-	-	560
Alagoas	27.843	-	-	14.661	13.182	-	-	738
Sergipe	21.927	-	-	9.788	12.139	-	-	1.774
Bahia	564.723	-	103.394	109.927	351.402	-	-	6.565
Southeast	924.565	-	363.247	528.247	32.614	-	-	63.986
Minas Gerais	586.521	-	317.082	236.826	32.614	-	-	52.895
Espirito Santo	46.074	-	0	46.074	-	-	-	2.825
Rio de Janeiro	43.750	-	0	43.750	-	-	-	4.865
São Paulo	248.219	-	46.165	202.054	-	-	-	3.402
South	576.743	-	3.122	379.785	-	193.836	-	41.804
Paraná	199.305	-	3.122	196.183	-	-	-	2.090

Continues

Major Regions and SI	Area (km ²)	Area (km ²)						
		Amazon	Scrubland	Atlantic Forest	Caatinga	Pampa	Swamp	Coastal System-Marine
Brazil	8.510.821	4.212.742	1.983.017	1.107.419	862.818	193.836	150.988	194.837
South	576.743	-	3.122	379.785	-	193.836	-	41.804
Santa Catarina	95.731	-	0	96.731	-	-	-	3.448
Rio Grande do Sul	281.707	-	0	87.871	-	193.836	-	36.266
Central-West	1.606.239	511.695	900.655	42.901	-	-	150.988	-
Mato Grosso do Sul	357.146	-	222.226	37.442	-	-	97.477	-
Mato Grosso	903.207	511.695	338.001	-	-	-	53.511	-
Goiás	340.126	-	334.668	5.458	-	-	-	-
Distrito Federal	5.761	-	5.761	-	-	-	-	-

Source: Elaboration a leave Of data of IBGE, (2019). Available in: <https://biblioteca.ibge.gov.br/visualizacao/livros/liv101676.pdf>. Accessed on: Aug 26, 2022

The most extensive biome is the Amazon, with an extension of 4,212,742 km², being, almost in its entirety, located in the North region and corresponding to 3,851,281 km² of this biome, mainly in the State of Amazonas, with an area of 1,559,168 km², with its lands belonging to this terrestrial ecosystem. Nevertheless, the smallest biome in terms of extension is the Pantanal, with 150,988 km², being located exclusively in the Midwest region of Brazil, mainly in the states of Mato Grosso do Sul (97,477 km²) and Mato Grosso (53,511 km²). The Coastal-marine biome has a territorial extension of 194,837 km² and has its coverage mainly in the Southeast region, being represented by a territorial extension of 63,986 km². Particularly, in Minas Gerais, this area totals 52,895 km² (Table 11).

In December 2022, the Chico Mendes Institute for Biodiversity Conservation (ICMBio), an agency subordinate to the Ministry of the Environment (MMA), released data regarding the distribution of 310 CUFs in terrestrial biomes and 24 CUs in Brazil's coastal-marine biome; taking into account the categories of CUs, the area of the biome occupied by the PAs (km²), the amount of CUs, the total area of the Biome (km²) and the percentage of the biome occupied by the PAs. In the case of biomes, specifically, the institute's information collection was based on the IBGE, based on the scale of 1:250,000. Thus, as there are PAs located on the boundary between two biomes or more, it was considered, for data collection purposes, the biome in which the UC has its territory overlapped by more than 50%. Table 12, below, deals with the distribution of Federal preservation areas, both Integral Protection and Sustainable Use, existing until December 2022, by Brazilian Terrestrial Biome.

Table 12 – Distribution of Federal Conservation Units, existing until December 2022, by Brazilian Terrestrial Biome

BIOME ¹	AREA (KM ²)	NUMBER FROM CU's	TOTAL BIOME AREA (km ²)	% OF BIOME OCCUPIED BY FEDERAL CU's
AMAZON	641.543,43	129	4.215.454,65	15,2
Protection Area Environmental	22.160,32	03		
Area of Relevance Ecological Interest	190,87	03		
Ecological Station	61.216,43	10		
National Forest	177.260,37	34		
National park	214.071,69	21		
Biological Reserve	39.981,62	10		
Development Reserve Sustainable	644,42	01		
Extractive Reserve	126.017,67	47		
CAATINGA	50.403,8	28	862.645,61	5,8
Environmental Protection Area	32.267,83	05		
Ecological Station	1.302,89	04		
National Forest	540,26	05		
Natural Monument	267,36	01		
National park	15.721,13	10		
Wildlife Refuge	292,34	01		
Biological Reserve	6,24	01		
Extractive Reserve	6,01	01		
ATLANTIC FOREST	41.887,1	104	1.106.853,38	3,8
Protection Area Environmental	26.684,98	13		
Area of Relevance Ecological Interest	118,38	7		
Ecological Station	353,88	8		
National Forest	268,79	21		
Natural Monument	174,43	1		
National park	8.758,4	25		
Wildlife Refuge	555,88	4		
Biological Reserve	2.142,57	17		
PAMPA	193.948,64	03	193.948,64	1
Protection Area Environmental	3.167,92	01		
Ecological Station	328,06	01		
National park	367,21	01		
TOTAL		310	984.906,59	

Note¹: Category of CU by Biome according to IBGE in the Scale 1:250,000. How there are CUs located on the boundary between two or more biomes, it is considered the biome that overlaps more than 50% of the territory of the CU;

Note: Brazilian Terrestrial Biome, according to IBGE, from the 1:250,000 Scale.

The authors, from data collected from the Chico Mendes Institute for Biodiversity Conservation (2022), an agency belonging to the Ministry of the Environment (MMA).

Analyzing Table 12, it is inferred that the terrestrial biome that has more Federal CUs is the Amazon, with 129 units, which protect an area of 641,543.43 km², or 15.2% of the territory of the biome. The most frequent category in this biome is the National Forest, with 34 preservation areas covering approximately 177,260.37 km². However, the National Parks, which total 21 units, consisting of a category that most protect green areas in the Amazon Biome, totaling these parks an area of about 214,071.69 km², or almost 33% of the entire area of the biome protected by CUs.

The Caatinga biome has 28 Federal CUs that protect approximately 50,403.8 km² or 5.8% of

the 862,645.61 km² of the total extension of this biome. Among the categories of CUs existing in this type of vegetation, the National Parks are the most frequent, with 10 CUs, which protect about 1,572.11 km². However, the Environmental Protection Area, despite being only 5 CUs, preserves an area of almost 32,267.83 km² or 64% of the total area protected by CUs of this biome.

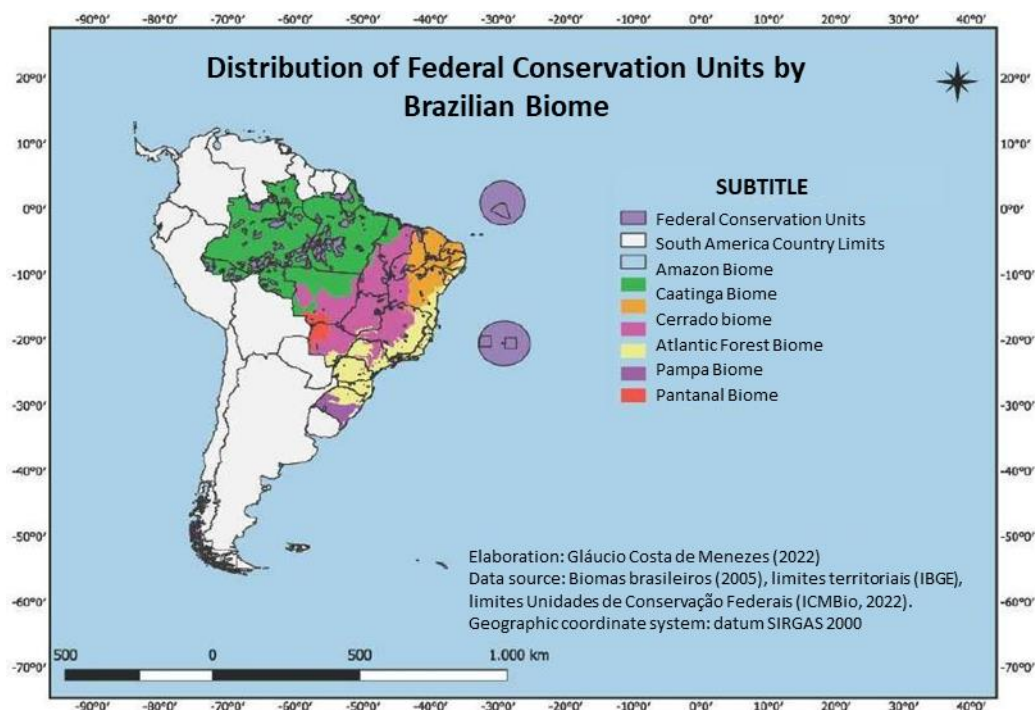
In the Cerrado biome, there were, until December 2022, a total of 44 CUFs, which protect 57,123.62 km² of the Approximately 1,984,567.96 km² of the biome's extension or 2.9%. The most frequent categories of CUs in the protection of the green area of this biome are the National Parks and the Environmental Protection Areas, with 13 and 10 CUs, respectively, which preserve 27,318.34 km² and 18,276.41 km².

The Atlantic Forest biome has 104 CUFs, both Integral Protection (IP) and Sustainable Use (US), which preserve 41,887.10 km² of the 1,106,853.38 km² of the biome or 3.8%. In this biome, the most common categories of preservation areas are the National Parks, with 25 PAs that protect 8,758.4 km² of vegetation, in addition to the Environmental Protection Areas, with 13 PAs, which protect 26,684.48 km². Together, these two categories total 38 CUFs, which preserve 35,442.88 km² or 84.6% of the extent of the protected biome.

In the case of the Pampa biome, it had, until December 2022, only three CUFs, which protect 3,863.2 km² of the 193,948.64 km² belonging to this biome. The categories of PAs are an Environmental Protection Area, with an extension of 3,167.92 km²; an Ecological Station with an extension of 328.06 km² and a National Park with a total perimeter of 367.21 km².

Map 4 shows the representation of the distribution of CUFs by the Brazilian biomes, including the coastal-marine biome.

Map 4 – Map containing the distribution of Federal Conservation Units by biome



Source: The authors

It is noticeable, in the cartographic representation, the presence of conservation units on our maritime coast. According to ICMBio, as of December 2022, there were 24 CUs in the Brazilian Coastal-Marine biome. Together, they protect Aproximately 917,957 km² of 3,555,796.37 km² or 25.8% of the total perimeter of this biome. In the calculation of the area covered by the preservation areas of the Coastal-Marine System, the Exclusive Economic Zone (EEZ) of Brazil of 200 nautical miles was considered.

In the case of the distribution by biomes of the UCFPIs created from the year 2000 to 2020, Table 13 provides an outline of how it occurs.

Table 13 - Calculation of Federal Conservation Units of Integral Protection in Brazil created in the period from 2000 to 2020 by terrestrial biome

Biome	Qty CUs Full Protection	Total Protection Area Integral (km ²)	% of Biome Protected
Amazon	16	173.748,69	0,67
Caatinga	08	5.045,86	0,609
Cerrado	07	19.493,94	0,95
Atlantic Forest	24	4.494,98	0,402
Marine Biome		115.763,88	3,18
TOTAL	55	318.547,35	

Source: Prepared by the author according to data from the Ministry of the Environment - Panel of Brazilian Conservation Units (2020).

In the period from 2000 to 2020, 16 UCFPI's were created that protect 173,748.69 km², which

corresponds to 0.67% of the Amazon biome. Regarding the Atlantic Forest biome, in the same period 24 PAs were created, which protect 4,494.98 km², that is, 0.40% of the Atlantic Forest biome. While, in the Cerrado biome, there were 7 CUs promulgated in the last 22 years, protecting 19,493.94 km (0.95% of the Cerrado biome). Concerning the Marine biome, in the period from 2000 to 2020, there was the legal creation of PAs that protect from anthropogenic actions close to 115,763.88 km² (3.18% of the Marine biome) (Table 13). However, these biomes suffer the effects of events such as relimitation, recategorization, and demotion in recent years, especially after 2008.

These events called PADDD can be divided into two groups: those promulgated and those proposed.

Table 14 - Distribution of PADDD events by affected biome

TERRESTRIAL BIOME	PADDD ENACTED	
	Number of events	The affected area (km ²)
Amazon	48	88.341
Atlantic Forest	5	601
Caatinga	1	34
Cerrado	13	23.500
TOTAL PADDD	67	112.476

Source: Menezes; Fontgalland (2022, np) data extracted from Pack *et al.* (2016, NP).

Regarding the biome most affected by promulgated events (Table 14), that is, those that are legally executed/PPAroved by a competent authority, the Amazon biome bore the effect of 48 events, which together reached a preservation area of about 88,341 km². On the other hand, the caatinga biome recorded the occurrence of only 1 PADDD1 event was enacted, having an area of about 34 km² reached. In total, the PADDD events promulgated affected the Amazon (48), Atlantic Forest (5), Caatinga (1), and Cerrado (13) biomes, covering an area of 112,477 km².

Table 15 - Proposed PADDD events distributed by Brazilian terrestrial biome

TERRESTRIAL BIOME	PADDD PROPOSED			
	ACTIVE		INACTIVE	
	Number of events	The affected area (Km ²)	Number of events	The affected area (km ²)
Amazon	10	65.715	19	107.607
Atlantic Forest	6	41	5	426
Caatinga	-	-	-	-
Cerrado	9	6.196	6	2.353
TOTAL PADDD	25	71.952	30	110.380

Source: Menezes; Fontgalland (2022, np) data extracted from Pack *et al.* (2016, NP).

The terrestrial biomes affected by these events were the Amazon, the Atlantic Forest, and the

Cerrado, with 10, 9, and 6 occurrences, respectively, and an affected area of approximately 72 thousand km² (Table 15). As primary causes, there is the disputed legality (1), the expansion of hydroelectric infrastructure (1), the increase in areas destined for family agriculture (1), growth in the number of actions of land claims (3), and rural settlements (9), the latter being the primary cause responsible for affecting around 27,906 km² of preserved areas.

Proposed inactive events, out of a total of 30, aim to reach the terrestrial biomes: Amazon (19), Atlantic Forest (5), and the Cerrado (6). However, only in the Amazon biome, the proposed inactive events of PADDD affected a territorial extension of 107,607 km². Among the primary causes of these events, the largest number was the challenge of legality, with 12 cases affecting a territorial extension of 93,244 km².

¹There is the occurrence of PADDD events classified as proposed, that is, those that had their legal process of promulgation and consequent execution initiated, which can be subdivided into active and inactive. The assets remain in the process of analysis to know whether or not they will be promulgated by the competent governmental body, which will be the one that has managed over the CU, while the PADDD events, proposed inactive, are those that, for some reason, had their process of feasibility analysis and execution interrupted.

The PAs that were studied in this study and that suffered the effect of PADDD events in the period from 2000 to 2020 are with their extension areas superimposed on the territorial limits of about 40 municipalities. Thus, to improve the analysis of the data collected, both from these municipalities and from the protected areas, these cities were divided into ten groups. Each group is related to a single UCFPI that has undergone some kind of rebounding or redefining action.

Table 16 – Division of municipalities into groups according to the conservation unit

GROUP - 1	GROUP - 2	GROUP - 3
Conservation Unit	Conservation Unit	Conservation Unit
Jericoacoara National Park	Mico Leão Preto Ecological Station	Serra de Itajaí National Park
Municipalities	Municipalities	Municipalities
Jijoca de Jericoacoara (57,97%)	Euclides da Cunha (35,58%)	Indaial (32,27%)
Cruz (14,29%)	Teodoro Sampaio (33,61%)	Apiúna (17,64%)
Camorim (1,24%)	Marabá Paulista (18,00%)	Blumenau (17,21%)
	Presidente Epitácio (12,81%)	Botuverá (10,84%)
		Guabiruba (9,17%)
		Presidente Nereu (8,60%)
		Vidal Ramos (2,19%)

GROUP - 4	GROUP - 5	GROUP - 6
Conservation Unit	Conservation Unit	Conservation Unit
Natural Monument of Pontões Capixabas	Chapada das Mesas National Park	Cuniã Ecological Station
Municipalities	Municipalities	Municipalities
Pancas (86,86%)	Carolina (83,87%)	Porto Velho (91,04%)
Águia Branca (13,14%)	Estreito (9,24%)	Canutama (8,96%)
	Riachão (6,89%)	

GROUP -7	GROUP -8	GROUP -9
Conservation Unit	Conservation Unit	Conservation Unit Campos
Parnaíba River Springs National Park	Jamanxim National Park	Amazônicos National Park
Municipalities	Municipalities	Municipalities
Alto Parnaíba (48,13%)	Itaituba (70,43%)	Nova Aripuanã (68,03%)
Barreiras do Piauí (20,52%)	Trairão (29,57%)	Manicoré (18,63%)
Corrente (4,59%)		Humaitá (0,01%)
Gilbués (4,49%)		Machadinha D'Oeste (12,94%)
São Gonçalo do Gurgéia (4,77%)		Colniza (0,38%)
Mateiros (7,76%)		
São Félix do Tocantins (6,39%)		
Lizarda (3,22%)		
Formosa do Rio Preto (0,14%)		

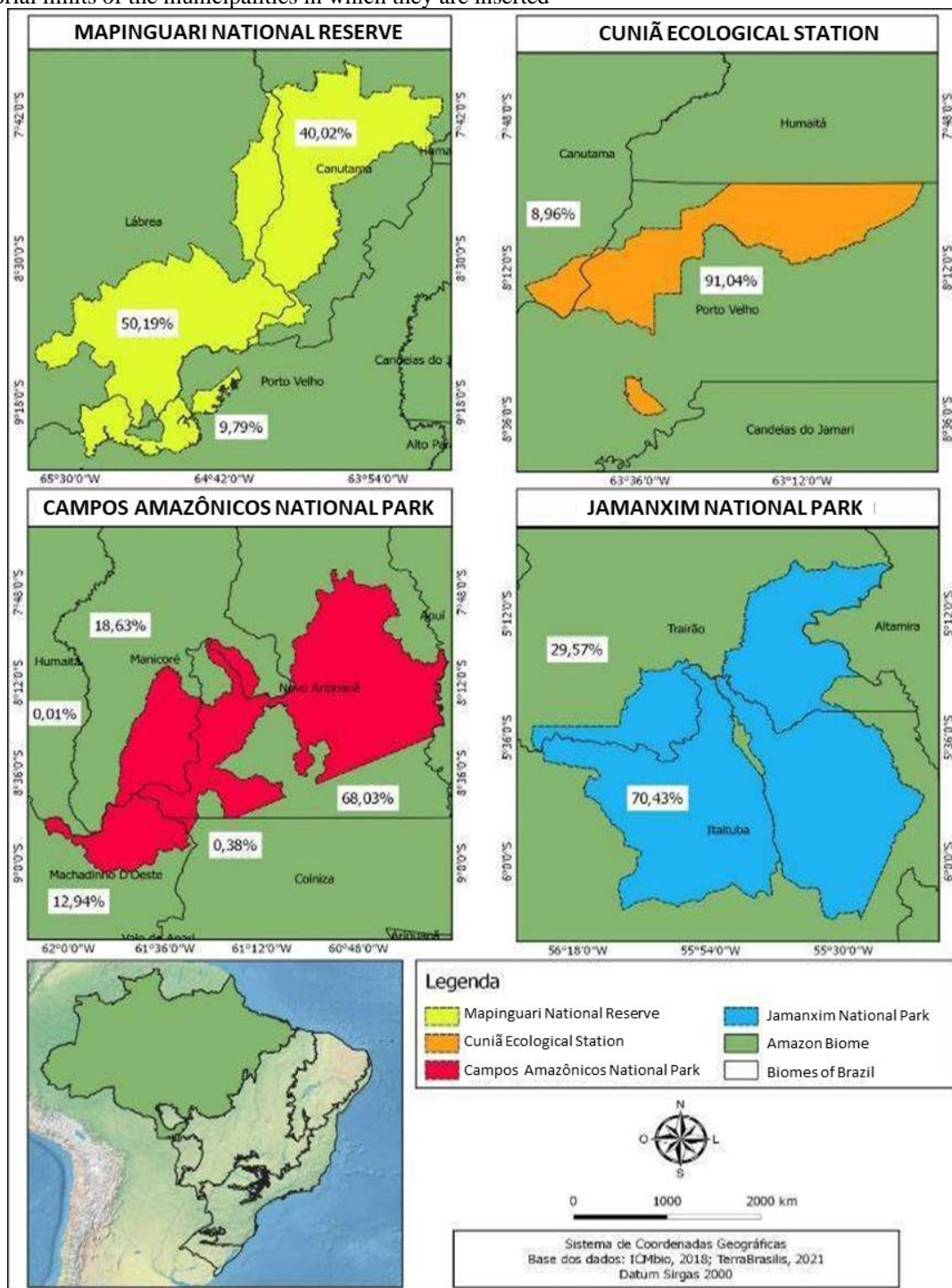
GROUP -10
Conservation Unit
Mapinguari National Park
Municipalities
Lábrea (50,19%)
Canutama (40,02%)
Porto Velho (9,79%)

Source: The authors from data from the Socioenvironmental Institute (ISA).

It was verified, from Table 16, that in the groups there are municipalities that have a large area of the CU superimposed on their territorial limits, in percentage terms, as in the case of Group 6, in which the UCFPI, Cuniã Ecological Station, is distributed 91.04% of its territorial extension in Porto Velho and only 8.96% in Canutama. In the case of Group 7, the UCFPI Parque Nacional das Nascentes do Rio Parnaíba is territorially distributed within the legal limits of nine municipalities, with the municipality of Alto Parnaíba owning 48.13% of the total area of the conservation unit, and the municipality of Formosa do Rio Preto, having only 0.14% of the continental area of this National Park.

Map 5 shows cartographic representations of the distribution of the UCFPIs under study, in percentage terms, by biome and according to the municipalities whose preservation areas are superimposed on the territorial perimeters.

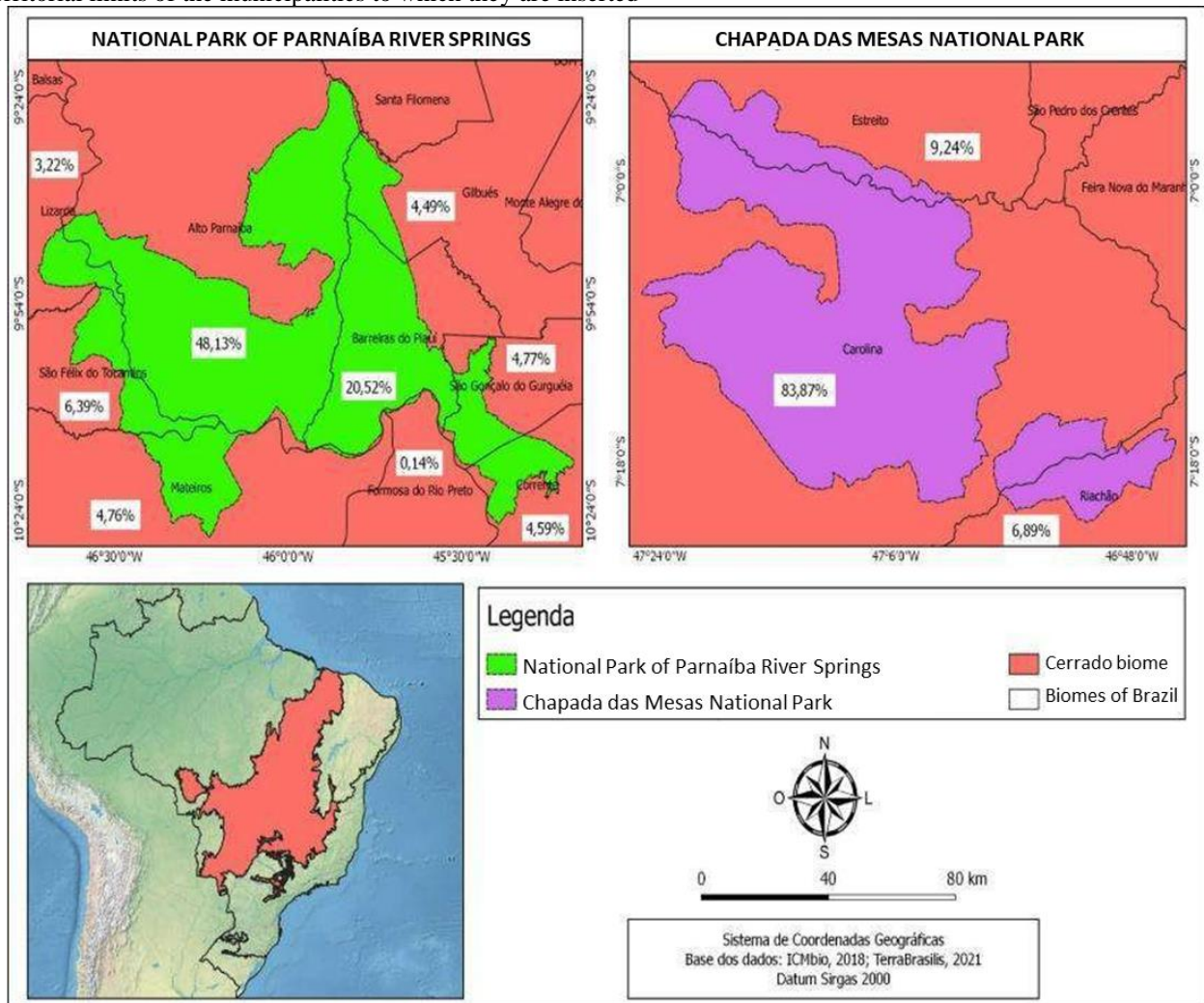
Map 5 - Map containing the percentage of overlap of the areas of the studied PAs, belonging to the Amazon biome, to the territorial limits of the municipalities in which they are inserted



Source: The authors.

In Map 6, above, it is possible to note that the four units of UCFPIs belonging to the Amazon biome and that suffered PADDD events between 2000 and 2020 Mapinguari National Reserve, Cuniã Ecological Station, Amazon Fields National Park, and the Jamanxim National Park have more than 50% of their preservation area superimposed on the territorial perimeter of only one municipality.

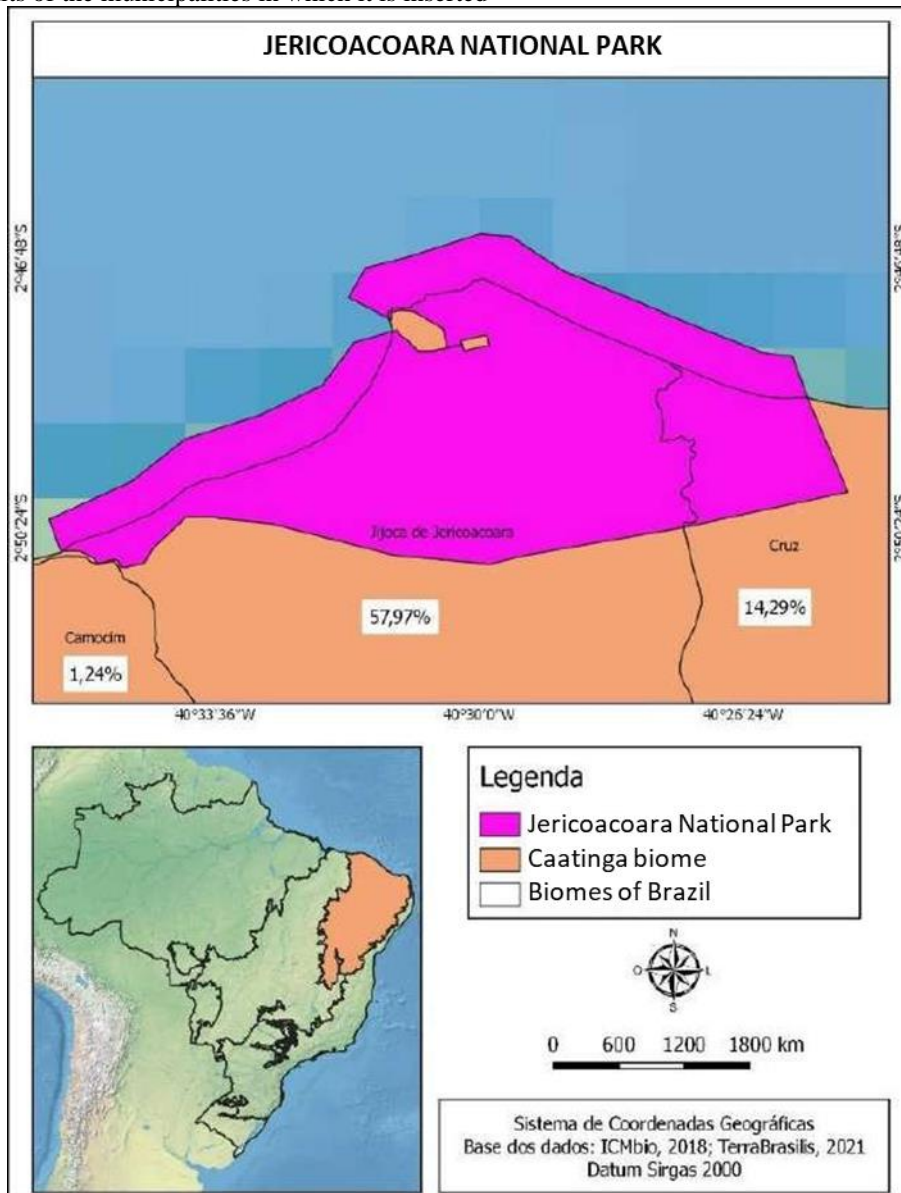
Map 6 - Map containing the percentage of overlap of the areas of the studied PAs, belonging to the Cerrado biome, to the territorial limits of the municipalities to which they are inserted



Source: The authors.

The Cerrado biome has two units of green areas protected from anthropogenic intervention, under the governance of the Federal Public Power, created in the period from 2000 to 2020 and which suffered events of the PADDD type. These units are the Parnaíba River Springs National Park and the Chapada das Mesas National Park. Its territorial extensions are inserted Approximately 48% and 83%, respectively, in the territorial limits of the municipalities of Alto Parnaíba (MA) and Carolina (MA), as observed in Map 7.

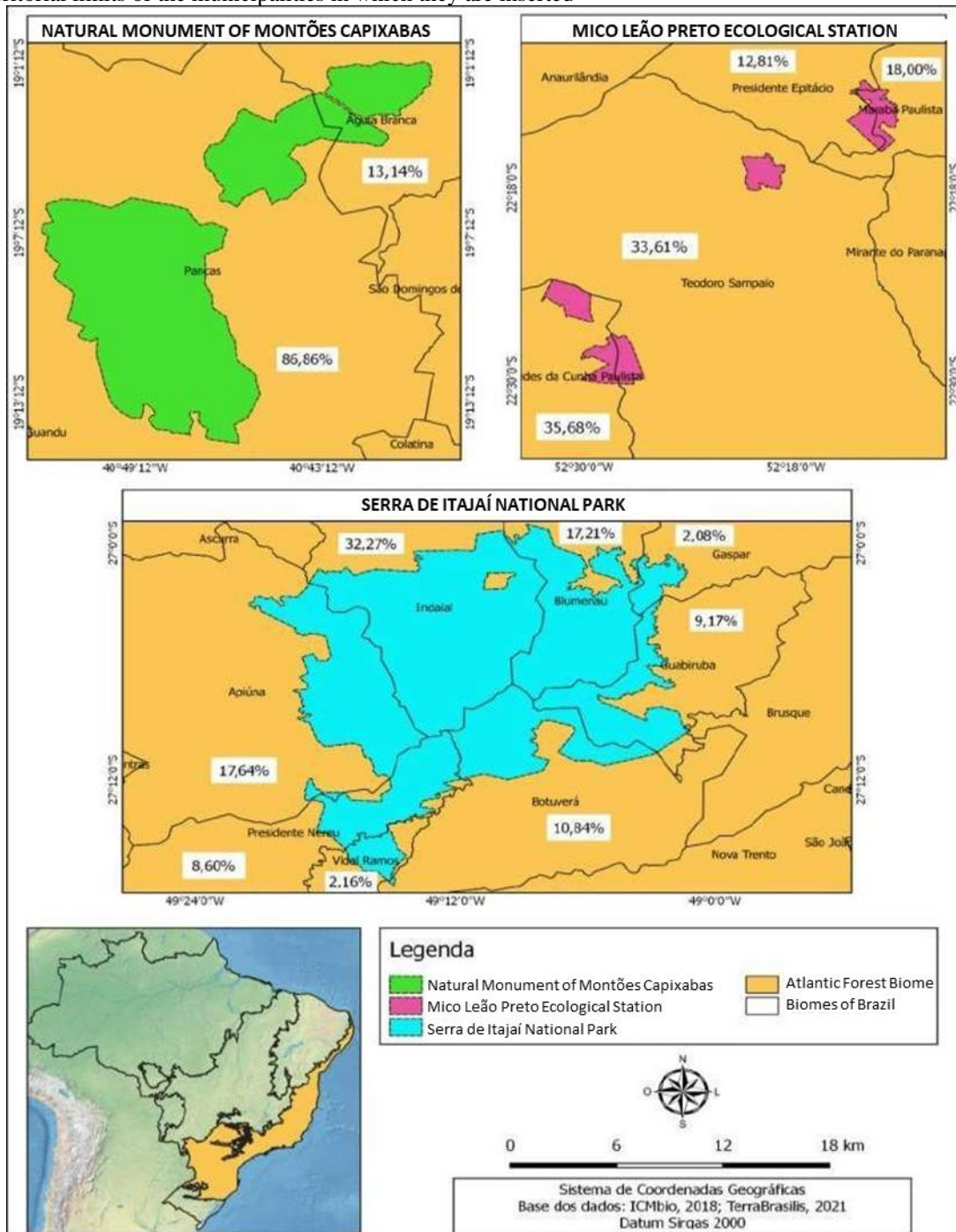
Map 7 - Map containing the percentage of overlap of the area of the studied UC, belonging to the Caatinga biome, to the territorial limits of the municipalities in which it is inserted

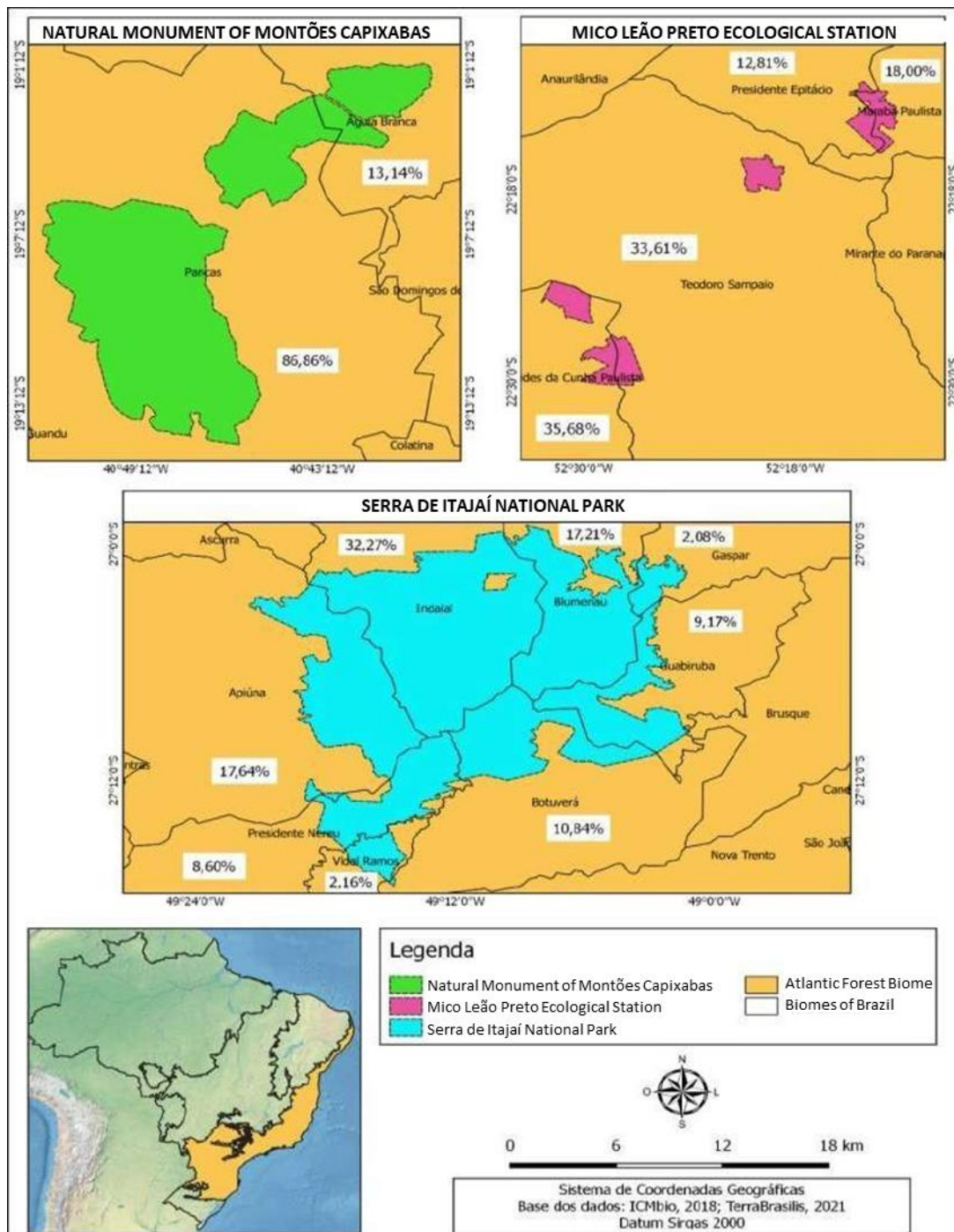


Source: The authors.

The Jericoacoara National Park is inserted in the Caatinga biome, with its territorial extension superimposed on the areas of three municipalities of Ceará in the following percentages: 58% in the municipality of Jijoca de Jericoacoara, 14% in the municipality of Cruz, and 1% in the municipality of Camocim. The remainder of the preservation area, about 27%, is made up of coastal-maritime CUs.

Map 8 - Map containing the percentage of overlap of the areas of the studied PAs, belonging to the Atlantic Forest biome, to the territorial limits of the municipalities in which they are inserted





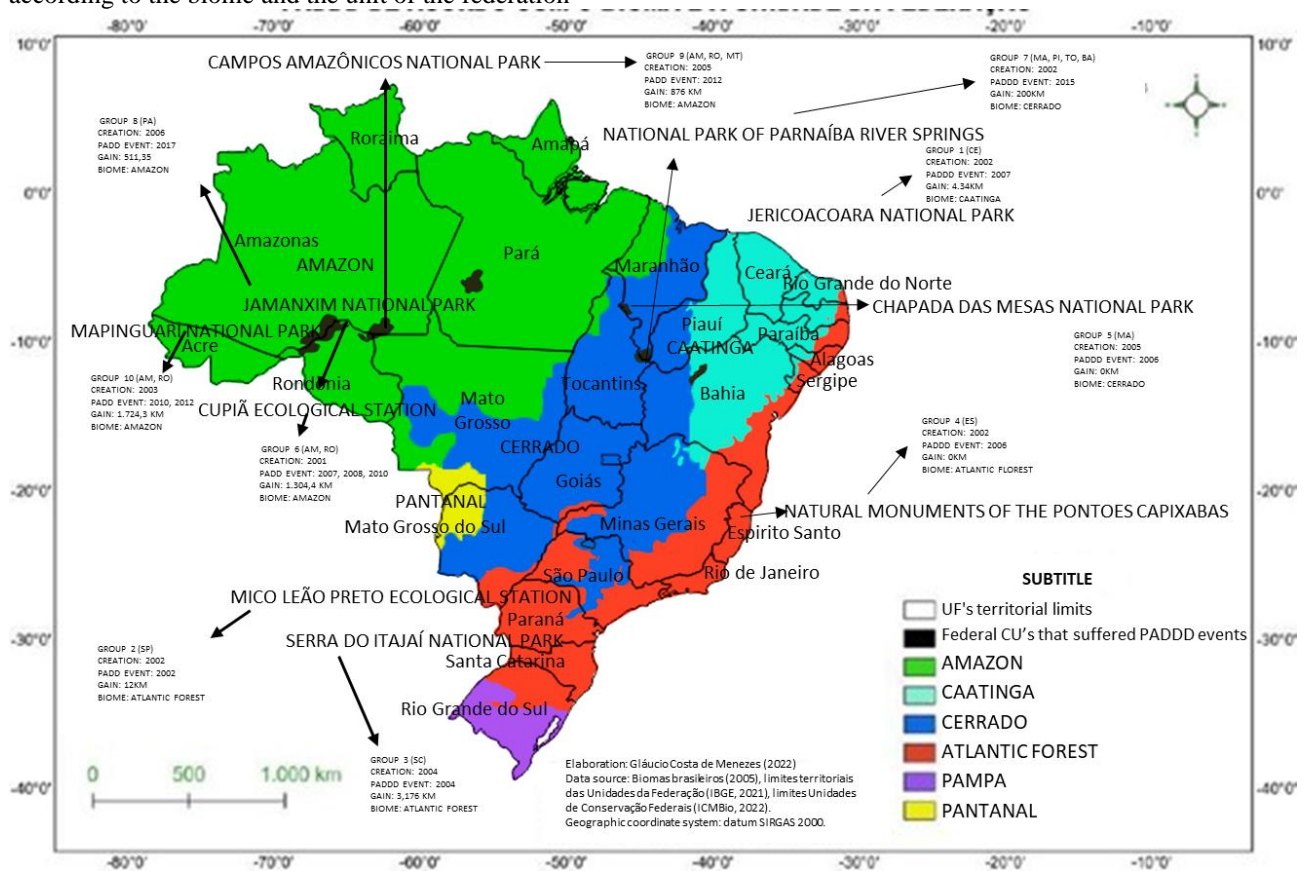
Source: The authors

In the Atlantic Forest biome, three UCFPI's suffered the effects of events created through an act of the Public Power that aimed to modify the laws or decrees that gave rise to these areas of nature protection. These CUs are superimposed on the areas belonging to numerous Brazilian municipalities. However, the largest percentage of these units are located in the municipalities of Pancas (ES), which has Aproximately 86% of the Natural Monument of Pontões Capixabas; Euclides da Cunha Paulista (SP), where about 35% of the Leão Preto Ecological Station is located; and Indaial (SC), which houses Aproximately 32% of the Serra de Itajaí National Park.

In recent years, these UCFPIs have suffered the action of events of the type of recategorization or relimitation, reaching, even, a single group of municipalities and a single area of preservation suffer up to three events of this nature.

Map 8 shows the distribution of the UCFPIs that suffered PADD-type events in the period under study, according to the biome in which the group of municipalities, whose territorial limits overlap the perimeter of the Conservation Units, are inserted.

Map 9 – Map containing the distribution of Federal CUs that suffered PADD events between the years 2000 and 2020 according to the biome and the unit of the federation



Source: The authors.

In Map 9, it is observed that Groups 6, 8, 9, and 10, as well as their respective Conservation Units, are in the Amazon biome and that the PADD events that occurred in these preservation areas caused significant gains in their territorial extensions, reaching increases of Approximately 1,724 km² and 1,364 km². However, there was a loss of 511.35 km². In all, in the Amazon biome, there was an increase of 3,966.7 km² of the protected area.

Groups 2, 3, and 4 are related to UCFPIs that are inserted in the Atlantic Forest biome and were affected by events that caused a gain of the protected area of Approximately 3,188 km². Groups 5 and 7 are located in the Cerrado biome and its

The respective protection areas suffered PADDD events, which provided an increase in the preservation of 200 km² of vegetation.

Finally, Group 1 is inserted in the Caatinga biome and the Conservation Unit that is superimposed on the territorial limits of these municipalities suffered a positive event of the PADDD type. This provided an increase of 4.34 km² of the protected area.

In all, the 10 groups of municipalities and their respective UCFPIs suffered 11 positive events of the PADDD type, which promote a gain of about 7,359.04 km² and a negative event that reduced 511.35 km² to the protection area of a UCFPI in the Amazon. That is, there was a total gain of 6,847.69 km² in the protected territorial extension of the Brazilian terrestrial biomes.

3 Analysis of the variation of the average income and GDP of the municipalities affected by PADDD events between the years 2000 and 2020.

According to the IBGE, the municipalities belonging to the ten groups observed in this research have UCFPIs that suffered the effects of PADDD events between the years 2000 and 2020, presenting, in their great majority, a very diversified salary income. Thus, to arrive at the average salary income of the population living in the cities targeted by this study, both in terms of the average number of salaries and value in reais, a sum of these variables was performed within each group and then the result was divided by the number of municipalities existing in each set.

Table 17 – Average salary of each group of municipalities based on the minimum wage from 2000 to 2020

YEAR	GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
2020	1,5	2,1	2,8	2,0	1,8
2019	1,6	2,1	2,8	2,2	1,8
2018	1,5	2,1	2,9	2,0	1,8
2017	1,4	2,1	2,9	2,0	1,8
2016	1,5	2,0	2,9	2,0	1,8
2015	1,6	2,2	2,9	1,9	1,8
2014	1,5	2,3	2,9	1,9	1,9
2013	1,4	2,3	2,9	2,0	1,9
2012	1,4	2,1	2,8	1,9	2,2
2011	1,4	2,2	2,9	1,8	2,2
2010	1,4	2,3	2,8	1,9	2,4
2009	1,5	2,3	2,9	1,7	2,3
2008	1,4	2,4	2,9	1,8	2,2
2007	1,4	2,2	2,9	1,7	1,4
2006	1,4*	2,2*	2,9*	1,7*	1,4*
2005	1,4*	2,2*	2,9*	1,7*	1,4*
2004	1,4*	2,2*	2,9*	1,7*	1,4*
2003	1,4*	2,2*	2,9*	1,7*	1,4*
2002	1,4*	2,2*	2,9*	1,7*	1,4*
2001	1,4*	2,2*	2,9*	1,7*	1,4*
2000	1,4*	2,2*	2,9*	1,7*	1,4*

YEAR	GROUP 6	GROUP 7	GROUP 8	GROUP 9	GROUP 10
2020	2,7	1,9	2,2	1,9	2,4
2019	2,7	1,9	2,2	1,8	2,4
2018	2,7	1,9	2,2	1,8	2,4
2017	2,7	1,8	2,2	1,8	2,3
2016	2,8	1,8	2,1	1,7	2,4
2015	2,8	1,8	2,2	1,8	2,4
2014	2,8	1,8	2,1	1,8	2,5
2013	2,8	1,8	2,1	1,7	2,6
2012	2,8	1,6	2,1	1,8	2,4

Continues

YEAR	GROUP 6	GROUP 7	GROUP 8	GROUP 9	GROUP 10
2011	2,0	1,7	2,1	1,8	1,9
2010	2,0	1,6	2,2	1,8	1,9
2009	2,1	1,7	2,0	1,8	2,0
2008	2,1	1,8	2,1	1,9	2,1
2007	2,1	1,6	2,1	1,9	2,1
2006	2,1*	1,6*	2,1*	1,9*	2,1*
2005	2,1*	1,6*	2,1*	1,9*	2,1*
2004	2,1*	1,6*	2,1*	1,9*	2,1*
2003	2,1*	1,6*	2,1*	1,9*	2,1*
2002	2,1*	1,6*	2,1*	1,9*	2,1*
2001	2,1*	1,6*	2,1*	1,9*	2,1*
2000	2,1*	1,6*	2,1*	1,9*	2,1*

Source: Author's elaboration based on data collected from IBGE – Cidades (2020).

*Estimated values.

In Table 17, it can be deduced that Group 3, composed of municipalities belonging to the State of Santa Catarina, is the one that presented the highest average salary in the period from 2000 to 2020, with 2.9 minimum wages. On the other hand, in Group 1, composed of municipalities in Ceará, the average salary in the same period varies from only 1.4 minimum wages to 1.5 minimum wage.

If we analyze the arithmetic mean of the average salary of the ten groups of municipalities where the UCFPIs are located that suffered events of the PADDD type, in the period from 2000 to 2020, we will arrive at 2.13 minimum wages or R\$ 2,225.85, if we consider the minimum wage in force as of February 1, 2020, which was R\$ 1,045.00; following Article 2 of Federal Law No. 14,013, of June 10, 2020.

By transforming the average minimum wages into monetary values, taking into account the value of the minimum wage in force in each year of the period between 2000 and 2020, values that are contained in Table 98 of the PPAendix, we will arrive at the values tabulated in Table 18, below.

Table 18 – Average incomes of the groups in monetary terms.

YEAR	G - 1	G - 2	G - 3	G - 4	G - 5	G - 6	G - 7	G - 8	G - 9	G - 10
2020	1.567,50	2.194,50	2.926,00	2.090,00	1.881,00	2.821,50	1.985,50	2.299,00	1.985,50	2.508,00
2019	1.596,80	2.095,80	2.794,40	2.195,60	1.796,40	2.694,60	1.896,20	2.195,60	1.796,40	2.395,20
2018	1.431,00	2.003,40	2.766,60	1.908,00	1.717,20	2.575,80	1.812,60	2.098,80	1.717,20	2.289,60
2017	1.311,80	1.967,70	2.717,30	1.874,00	1.686,60	2.529,90	1.686,60	2.061,40	1.686,60	2.155,10
2016	1.320,00	1.760,00	2.552,00	1.760,00	1.584,00	2.464,00	1.584,00	1.848,00	1.496,00	2.112,00
2015	1.260,80	1.733,60	2.285,20	1.497,20	1.418,40	2.206,40	1.418,40	1.733,60	1.418,40	1.891,20
2014	1.086,00	1.665,20	2.099,60	1.375,60	1.375,60	2.027,20	1.303,20	1.520,40	1.303,20	1.810,00
2013	949,20	1.559,40	1.966,20	1.356,00	1.288,20	1.898,40	1.220,40	1.423,80	1.152,60	1.762,80
2012	870,80	1.306,20	1.741,60	1.181,80	1.368,40	1.741,60	995,20	1.306,20	1.119,60	1.492,80
2011	763,00	1.199,00	1.580,50	981,00	1.199,00	1.090,00	926,50	1.144,50	981,00	1.035,50
2010	714,00	1.173,00	1.428,00	969,00	1.224,00	1.020,00	816,00	1.122,00	918,00	969,00
2009	697,50	1.069,50	1.348,50	790,50	1.069,50	976,50	790,50	930,00	837,00	930,00
2008	581,00	996,00	1.203,50	747,00	913,00	871,50	747,00	871,50	788,50	871,50
2007	532,00	836,00	1.102,00	646,00	532,00	798,00	608,00	798,00	722,00	798,00
2006	490,00*	770,00*	1.015,00*	595,00*	490,00*	735,00*	560,00*	735,00*	665,00*	735,00*
2005	420,00*	660,00*	870,00*	510,00*	420,00*	630,00*	480,00*	630,00*	570,00*	630,00*
2004	364,00*	572,00*	754,00*	442,00*	364,00*	546,00*	416,00*	546,00*	494,00*	546,00*
2003	336,00*	528,00*	696,00*	408,00*	336,00*	504,00*	384,00*	504,00*	456,00*	504,00*
2002	280,00*	440,00*	580,00*	340,00*	280,00*	420,00*	320,00*	420,00*	380,00*	420,00*
2001	252,00*	396,00*	522,00*	306,00*	252,00*	378,00*	288,00*	378,00*	342,00*	378,00*
2000	211,40*	332,20*	437,90*	256,70*	211,40*	317,10*	241,60*	317,10*	286,90*	317,10*

*Estimates of values.

Source: The authors.

When we observe Table 18, it can be inferred that the average income of Group 3 in 2020, which, in monetary terms, is R\$ 2,926.00, is almost double the average income of Group 1, in the same period, which was R\$ 1,567.50. An explanatory factor for this disproportion between the values may be the geographical location of the UCFPIs and the municipalities in which the area overlaps the territorial limits since Group 1 is composed of Cearense cities and Group 3 of cities of the State of Santa Catarina, Federation units that have different levels of economic development.

In addition to the income of the municipalities analyzed in this study, another important variable to arrive at the answer to the problem presented in previous lines is the Gross Domestic Product of the municipal public entities whose areas are superimposed on the territorial extensions of the UCFPIs that have been affected by events of relimitation or recategorization in recent years.

GDP corresponds to the market value of the flow of final goods and services made available by an economy in a given period (usually a year), providing the monitoring of its structural changes and its conjunctural course. The GDP is calculated by the IBGE, based on a methodology recommended by the United Nations (UN), from a thorough survey and systematization of primary and secondary information ascertained or appropriated by that institution. (LAWRENCE; ROMERO, 2002).

For Matos and Garcia (2009), the Gross Domestic Product (GDP), at market price, measures the total of goods and services produced by the producing units established in a given locality in a given period, thus corresponding to the sum of the values added by the various economic sectors plus taxes on products not included in the valuation of production, fewer subsidies. Also according to the authors, GDP is, therefore, equal to the sum of the final consumption of goods and services valued at market price, being equivalent, still, to the sum of primary incomes.

Table 19 lists the values of this variable, in reais, according to the group of municipalities, for the period from 2000 to 2020.

Table 19 – Value, in reais, of the nominal GDP, of the groups in the period from 2000 to 2020

Year	G - 1	G - 2	G - 3	G - 4	G - 5	G - 6	G - 7	G - 8	G - 9	G - 10
2000	44.596,33	87.620	530.636,87	53.628,50	41.993	743.626	19.545,50	80.892	44.597,80	510.405,33
2001	50.049,33	90.279,50	583.507,87	48.664,50	47.364	895.475,50 ¹	25.919,50	111.872	50.770	613.274
2002	61.886,33 ¹	103.815,50 ³	627.470,12	46.631 ¹	56.105	1.085.474	28.182,62 ¹	136.435,50	74.826	744.258,66
2003	72.222,66	112.388,50	732.005	59.183	67.150,66	1.347.337	42.481,62	177.140	95.174,60	919.958,33
2004	85.462	120.750	814.712,50 ¹	67.058,50	76.683	1.582.962,50	60.242,10	214.231	109.536,60	1.076.895
2005	91.015,66	132.220,50	902.203,87	78.237	87.002,33 ¹	1.864.195,50	61.259,25	216.110,50	137.951	1.273.573,66
2006	100.772,66	145.760	1.036.782,25	92.018,50	83.637 ²	1.911.322,50	51.338,50	251.837,50 ¹	144.720,40 ¹	1.320.782,66
2007	105.817,33 ²	152.684,50	1.149.244,75	119.973	96.646	2.209.277 ²	67.228,31	297.216,50	151.407,20	1.530.917
2008	125.184,66	161.751,25	1.272.908,50	110.567,50 ²	140.691,66	2.556.390,50 ²	101.958,50	320.825	194.273	1.826.822,33 ¹
2009	135.944	187.088,25	1.343.750	109.763,50	178.044,33	3.328.262,50	119.162,62	338.746,50	230.769,80	2.350.379,33
2010	188.664,33	272.320,25	1.720.016,25	114.010	245.265	4.571.609 ²	139.766,50	504.811	208.615,60	3.116.181 ²
2011	204.171	302.390,25	1.933.517,25	135.312,50	267.829,33	5.601.630	205.465,25	531.922,50	258.250	3.816.710,33
2012	260.015,33	317.255	2.118.553,62	150.662,50	428.736,33	6.020.619	289.509,20	542.381,50	282.785,60 ²	4.119.844,66 ²
2013	238.086,33	391.100,50	2.280.744	146.457	445.374,33	5.890.567	240.644,75	683.583,50	320.477	4.053.940,33
2014	288.475,30	423.743,48	2.817.131,67	180.825,38	379.807,40	6.440.619,07	289.626,33	822.592,82	363.473,65	4.416.604,90
2015	311.574,38	546.444,54	2.730.434,56	189.377,08	412.895,49	7.029.233,35	320.689,06 ²	914.294,55	390.605,06	4.816.475,91
2016	357.494,60	388.974,54	2.740.516,23	190.082,79	351.801,11	7.425.185,06	215.463,68	953.978,97	333.967,41	5.099.813,83
2017	401.234,53	394.952,25	2.907.029,14	214.709,81	470.658,96	8.538.854,85	353.906,47	1.050.205,09 ²	470.366,37	5.857.818,93
2018	400.458,89	367.668,17	3.073.315,00	440.418,85	552.514,38	8.381.830,55	497.851,83	1.056.693,01	507.650,20	5.752.460,50
2019	499.856,47	398.468,67	3.190.345,92	206.978,53	543.661,03	9.018.973,04	398.358,89	1.166.703,17	529.924,24	6.014.810,23
2020*	49.857,00	398.469,00	3.190.346,00	206.979,00	543.661,00	9.018.974,00	398.359,00	1.166.704,00	529.925,00	6.014.811,00

Source: The authors from IBGE data – Cities (2020)

¹ GDP declared in the year of creation of the conservation unit under study;

² GDP declared in the year of occurrence of a PADDD-type event in the conservation unit under study;

³ GDP declared in the year of creation of the conservation unit under study, and which was the same year of occurrence of a PADDD-type event in this conservation unit;

*Estimated value.

In Table 19, the GDP is in its nominal form, that is, it still suffers the influence of the inflation of the period and corresponds to the arithmetic average of the GDPs of each municipality belonging to the group, for each year of the historical series under analysis, being used the following formula:

$$PIB_{grup\ x\ (t)} = \frac{\text{Sum of GDPs of municipalities belonging to group } x \text{ in year } t}{\text{Number of municipalities in group } x} \quad (\text{Equation 1})$$

Where x corresponds to the group number and can range from 1 to 10; t is the year of the historical series of GDP that one wants to obtain, ranging from 2000 to 2020. Also according to Table 19, the values that are marked with the number "1" correspond to the total GDP of the municipality in the year in which the UCFPIs under study were created. The GDPs marked with the number "2" refer to the GDP of the year in which the PADDD event occurred. The GDP marked with the number "3" corresponds to the total wealth produced by the municipality in that year; including, the year in which both the creation of the conservation unit and the PADDD-type event occurred. In 30% of the groups previously mentioned, PADDD-type events interrupted a sequence of growth in the production of total wealth produced by the municipalities that make up the groups.

In group 4, in 2007, the GDP recorded was R\$ 119,937. The following year, in 2008, the GDP recorded was R\$ 110,567.50. However, in 2009, when a PADDD event occurred, the GDP suffered a slight retraction, passing to the value of R\$109,763.50.

Regarding group 7, there was a PADDD-type event in 2015, when the GDP registered R\$ 320,689.06, against R\$ 289,626.33 in wealth produced in 2014. However, in 2016, which was the year after the PADDD event, the GDP totaled Aproximately R\$ 215,463.68 reais. That is, there was a decrease of about R \$ 105,225.68, or 32.8% compared to the same previous period.

Group 10 also suffered a PADDD-type event in 2012, a year in which goods, products, and services totaled R\$ 4,119,844.66 of wealth for the municipalities belonging to this group. In 2011, the GDP was R\$ 3,816,710.33. Contrary to the following trend, the GDP of group 10 decreased to R\$ 4,053,940.33. However, there is both nominal and real GDP, the latter corresponding to the former calculated without the harmful effects of inflation. That is, GDP can be measured at current (nominal or monetary) and constant (real) prices, both of which represent important measures of performance, serving monetary values to give an idea of the size of the system, as they result from the aggregation of the physical production of all goods and services by their respective prices, discounting intermediate transactions. However, as the currency can suffer corrosion of its purchasing power over an economic cycle, in real values, the average inflation rate is discounted, portraying the effective variation of the economy in a period. (LAWRENCE; ROMERO, 2002).

Inflation can be understood as a generalized and permanent rise in the price levels of the economic system, resulting in deterioration of the purchasing power of the currency and depreciation of asset values. The complexity of calculating inflation stems from the need to measure the price variation of physically distinct products and services that vary at different rates. (LAWRENCE; ROMERO, 2002).

Table 20 shows the GDP values of the groups of municipalities that have UCFPIs that suffered some type of PADDD event in the periods from 2000 to 2020.

Table 20 – Value, in reais, of the real GDP, of the groups in the period from 2000 to 2020

Year	GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5	GROUP 6	GROUP 7	GROUP 8	GROUP 9	GROUP 10
2000	12.351,84	24.268,11	146.970,47	14.853,48	11.630,80	205.962,06	5.413,52	22.404,65	12.352,25	141.366,94
2001	14.885,00	26.849,72	173.539,10	14.473,14	14.086,37	266.320,34 ¹	7.708,63	33.271,47	15.099,33	182.391,74
2002	20.713,70 ¹	34.747,63 ³	210.017,78	15.607,66 ¹	18.778,66	363.314,26	9.432,88 ¹	45.665,73	25.044,68	249.107,56
2003	29.734,72	46.271,36	301.373,05	24.366,17	27.646,53	554.710,77	17.490,07	72.930,13	39.184,24	378.755,13
2004	38.595,49	54.531,91	367.932,30 ¹	30.284,29	34.630,81	714.881,68	27.205,93	96.748,86	49.467,82	486.336,54
2005	43.442,16	63.109,40	430.625,68	37.342,85	41.526,58 ¹	889.788,32	29.239,30	103.150,45	65.844,59	607.882,04
2006	47.536,52	68.757,96	489.071,30	43.407,00	39.453,28 ²	901.609,75	24.217,42	118.796,88 ¹	68.267,56 ¹	623.040,08
2007	54.474,82 ²	78.602,06	591.631,79	61.762,16	49.753,41	1.137.336,94 ²	34.609,17	153.007,21	77.944,50	788.116,86
2008	67.762,62	87.556,16	689.027,01	59.850,33 ²	76.156,58	1.383.777,47 ²	55.190,27	173.662,99	105.160,23	988.861,28 ¹
2009	77.447,73	106.584,77	765.538,65	62.532,62	101.432,42	1.896.121,75	67.887,32	192.984,96	131.470,29	1.339.018,59
2010	113.845,24	164.325,52	1.037.905,05	68.796,77	147.999,64	2.758.634,44 ²	84.338,95	304.616,82	125.884,38	1.880.389,21 ²
2011	131.223,73	194.350,70	1.242.700,21	86.967,35	172.137,88	3.600.250,66	132.055,56	341.874,48	165.981,10	2.453.056,32
2012	176.893,21	215.834,41	1.441.290,99	102.498,47	291.677,21	4.095.937,82	196.958,43	368.992,11	192.384,24 ²	2.802.806,08 ²
2013	171.544,30	281.793,00	1.643.305,71	105.523,81	320.898,00	4.244.230,13	173.387,67	492.530,80	230.907,85	2.920.916,73
2014	221.189,46	324.906,82	2.160.045,75	138.648,50	291.218,68	4.938.367,64	222.072,02	630.725,98	278.694,72	3.386.447,55
2015	264.382,16	463.678,01	2.316.872,77	160.693,32	350.356,80	5.964.559,48	272.116,30 ²	775.812,09	331.442,56	4.086.954,53
2016	322.444,85	350.838,41	2.471.828,47	171.446,55	317.309,56	6.697.199,48	194.339,03	860.448,25	301.224,33	4.599.814,04
2017	370.723,95	364.919,38	2.685.973,52	198.382,90	434.869,22	7.889.545,27	326.994,80	970.345,64 ²	434.598,88	5.412.380,05
2018	383.912,27	352.476,44	2.946.328,25	422.221,12	529.684,96	8.035.500,48	477.281,02	1.013.031,36	486.674,53	5.514.773,75
2019**	499.856,47	398.468,67	3.190.345,92	206.978,53	543.661,03	9.018.973,04	398.358,89	1.166.703,17	529.924,24	6.014.810,23
2020*	499.857,00	398.469,00	3.190.346,00	206.979,00	543.662,00	9.018.974,00	398.359,00	1.166.704,00	529.925,00	6.014.811,00

Source: The authors from IBGE data – Cities (2020);

¹ GDP declared in the year of creation of the conservation unit under study;

² GDP declared in the year of occurrence of a PADDD-type event in the conservation unit under study;

³ GDP declared in the year of creation of the conservation unit under study, and that was the same year of occurrence of a PADDD-type event in this conservation unit.

*Estimated value

** Base year

In Table 20, it can be seen that the year 2019 was chosen as the base year to calculate the real GDP of the groups of municipalities under analysis, thus allowing us to know how much the GDP of Group 1 calculated for the year 2005 would be worth in 2019, which would be, in this case, R\$ 43,442.16.

Also according to Table 20, it can be seen that Group 10 had the largest increase in real GDP in the period from 2000 to 2020, from R\$ 141,366.94 to R\$ 6,014,810.23. The Mapinguari National Park, a conservation unit whose area is superimposed on the territorial limits of the municipalities of this group, was created in 2008 and, this year, the real GDP was R\$988,861.28. However, in the years 2010 and 2012, this preservation area suffered two PADDD events and, in that year, the real GDPs of the group were R\$ 1,880,389.21 and R\$ 2,802,806.08, respectively.

Group 1, on the other hand, has the lowest evolution of real GDP during the period between 2000 and 2020. In 2000, the real GDP of the group was R \$ 12,351.84, already in 2019 this amount rose to R \$ 499,856.47 or almost 40 times higher. The conservation unit whose area is superimposed on the territorial limits of the municipalities of Ceará belonging to this group is the Jericoacoara National Park, which was created in 2002, when the real GDP was R\$ 20,713.70, and suffered a PADDD event in 2007, the year in which the sum of the group's wealth totaled R\$ 54,474.82.

Except for Group 7, where the real GDP calculated in the year of occurrence of the PADDD event (2015) is higher than the real GDP calculated in the subsequent year (2016), in the other groups, the real GDP increased in the year following the occurrence of the PADDD event in the UCFPIs that is located in the territories of the municipalities belonging to each group. An example of this fact is what happened in Group 10, in which the Mapinguari National Park Conservation Unit, located in the Amazon biome, was affected by two legal acts emanating from the Federal Public Power that limited the park and increased its extension by 1,724.3 km². The first act occurred in 2010 when the real GDP of this group was R \$ 1,880,389.21 and this increased to R \$ 2,453,056.32 in 2011. When, in 2012, another PADDD event occurred, real GDP was in the order of R\$ 2,802,806.08, reaching the level of R\$ 2,920,916.73 in 2013, that is, a growth of R\$ 118,110.65 or Approximately 4%.

The nominal GDP of this group decreased between 2012 and 2013, from R\$ 4,119,844.66 to R\$ 4,053,940.33, a decrease of 1.6%.

Another inference that can be reached is that there were reductions in certain periods in the real GDP of the groups. However, these reductions did not occur in the year in which the creation of conservation units took place, nor in years in which the Federal Government promulgated some decree or law of extinction, relimitation, or recategorization of any of the protected green areas, the object of study of this work.

Table 21 shows the evolution of changes in the real GDP of the groups over the period

between 2000 and 2019.

Table 21 – Change in real GDP, in absolute terms, of the groups in the period from 2000 to 2019

PERIOD	GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
2000 – 2001	2.533,16	2.581,61	26.568,63	-380,34*	2.455,57
2001 – 2002	5.828,70	7.897,91	36.478,68	1.134,51	4.692,29
2002 – 2003	9.021,02	11.523,73	91.355,27	8.758,52	8.867,87
2003 – 2004	8.860,77	8.260,55	66.559,25	5.918,11	6.984,28
2004 – 2005	4.846,66	8.577,49	62.693,38	7.058,56	6.895,77
2005 – 2006	4.094,36	5.648,56	58.445,62	6.064,15	-2.073,30*
2006 – 2007	6.938,30	9.844,10	102.560,49	18.355,16	10.300,13
2007 – 2008	13.287,80	8.954,10	97.395,22	-1.911,83*	26.403,17
2008 – 2009	9.685,11	19.028,61	76.511,64	2.682,29	25.275,84
2009 – 2010	36.397,51	57.740,75	272.366,40	6.264,15	46.567,22
2010 – 2011	17.378,49	30.025,18	204.795,15	18.170,58	24.138,24
2011 – 2012	45.669,48	21.483,71	198.590,78	15.531,12	119.539,33
2012 – 2013	-5.348,91	65.958,59	202.014,73	3.025,34	29.220,79
2013 – 2014	49.645,17	43.113,83	516.740,04	33.124,69	-29.679,32
2014 – 2015	43.192,70	138.771,19	156.827,02	22.044,82	59.138,12
2015 – 2016	58.062,68	-112.839,61	154.955,70	10.753,23	-33.047,24
2016 – 2017	48.279,10	14.080,98	214.145,04	26.936,35	117.559,66
2017 – 2018	13.188,32	-12.442,95	260.354,73	223.838,22	94.815,74
2018 – 2019	115.944,20	45.992,23	244.017,67	-215.242,59	13.976,07

PERIOD	GROUP 6	GROUP 7	GROUP 8	GROUP 9	GROUP 10
2000 – 2001	60.358,28	2.295,11	10.866,82	2.747,08	41.024,81
2001 – 2002	96.993,92	1.724,25	12.394,26	9.945,35	66.715,82
2002 – 2003	191.396,52	8.057,18	27.264,40	14.139,56	129.647,57
2003 – 2004	160.170,90	9.715,87	23.818,73	10.283,58	107.581,41
2004 – 2005	174.906,64	2.033,36	6.401,59	16.376,77	121.545,50
2005 – 2006	11.821,43	-5.021,88	15.646,43	2.422,97	15.158,04
2006 – 2007	235.727,19	10.391,75	34.210,33	9.676,94	165.076,78
2007 – 2008	246.440,53	20.581,10	20.655,78	27.215,72	200.744,42
2008 – 2009	512.344,27	12.697,06	19.321,97	26.310,06	350.157,31
2009 – 2010	862.512,70	16.451,62	111.631,86	-5.585,91	541.370,62
2010 – 2011	841.616,22	47.716,62	37.257,65	40.096,72	572.667,11
2011 – 2012	495.687,16	64.902,87	27.117,63	26.403,14	349.749,76
2012 – 2013	148.292,31	-23.570,76	123.538,69	38.523,60	118.110,65
2013 – 2014	694.137,50	48.684,35	138.195,18	47.786,87	465.530,82
2014 – 2015	1.026.191,85	50.044,28	145.086,11	52.747,85	700.506,97
2015 – 2016	732.639,99	-77.777,27	84.636,15	-30.218,24	512.859,52
2016 – 2017	1.192.345,80	132.655,77	109.897,40	133.374,56	812.566,01
2017 – 2018	145.955,21	150.286,22	42.685,71	52.075,65	102.393,70
2018 – 2019	983.472,56	-78.922,13	153.671,81	43.249,71	500.036,48

Source: The authors.

Group 2 suffered two decreases in real GDP, one between 2015 and 2016, for R\$ 112,839.61; and another less expressive, in the amount of R\$ 12,442.95, between the years 2017 and 2018. In Group 5, there were three reductions in real GDP between one year and another, which were R\$ 2,073.30, R\$ 21,679.32, and R\$ 33,047.24, between the years 2005 and 2006, 2013, and 2014, 2015 and 2016, respectively.

In Group 1, between 2012 and 2013, real GDP decreased by R\$ 5,348.91. In Group 7, the sum of wealth, in its real value, suffered four decreases, the first of R\$ 5,021.88, between 2005 and 2006, the second of R\$ 23,570.76 between the years 2012 and 2013, another of R\$ 77,777.27 between the years 2015 and 2016, and a list of R\$ 78,992.13, between the years 2018 and 2020.

Between 2009 and 2010, and between 2015 and 2016, Group 9 suffered the impacts of two reductions in real GDP in imports of R\$5,585.91 and 30,218.24, respectively.

On the other hand, in groups 1, 2, 4, 5, 7, and 9 there were periods in which real GDP suffered a decrease in its value, ranging from R\$ 380.34 between the years 2000 and 2001, to 215,242.59 between the years 2018 and 2019, as occurred in Group 4. This group also suffered a third reduction, between the years 2007 and 2008, for R\$ 1,911.83.

In the case of Groups 3, 6, 8, and 10, the variations in real GDP have always been positive and, in some situations, even significant, as occurred in Group 6, in which there was an increase of R\$ 1,026,191.85 from 2014 to 2015, and from R\$ 1,192,345.80 from the amount in 2016 to the amount calculated in 2017. In Group 10 there was also a significant increase in real GDP from one year to the next, when, in 2017, this variable was R\$ 812,566.01 higher than in the previous year.

In addition to the data referring to the Gross Domestic Product (GDP) and the average income of the municipalities belonging to each group, as well as the territorial extension of the Conservation Units before and after suffering the effects of the occurrence of the PADDD Events, data on the employed population were collected – to contribute to the answer to the question about the economic and legal effects of the PADDD events in the municipalities with UCFPI's through an econometric analysis – and wages and other remuneration paid.

According to the IBGE (2007), employed persons (OP) can be considered a complementary part of the Economically Active Population (EAP), being that portion of the population that worked work, paid or not, in the reference week of the research, for at least one full hour in the reference week or that had some type of work with remuneration from which they were temporarily away this week. Also according to the institute, this population that performs some type of work can be distributed into four types of categories, taking into account as a selection criterion their position in the occupation. The categories are as follows: i) employee, which is the person who works for another individual who performs the function of the employer, having the employee submit to a mandatory working day; ii) a self-employed person, that is, an individual who operates his enterprise alone or with another person, in this case, a partner, this entrepreneur not having any employee, but can count on the help of an unpaid worker; iii) a person who performs the function of the employer, that is, works operating his own business and has at least one employee; and, finally, iv) unpaid worker, falling into this category people who work without remuneration in an enterprise of members of the

household unit that was self-employed or employer.

Table 22 tabulates the data regarding the Employed Population, or Employed Persons (OP), of the groups of municipalities under study for the period from 2000 to 2020, whose source of information was the IBGE – Cities (2020).

Table 22 – Quantitative of the Employed Population of the groups under study, in terms of inhabitants, for the period from 2000 to 2020

Year	G - 1	G - 2	G - 3	G - 4	G - 5	G - 6	G - 7	G - 8	G - 9	G - 10
2000	207*	972*	104.776*	52.522*	53*	38.538*	363*	18.104*	22.079*	13.504*
2001	648*	1.156*	108.519*	54.566*	92*	41.432*	386*	19.461*	23.439*	14.420*
2002	1.088*	1.374*	112.395*	56.689*	160*	44.543*	409*	20.920*	24.882*	15.398*
2003	1.528*	1.634*	116.410*	58.895*	276*	47.888*	434*	22.489*	26.414*	16.442*
2004	1.969*	1.944	120.569*	61.187*	476*	51.485*	461*	24.175*	28.040*	17.557*
2005	2.409*	2.312*	124.875*	63.569*	823*	55.351*	490*	25.987*	29.767*	18.747*
2006	2.849	2.749	129.336	66.042	1.422	59.508	520*	27.935	31.600	20.018
2007	3.290	3.269	133.956	68.613	2.457	63.977	552	30.030	33.545	21.376
2008	3.092	3.653	137.768	70.711	3.280	70.027	514	32.246	35.868	22.876
2009	3.232	3.608	142.941	73.275	4.634	82.828	572	35.299	39.953	25.275
2010	3.440	3.692	149.168	76.430	3.836	96.648	797	41.812	44.602	29.070
2011	3.612	3.763	156.069	79.916	3.089	101.691	849	48.748	47.106	32.235
2012	2.743	4.167	158.141	81.154	2.555	103.346	612	51.151	48.125	33.296
2013	3.767	3.972	161.954	82.963	2.689	100.708	730	52.038	47.829	33.533
2014	4.422	3.829	162.134	82.982	2.598	99.412	873	50.790	46.917	32.860
2015	3.946	3.603	158.220	80.911	2.672	91.544	869	50.140	44.880	31.963
2016	3.806	3.242	155.105	79.173	2.391	86.248	817	46.180	43.103	30.033
2017	4.094	3.084	156.680	79.882	2.555	85.814	922	43.585	42.852	29.119
2018	4.204	3.037	159.729	81.383	2.752	84.405	959	43.386	42.598	28.981
2019	4.622	3.158	159.821	81.489	2.825	83.085	1.001	42.703	42.419	28.707
2020	4.446	3.143	161.816	82.480	2.672	82.928	1.227	42.156	25.797	23.060

Source: The authors using data from IBGE – Cities (2020).

*Estimated values.

Table 22 shows that Group 3 has the largest number of Employed Persons for the period under study among the other groups, ranging from 104,776 in 2000 to 161,816 in 2020. The municipalities belonging to this group are located in the State of Santa Catarina and the Atlantic Forest Biome. Group 7 – which is inserted in the Cerrado Biome and has municipalities belonging to the states of Maranhão, Piauí, Tocantins, and Bahia – has the lowest number of Employed People compared to the other groups for the period between the years 2000 to 2020. In the case of this group, in 2000, only 363 people were performing some paid or unpaid work during the reference week of data collection. In 2020, there were 1,227 in the same situation.

Regarding the percentage of the employed population, Table 23, below, presents the data for the groups on this variable for the years 2000 to 2020.

Table 23 – Percentage of the Employed Population of the groups under study for the period from 2000 to 2020

Year	G - 1	G - 2	G - 3	G - 4	G - 5	G - 6	G - 7	G - 8	G - 9	G - 10
2000	14,87*	9,62*	82,35*	43,27*	7,12*	24,43*	14,17*	19,22*	23,41*	18,87*
2001	14,70*	9,87*	79,30*	42,26*	7,25*	24,08*	13,64*	18,82*	22,82*	18,37*
2002	14,52*	10,12*	76,36*	41,28*	7,38*	23,75*	13,13*	18,43*	22,26*	17,89*
2003	14,34*	10,38*	73,52*	40,31*	7,52*	23,41*	12,64*	18,04*	21,70*	17,42*
2004	14,17*	10,65*	70,79*	39,37*	7,66*	23,09*	12,16*	17,67*	21,16*	16,97*
2005	13,99*	10,92*	68,17*	38,46*	7,79*	22,76*	11,71*	17,30*	20,63*	16,52*
2006	13,82*	11,20*	65,64*	37,56*	7,94*	22,45*	11,27*	16,94*	20,12*	16,09*
2007	13,64*	11,48*	63,20*	36,68*	8,08*	22,13*	10,84*	16,59*	19,62*	15,67*
2008	13,46*	11,78*	60,85*	35,83*	8,23*	21,82*	10,44*	16,24*	19,13*	15,25*
2009	13,29*	12,08*	58,60*	34,99*	8,38*	21,52*	10,05*	15,91*	18,65*	14,85*
2010	13,11*	12,39*	56,42*	34,18*	8,53*	21,21*	9,67*	15,57*	18,19*	14,46*
2011	12,94*	12,70*	54,33*	33,38*	8,68*	20,92*	9,31*	15,25*	17,73*	14,09*
2012	12,76*	13,03*	52,31*	32,60*	8,84*	20,62*	8,96*	14,93*	17,29*	13,72*
2013	12,59*	13,36*	50,37*	31,84*	9,00*	20,34*	8,62*	14,62*	16,86*	13,36*
2014	12,41	13,70	48,50	31,10	9,17	20,05	8,30	14,32	16,44	13,01
2015	12,23	14,05	46,70	30,38	9,33	19,77	7,99	14,02	16,03	12,66
2016	12,06	13,00	45,10	29,05	8,33	19,19	7,11	13,44	15,39	11,98
2017	13,23	12,70	45,00	28,85	8,87	18,59	8,86	14,02	15,85	12,91
2018	14,13	12,55	45,30	28,93	9,53	18,90	9,50	14,05	16,17	13,24
2019	15,47	13,08	44,70	28,89	9,70	19,21	9,38	14,14	16,33	13,28
2020	14,57	13,73	44,70	29,21	9,27	19,46	10,81	15,01	10,91	12,24

Source: The authors using data from IBGE – Cities (2020).

*Estimated values.

In percentage terms, Group 7 continues to stand out when we compare it with the other groups, as the employed population of this group varied from 82.35% in 2000 to Aproximately 44.70% in

2020. Even after suffering a decrease in percentage terms during the study period, the group continued to be the one with the highest percentage among the others. On the other hand, Group 5, inserted in the Cerrado Biome and having municipalities belonging to the State of Maranhão, was the one that presented the lowest percentage of employed population compared to the other groups, never exceeding double digits during the years 2000 to 2020, with oscillations in certain periods, ranging from 7.12% in 2000 to Approximately 9.27%, in 2020. Its peak occurred in 2019, when about 9.70% of the population, according to IBGE – Cidades (2020), exercised some type of paid or unpaid work in the reference week of the survey.

Another variable whose data were collected from IBGE – Cities (2020) and which is umbilically linked to the quantity of Employed Population and the average income of the municipalities under study, taking into account the years 2000 to 2020, is the number of salaries and other remuneration paid for each year of study. In Table 24, the following can be observed this value in terms of thousands of reais.

Table 24 – Total salaries and other remuneration in thousands of R\$

YEAR	G -1	G -2	G -3	G -4	G -5
2000	350.000*	11.689.529*	763.926.405*	387.610.010*	74.794.212*
2001	700.000*	13.426.244*	845.219.563*	429.164.530*	66.488.922*
2002	1.120.000*	15.420.982*	935.163.525*	475.173.987*	59.105.868*
2003	4.178.667*	17.712.079*	1.034.678.865*	526.115.981*	52.542.641*
2004	7.237.333*	20.343.564*	1.144.784.120*	582.519.315*	46.708.208*
2005	10.296.000*	23.366.010*	1.266.606.217*	644.969.484*	41.521.641*
2006	13.354.667	26.837.500	1.401.392.000	714.114.750	36.911.000
2007	16.413.333	30.824.750	1.550.521.000	790.672.875	32.812.333
2008	20.048.667	37.694.750	1.837.080.000	937.387.375	31.978.333
2009	22.141.333	39.851.500	2.046.949.000	1.043.400.250	65.958.667
2010	26.449.333	46.540.250	2.387.072.000	1.216.806.125	85.700.333
2011	29.906.000	52.259.250	2.778.524.000	1.415.391.625	51.737.000
2012	23.797.333	59.163.000	3.120.645.000	1.589.904.000	42.814.667
2013	38.761.000	65.638.500	3.502.223.000	1.783.930.750	37.027.667
2014	46.559.333	65.076.500	3.889.024.000	1.977.050.250	40.379.000
2015	51.652.000	64.483.750	4.089.797.000	2.077.140.375	44.782.667
2016	61.292.333	62.167.250	4.331.043.000	2.196.605.125	46.532.000
2017	70.789.667	59.805.250	4.618.963.000	2.339.384.125	51.234.000
2018	72.002.333	60.356.500	4.825.741.000	2.443.048.750	59.741.667
2019	79.426.667	64.148.750	4.984.327.000	2.524.237.875	62.472.000
2020	76.004.667	62.659.000	4.902.704.000	2.482.681.500	61.396.333

YEAR	G -6	G -7	G -8	G -9	G -10
2000	218.921.260*	1.208.742*	100.500.943*	124.904.264*	74.895.618*
2001	239.765.722*	1.398.308*	110.121.651*	142.587.993*	84.188.789*
2002	262.594.877*	1.617.603*	120.663.326*	162.775.354*	94.635.072*
2003	287.597.697*	1.871.290*	132.214.129*	185.820.806*	106.377.547*
2004	314.981.146*	2.164.762*	144.870.663*	212.128.994*	119.577.047*
2005	344.971.895*	2.504.260*	158.738.775*	242.161.849*	134.414.363*
2006	377.818.195	2.897.000	173.934.447	276.446.704	151.092.717
2007	413.791.938	3.351.333	190.584.764	315.585.549	169.840.549
2008	485.099.854	3.708.222	208.750.080	354.587.348	189.015.217

2009	537.689.292	5.117.778	245.108.816	414.136.135	221.454.243
2010	641.382.396	7.875.667	272.782.479	484.626.500	255.094.882
2011	750.545.979	9.527.556	325.454.976	545.433.902	293.472.144

Continues

YEAR	G -6	G -7	G -8	G -9	G -10
2012	820.820.500	7.213.556	378.879.767	606.731.848	330.941.724
2013	913.372.708	10.559.222	415.689.861	670.739.942	365.663.008
2014	1.007.038.958	13.633.333	463.503.021	720.338.938	399.158.431
2015	1.058.759.688	15.352.778	511.195.868	765.339.225	430.629.290
2016	1.120.693.896	16.659.222	537.709.455	812.195.740	455.521.472
2017	1.192.958.063	19.034.778	569.864.337	855.227.985	481.375.700
2018	1.247.141.375	20.159.111	606.558.587	891.567.723	506.095.140
2019	1.291.989.771	21.820.333	634.480.854	898.688.892	518.330.026
2020	1.272.576.750	25.433.333	658.711.552	403.623.594	362.589.493

Source: The authors.

*Estimated values

From the observation of the data in Table 24, we concluded that Group 3 was the one that spent the most on salaries and other remuneration paid to the Employed Population during the entire period under analysis, ranging from R\$ 763,926,405 in 2000 to Aproximately R\$ 4,902,704,000 reais in 2020. If we add the values of all the years, the municipalities of Group 7 spent in 20 years the amount of R\$ 56,256,383,695. Group 7 had the lowest expenditure in terms of salaries and other remuneration paid to employed personnel between 2000 and 2020, with amounts of R\$ 1,208,742 and R\$ 25,433,333, respectively. This totaled, at the end of the two decades, the amount of only R \$ 193,108,188. If we make a simple calculation, we will see that the amount paid by Group 3 is Aproximately 291 times the total amount paid by Group 7 in the same twenty-year period.

3.1 Econometric experiments and PPAlications

The PADD events are acts of the Public Power whose objectives aim to reduce or expand the limits established by law for the UCFPIs, as well as to recategorize and even extinguish these strategies of nature preservation. However, it is important to emphasize that such actions can influence economically and legally the municipalities in which the protected areas have their territorial limits overlPPAed, causing interference in some variables characterizing these cities, such as GDP, the average income of the population of these locations, the number of people employed, the total value of wages and other remuneration spent by the public power and the private initiative. However, how to know if this influence caused by PADD events in these independent variables mentioned above is positive or negative so that public policies for the development of these cities and the management of these conservation units can be directed? To answer this question, the tools offered by econometrics seem to be quite satisfactory, especially Multiple Regression and the analysis of Ordinary Least Squares.

For Hoffmann (2016), econometrics consists of the application of mathematical and statistical methods to economic problems, with regression analysis being the most important method in this field of science, because it is always interesting to know the effects that some variables exert, or that seem to exert, on others; Considering that, even if there is no causal relationship between the variables, they can be related using a mathematical expression that can be useful to estimate the value of one of the variables when we know the values of the others (these of easier obtainment or predecessors of the first in time), under certain conditions.

In the case of this study, the independent or explanatory variable will be the real GDP of these municipalities with UCFPI, municipalities that will be grouped into 10 groups, or "y", and the independent variables will be the extent of the conservation units in km², both before and after the occurrence of PADDD-type events, the average income of these groups measured in reais, the number of employed persons and the total value of wages and other remuneration received, in reais, by the individuals who were employed in the reference week. The period of analysis comprised the years 2000 to 2020.

However, as we know that only these variables will not be enough to explain the independent variable, the term "*u*" will be inserted in the equation, which will represent precisely this measurement error, that is, according to Hoffmann (2016), it is common for the dependent variable to be affected by other factors, in addition to those considered in the adopted model.

Therefore, in the case of this study, the representative equation of the problem will be:

$$Y_{\ln PIB_{real}} = \beta_0 + \beta_1 X_{(UC\ extensio)} + \beta_2 X_{average\ income} + \beta_3 X_{pop.\ occupy} + \beta_4 \cdot X_{salt-other\ remuneration} \quad (\text{Equation 2})$$

The use of the method of least squares, for Hoffmann (2016), consists of adopting the estimators that minimize the sum of the squares of the deviations between estimated values and values observed in the sample. Therefore, due to this characteristic mentioned now in past lines, the method of least squares will be used.

Next, with the help of Excel and the R Program, we will present the results of the econometric analyses of the dependent variables and the independent variables by city group and by conservation unit.

3.1.1 Group 1

Group 1 is composed of three municipalities of Jejioca de Jericoacoara, Cruz, and Camorim,

whose territorial limits are superimposed on the UCFPI, Jericoacoara National Park, which is inserted in the Caatinga Biome. This area of integral protection was created in 2002, with a territorial extension of Aproximately 85 km², and suffered the positive effects of a PADDD event of the relimitation type in 2007, gaining an area of about 4 km², then having a total territorial extension of 89 km².

Table 25 shows the data regarding the dependent variable and the independent variables for the period from 2000 to 2020.

Table 25 – Value of dependant and independent variables of Group 1

Year	In Real GDP (Y)	Extension of the CU in km ² (x ₁)	Average income in R\$ (x ₂)	Employed Population (x ₃)	Salary / Other remuneration in R\$ (x ₄)
2000	11	0	211*	207*	350.000*
2001	11	0	252*	648*	700.000*
2002 ¹	11	85	280*	1.088*	1.120.000*
2003	11	85	336*	1.528*	4.178.667*
2004	11	85	364*	1.969*	7.237.333*
2005	11	85	420*	2.409*	10.296.000*
2006	12	85	490*	2.849	13.354.667
2007 ²	12	85	532	3.290	16.413.333
2008	12	89	581	3.092	20.048.667
2009	12	89	698	3.232	22.141.333
2010	12	89	714	3.440	26.449.333
2011	12	89	763	3.612	29.906.000
2012	12	89	871	2.743	23.797.333
2013	12	89	949	3.767	38.761.000
2014	13	89	1.086	4.422	46.559.333
2015	13	89	1.261	3.946	51.652.000
2016	13	89	1.320	3.806	61.292.333
2017	13	89	1.312	4.094	70.789.667
2018	13	89	1.431	4.204	72.002.333
2019	13	89	1.597	4.622	79.426.667
2020	13	89	1.568	4.446	76.004.667

Source: The authors based on data from IBGE – Cities (2020).

¹ Year of creation of the CU.

²Year of occurrence of the PADDD event

*Estimated values.

From the observation of Table 25, it is possible to observe that the variable InPIB real presented a growth trend between the years 2000 to 2020, going from 11 to 13. The extension of the conservation unit remained constant at 85 km², from 2002, the year of creation, until 2006, increasing in 2007 to 89 km², due to the influence of positive effects of a PADDD event of the redelimitation type, which occurred and that altered the territorial limits of the UCFPI, Jericoacoara National Park, about the original perimeter established by the Federal Public Power in the legal device that created the conservation unit. From 2008 to 2020 the variable Extension of the CU remained constant.

In the case of the Average Income variable, it grew in the period from 2000 to 2019, from

R\$211 to R\$1,597. However, in 2020, there was a small decrease in the average income of the population of the municipalities of Group 1, to Aproximately R\$1,568.

The variable Employed Population suffers certain oscillations during the period from 2000 to 2020, growing from 207 employed people in the initial year of the series and reaching 3,290 in 2007, the year of occurrence of a PADDD-type event in the federal conservation units of integral protection belonging to Group 1. In 2008, the employed population increased to 3,092, increasing again in 2009 to 3,232. In 2012, there was a further reduction in the number of employed people, from 3,612 in 2011 to only 2,743. In 2013, it increased again to 3,767; in 2014, it reached 4,422, and in 2015, it decreased to 3,946. In 2017, the number of this variable grew again to 4,094, reaching 4,446 people in 2020.

The variable Salary / Other Remuneration increased its amount between the years 2000 to 2011, from R\$ 350,000 to R\$ 29,906,000. In 2012, it decreased to R\$ 23,797,333, growing again in 2013, when it totaled R\$ 38,761,000. The growth trend occurred until 2019, when this variable totaled, in the end, R\$ 79,426,667. Finally, there was a slight drop in this final value, reaching, in 2020, R \$ 76,004,667.

These data were analyzed from the econometric point of view, and the following results were found for the linear regression of the dependent variable Real GDP:

Table 26 – Regression statistics for Group 1

R multiple	0,988748037
R^2	0,97762268
R^2 –adjusted	0,97202835
Standard error	0,128846453
Observations	21

Source: The authors.

According to the regression statistics in Table 26, the R^2 presented a value closer to 1, which shows that the variables chosen explain Aproximately 97.76% of the phenomenon that occurs with the dependent variable. The R – multiple also presents a significant value, of about 98.87%, that is, very close to 1. The standard error indicates that the values estimated with the regression are far from the mean of 0.1288.

Regarding the analysis of variance of Group 1, it can be defined as a study on the Total Sum of Squares (STQ), a total sum that decomposes into two components, the first being the Sum of Squares Explained Regression (SQE) and the second the Sum of Residual Squares (SQR). In this regard, the following results were presented:

Table 27 – Analysis of variance (ANOVA Table) of Group 1

	<i>Gl</i>	<i>SQ</i>	<i>MQ</i>	<i>F</i>	<i>F of signification</i>
Regression	4	11,60454482	2,901136205	174,75241	5.54602E-13
Residue	16	0,265622535	0,016601408		
Total	20	11,87016736			

Source: The authors.

In Table 27, it can be observed that the degree of freedom (*gl*) for Group 1 is 4 for the regression, meaning that four explanatory variables will be used in the model and 16 for the residuals, totaling 20.

The sum of squares was higher for the regression analysis than for the residue analysis, which demonstrates that the independent variables chosen better explain the possible changes in the dependent variable than the calculated residuals.

The value of the F-statistic of significance was 5.54602 E-13, that is, very close to zero, being much lower than 5%, so that one can reject, in the case of Group 1, the null hypothesis that the regressors do not influence the returning.

Table 28 shows the values of the coefficients of the variables Extension of the CU (x_1), Average Income (x_2), Employed Population (x_3), and Salary/other salaries (x_4), calculated through the analysis of the data from Group 1.

Table 28 – Analysis of Group 1 variables

	<i>Coefficients</i>	<i>Standard error</i>	<i>Stat t</i>	<i>P-value</i>
Intersection	10,26701014	0,133254521	77,04811852	5.35838E-22
CU Extensio	0,00224122	0,001787768	1,253641311	0,227981633
Average income	0,001894514	0,000448043	4,228423729	0,000639361
Employed Population	0,000126991	6.49653E-05	1,954743112	0,068316231
Salary / Other remuneration	-1.07E-08	7.43031E-09	-1,44425404	0,167964778

Source: The authors.

According to the results found, the value of the intersection is 10.267, that is, when the value of x is zero, the value of real GDP starts from 10.26%.

The coefficients of the Extension of the CU (X_1), the Average Income (X_2), and the Employed Population (X_3) were, respectively, 0.0022, 0.0018 and 0.0001, or 0.22%, 0.18%, and 0.01% Aproximately, which demonstrates that these variables positively influence the dependent variable Y since an increase of 1% in real GDP will cause an increase of 0.22% in the extension of the conservation unit in km^2 , of 0.18% in the average income of the population and 0.01% in the number of employed persons.

The variable salary/other remuneration (X_4) has a coefficient with error, making it clear that

the total value of wages and other remuneration paid to the employed population does not influence, in the case of Group 1, the variation in real GDP.

The standard deviation and mean of the independent variables were calculated for Group 1. The results are shown in Table 29:

Table 29 – Standard Deviation and Mean of Group 1

Variable	Standard deviation	Average
Average Income (R\$)	456,91	811,18
Extension of the CU (km ²)	26,43	79,28
Employed Population (inhabit.)	1.282	3.020
Salary / Other remuneration (R\$)	26.943.279,37	32.022.888,89

Source: The authors.

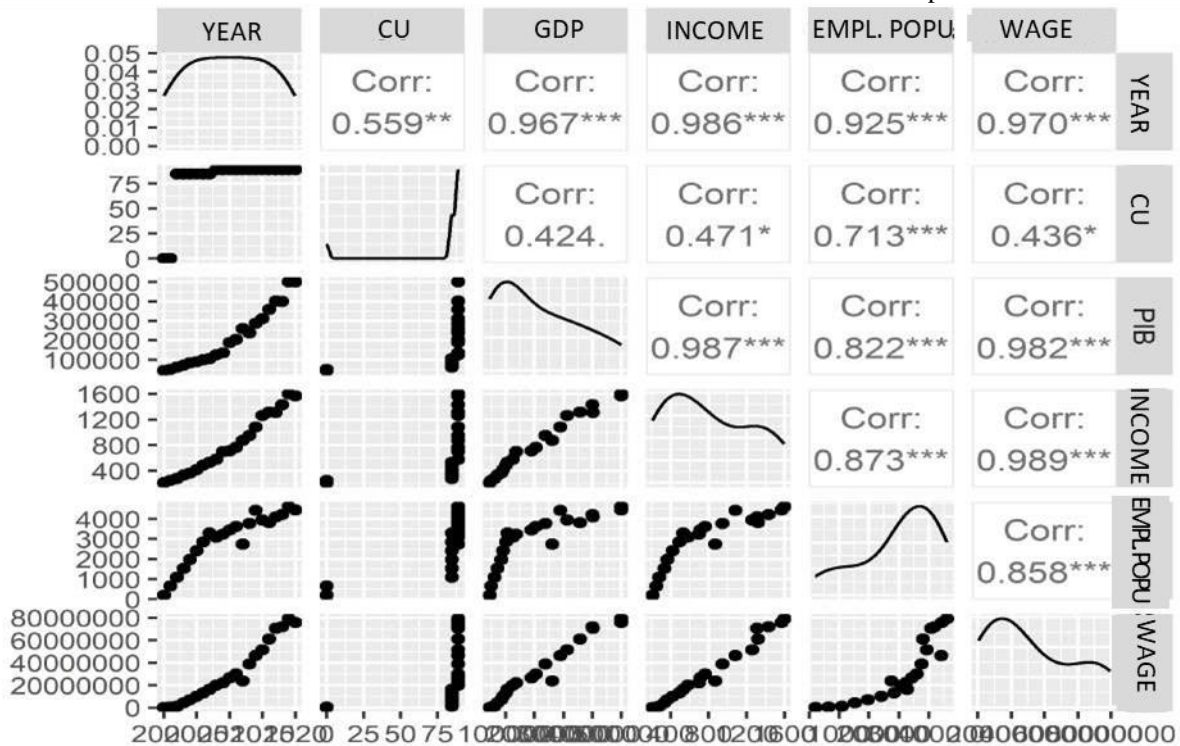
The standard deviation can be defined as a measure used in statistics that expresses how much a given set of data is dispersed, indicating the measure of this quantity of how much a given set of data can be considered uniform. In the case of the Mean Income of Group 1, the standard deviation was calculated at R\$ 456.91, while the standard deviation of the Extension of the CU was 26.43 km². The variables Employed Population and Salary / Other Remuneration presented standard deviations estimated at 1,282.25 and R\$ 26,943,279.37, respectively.

The mean is a statistical measure that is calculated by summing all the values of a data set and then dividing that total by the number of elements in that set. In Table 29, the averages were estimated at R\$ 811.18, 79.28 km², 3,020 employed persons, and R\$ 32,022,888.89, respectively, for the variables Average Income, Extension of the CU, Employed People, and Salary / Other remunerations.

According to Oliveira (2019), Pearson's correlation coefficient (R), *also called linear correlation or Pearson's R*, is a degree of relationship between two quantitative variables and expresses the degree of correlation through values between -1 and 1. Thus, when the correlation coefficient approaches 1, there is an increase in the value of one variable when the other also increases, that is, there is a positive linear relationship. In addition, when the coefficient approaches -1, it is also possible to say that the variables are correlated, but in this case, when the value of one variable increases that of the other decreases, and when a correlation coefficient close to zero indicates that there is no relationship between the two variables.

The correlations between the variables involved in the estimates of the economic and legal effects of PADDD events in the municipalities with fully protected federal conservation units belonging to Group 1 are listed in Table 30:

Table 30 – Correlation Coefficients between the variables of Group 1



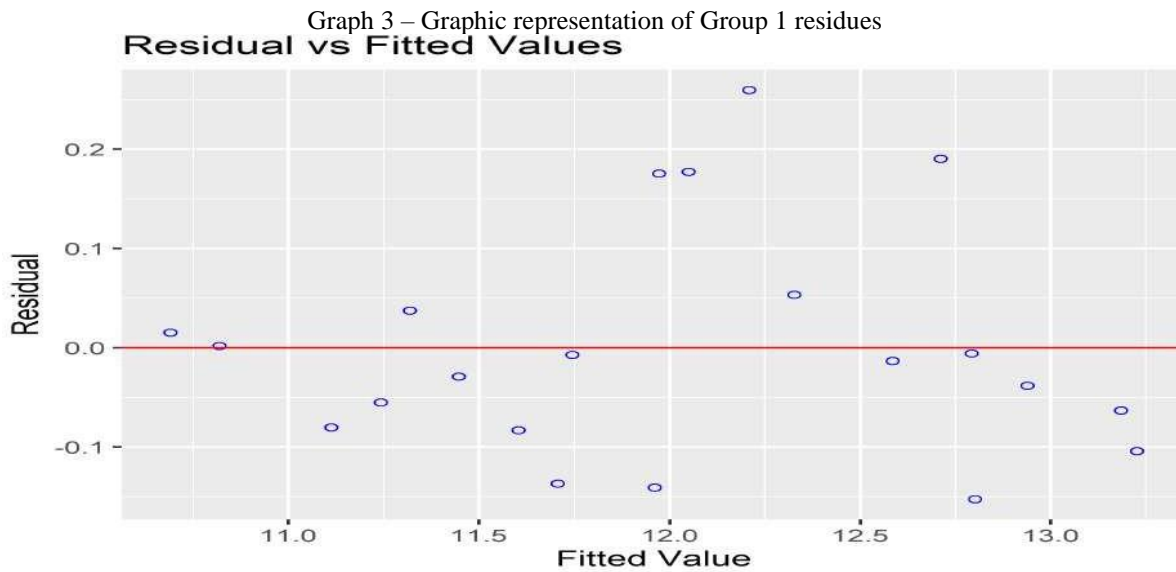
Source: The authors.

In Table 30, it is observed that the variables Average Income and Salary / Other remuneration presented the highest correlation coefficient of Group 1, which was 0.989, which denotes a high degree of attraction between them. The variables Average Income and InReal GDP and InReal GDP and Salary / Other Remuneration presented a correlation coefficient also relevant, close to 1, of values 0.987 and 0.982; respectively.

With the variable relation Extension of the CU, the highest correlation coefficient was with the variable Employed Population, with a value of 0.713, which indicates that they have a force of attraction considered high (Table 30).

The lowest positive correlation coefficient was 0.424 and occurred between the variables InReal GDP and Extension of the CU, indicating that there is a relatively weak force of attraction between them.

The following graph expresses the degree of dispersion for Group 1, indicating that they are very dispersed with the mean.



The authors

The Homoscedasticity test was also performed to determine the reliability of the model, the result of which is shown in the Table below:

Table 31 – Result of the Homoscedasticity test of Group 1

TEST SUMMARY	
DF	1
<i>Chi</i> ²	0.8215856
Prob > <i>Chi</i> ²	0.364717

Source: The authors.

The information presented so far leads to the conclusion that the hypothesis must be accepted and, therefore, the variance between the chosen variables is constant, and the model used for Group 1 is reliable.

Finally, the following equation can be estimated for Group 1:

$$Y_{\ln PIB \text{ real}} = Exp. [10,26 + 0,0022. X_{\text{Extension of the UC}} + 0,0018. X_{\text{Average income}} + 0,0001. X_{\text{Employed population}}] \quad (\text{Equation 3})$$

3.1.2 Group 2

Group 2 is composed of four municipalities in São Paulo: Euclides da Cunha, Teodoro Sampaio, Marabá Paulista, and Presidente Epitácio, whose territorial limits are superimposed on the UCFPI Estação Ecológica Mico Leão Preto, which is inserted in the Atlantic Forest Biome. This area of integral protection was created in 2002, with a territorial extension of 55 km², and suffered the positive effects of a PADD event of the redelimitation type, in the same year of creation, gaining

an increase of the area of 12 km², then having a total area of 67 km².

Table 32 shows the data regarding the dependent variable and the independent variables for the period from 2000 to 2020.

Table 32 – Value of dependent and independent variables of Group 2

Year	lnReal GDP (Y)	CU Extension in km ² (X ₁)	Average Income in R\$ (X ₂)	Population Occupied (X ₃)	Salary / Other Remuneration in R\$ (X ₄)
2000	10	0	332*	972*	11.689.529*
2001	10	0	396*	1.156*	13.426.244*
2002 ¹	10	55	440*	1.374*	15.420.982*
2003	11	67	528*	1.634*	17.712.079*
2004	11	67	572*	1.944*	20.343.564*
2005	11	67	660*	2.312*	23.366.010*
2006	11	67	770*	2.749	26.837.500
2007	11	67	836	3.269	30.824.750
2008	11	67	996	3.653	37.694.750
2009	12	67	1.070	3.608	39.851.500
2010	12	67	1.173	3.692	46.540.250
2011	12	67	1.199	3.763	52.259.250
2012	12	67	1.306	4.167	59.163.000
2013	13	67	1.559	3.972	65.638.500
2014	13	67	1.665	3.829	65.076.500
2015	13	67	1.734	3.603	64.483.750
2016	13	67	1.760	3.242	62.167.250
2017	13	67	1.968	3.084	59.805.250
2018	13	67	2.003	3.037	60.356.500
2019	13	67	2.096	3.158	64.148.750
2020	13	67	2.195	3.143	62.659.000

Source: The authors based on data from IBGE – Cities (2020).

¹ Year of creation of the UC and occurrence of the PADDD event.

*Estimated values.

Table 32 shows that the variables lnReal GDP and Average Income showed a trend of growth during the years 2000 to 2020, going from 10 to 13 and from R\$ 332 to R\$ 2,195, respectively, for each variable.

The extension of the conservation unit increased in 2002, the same year of creation of the nature protection area, from 55 km² to 67 km², due to the influence of positive effects of a PADDD event of the relimitation type that occurred that year and that changed the territorial limits of the

UCFPI Estação Ecológica Mico Leão Preto, with the original perimeter established by the Federal Public Power in the legal device that created the conservation unit. From 2003 to 2020, the variable Extension of the CU remained constant.

The variable Employed Population had a growth about its quantity in absolute terms from 2000 to 2008, from 972 to 3,653 employed people, suffering a reduction in 2009 to 3,608, but growing again from 2010 to 3,692, until 2013 when it reached a total of 3,972, starting to decrease again in 2014 to 3,829, a trend that continued through 2018. In 2019, the number of people employed in the reference week increased again to 3,158, however, in 2020, there was another small reduction, ending the period under analysis with only 3,143 employed individuals.

In the case of the variable Salary / Other remuneration, its value increased in the period from 2000 to 2013, from R\$11,689,529 to R\$65,638,500. However, in 2014, this amount decreased to R\$65,076,500, continuing this downward trend until 2018, when it reached the level of R\$60,356,500. As well as the number of employed people, in 2019, the variable rose to R \$ 64,148,750, but shrank again in 2020, closing the period from 2000 to 2020 with several salaries and other remuneration paid to employed personnel in the amount of R \$ 62,659,000.

These data were analyzed from the econometric point of view, and the following results were found for the regression of the vari

Dependent on real GDP:

Table 33 – Regression statistics for Group 2

R multiple	0,995055622
R²	0,99013569
R²-adjusted	0,987669613
Standard error	0,109134431
Observations	21

Source: The authors.

According to the multiple regression statistics in Table 33, they presented a value closer to 1, which shows that the variables chosen explain Aproximately 99.01% of the phenomenon that occurs with the dependent variable. The R – multiple also presented an expressive value, of about 99.50%, that is, very close to 1. The standard error indicates that the values estimated with the regression are far from the mean of 0.1091. R^2

Regarding the analysis of variance of Group 2, which can be defined as a study on the Total Sum of Squares (STQ), a total sum that is decomposed into two components, the first being the Sum of Squares Explained Regression (SQE) and the second the Sum of Residual Squares (SQR), presented the following results:

Table 34 - Analysis of variance (ANOVA Table) of Group 2

	<i>Gl</i>	<i>SQ</i>	<i>MQ</i>	<i>F</i>	<i>F of signification</i>
Regression	4	19,12808834	4,782022086	401,502264	7.99745E-16
Residue	16	0,190565185	0,011910324		
Total	20	19,31865353			

Source: The authors.

In Table 34, it can be seen that the degree of freedom (*gl*) for Group 2 is 4 for the regression, meaning that four explanatory variables will be used in the model; and 16 for the residuals, totaling 20.

The sum of squares was higher for the regression analysis than for the residue analysis, which demonstrates that the independent variables chosen better explain the possible changes in the dependent variable than the calculated residuals.

The value of the F statistic of significance was 7.99745E-16, that is, very close to zero, being much lower than 5% so in the case of Group 2, the null hypothesis that the regressors do not influence the return is rejected.

Table 35 shows the values of the coefficients of the variables Extension of the CU (X_1), Average Income (X_2), Employed Population (X_3) and Salary/Other Remuneration (X_4) calculated through the analysis of the data from Group 1.

Table 35 - Analysis of Group 2 variables

	<i>Coefficients</i>	<i>Standard error</i>	<i>Stat t</i>	<i>P-value</i>
Intersection	9,624233238	0,089374754	107,6840246	2.55337E-24
CU Extension	0,006435913	0,001790743	3,593989847	0,002429871
Average income	0,000428514	0,000167649	2,556017794	0,021144353
Employed Population	-8.54664E-05	6.95451E-05	-1,22893448	0,236865124
Salary / Other remuneration	3.54781E-08	6.64518E-09	5,338926157	6.65104E-05

Source: The authors.

According to the results found, the value of the intersection is 9.62; that is, when the value of x is zero, the value of real GDP starts from 9.62%.

The coefficients of the Extension of the CU in R\$ (X_1) and of the Average Income (X_2) were, respectively, 0.0064 and 0.0004, or 0.64% and 0.04%; Approximately. This demonstrates that these variables positively influence the dependent variable Y since an increase of 1% in real GDP will cause an increase of 0.64% in the extension of the conservation unit in km^2 and 0.04% in the average income of the population.

The variables Employed Population (X_3) and Salary/Other Wages (X_4) presented

coefficients with error, making it clear that the quantity of the employed population and the total value of wages and other remuneration paid to these people do not influence, in the case of Group 2, the variation of real GDP.

The Standard Deviation and the mean of the independent variables were calculated for Group 2, as well as the results found are shown in Table 36:

Table 36 – Standard Deviation and Mean and Group 2

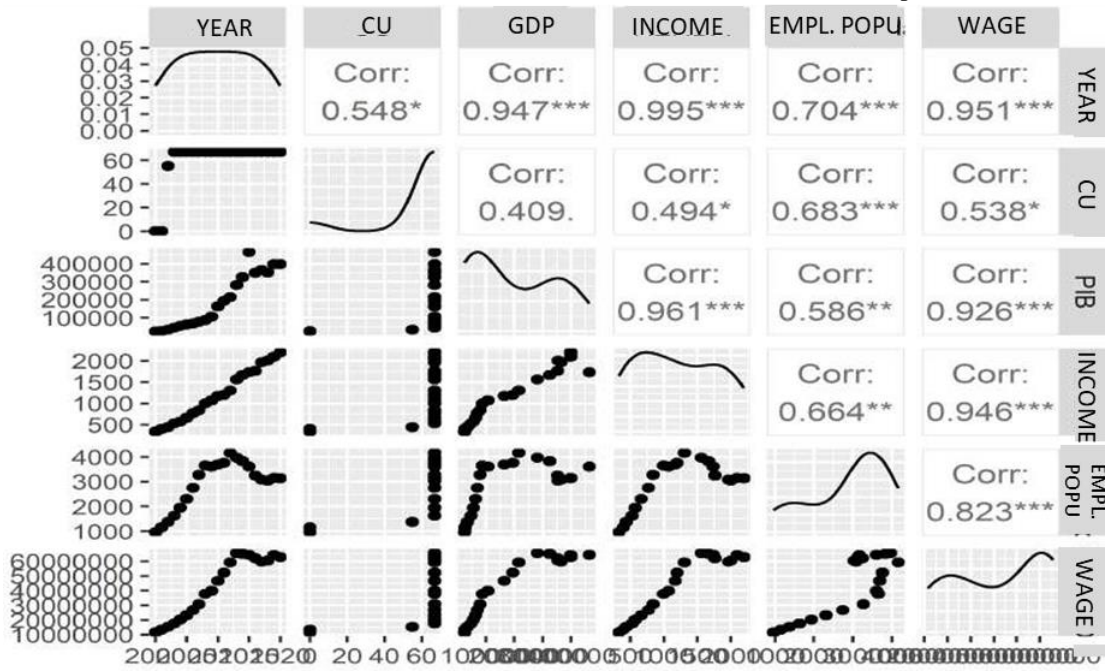
Variable	Standard deviation	Average
Average Income (R\$)	611,26	1.202,74
Extension of the CU (km ²)	20,13	60,05
Employed Population (inhabit.)	973	2.922
Salary / Other remuneration (R\$)	20.256.476,51	42.831.662,30

Source: The authors.

In the case of the Mean Income of Group 2, the standard deviation was calculated at R\$ 611.26. The standard deviation of the CU Extension was 20.13 km². The variables Employed Population and Salary / Other remuneration presented standard deviations estimated at 973 and R\$ 20,256,476.51, respectively. The average, which is a statistical measure, was estimated at R\$ 1,202.74, 60.05 km², 2,922 employed persons, and R\$ 42,831,662.30, respectively, for the variables Average Income, Extension of the CU, Employed People, and Salary / Other Remunerations.

The correlations that show the forces of attraction between the variables involved in the estimates of the economic and legal effects of PADDD events in the municipalities belonging to Group 2 are listed in Table 37:

Table 37 – Correlation Coefficients between the variables of Group 2



Source: The authors.

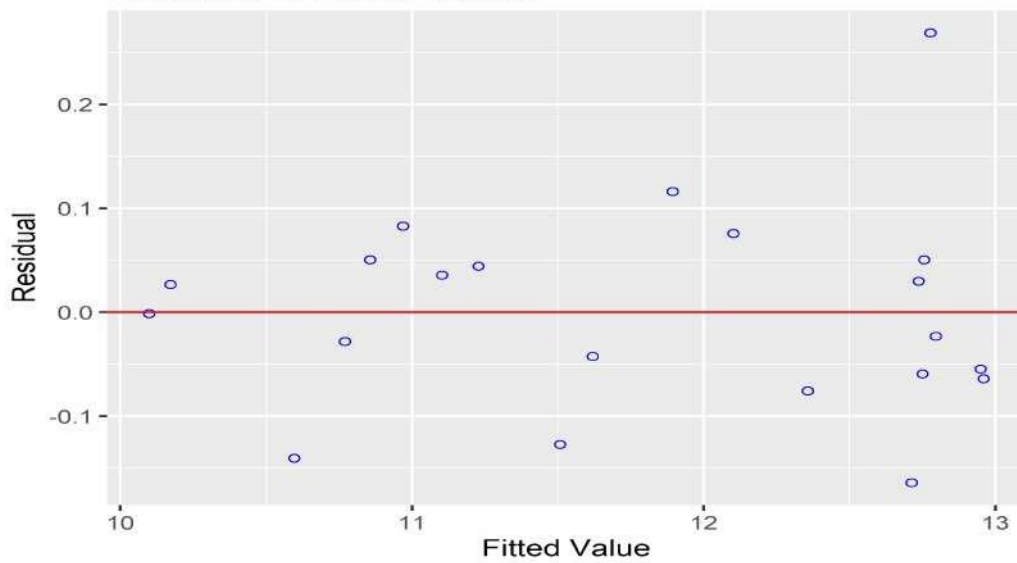
Table 37 shows that the variables Average Income and Real GDP presented the highest correlation coefficient of Group 2, which was 0.961, which denotes a high degree of attraction between them. The variables lnGDP and salary/other salaries and Average Income and Salary / Other remuneration presented, respectively, the following values: 0.926 and 0.946.

Regarding the variable Extension of the CU, the highest correlation coefficient was with the variable Employed Population, with a value of 0.683; which indicates that they have a force of attraction considered moderate.

The lowest correlation coefficient was 0.401 and occurred between the variables Extension of the CU and lnReal GDP, indicating that there is a relatively weak force of attraction between them, due to the proximity to zero

Graph 4 expresses the degree of dispersion for Group 2, indicating that they are very dispersed about the mean.

Graph 4 – Graphic representation of Group 2 residues
Residual vs Fitted Values



Source: The authors.

The homoscedasticity test was also performed to determine the reliability of the model, the result of which is shown in Table 38:

Table 38 – Result of the homoscedasticity test of Group 2

TEST SUMMARY	
DF	1
Chi²	1.863164
Prob > Chi²	0.17226

Source: The authors.

Analyzing the information presented above, we conclude that the hypothesis must be accepted. Thus, the variance between the chosen variables is constant, and the model used for Group 2 is reliable.

Finally, the following equation can be estimated for Group 2:

$$Y_{\ln PIB \text{ real}} = \text{Exp.} [9,624 + 0,0064. + 0,0004.] X_{\text{Extension of the UC}} X_{\text{Average income}} \quad (\text{Equation 4})$$

3.1.3 Group 3

Group 3 is composed of eight municipalities in the interior of the State of Santa Catarina, namely Indaial, Apiúna, Blumenau, Botuverá, Guabiruba, Presidente Nereu, Vidal Ramos, and Gaspar; whose territorial limits are superimposed on the UCFPI Serra de Itajaí National Park, which is inserted in the Atlantic Forest Biome. This area of integral protection was created in 2004, with a territorial extension of 571 km², and suffered the positive effects of a PADDD event of the

redelimitation type, in the same year of creation, gaining an area of 3 km², then having a total area of 574 km².

Table 39 shows the data regarding the dependent variable and the independent variables for the period from 2000 to 2020.

Table 39 – Value of dependent and independent variables of Group 3

Year	lnReal GDP (Y)	CU Extension in km ² (X ₁)	Average Income in R\$ (X ₂)	Population Busy (X ₃)	Salary / Other Remuneration in R\$ (X ₄)
2000	12	0	438*	104.776*	763.926.405*
2001	12	0	522*	108.519*	845.219.563*
2002	12	0	580*	112.395*	935.163.525*
2003	13	0	696*	116.410*	1.034.678.865*
2004 ¹	13	571	754*	120.569*	1.144.784.120*
2005	13	574	870*	124.875*	1.266.606.217*
2006	13	574	1.015*	129.336	1.401.392.000
2007	13	574	1.102	133.956	1.550.521.000
2008	13	574	1.204	137.768	1.837.080.000
2009	14	574	1.349	142.941	2.046.949.000
2010	14	574	1.428	149.168	2.387.072.000
2011	14	574	1.581	156.069	2.778.524.000
2012	14	574	1.742	158.141	3.120.645.000
2013	14	574	1.966	161.954	3.502.223.000
2014	15	574	2.100	162.134	3.889.024.000
2015	15	574	2.285	158.220	4.089.797.000
2016	15	574	2.552	155.105	4.331.043.000
2017	15	574	2.717	156.680	4.618.963.000
2018	15	574	2.767	159.729	4.825.741.000
2019	15	574	2.794	159.821	4.984.327.000
2020	15	574	2.926	161.816	4.902.704.000

Source: The authors based on data from IBGE – Cities (2020).

¹ Year of creation of the UC and occurrence of the PADDD event.

*Estimated values.

From the observation of Table 39, it can be seen that the variables lnReal GDP and Average Income presented a trend of growth during the years 2000 to 2020, going from 12 to 15, and from R\$ 438 to R\$ 2,926, respectively, each variable.

The extension of the conservation unit increased in 2004, the same year of creation of the nature protection area, from 571 km² to 574 km², due to the influence of positive effects of a PADDD event of the redelimitation type, which occurred that year and which altered the territorial limits of the UCFPI Serra de Itajaí National Park, concerning the original perimeter established by the Federal Public Power in the legal provision that created the conservation unit. From 2005 to 2020, the variable Extension of the CU remained constant.

The variable Employed Population had a growth in its quantity in absolute terms from 2000 to 2014, from 104,776 to 162,134 employed people, suffering a reduction in 2015 to 158,220, but growing again from 2018 to 159,821, reaching 161,816 in 2020.

In the case of the variable Salary / Other remuneration, its total value grew in the period from 2000 to 2019, going from an estimated value in the amount of R \$ 763,926,405 to R \$ 4,984,327,000. However, in 2020, this amount was reduced to R \$ 4,902,704,000, even though there was a growth in the number of employed population from 2019 to 2020 of about 2,000 people, or 1.2%.

These data were analyzed from the econometric point of view, and the following results were found for the regression of the dependent variable Real GDP:

Table 40 – Regression statistics for Group 3

R multiple	0,997366179
R^2	0,994739294
R^2 –adjusted	0,993424118
Standard error	0,082081844
Observations	21

Source: The authors.

According to the multiple regression statistics in Table 40, they presented a value closer to 1, which shows that the variables chosen explain Aproximately 99.47% of the phenomenon that occurs with the dependent variable. The R – multiple also presented an expressive value, of about 99.73%, that is, very close to 1. The standard error indicates that the values estimated with the regression are far from the mean 0.082. R^2

Regarding the analysis of variance of Group 3 – which can be defined as a study on the Total Sum of Squares (STQ), this total sum is decomposed into two components: the first, the Sum of Squares Explained Regression (SQE); the second, the Sum of Residual Squares (SQR); presenting the following results:

Table 41 – Analysis of variance (ANOVA Table) of Group 3

	<i>Gl</i>	<i>SQ</i>	<i>MQ</i>	<i>F</i>	<i>F of meaning</i>
Regression	4	20,38353349	5,095883373	756,354278	5.25483E-18
Residue	16	0,107798867	0,006737429		
Total	20	20,49133236			

Source: The authors.

In Table 41, it can be observed that the degree of freedom (*gl*) for Group 3 is 4 for the regression, meaning that four explanatory variables will be used in the model and 16 for the residuals, totaling 20.

The sum of squares was higher for the regression analysis than for the residue analysis, which demonstrates that the independent variables chosen better explain the possible changes in the dependent variable than the calculated residuals.

The value of the F statistic of significance was 7.99745E-16, that is, very close to zero, being much lower than 5%, so one can reject, in the case of Group 3, the null hypothesis that the regressors do not influence the returning.

Table 42 summarizes the values of the coefficients of the variables Extension of the CU (), Average Income (), Employed Population (), and Salary/Other Remuneration (), $X_1X_2X_3X_4$ calculated through the analysis of the data from Group 3.

Table 42 – Analysis of Group 3 variables

	<i>Coefficients</i>	<i>Standard error</i>	<i>Stat t</i>	<i>P-value</i>
Intersection	9,625527056	0,35962177	26,76569566	1.02877E-14
UC Extension	0,0004333	0,00016989	2,550432177	0,021384563
Average income	0,000593622	0,00027024	2,196607693	0,043129126
Employed Population	2.00351E-05	3.37894E-06	5,929421681	2.11723E-05
Salary / Other remuneration	4.09212E-11	1.58909E-10	0,257513638	0,800064884

Source: The authors.

According to the results found, the value of the intersection is 9.62, that is, when the value of x is zero, the value of real GDP is 9.62%.

The coefficient of the variable Extension of the CU, in R\$ (), was Aproximately 0.0004 or 0.04%. This demonstrates that it positively influences the dependent variable Y, since a 1% increase in the extent of the CU, in km², will cause an increase of 0.043% in real GDP. X_1

The variable Average Income, in R\$ (), presented a coefficient of 0.00059 so that the increase of 1% in the average income of the population will cause an increase of Aproximately 0.059% in the real GDP of the municipalities of Group 3. X_2

The variables Employed Population () and Salary/Other Remuneration () X_3X_4 presented coefficients with error, making it clear that the number of employed persons and the total salaries and other remuneration paid to them do not influence, in the case of Group 3, the variation of real GDP.

The Standard Deviation and the mean of the independent variables were calculated for Group 3. The results are shown in Table 43:

Table 43 – Standard Deviation and Mean and Group 3

Variable	Standard deviation	Average
Average Income (R\$)	837,59	1.589,82
Extension of the UC (km ²)	452,98	464,50
Employed Population (inhabit.)	20.020	1.590
Salary / Other remuneration (R\$)	1.531.677.599,94	2.678.875.414,06

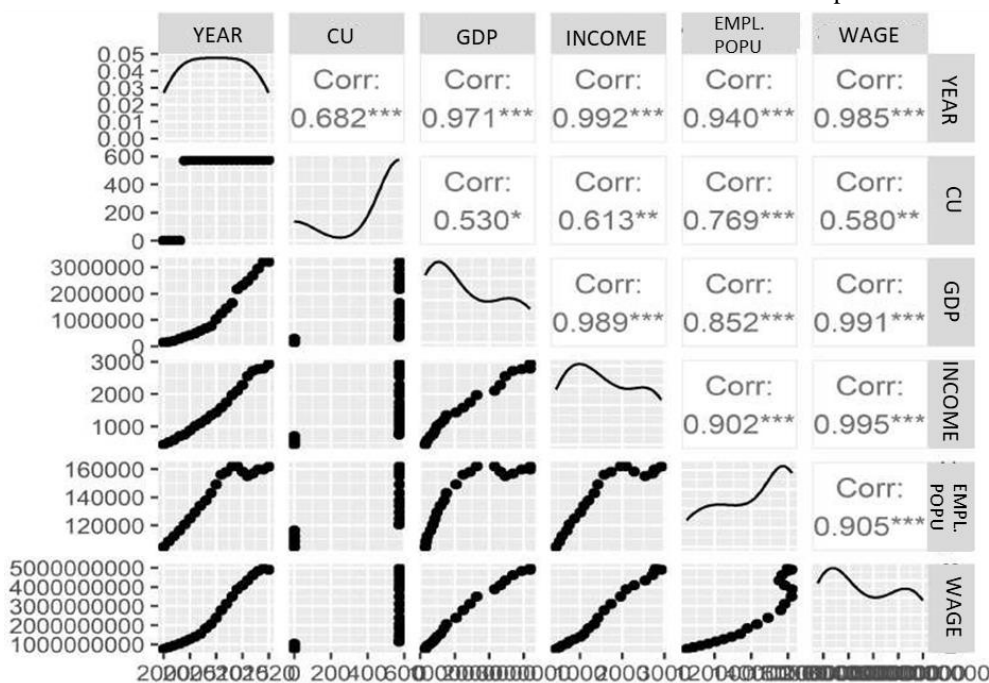
Source: The authors.

In the case of the Mean Income of Group 3, the standard deviation was calculated at R\$ 837.59. The standard deviation of the CU Extension was 452.98 km². The variables Employed Population and Salary / Other Remuneration presented standard deviations estimated at 20,020 and R\$ 1,531,677,599.94, respectively.

The average, which is a statistical measure, was estimated at R\$ 1,589.82, 464.50 km², 1,590 employed persons and R\$ 2,678,875,414.06, respectively, for the variables Average Income, Extension of the CU, Employed People, and Salary / Other Remuneration.

The correlations that show the forces of attraction between the variables involved in the estimates of the economic and legal effects of PADDD events in the municipalities belonging to Group 3 are listed in Table 44:

Table 44 – Correlation Coefficients between the variables of Group 3



Source: The authors.

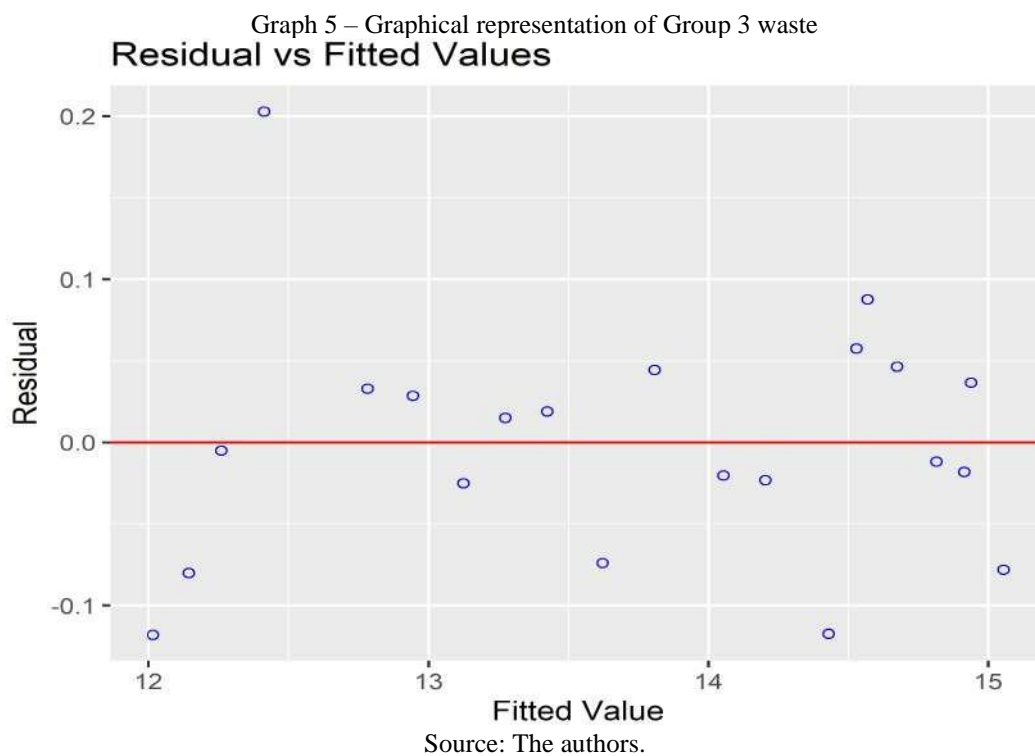
In Table 44, it can be observed that the variables Average Income and Salary / Other remunerations, lnReal GDP and Salary / Other remunerations, and lnReal GDP and Average Income

presented the highest correlation coefficients, the first being 0.995, the second 0.991 and the third 0.989.

Regarding the variable Extension of the CU, the highest correlation coefficient was with the variable Employed Population, with a value of 0.769. This indicates that they have a strong attraction.

The lowest correlation coefficient was 0.530 and occurred between the variables Extension of the CU and real lnGDP, indicating that there is a moderate force of attraction between them.

Graph 5 expresses the degree of dispersion for Group 3, indicating that they are very dispersed about the mean.



The homoscedasticity test was also performed to determine the reliability of the model, the result of which is shown in the following table:

Table 45 – Result of the homoscedasticity test of Group 3

TEST SUMMARY	
DF	1
<i>Chi</i> ²	3.107754
Prob > <i>Chi</i> ²	0.07792035

Source: The authors.

Analyzing the information already presented, we conclude that the hypothesis must be accepted. Thus, the variance between the chosen variables is constant, and the model used for Group 3 is reliable.

Finally, the following equation can be estimated for Group 3:

$$Y_{lnPIB\ real} = Exp. [9,625 + 0,0004. X_{Extension\ of\ the\ UC} + 0,0005. X_{Average\ income}] \quad (Equation\ 5)$$

3.1.4 Group 4

Group 4 is composed of two municipalities in the State of Espírito Santo, Pancas and Agua Branca, whose territorial limits are superimposed on the UCFPI, Natural Monument of Pontões Capixabas, which is inserted in the Atlantic Forest Biome. This area of integral protection was created in 2002, with a territorial extension of 176 km², and suffered the effects of a PADDD event of the recategorization type in 2008.

Table 46 shows the data regarding the dependent variable and the independent variables for the period from 2000 to 2020.

Table 46 – Value of dependent and independent variables of Group 4

Year	unreal GDP (Y)	CU Extension in km ² (X ₁)	Average Income in R\$ (X ₂)	Population Busy (X ₃)	Salary / Other Remuneration in R\$ (X ₄)
2000	10	0	257*	52.522*	387.610.010*
2001	10	0	306*	54.566*	429.164.530*
2002 ¹	10	176	340*	56.689*	475.173.987*
2003	10	176	408*	58.895*	526.115.981*
2004 ²	10	176	442*	61.187*	582.519.315*
2005	11	176	510*	63.569*	644.969.484*
2006	11	176	595*	66.042	714.114.750
2007	11	176	646	68.613	790.672.875
2008 ²	11	176	747	70.711	937.387.375
2009	11	176	791	73.275	1.043.400.250
2010	11	176	969	76.430	1.216.806.125
2011	11	176	981	79.916	1.415.391.625
2012	12	176	1.182	81.154	1.589.904.000
2013	12	176	1.356	82.963	1.783.930.750
2014	12	176	1.376	82.982	1.977.050.250
2015	12	176	1.497	80.911	2.077.140.375
2016	12	176	1.760	79.173	2.196.605.125
2017	12	176	1.874	79.882	2.339.384.125
2018	13	176	1.908	81.383	2.443.048.750
2019	12	176	2.090	81.489	2.524.237.875
2020	12	176	2.196	82.480	2.482.681.500

Source: The authors based on data from IBGE – Cities (2020).

¹ Year of creation of the CU

² Year of occurrence of the PADDD event.

*Estimated values.

From the observation of Table 46, it can be observed that the variable lnReal GDP remained constant between the years 2000 to 2004 in 10. It then rose to 11 in 2005 and maintained that level until 2011, growing again in 2012 and reaching 12. In 2018 it rose to 13, but in 2019 it returned to 12, remaining at that level until 2020.

The Average Income showed a trend of growth during the years 2000 to 2020, going from R\$ 257 to R\$ 2,196, respectively.

The extension of UCFPI, Natural Monument of Pontões Capixabas, has remained constant since its creation in 2002 until 2020; considering that the PADDD event that it suffered in 2008 was only of the recategorization type, that is, the nature protection area only changed its category among those existing in Federal Law No. 9,985 of 2000 that establishes the SNUC, keeping unchanged the territorial limits of the conservation unit existing in the legal document emanating from the Federal Public Power that created it.

The variable Employed Population had an increase in its quantity in absolute terms, from 2000 to 2014, from 52,522 to 82,982 employed persons; and suffered a reduction in 2015 to 80,911, but growing again in 2017 to 79,882; reaching 82,480, in the year 2020, the number of inhabitants of Group 4 of municipalities that had some occupation.

In the case of the variable Salary / Other remunerations, its total value grew in the period from 2000 to 2019, going from an estimated value in the amount of R \$ 387,610,010 to R \$ 2,524,237,875. However, in 2020, this amount was reduced to R \$ 2,482,681,500, even though there was an increase in the number of the employed population from 2019 to 2020 of about

1,000 people or 1.2%.

These data were analyzed from the econometric point of view, and the following results were found for the regression of the dependent variable Real GDP:

Table 47 – Regression statistics for Group 4

R multiple	0,973810931
R²	0,948307729
R² –adjusted	0,935384661
Standard error	0,245210246
Observations	21

Source: The authors.

According to the multiple regression statistics in Table 47, they presented a value closer to 1, which shows that the variables chosen explain Aproximately 94.83% of the phenomenon that occurs with the dependent variable. The R – multiple also presented a significant value, of about 97.38%, that is, very close to 1. The standard error indicates that the values estimated with the regression are

far from the mean of $0.02452.R^2$

Regarding the analysis of variance of Group 4, which can be defined as a study on the Total Sum of Squares (STQ), a total sum that is decomposed into two components, the first being the Sum of Explained Squares of Regression (SQE) and the second the Sum of Residual Squares (SQR), presented the following results:

Table 48 – Analysis of variance (ANOVA Table) of Group 4

	<i>Gl</i>	<i>SQ</i>	<i>MQ</i>	<i>F</i>	<i>F of signification</i>
Regression	4	17,6490317	4,412257924	73,38100672	4.37743E-10
Residue	16	0,962049036	0,060128065		
Total	20	18,61108073			

Source: The authors.

In Table 48, it can be observed that the degree of freedom (*gl*) for Group 4 is 4 for the regression, meaning that four explanatory variables will be used in the model and 16 for the residuals, totaling 20.

The sum of squares was higher for the regression analysis than for the residue analysis, which demonstrates that the independent variables chosen better explain the possible changes in the dependent variable than the calculated residuals.

The value of the F-statistic of significance was 4.37743E-10, that is, very close to zero, being much lower than 5%, so that one can reject, in the case of Group 4, the null hypothesis that the regressors do not influence the returning.

Table 49 summarizes the values of the coefficients of the variables Extension of the CU (), Average Income (), Employed Population (), and Salary/Other Remuneration ($X_1X_2X_3X_4$) calculated through the analysis of the data from Group 4.

Table 49 – Analysis of Group 4 variables

	<i>Coefficients</i>	<i>Standard error</i>	<i>Stat t</i>	<i>P-value</i>
Intersection	7,770798499	0,780895915	9,951132222	2.94049E-08
CU Extension	0,001915711	0,001418871	1,350166348	0,195753808
Average income	0,000229074	0,000719326	0,318456489	0,754257874
Employed Population	2.82352E-05	1.57796E-05	1,789348757	0,092503242
Salary / Other remuneration	6.02696E-10	6.79018E-10	0,887598931	0,387904798

Source: The authors.

According to the results found, the value of the intersection is 7.77, that is, when the value of x is zero, the value of real GDP is from 7.77%.

X_1 The coefficient of the variable Extension of the CU in R\$ () was Aproximately 0.0019 or

0.19%. This demonstrates that it positively influences the dependent variable Y since a 1% increase in the extent of the CU in km² will cause an increase of 0.19% in real GDP.

X₂ The variable Average Income in R\$ () presented a coefficient of 0.00022, so the increase of 1% in Average Income will cause an increase of Aproximately 0.022% in the real GDP of the municipalities of Group 4.

X₃X₄ The variables Employed Population () and Salary/Other Wages () presented coefficients with error, making it clear that the number of employed persons and the total of wages and other remuneration paid to them do not influence, in the case of Group 4, the variation of real GDP.

The Standard Deviation and the mean of the independent variables were calculated for Group 4. The results are shown in Table 50:

Table 50 – Standard Deviation and Mean and Group 4

Variable	Standard deviation	Average
Average Income (R\$)	633,63	1.058,54
Extension of the CU (km ²)	157,18	158,96
Employed Population (habit.)	10.524	1.059
Salary / Other remuneration (R\$)	775.412.532,07	1.360.824.240,80

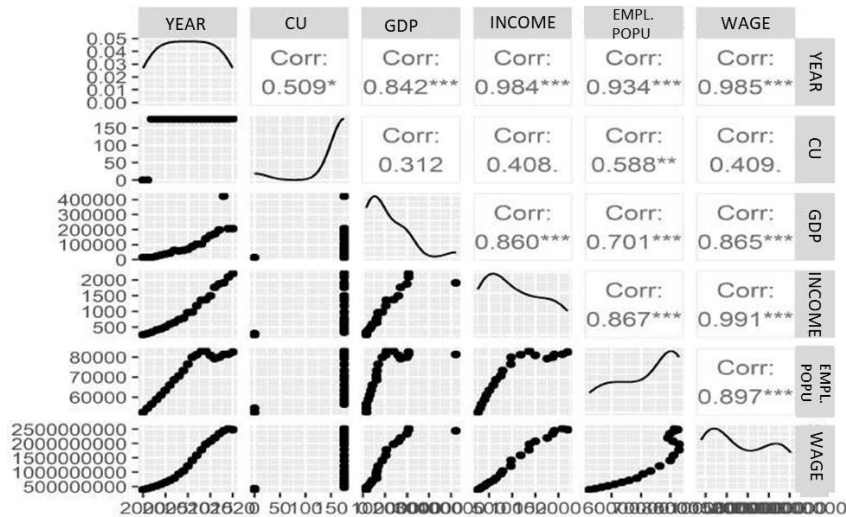
Source: The authors.

In the case of the Mean Income of Group 4, the standard deviation was calculated at R\$ 633.63. The standard deviation of the CU Extension was 157.18 km². The variables Employed Population and Salary / Other remuneration presented standard deviations estimated at 10,524 and R\$ 775,412,532.07, respectively.

The average, which is a statistical measure, was estimated at R\$ 1,058.54, 158.96 km², 1,059 employed persons, and R\$ 1,360,824,240.80, respectively, for the variables Average Income, Extension of the CU, Employed People and Salary / Other remuneration.

The correlations that show the forces of attraction between the variables involved in the estimates of the economic and legal effects of PADDD events in the municipalities with federal conservation units of full protection belonging to Group 4 are listed in Table 51:

Table 51 – Correlation Coefficients between the variables of Group 4



Source: The authors.

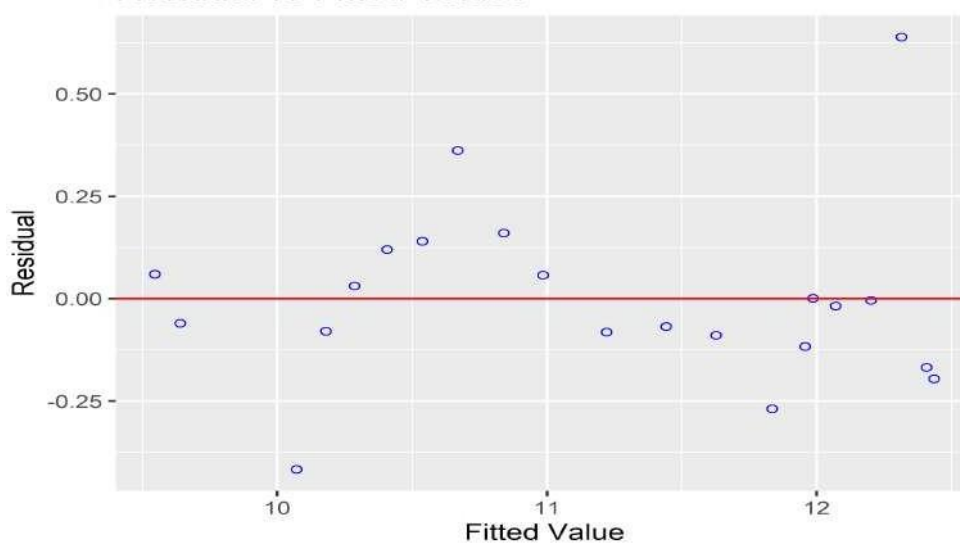
Table 51 shows that the variables Average Income and Salary / Other Earnings presented the highest correlation coefficient of Group 4, which was 0.991. This denotes a great degree of attraction between them. The variables lnGDP and Salary / Other remuneration and Employed Population and Salary / Other remuneration presented, respectively, the following values: 0.865 and 0.897.

With the variable relation Extension of the CU, the highest correlation coefficient was with the variable Employed Population, with a value of 0.588; which indicates that they have a force of attraction considered moderate.

The lowest correlation coefficient was 0.312 and occurred between the variables Extension of the CU and real lnGDP, indicating that there is a relatively weak force of attraction between them, due to the proximity to zero

Graph 6 expresses the degree of dispersion for Group 4, indicating that they are very dispersed about the mean.

Graph 6 – Graphic representation of Group 4 residues
Residual vs Fitted Values



Source: The authors.

The homoscedasticity test was also performed to determine the reliability of the model, the result of which is shown in Table 52, as follows:

Table 52 – Result of the homoscedasticity test of Group 4

TEST SUMMARY	
DF	1
<i>Chi</i> ²	1.240705
Prob > <i>Chi</i> ²	0.2653351

Source: The authors.

H_0 Analyzing the information already presented, we conclude that the hypothesis must be accepted. Thus, the variance between the chosen variables is constant, and the model used for Group 4 is reliable.

Finally, the following equation can be estimated for Group 4:

$$Y_{\ln PIB_{real}} = Exp. [7,7707 + 0,0019. + 0,0002.] \quad X_{Extension\ of\ the\ UC} \quad X_{Average\ income} \quad (Equation\ 6)$$

3.1.5 Group 5

Group 5 is composed of the Maranhão municipalities of Carolina, Estreito, and Riachão, whose territorial limits are superimposed on the UCFPI, Chapada das Mesas National Park, which is inserted in the Cerrado Biome. This area of integral protection was created in 2005, with a territorial

extension of 1,600 km², and suffered the effects of a PADDD event of the relimitation type in 2006.

Table 53 shows the data regarding the dependent variable and the independent variables for the period from 2000 to 2020.

Table 53 – Value of dependent and independent variables of Group 5

Year	In Real GDP (Y)	Extension of the CU in km ² (X ₁)	Average Income in R\$ (X ₂)	Employed Population (X ₃)	Salary / Other Remuneration in R\$ (X ₄)
2000	9	0	211*	53*	74.794.212*
2001	10	0	252*	92*	66.488.922*
2002	10	0	280*	160*	59.105.868*
2003	10	0	336*	276*	52.542.641*
2004	10	0	364*	476*	46.708.208*
2005 ¹	11	1.600	420*	823*	41.521.641*
2006 ²	11	1.600	490*	1.422	36.911.000
2007	11	1.600	532	2.457	32.812.333
2008	11	1.600	913	3.280	31.978.333
2009	12	1.600	1.070	4.634	65.958.667
2010	12	1.600	1.199	3.836	85.700.333
2011	12	1.600	1.224	3.089	51.737.000
2012	13	1.600	1.288	2.555	42.814.667
2013	13	1.600	1.368	2.689	37.027.667
2014	13	1.600	1.376	2.598	40.379.000
2015	13	1.600	1.418	2.672	44.782.667
2016	13	1.600	1.584	2.391	46.532.000
2017	13	1.600	1.687	2.555	51.234.000
2018	13	1.600	1.717	2.752	59.741.667
2019	13	1.600	1.796	2.825	62.472.000
2020	13	1.600	1.881	2.672	61.396.333

Source: The authors based on data from IBGE – Cities (2020).

¹ Year of creation of the CU

² Year of occurrence of the PADDD event.

*Estimated values.

From the observation of Table 53, it can be observed that the variable InReal GDP increased from 9 to 10 in 2001, remaining constant between 2001 and 2004 and rising to 11 in 2005, the year of creation of the conservation unit, remaining constant until 2008. In 2009, it rose to 12 and only increased again in 2012, when it rose to 13 and remained at that value until 2020.

The Average Income showed a trend of growth during the year 2000 to 2020, going from R\$ 211 to R\$ 1,881, respectively.

The extension of UCFPI, Chapada das Mesas National Park, has remained constant since its creation in 2005 until 2020, given that the PADDD event it suffered in 2006 was of the rebounding type. However, there was no gain in area, keeping unchanged the territorial limits of the conservation unit existing in the legal document issued by the Federal Public Power that created it.

The variable Employed Population had a growth about its quantity in absolute terms from

2000 to 2009, from only 53 to 4,634 employed people, suffering a reduction in 2010 to 3,836, but growing again from 2013 to 2,689. In 2014, the number of employed population decreased again, to 2,598, growing again to 2,672 in 2015. In 2016, the number decreased again to 2,391, increasing again from 2017 to 2019, reaching 2,825. However, in 2020, the last year of the series under study, the number of the population that had some type of occupation decreased to 2,672 people.

In the case of the variable Salary / Other remuneration, its total value decreased between 2000 and 2001, from R\$ 74,794,212 to R\$ 66,488,922, continuing the decrease of this variable until 2008, when it reached only R\$ 31,978,333. In 2009, the variable grew again, totaling, in 2010, the amount of R\$ 85,700,333. However, a new downward trend began in 2011, reaching a value of R\$ 40,379,000 in 2014. In 2015, the trend reversed and the total value of wages and other remuneration paid to the employed population increased to R\$ 44,782,667 this year. However, between the years 2019 and 2020, the total value of this variable shrank slightly from R\$ 62,472,000 to R\$ 61,396,333, respectively.

These data were analyzed from the econometric point of view, and the following results were found for the logarithmic of the dependent variable real GDP:

Table 54 – Regression statistics for Group 5

R multiple	0,990134114
R²	0,980365564
R² –adjusted	0,975456955
Standard error	0,203276183
Observations	21

Source: The authors.

According to the multiple regression statistics in Table 54, they presented a value closer to 1, which shows that the variables chosen explain Aproximately 98.03% of the phenomenon that occurs with the dependent variable. The R – multiple also presented a significant value, of about 99.01%, that is, very close to 1. The standard error indicates that the values estimated with the regression are far from the mean of 0.2032.**R²**

Regarding the analysis of variance of Group 5, which can be defined as a study on the Total Sum of Squares (STQ), a total sum that decomposes into two components, the first being the Sum of Explained Squares of Regression (SQE) and the second the Sum of Residual Squares (SQR), presented the following results:

Table 55 - Analysis of variance (ANOVA Table) of Group 5

	<i>Gl</i>	<i>SQ</i>	<i>MQ</i>	<i>F</i>	<i>F of signification</i>
Regression	4	33,01129787	8,252824	199,7237	1.95E-13
Residue	16	0,661139307	0,041321		
Total	20	33,67243718			

Source: The authors.

Table 55 shows that the degree of freedom (*gl*) for Group 5 is 4 for the regression, meaning that four explanatory variables will be used in the model and 16 for the residuals, totaling 20.

The sum of squares was higher for the regression analysis than for the residue analysis. This demonstrates that the independent variables chosen explain the possible changes in the dependent variable better than the calculated residuals.

The value of the F statistic of significance was 1.95E-13, that is, very close to zero, being much lower than 5%. Thus, in the case of Group 5, the null hypothesis that regressors do not influence the return can be rejected.

Table 56 summarizes the values of the coefficients of the variables Extension of the CU (), Average Income (), Employed Population () and Salary/Other Remuneration ($X_1X_2X_3X_4$) calculated through the analysis of the data from Group 5.

Table 56 - Analysis of Group 5 variables

	<i>Coefficients</i>	<i>Standard error</i>	<i>Stat t</i>	<i>P-value</i>
Intersection	9,891321362	0,244267547	40,4938	1.5E-17
CU Extension	9.20598E-05	0,00015197	0,605775	0,553162
Average income	0,002145565	0,000125059	17,15644	1E-11
Employed Population	-1.44046E-05	7.11788E-05	-0,20237	0,842177
Salary / Other remuneration	-1.03582E-08	4.00977E-09	-2,58325	0,02001

Source: The authors.

According to the results found, the value of the intersection is 9.89, that is, when the value of x is zero, the value of real GDP starts from 9.89%.

X_2 The variable Average Income in R\$ () presented a coefficient of 0.0021, so the increase of 1% in Average Income will cause an increase of Aproximately 0.21% in the real GDP of the municipalities of Group 5.

X_1X_3 The variables Extension of the CU (), Employed Population (), and Salary/Other remuneration () presented coefficients with error, making it clear that the extent of the CU, the number of employed persons, and the total salaries and other remuneration paid to them do not influence, in the case of Group 5, the variation of real GDP. X_4

The Standard Deviation and the mean of the independent variables were calculated for Group 5. The results are shown in Table 57:

Table 57 – Standard Deviation and Mean and Group 5

Variable	Standard deviation	Average
Average Income (R\$)	579,96	1.019,37
Extension of the CU (km ²)	1.179,29	1.219,38
Employed Population (hab.)	1.317	1.019
Salary / Other remuneration (R\$)	14.194.121,54	52.030.436,13

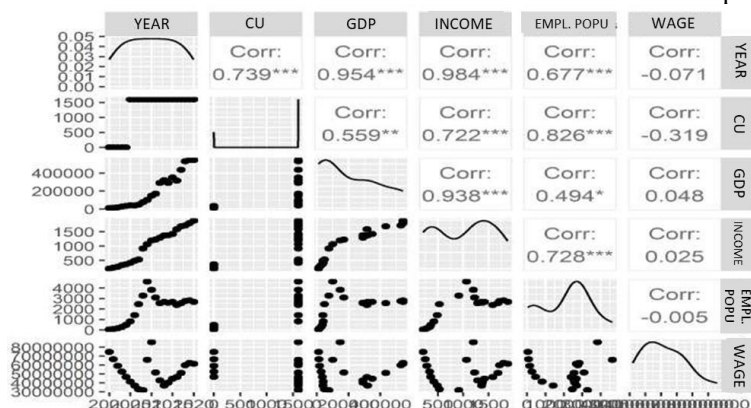
Source: The authors.

In the case of the Mean Income of Group 5, the standard deviation was calculated at R\$579.96. The standard deviation of the CU Extension was 1,179.29 km². The variables Employed Population and Salary / Other Remuneration presented standard deviations estimated at 1,317 and R\$14,194,121.54, respectively.

The average, which is a statistical measure, was estimated at R\$ 1,019.37, 1,219.38 km², 1,019 employed persons, and R\$ 52,030,436.13, respectively, for the variables Average Income, Extension of the CU, Employed People, and Salary / Other remunerations.

The correlations that show the forces of attraction between the variables involved in the estimates of the economic and legal effects of PADDD events in the municipalities belonging to Group 5 are listed in Table 58:

Table 58 – Correlation Coefficients between the variables of Group 5



Source: The authors.

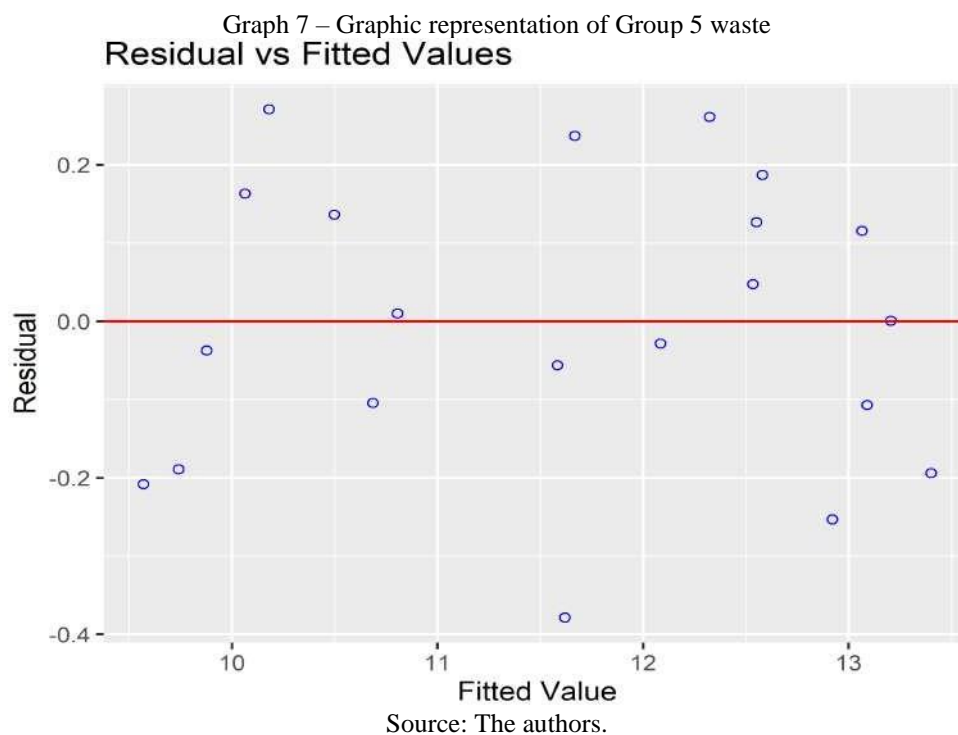
Table 58 shows that the variables Mean Income and real GDP presented the highest correlation coefficient of Group 5, which was 0.938. This denotes a great degree of attraction between them. The variables Average Income and Salary / Other Remuneration presented a relevant correlation coefficient close to 1, of value 0.728.

Regarding the variable Extension of the CU, the highest correlation coefficient was with the variable Employed Population, with a value of 0.826. This indicates that they have a force of attraction considered high.

In Group 5, negative correlation coefficients PPAeared, closer to -1. This means that the relationship between the variables involved is inversely proportional, that is, when one decreases the other increases. This fact occurred between the variables Extension of the CU and Salary / Other remunerations, which presented a result of a value coefficient of -0.319 , and between the Employed Population and Salary / Other remunerations, which presented a value coefficient of -0.005 .

The lowest positive correlation coefficient was 0.048 and occurred between the variables Salary / Other remuneration and real lnGDP, indicating that there is a relatively weak force of attraction between them, due to the proximity to zero.

Graph 7 expresses the degree of dispersion for Group 5, indicating that they are very dispersed about the mean.



The homoscedasticity test was also performed to determine the reliability of the model, the result of which is shown in Table 59, as follows:

Table 59 – Result of the homoscedasticity test of Group 5

TEST SUMMARY	
DF	1
Chi²	0.03737241
Prob > Chi²	0.8467088

Source: The authors.

H_0 Analyzing the information already presented, we conclude that the hypothesis must be accepted. Thus, the variance between the chosen variables is constant, and the model used for Group 5 is reliable.

Finally, the following equation can be estimated for Group 5:

$$Y_{\ln PIB \text{ real}} = Exp. [9,8913 + 0,0021.] \quad X_{\text{Average income}} \text{ (Equation 7)}$$

3.1.6 Group 6

Group 6 is composed of the municipalities of Porto Velho (RO) and Canutama (AM), whose territorial limits are superimposed on the UCFPI, Cuniã Ecological Station, which is inserted in the Amazon Biome. This area of integral protection was created in 2001, with a territorial extension of 532 km², and suffered the effects of three PADDD events of the relimitation type in the years 2007, 2008, and 2010. This added, respectively, 195 km², 532 km², and 638 km²; which totaled 1,365 km², leaving at the end of the events a protected green area of Aproximately 1,897 km².

Table 60 shows the data regarding the dependent variable and the independent variables for the period from 2000 to 2020.

Table 60 – Value of dependent and independent variables of Group 6

Year	lnReal GDP (Y)	Extension of the CU in km ² (X ₁)	Average Income in R\$ (X ₂)	Population Occupied (X ₃)	Salary / Other Remuneration in R\$ (X ₄)
2000	12	0	317*	38.538*	218.921.260*
2001 ¹	12	532	378*	41.432*	239.765.722*
2002	13	532	420*	44.543*	262.594.877*
2003	13	532	504*	47.888*	287.597.697*
2004	13	532	546*	51.485*	314.981.146*
2005	14	532	630*	55.351*	344.971.895*
2006	14	532	735*	59.508	377.818.195
2007 ²	14	727	798	63.977	413.791.938
2008 ²	14	1.258	872	70.027	485.099.854
2009	14	1.258	977	82.828	537.689.292
2010 ²	15	1.897	1.020	96.648	641.382.396
2011	15	1.897	1.090	101.691	750.545.979
2012	15	1.897	1.742	103.346	820.820.500
2013	15	1.897	1.898	100.708	913.372.708
2014	15	1.897	2.027	99.412	1.007.038.958

Continue

Year	lnReal GDP (Y)	Extension of the CU in km ² (X ₁)	Average Income in R\$ (X ₂)	Population Occupied (X ₃)	Salary / Other Remuneration in R\$ (X ₄)
2015	16	1.897	2.206	91.544	1.058.759.688
2016	16	1.897	2.464	86.248	1.120.693.896
2017	16	1.897	2.530	85.814	1.192.958.063
2018	16	1.897	2.576	84.405	1.247.141.375
2019	16	1.897	2.695	83.085	1.291.989.771
2020	16	1.897	2.822	82.928	1.272.576.750

Source: The authors based on data from IBGE – Cities (2020).

¹Year of creation of the CU; ²Year of occurrence of the PADDD event

*Estimated values.

From the observation of Table 60, it can be seen that the variables lnReal GDP remained constant between the years 2000 and 2001, in 12. Then it rose to 13 in 2002 and maintained this level until 2004, growing again in 2005, reaching 14 and remaining at this value until 2009. In 2010, the year of occurrence of the third PADDD event rose to 15, remaining constant until 2014. However, in 2015, it rose to 16, remaining at this level until 2020.

The Average Income showed a trend of growth during the years 2000 to 2020, going from R\$ 317 to R\$ 2,822, respectively.

The extension of UCFPI, the Cuniã Ecological Station, remained constant from its creation in 2001 until 2006; It has a territorial extension of 532 km². In 2007, came the effects of the first PADDD event of the redelimitation type, positively influencing the conservation unit, which gained more than 195 km², going to a total area of 727 km². The following year, in 2008, came the second positive PADDD event of relimitation, causing the legally established limits of the conservation unit to increase another 638 km², passing the territorial extension of the protected green area to Aproximately 1,258 km². Finally, two years later, in 2010, the conservation unit changed its perimeter, thanks to the occurrence of a third positive PADDD event of relimitation that modified the territorial limits of the conservation unit contained in the legal documents issued by the Federal Public Power that created it, passing to a total area of 1,897 km², remaining constant the variable extension of the CU in this value until 2020.

The variable Employed Population had an increase concerning its quantity in absolute terms, from 2000 to 2012, from 38,538 to 103,346 employed people, suffering a reduction in 2013 to 100,708. It continued in this downward trend until 2020 when it reached the level of only 82,928 inhabitants of Group 6 of municipalities having some occupation.

In the case of the variable Salary / Other remuneration, its total value grew in the period from 2000 to 2019, going from an estimated value in the amount of R \$ 218,921,260 to R \$ 1,291,989,771. However, in 2020, this amount was reduced to R\$1,272,576,750, similar to what occurred with the

variable Employed Population, which also decreased in this period.

These data were analyzed from the econometric point of view, and the following results were found for the multiple regression of the dependent variable Real GDP:

Table 61 – Regression statistics for Group 6

R multiple	0,98433577
R^2	0,968916908
R^2 -adjusted	0,961146134
Standard error	0,241164159
Observations	21

Source: The authors.

According to the multiple regression statistics in Table 61, they presented a value closer to 1, which shows that the chosen variables explain Aproximately 96.89% of the phenomenon that occurs with the dependent variable. The R – multiple also presented an expressive value, of about 98.43%, that is, very close to 1. The standard error indicates that the values estimated with the regression are far from the mean of 0.02411. R^2

Regarding the analysis of variance of Group 6, which can be defined as a study on the Total Sum of Squares (STQ), a total sum that is decomposed into two components, the first being the Sum of Explained Squares of Regression (SQE) and the second the Sum of Residual Squares (SQR), presented the following results:

Table 62 – Analysis of variance (ANOVA Table) of Group 6

	<i>Gl</i>	<i>SQ</i>	<i>MQ</i>	<i>F</i>	<i>F of signification</i>
Regression	4	29,00733	7,251834	124,687	7.63E-12
Residue	16	0,930562	0,05816		
Total	20	29,9379			

Source: The authors.

In Table 62, it can be observed that the degree of freedom (*gl*) for Group 6 is 4, for the regression, meaning that four explanatory variables will be used in the model and 16 for the residuals, totaling 20.

The sum of squares was higher for the regression analysis than for the residue analysis. This demonstrates that the independent variables chosen explain the possible changes in the dependent variable better than the calculated residuals.

The value of the F statistic of significance was 7.63E-12, that is, very close to zero, being much lower than 5%, so that one can reject, in the case of Group 6, the null hypothesis that the regressors do not influence the returnee.

Table 63 summarizes the values of the coefficients of the variables Extension of the CU (X_1), Average Income (X_2), Employed Population (X_3), and Salary/Other Remuneration (X_4) calculated through the analysis of the data from Group 6.

Table 63 – Analysis of Group 6 variables

	<i>Coefficients</i>	<i>Standard error</i>	<i>Stat t</i>	<i>P-value</i>
Intersection	11,52457	0,361677	31,86428	6.64E-16
CU Extension	-3.8E-06	0,000431	-0,00891	0,993001
Average income	0,000302	0,00056	0,539648	0,596871
Employed Population	2.1E-05	8.95E-06	2,346973	0,032128
Salary / Other remuneration	1.45E-09	1.52E-09	0,952934	0,354799

Source: The authors.

According to the results found, the value of the intersection is 11.52, that is, when the value of x is zero, the value of real GDP starts from 11.52%.

X_2 The variable Average Income in R\$ (X_2) presented a coefficient of 0.0003, so the increase of 1% in Average Income will cause an increase of Aproximately 0.03% in the value of the real GDP of the municipalities of Group 6.

X_3 The variables Extension of the CU, Employed Population (X_3), and Salary/Other remuneration (X_4) presented coefficients with error, making it clear that the extent of the UC, the number of employed persons, and the total salaries and other remuneration paid to them do not influence, in the case of Group 6, the variation of real GDP.

The Standard Deviation and the mean of the independent variables were calculated for Group 6 and the results found are shown in Table 64:

Table 64 – Standard Deviation and Mean and Group 6

Variable	Standard deviation	Average
Average Income (R\$)	886,06	1.392,64
Extension of the CU (km ²)	1.237,33	1.300,16
Employed Population (hab.)	21.772	1.393
Salary / Other remuneration (R\$)	388.808.836,24	704.786.283,78

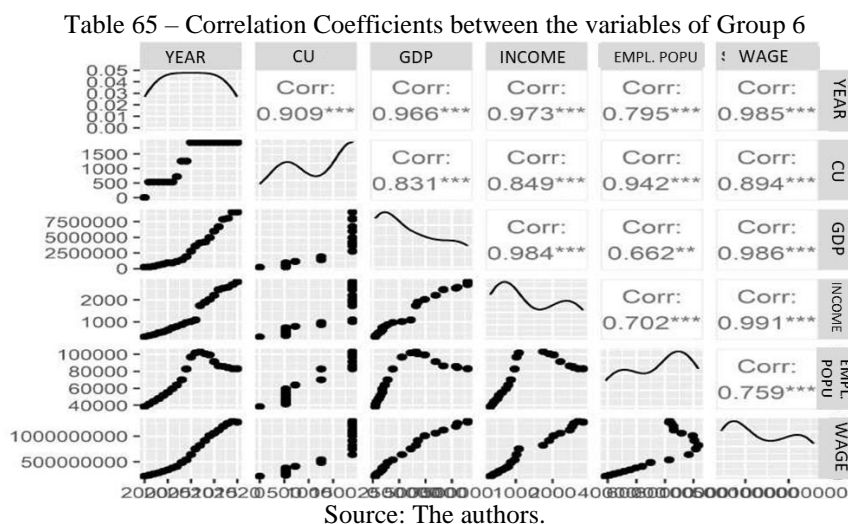
Source: The authors.

In the case of the Mean Income of Group 6, the standard deviation was calculated at R\$886.06. The standard deviation of the CU Extension was 1,237.33 km². The variables Employed Population and Salary / Other Remuneration presented standard deviations estimated at 21,772 and R\$388,808,836.24, respectively.

The average, which is a statistical measure, was estimated at R\$ 1,392.64, 1,300.16 km², 1,393

employed persons, and R\$ 704,786,283.78, respectively, for the variables Average Income, Extension of the CU, Employed People, and Salary / Other Remunerations.

The correlations that show the forces of attraction between the variables involved in the estimates of the economic and legal effects of PADD events in the municipalities with federal conservation units of full protection belonging to Group 6 are listed in Table 65:

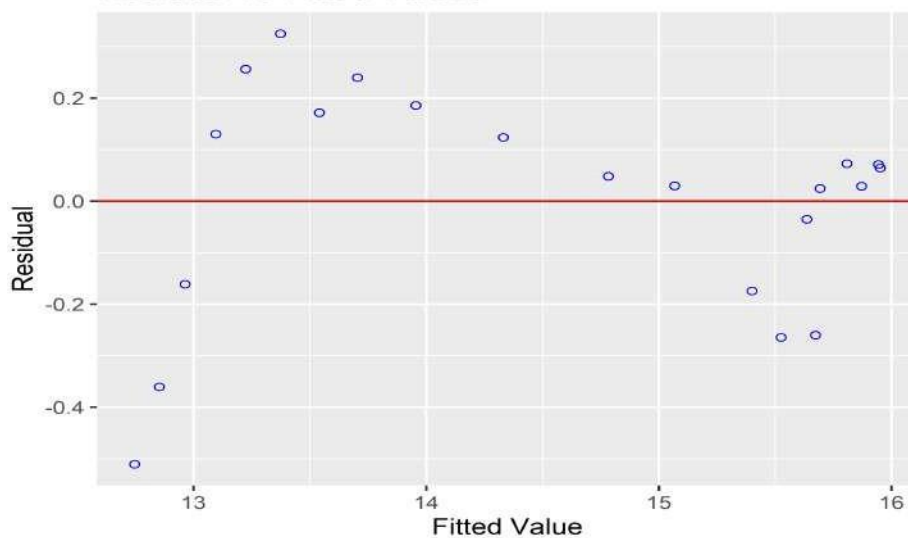


In Table 65, it can be observed that the variables Average Income and Salary / Other remuneration presented the highest correlation coefficient of Group 6, which was 0.991, which denotes a great degree of attraction between them. The variables Average Income and lnReal GDP presented a relevant correlation coefficient, close to 1, of value 0.984.

Concerning the variable Extension of the CU, the highest correlation coefficient was with the variable Employed Population, with a value of 0.942. This indicates that they have a force of attraction considered high.

The lowest positive correlation coefficient was 0.662 and occurred between the variables lnPIB and Employed Population, indicating that there is a relatively moderate force of attraction between them. Graph 8 expresses the degree of dispersion for Group 6, indicating that they are very dispersed about the mean.

Graph 8 – Graphic representation of Group 6 residues
Residual vs Fitted Values



Source: The authors.

The homoscedasticity test was also performed to determine the reliability of the model, the result of which is shown in Table 66:

Table 66 – Result of the homoscedasticity test of Group 6

TEST SUMMARY	
DF	1
χ^2	6.460121
Pro > χ^2	0.01103221

Source: The authors.

H_0 Analyzing the information already presented, we conclude that the hypothesis must be accepted. Thus, the variance between the chosen variables is constant, and the model used for Group 6 is reliable.

Finally, the following equation can be estimated for Group 6:

$$= Y_{\ln PIB \text{ real Exp.}} [11,524 + 0,0003.] X_{\text{Average income}} \quad (\text{Equation 8})$$

3.1.7 Group 7

Group 7 is composed of the following municipalities: Alto Parnaíba (MA), Barreira do Piauí (PI), Corrente (PI), Gilbués (PI), São Gonçalo do Gurgéia (PI), Mateiros (TO), São Félix do Tocantins (TO), Lizarda (TO) and Formosa do Rio Preto (BA), whose territorial limits are superimposed on UCFPI, Parnaíba River Springs National Park, which is inserted in the Cerrado Biome. This area of

integral protection was created in 2002, with a territorial extension of 7,298 km², and suffered the positive effects of a PADD event of the relimitation type in 2015, having an increase in its initial territorial extension delimited by the act of the Federal Public Power that created the unit in Aproximately 200 km², now having a final nature protection area with a perimeter of about 7,498 km².

Table 67 shows the data regarding the dependent variable and the independent variables for the period from 2000 to 2020.

Table 67 – Value of dependent and independent variables of Group 7

Year	lnReal GDP (Y)	Extension of CU in km ² (X ₁)	Average Income in R\$ (X ₂)	Population Busy (X ₃)	Salary / Other Remuneration in R\$ (X ₄)
2000	9	0	242*	363*	1.208.742*
2001	9	0	288*	386*	1.398.308*
2002 ¹	9	7.298	320*	409*	1.617.603*
2003	10	7.298	384*	434*	1.871.290*
2004	10	7.298	416*	461*	2.164.762*
2005	10	7.298	480*	490*	2.504.260*
2006	10	7.298	560*	520	2.897.000
2007	10	7.298	608	552	3.351.333
2008	11	7.298	747	514	3.708.222
2009	11	7.298	791	572	5.117.778
2010	11	7.298	816	797	7.875.667
2011	12	7.298	927	849	9.527.556
2012	12	7.298	995	612	7.213.556
2013	12	7.298	1.220	730	10.559.222
2014	12	7.298	1.303	873	13.633.333
2015 ²	13	7.498	1.418	869	15.352.778
2016	12	7.498	1.584	817	16.659.222
2017	13	7.498	1.687	922	19.034.778
2018	13	7.498	1.813	959	20.159.111
2019	13	7.498	1.896	1.001	21.820.333
2020	13	7.498	1.986	1.227	25.433.333

Source: The authors based on data from IBGE – Cities (2020).

¹ Year of creation of the CU

² Year of occurrence of the PADD event.

*Estimated values.

From the observation of Table 67, it can be observed that the variables lnReal GDP remained

constant, in 9, between the years 2000 and 2002. Then it rose to 10 in 2003 and maintained this level until 2007, growing again in 2008, reaching 11 and remaining at this value until 2010. In 2011, it rose to 12, remaining constant until 2014. However, in 2015, the year of occurrence of the PADDD event, it rose to 13, returning to 12 in 2016. In the period between 2017 and 2020, the variable presented a constant value of 13. The Average Income showed a trend of growth during the years 2000 to 2020, going from R\$ 242 to R\$ 1,986, respectively.

The extension of UCFPI, Parnaíba River Springs National Park, remained constant from its creation in 2002 until 2014; It has a territorial extension of 7,298 km². In 2015, came the effects of the PADDD event of the network-type limitation, which positively influenced the conservation unit, which gained another 200 km², moving to a total area of 7,498 km² and remaining constant the variable extension of the CU in this value until 2020.

The variable Employed Population had an increase with its quantity in absolute terms from 2000 to 2007, from 307 to 552 employed people, suffering a reduction in 2008 to 514. In 2009, the number of people employed in Group 7 was 572, reaching 849 in 2011. In 2012, the quantity of this variable decreased again, to 612, growing again in 2013 and reaching the total number of employed people in 2015 of 869 individuals. In 2016, the number decreased to 817, but again had a positive growth trend in 2017, reaching 2020 a total of 1,227 employed people.

In the case of the variable Salary / Other remuneration, its total value grew in the period from 2000 to 2020, from an estimated value of R\$ 1,208,742 to R\$ 25,433,333.

These data were analyzed from the econometric point of view, and the following results were found for the multiple regression of the dependent variable Real GDP:

Table 68 – Regression statistics for Group 7

R – multiple	0,984417239
R²	0,9690773
R² – adjusted	0,961346626
Standard error	0,275530238
Observations	21

Source: The authors.

R² According to the multiple regression statistics in Table 68, they presented a value closer to 1, which shows that the variables chosen explain Aproximately 96.90% of the phenomenon that occurs with the dependent variable. The R – multiple also presented an expressive value, of about 98.44%, that is, very close to 1. The standard error indicates that the values estimated with the regression are far from the mean of 0.2755.

Regarding the analysis of variance of Group 7, which can be defined as a study on the Total

Sum of Squares (STQ), a total sum that is decomposed into two components, the first being the Sum of Squares Explained Regression (SQE) and the second the Sum of Residual Squares (SQR), presented the following results:

Table 69 – Analysis of variance (ANOVA Table) of Group 7

	<i>Gl</i>	<i>SQ</i>	<i>MQ</i>	<i>F</i>	<i>F of signification</i>
Regression	4	38,0662	9,51655	125,3548	7.32E-12
Residue	16	1,214671	0,075917		
Total	20	39,28087			

Source: The authors.

In Table 69, it can be observed that the degree of freedom (*gl*) for Group 7 is 4 for the regression, meaning that four explanatory variables and 16 for the residuals will be used in the model, totaling 20.

The sum of squares was higher for the regression analysis than for the residue analysis, which demonstrates that the independent variables chosen better explain the possible changes in the dependent variable than the calculated residuals.

The value of the significance F statistic was 7.32E-12, that is, very close to zero and much lower than 5% so in the case of Group 7, the null hypothesis that the regressors do not influence the return can be rejected.

Table 70 summarizes the values of the coefficients of the variables Extension of the CU (X_1), Average Income (X_2), Employed Population (X_3), and Salary/Other Remuneration (X_4) calculated through the analysis of the data from Group 7.

Table 70 – Analysis of the variables of Group 7

	<i>Coefficients</i>	<i>Standard error</i>	<i>Stat t</i>	<i>P-value</i>
Intersection	6,340289	0,460656	13,76361	2.76E-10
CU Extension	3.32E-05	3.9E-05	0,849597	0,408082
Average income	0,004903	0,000756	6,485508	7.52E-06
Employed Population	0,004156	0,001053	3,948011	0,001151
Salary / Other remuneration	-3.2E-07	6.91E-08	-4,67332	0,000254

Source: The authors.

According to the results found, the value of the intersection is 6.34, that is, when the value of x is zero, the value of real GDP starts from 6.34%.

X_2 The variable Average Income in R\$ (X_2) presented a coefficient of 0.0049, so the increase of 1% in the Average Income will cause an increase of Aproximately 0.0049% in the real GDP of the municipalities of Group 7. In the case of the Employed Population (X_3), the coefficient was 0.0041, so

a 1% increase in the quantity of the employed population will cause an increase of Aproximately 0.41% in real GDP. X_3

X_1 The variables Extension of the CU () and Salary/Other remuneration () presented coefficients with error, making it clear that the extension of the CU, the number of employed persons, and the total salaries and other remuneration paid to them do not influence, in the case of Group 7, the variation of real GDP. X_4

The Standard Deviation and the mean of the independent variables were calculated for Group 7. The results are shown in Table 71:

Table 71 – Standard Deviation and Mean and Group 7

Variable	Standard deviation	Average
Average Income (R\$)	573,57	975,22
Extension of the CU (km ²)	6.571,99	6.660,18
Employed Population (inhab.)	241	975
Salary / Other remuneration (R\$)	7.782.801,28	9.195.627,99

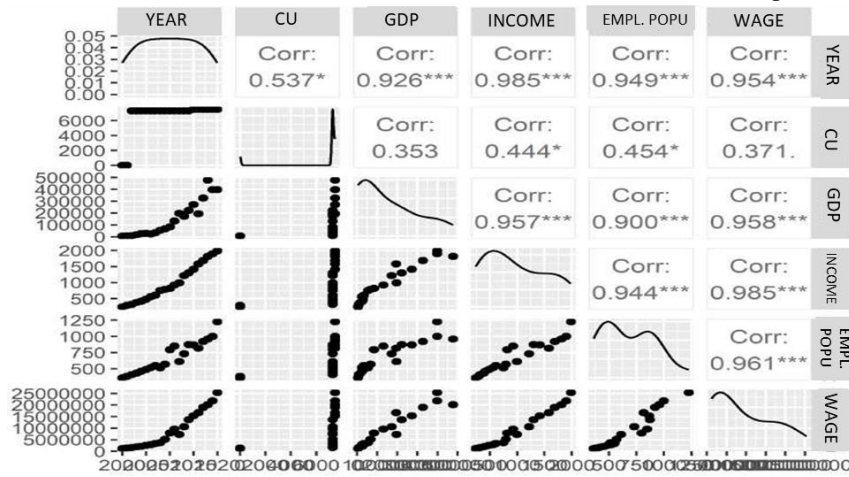
Source: The authors.

In the case of the Average Income of Group 7, the standard deviation was calculated at R\$ 573.57, while the standard deviation of the Extension of the CU was 6,571.99 km². The variables Employed Population and Salary / Other Remuneration presented standard deviations estimated at 241 and R\$ 7,782,801.28, respectively.

The average, which is a statistical measure, was estimated at R\$ 975.22, 6,660.18 km², 975 employed persons, and R\$ 9,195,627.99, respectively, for the variables Average Income, Extension of the CU, Employed People, and Salary / Other Remunerations.

The correlations that show the forces of attraction between the variables involved in the estimates of the economic and legal effects of PADD events in the municipalities belonging to Group 7 are listed in Table 72:

Table 72 – Correlation Coefficients between the variables of Group 7



Source: The authors.

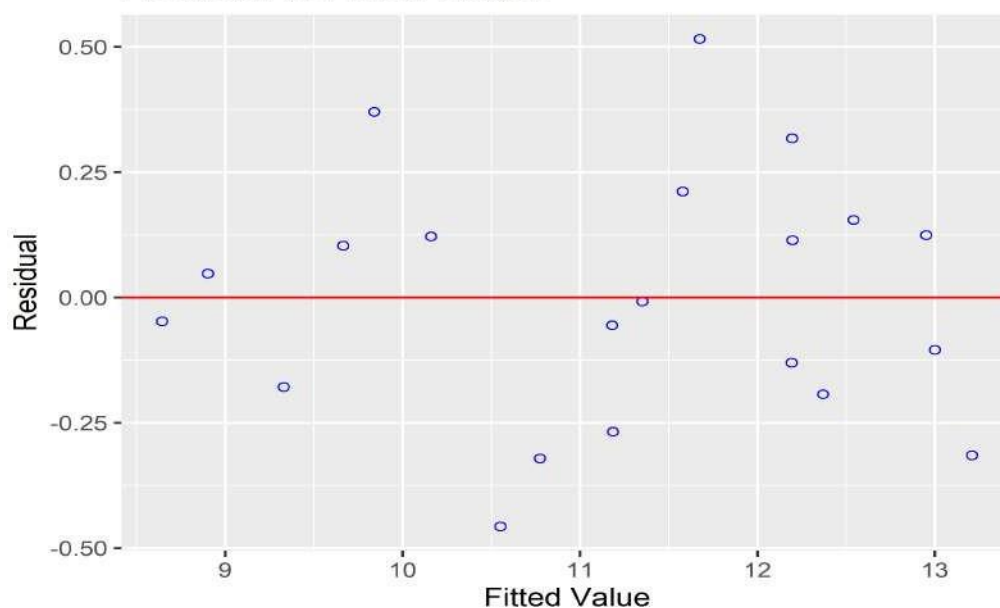
Table 72 shows that the variables Average Income and Salary / Other Earnings presented the highest correlation coefficient of Group 7, which was 0.985; which denotes a great degree of attraction between them. The variables Average Income and InReal GDP and Employed Population and Salary / Other Remuneration presented a relevant correlation coefficient, close to 1, of values 0.957 and 0.961, respectively.

With the variable relation Extension of the CU, the highest correlation coefficient was with the variable Employed Population, with a value of 0.954, which indicates that they have a force of attraction considered high.

The lowest positive correlation coefficient was 0.353 and occurred between the variables InReal GDP and Extension of the CU, indicating that there is a relatively weak force of attraction between them.

Graph 9 expresses the degree of dispersion for Group 7, indicating that they are very dispersed about the mean.

Graph 9 – Graphic representation of Group 7 residues
Residual vs Fitted Values



Source: The authors.

The homoscedasticity test was also performed to determine the reliability of the model, the result of which is shown in Table 73:

Table 73 – Result of the homoscedasticity test of Group 7.

TEST SUMMARY	
DF	1
χ^2	0.04608211
Prob > χ^2	0.8300266

Source: The authors.

Analyzing the information already presented, we conclude that hypothesis H0 should be accepted. Thus, the variance between the chosen variables is constant, and the model used for Group 7 is reliable.

Finally, the following equation can be estimated for Group 7:

$$Y_{lnPIB\ real} = Exp. [6.34 + 0.0049 \cdot X_{Average\ income} + 0.0041 \cdot X_{Employed\ population}] \quad (\text{Equation 9})$$

3.1.8 Group 8

Group 8 is composed of the municipalities of Itaituba and Trairão in Pará, whose territorial limits are superimposed on UCFPI, Jamanxim National Park, which is part of the Amazon Biome. This area of integral protection was created in the year 2006, with a territorial extension of 9,100 km², and suffered the negative effects of a PADDD event of the relimitation type in the year 2017, having a loss in its initial territorial extension delimited by the act of the Federal Public Power that created

the unit in Approximately 511 km², now having a final nature protection area with a perimeter of about 8,589 km².

Table 74 shows the data regarding the dependent variable and the independent variables for the period from 2000 to 2020.

Table 74 – Value of dependent and independent variables of Group 8

Year	lnReal GDP (Y)	Extension of the CU in km ² (X ₁)	Average Income in R\$ (X ₂)	Population Occupied (X ₃)	Salary / Other Remuneration in R\$ (X ₄)
2000	10	0	317*	18.104*	100.500.943*
2001	10	0	378*	19.461*	110.121.651*
2002 ¹	11	0	420*	20.920*	120.663.326*
2003	11	0	504*	22.489*	132.214.129*
2004	11	0	546*	24.175*	144.870.663*
2005	12	0	630*	25.987*	158.738.775*
2006	12	9.100	735*	27.935	173.934.447
2007	12	9.100	798	30.030	190.584.764
2008	12	9.100	872	32.246	208.750.080
2009	12	9.100	930	35.299	245.108.816

Continues

Year	lnReal GDP (Y)	Extension of the CU in km ² (X ₁)	Average Income in R\$ (X ₂)	Population Occupied (X ₃)	Salary / Other Remuneration in R\$ (X ₄)
2010	13	9.100	1.122	41.812	272.782.479
2011	13	9.100	1.145	48.748	325.454.976
2012	13	9.100	1.306	51.151	378.879.767
2013	13	9.100	1.424	52.038	415.689.861
2014	13	9.100	1.520	50.790	463.503.021
2015 ²	14	9.100	1.734	50.140	511.195.868
2016	14	9.100	1.848	46.180	537.709.455
2017	14	8.589	2.061	43.585	569.864.337
2018	14	8.589	2.099	43.386	606.558.587
2019	14	8.589	2.196	42.703	634.480.854
2020	14	8.589	2.299	42.156	658.711.552

Source: The authors based on data from IBGE – Cities (2020).

¹ Year of creation of the CU

² Year of occurrence of the PADDD event.

*Estimated values.

From the observation of Table 74, it can be observed that the variables lnReal GDP remained

constant, in 10, between the years 2000 and 2001. It then rose to 11 in 2002 and maintained this level until 2004, growing again in 2005, reaching 12, and remaining at this value until 2009. In 2010 it rose to 13, remaining constant until 2014. However, in 2015, it rose to 14, remaining at this value until 2020.

The Average Income showed a growth trend during the years 2000 to 2020, going from R\$ 317 to R\$ 2,299, respectively.

The extension of UCFPI, Jamanxim National Park, has remained constant since its creation in 2006 until 2016, with a territorial extension of 9,100 km². In 2017, there were the effects of the PADDD event of the network type, which negatively influenced the conservation unit, which lost about another 511 km², passing to a total area of 8,589 km², remaining constant the variable extension of the CU in this value until 2020.

The variable Employed Population had an increase in its quantity in absolute terms from 2000 to 2013, from 18,104 to 52,038 employed people, suffering a reduction in 2014 to 50,790. This trend of decrease in the employed population that began in 2014 lasted until 2020 when only 42,156 people were exercising some occupation in the municipalities belonging to Group 8.

In the case of the variable Salary / Other remuneration, its total value grew in the period from 2000 to 2020, from an estimated value of R\$ 100,500,943 to R\$ 658,711,552.

These data were analyzed from the econometric point of view, and the following results were found for the multiple regression of the dependent variable Real GDP:

Table 75 – Regression statistics for Group 8

R multiple	0,989934114
R²	0,97996955
R² – adjusted	0,974961937
Standard error	0,193557158
Observations	21

Source: The authors.

According to the multiple regression statistics in Table 75, they presented a value closer to 1, which shows that the variables chosen explain Aproximately 97.99% of the phenomenon that occurs with the dependent variable. The R – multiple also presented a significant value, of about 98.99%, that is, very close to 1. The standard error indicates that the values estimated with the regression are far from the mean of 0.1935.**R²**

Regarding the analysis of variance of Group 8, which can be defined as a study on the Total Sum of Squares (STQ), a total sum that is decomposed into two components, the first being the Sum of Explained Squares of Regression (SQE) and the second the Sum of Residual Squares (SQR),

presented the following results:

Table 76 – Analysis of variance (ANOVA Table) of Group 8

	<i>Gl</i>	<i>SQ</i>	<i>MQ</i>	<i>F</i>	<i>F of signification</i>
Regression	4	29,32651	7,331627	195,696	2.29E-13
Residue	16	0,59943	0,037464		
Total	20	29,92594			

Source: The authors.

In Table 76, it can be seen that the degree of freedom (*gl*) for Group 8 is 4 for the regression, meaning that four explanatory variables will be used in the model, and 16 for the residuals, totaling 20.

The sum of squares was higher for the regression analysis than for the residue analysis, which demonstrates that the independent variables chosen better explain the possible changes in the dependent variable than the calculated residuals.

The value of the F statistic of significance was 2.29E-13, that is, very close to zero, being much lower than 5%. Thus, in the case of Group 8, the null hypothesis that regressors do not influence the return can be rejected.

Table 77 summarizes the values of the coefficients of the variables Extension of the CU (), Average Income (), Employed Population (), and Salary/Other Remuneration () calculated through the analysis of the data of Group 8. $X_1X_2X_3X_4$

Table 77 – Analysis of the variables of Group 8

	<i>Coefficients</i>	<i>Standard error</i>	<i>Stat t</i>	<i>P-value</i>
Intersection	9,303071	0,220799	42,13369	7.99E-18
CU Extension	-1.6E-05	2.45E-05	-0,64949	0,525239
Average income	0,003799	0,000909	4,1798	0,000708
Employed Population	4.14E-05	9.32E-06	4,436504	0,000415
Salary / Other remuneration	-8.5E-09	3.05E-09	-2,77372	0,013556

Source: The authors.

According to the results found, the value of the intersection is 9.30, that is, when the value of *x* is zero, the value of real GDP starts from 9.30%.

X_2 The variable Average Income in R\$ () presented a coefficient of 0.0037, so the increase of 1% in Average Income will cause an increase of Aproximately 0.0037% in the real GDP of the municipalities of Group 8.

The variables Extension of the CU (), Employed Population), and Salary/Other remuneration () presented coefficients with error, making it clear that they do not influence, in the case of Group

8, the variation of real GDP. $X_1(X_3X_4)$

The Standard Deviation and the mean of the independent variables were calculated for Group 8. The results are shown in Table 78:

Table 78 – Standard Deviation and Mean and Group 8

Variable	Standard deviation	Average
Average Income (R\$)	651,20	1.184,90
Extension of the CU (Km ²)	6.172,46	6.402,58
Employed Population (Hab.)	11.728	1.185
Salary / Other remuneration (R\$)	194.270.707,67	331.443.731,01

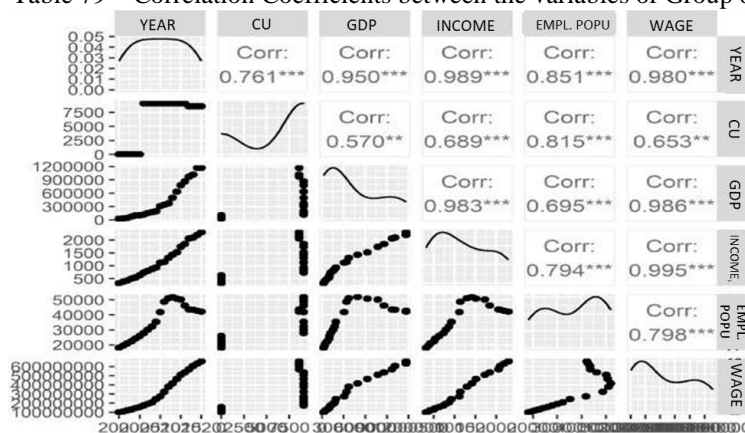
Source: The authors.

In the case of the Mean Income of Group 8, the standard deviation was calculated at R\$ 651.20. The standard deviation of the CU Extension was 6,172.46 km². The variables Employed Population and Salary / Other Remuneration presented standard deviations estimated at 11,728 and R\$ 194,270,707.67, respectively.

The average, which is a statistical measure, was estimated at R\$ 1,184.90, 6,402.58 km², 1,185 employed persons, and R\$ 331,443,731.01, respectively, for the variables Average Income, Extension of the CU, Employed People, and Salary / Other Remuneration.

The correlations that show the forces of attraction between the variables involved in the estimates of the economic and legal effects of PADDD events in the municipalities with federal conservation units of full protection belonging to Group 8 are listed in Table 79:

Table 79 – Correlation Coefficients between the variables of Group 8



Source: The authors.

Table 79 shows that the variables Average Income and Salary / Other Earnings presented the highest correlation coefficient of Group 8, which was 0.995. This denotes a great degree of attraction between them. The variables Average Income and In Real GDP and Real lnGDP and Salary / Other

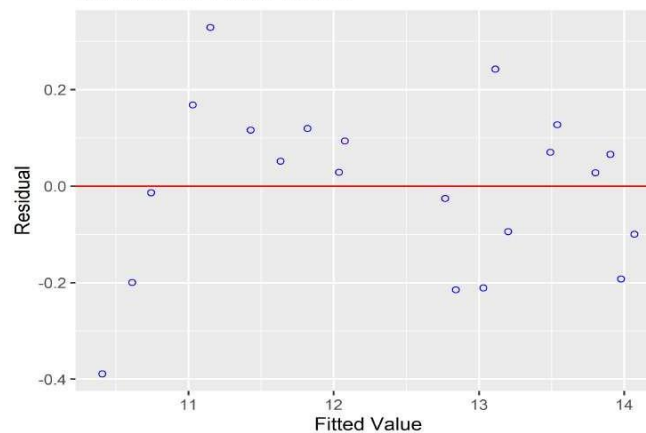
Remuneration presented a relevant correlation coefficient, close to 1, of values 0.983 and 0.986, respectively.

Regarding the variable Extension of the CU, the highest correlation coefficient was with the variable Employed Population, with a value of 0.815, which indicates that they have a force of attraction considered high.

The lowest positive correlation coefficient was 0.570 and occurred between the variables lnReal GDP and Extension of the CU, indicating that there is a relatively moderate force of attraction between them.

Graph 10 expresses the degree of dispersion for Group 8, indicating that they are very dispersed about the mean.

Graph 10 – Graphic representation of Group 8 residues
Residual vs Fitted Values



Source: The authors.

The homoscedasticity test was also performed to determine the reliability of the model, the result of which is shown in Table 80:

Table 80 – Result of the homoscedasticity test of Group 8

TEST SUMMARY	
DF	1
<i>Chi</i> ²	2.981827
Prob > <i>Chi</i> ²	0.08420417

Source: The authors.

Analyzing the information already presented, we conclude that the hypothesis must be accepted. Thus, the variance between the chosen variables is constant, and the model used for Group 8 is reliable. H_0

Finally, the following equation can be estimated for Group 8:

$$= Y_{\ln PIB \text{ real } Exp. [9,30 + 0,0037.]} X_{Average \text{ income}} \quad (\text{Equation 10})$$

3.1.9 Group 9

Group 9 is composed of the municipalities of Nova Aripuanã (AM), Manicoré (AM), Humaitá (AM), Colniza (MT), and Machadinho D'Oeste (MT), whose territorial limits are superimposed on the UCFPI, the Campos Amazônicos National Park, which is inserted in the Amazon Biome. This area of integral protection was created in 2006, with a territorial extension of 8,736 km², and suffered the negative effects of a PADDD event of the relimitation type in the year 2012, having a gain in its initial territorial extension delimited by the act of the Federal Public Power that created the unit in Aproximately 878 km², now having a final nature protection area with a perimeter of about 9,613 km².

Table 81 shows the data regarding the dependent variable and the independent variables for the period from 2000 to 2020.

Table 81 – Value of dependent and independent variables of Group 9

Year	lnReal GDP (Y)	Extension of the CU in km ² (X ₁)	Average Income in R\$ (X ₂)	Population Busy (X ₃)	Salary / Other Remuneration in R\$ (X ₄)
2000	9	0	287*	22.079*	124.904.264*
2001	10	0	342*	23.439*	142.587.993*
2002	10	0	380*	24.882*	162.775.354*
2003	11	0	456*	26.414*	185.820.806*
2004	11	0	494*	28.040*	212.128.994*
2005	11	0	570*	29.767*	242.161.849*
2006 ¹	11	8.736	665*	31.600	276.446.704
2007	11	8.736	722	33.545	315.585.549
2008	12	8.736	789	35.868	354.587.348
2009	12	8.736	837	39.953	414.136.135
2010	12	8.736	918	44.602	484.626.500
2011	12	8.736	981	47.106	545.433.902
2012 ²	12	9.613	1.120	48.125	606.731.848
2013	12	9.613	1.153	47.829	670.739.942
2014	13	9.613	1.303	46.917	720.338.938
2015 ²	13	9.613	1.418	44.880	765.339.225
2016	13	9.613	1.496	43.103	812.195.740
2017	13	9.613	1.687	42.852	855.227.985
2018	13	9.613	1.717	42.598	891.567.723
2019	13	9.613	1.796	42.419	898.688.892
2020	13	9.613	1.986	25.797	403.623.594

Source: The authors based on data from IBGE – Cities (2020).

¹ Year of creation of the CU

² Year of occurrence of the PADDD event.

*Estimated values.

From the observation of Table 81, it can be observed that the variable lnReal GDP, in 2000,

was 9 and, in 2001, increased to 10, remaining constant until 2002. It then rose to 11 in 2003 and maintained this level until 2007, growing again in 2008, when it reached 12, and remaining with this value until 2013. In 2014, it rose to 13, remaining constant until 2020.

The Average Income showed a growth trend during the years 2000 to 2020, from R\$ 287 to R\$ 1,986, respectively.

The extension of UCFPI, the Campos Amazônicos National Park, has remained constant since its creation in 2006 until 2011, with a territorial extension of 8,736 km². In 2012, the effects of the PADDD event of the redelimitation type occurred, which positively influenced the conservation unit, which gained about 878 km², going to a total area of 9,613 km²; remaining constant the variable extension of the CU in this value until 2020.

The variable Employed Population had an increase concerning its quantity in absolute terms from 2000 to 2012, from 22,079 to 48,125 employed people, suffering a reduction in 2013 to 47,289. This trend of decrease in the employed population that began in 2013 lasted until 2020 when only 25,797 people were exercising some occupation in the municipalities belonging to Group 9.

In the case of the variable Salary / Other remuneration, its total value grew in the period from 2000 to 2020, from an estimated value of R\$ 124,904,264 to R\$ 403,623,594.

These data were analyzed from the econometric point of view, and the following results were found for the multiple regression of the dependent variable Real GDP:

Table 82 – Regression statistics for Group 9

R multiple	0,983221468
R^2	0,966724456
R^2 –adjusted	0,95840557
Standard error	0,233512264
Observations	21

Source: The authors.

According to the multiple regression statistics in Table 82, they presented a value closer to 1, which shows that the variables chosen explain Aproximately 96.67% of the phenomenon that occurs with the dependent variable. The R – multiple also presented a significant value, of about 98.32%, that is, very close to 1. The standard error indicates that the values estimated with the regression are far from the mean of 0.2335. R^2

Regarding the analysis of variance of Group 9, which can be defined as a study on the Total Sum of Squares (STQ), a total sum that decomposes into two components, the first being the Sum of Explained Squares of Regression (SQE) and the second the Sum of Residual Squares (SQR), presented the following results:

Table 83 – Analysis of variance (ANOVA Table) of Group 9

	<i>Gl</i>	<i>SQ</i>	<i>MQ</i>	<i>F</i>	<i>F of signification</i>
Regression	4	25,34643665	6,336609163	116,2084026	1.31282E-11
Residue	16	0,87244764	0,054527978		
Total	20	26,21888429			

Source: The authors.

In Table 83, it can be observed that the degree of freedom (*gl*) for Group 9 is 4 for the regression, meaning that four explanatory variables will be used in the model and 16 for the residuals, totaling 20.

The sum of squares was higher for the regression analysis than for the residue analysis, which demonstrates that the independent variables chosen better explain the possible changes in the dependent variable than the calculated residuals.

The value of the F-statistic of significance was 1.31282E-11, that is, very close to zero, being much lower than 5%. Thus, in the case of Group 9, the null hypothesis that the regressors do not influence the returnee can be rejected.

Table 84 summarizes the values of the coefficients of the variables Extension of the CU (), Average Income (), Employed Population (), and Salary/Other Remuneration () calculated through the analysis of the data from Group 9. $X_1X_2X_3X_4$

Table 84 – Analysis of the variables of Group 9

	<i>Coefficients</i>	<i>Standard error</i>	<i>Stat t</i>	<i>P-value</i>
Intersection	8,203506007	0,449548175	18,24833568	3.91269E-12
CU Extension	-1.75565E-06	2.88929E-05	-0,060764266	0,952299493
Average income	0,002121274	0,00031844	6,661457137	5.46659E-06
Employed Population	5.50282E-05	1.7424E-05	3,1581842	0,006089704
Salary / Other remuneration	- 1.32005E-09	7.63146E-10	-1,729749638	0,102915005

Source: The authors.

According to the results found, the value of the intersection is 8.20, that is, when the value of *x* is zero, the value of real GDP starts from 8.20%.

The variable Average Income in R\$ () presented a coefficient of 0.0021, so the increase of 1% in Average Income will cause an increase of Aproximately 0.0021% in the real GDP of the municipalities of Group 9. X_2

X_1X_3 The variables Extension of the CU (), Employed Population (), and Salary / Other remuneration presented coefficients with error, making it clear that the extent of the number of employed persons and the total of wages and other remuneration paid to them do not influence, in the

case of Group 9, the variation of real GDP.

The Standard Deviation and the mean of the independent variables were calculated for Group 9 and the results found are shown in Table 85:

Table 85 – Standard Deviation and Mean and Group 9

Variable	Standard deviation	Average
Average Income (R\$)	523,06	1.005,52
Extension of the CU (Km ²)	6.300,35	6.615,86
Employed Population (Hab.)	9.130	1.006
Salary / Other remuneration (R\$)	268.473.858,07	480.269.013,39

Source: The authors.

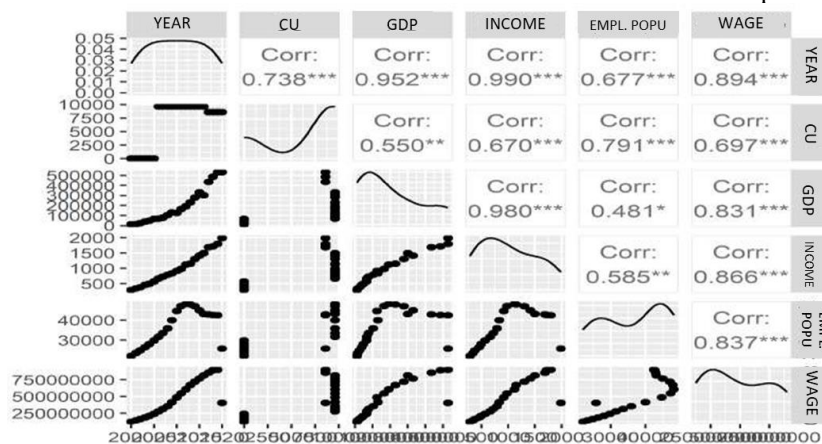
In the case of the Average Income of Group 9, the standard deviation was calculated at R\$ 523.06. Already

the standard deviation of the CU Extension was 6,300.35 km². The variables Employed Population and Salary / Other remuneration presented standard deviations estimated at 9,130 and R\$ 268,473,858.07, respectively.

The mean, which is a statistical measure, was estimated at R\$ 1005.52, 6,615.86 km², 1,006 employed persons, and R\$ 480,269,013.39, respectively, for the variables Average Income, Extension of the CU, Employed People, and Salary / Other remuneration.

The correlations that show the forces of attraction between the variables involved in the estimates of the economic and legal effects of PADDD events in the municipalities belonging to Group 9 are listed in Table 86:

Table 86 – Correlation Coefficients between the variables of Group 9



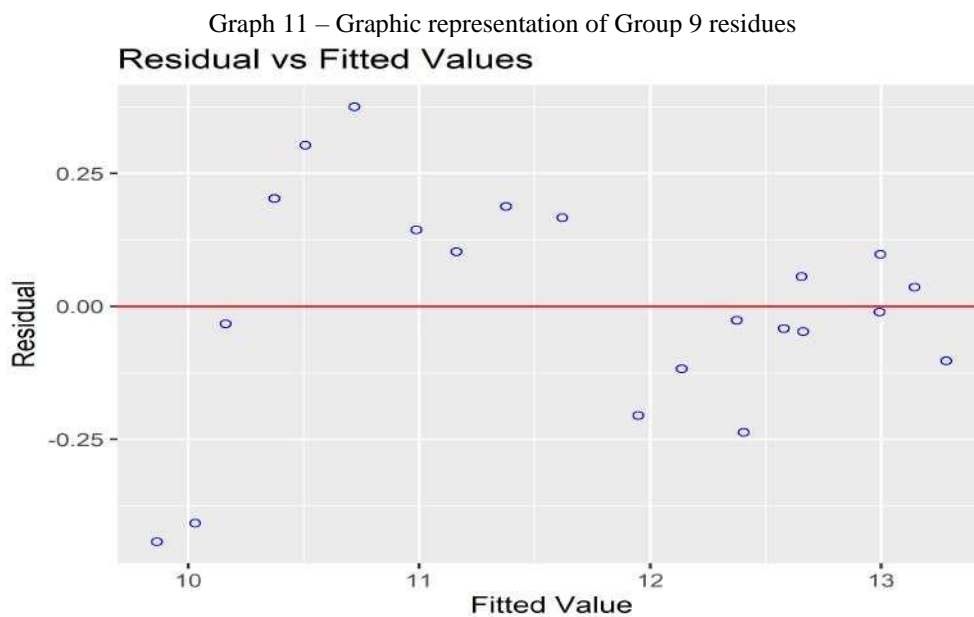
Source: The authors.

Table 86 shows that the variables Mean Income and real GDP presented the highest correlation coefficient of Group 9, which was 0.980. This denotes a high degree of attraction between them. The variables Average Income and Salary / Other Remuneration and Real GDP and Average Income presented a relevant correlation coefficient, close to 1, of values 0.866 and 0.837, respectively.

Regarding the variable Extension of the CU, the highest correlation coefficient was with the variable Employed Population, with a value of 0.791. This indicates that they have a force of attraction considered high.

The lowest positive correlation coefficient was 0.481 and occurred between the variables lnReal GDP and Employed Population, indicating that there is a relatively moderate force of attraction between them.

Graph 11 expresses the degree of dispersion for Group 9, indicating that they are very dispersed about the mean.



Source: The authors.

The homoscedasticity test was also performed to determine the reliability of the model, the result of which is shown in Table 87:

Table 87 – Result of the homoscedasticity test of group 9

TEST SUMMARY	
DF	1
<i>Chi</i> ²	9.095445
Prob > <i>Chi</i> ²	0.002562469

Source: The authors.

Analyzing the information already presented, it is concluded that the hypothesis must be accepted and, therefore, the variance between the chosen variables is constant, and the model used for Group 9 is reliable. H_0

Finally, the following equation can be estimated for Group 9:

$$= Y_{\ln PIB \text{ real } Exp. [8,20 + 0,0021.] X_{Average \text{ income}} \quad (\text{Equation 11})$$

3.1.10 Group 10

Group 10 is composed of the municipalities of Lábrea (AM), Canutama (AM), and Porto Velho (RO), whose territorial limits are superimposed on the UCFPI, Mapinguari National Park, which is inserted in the Amazon Biome. This area of integral protection was created in 2008, with a territorial extension of 15,724 km², and suffered the effects of the PADDD events of the relimitation type in the years 2010 and 2012. The first had a positive impact, with the expansion of the protected area by Aproximately 1,809 km², increasing the territorial extension of the CU from 15,724 km² to 17,533 km². The second event had a negative effect, as it provided a reduction of Aproximately 85 km², leaving the CU with a total area of legal protection of 17,448 km².

Table 88 shows the data regarding the dependent variable and the independent variables for the period from 2000 to 2020.

Table 88 – Value of dependent and independent variables of Group 10

Year	lnReal GDP (Y)	Extension of the CU in km ² (X ₁)	Average Income in R\$ (X ₂)	Employed Population (X ₃)	Salary / Other Remuneration in R\$ (X ₄)
2000	12	0	317*	13.504*	74.895.618*
2001	12	0	378*	14.420*	84.188.789*
2002 ¹	12	0	420*	15.398*	94.635.072*
2003	13	0	504*	16.442*	106.377.547*
2004	13	0	546*	17.557*	119.577.047*
2005	13	0	630*	18.747*	134.414.363*
2006	13	0	735*	20.018	151.092.717
2007	14	0	798	21.376	169.840.549
2008	14	15.724	872	22.876	189.015.217
2009	14	15.724	930	25.275	221.454.243
2010	14	17.533	969	29.070	255.094.882
2011	15	17.533	1.036	32.235	293.472.144
2012	15	17.448	1.493	33.296	330.941.724

2013	15	17.448	1.763	33.533	365.663.008
2014	15	17.448	1.810	32.860	399.158.431
2015 ²	15	17.448	1.891	31.963	430.629.290
2016	15	17.448	2.112	30.033	455.521.472
2017	16	17.448	2.155	29.119	481.375.700
2018	16	17.448	2.290	28.981	506.095.140
2019	16	17.448	2.395	28.707	518.330.026
2020	16	17.448	2.508	23.060	362.589.493

Source: The authors based on data from IBGE – Cities (2020)

¹ Year of creation of the CU

² Year of occurrence of the PADDD event.

*Estimated values.

From the observation of Table 88, it can be observed that the variables InReal GDP remained constant, in 12, between the years 2000 and 2002. Then it rose to 13 in 2003 and maintained this level until 2006, growing again in 2007, reaching 14; and remaining with this value until 2010. In 2011 it rose to 15, remaining constant until 2016. However, in 2017, it rose to 16, remaining at this value until 2020.

The Average Income showed a trend of growth during the years 2000 to 2020, going from R \$ 317 to R \$ 2,508, respectively.

The extension of UCFPI, Mapinguari National Park, has remained constant since its creation in 2008 until 2009; It has a territorial extension of 15,724 km². In 2010, the effects of the PADDD event of the network type occurred, which positively influenced the CU, which gained about another 1,809 km², moving to a total area of 17,533 km². Already in the year 2012, there was a second PADDD event, also of relimitation, but that harmed the CU, reducing its territorial extension by 85 km², which, from then on, began to have a natural area legally protected by an act of the Federal Public Power of about 17,448 km².

The variable Employed Population had an increase in its quantity in absolute terms, from 2000 to 2014, from 13,504 to 32,860 employed people, suffering a reduction in 2015 to 31,963. This trend of decrease in the employed population that began in 2015 lasted until 2020 when only 23,060 people were exercising some occupation in the municipalities belonging to Group 10.

In the case of the variable Salary / Other remuneration, its total value grew in the period from 2000 to 2019, from an estimated value of R\$ 74,895,618 to R\$ 518,330,026. In 2020, this amount was reduced to R\$ 362,589,493.

These data were analyzed from the econometric point of view, and the following results were found for the multiple regression of the dependent variable Real GDP:

Table 89 – Regression statistics for Group 10

R multiple	0,964306778
R^2	0,929887563
R^2 adjusted	0,912359454
Standard error	0,338957029
Observations	21

Source: The authors.

According to the multiple regression statistics in Table 89, they presented a value closer to 1, which shows that the variables chosen explain Approximately 92.98% of the phenomenon that occurs with the dependent variable. The R – multiple regressor also presented a significant value, of about 96.43%, that is, very close to 1. This makes valid our hypothesis that the occurrence of the PADDD event can infer more about the pattern of behavior of the other variables. The standard error indicates that the values estimated with the regression are far from the mean of $0.3389.R^2$

Regarding the analysis of variance of Group 10, which can be defined as a study on the Total Sum of Squares (STQ), a total sum that is decomposed into two components, the first being the Sum of Squares Explained Regression (SQE) and the second the Sum of Residual Squares (SQR), presented the following results:

Table 90 – Analysis of variance (ANOVA Table) of Group 10

	<i>Gl</i>	<i>SQ</i>	<i>MQ</i>	<i>F</i>	<i>F of signification</i>
Regression	4	24,38061442	6,095153604	53,05121895	4.92784E-09
Residue	16	1,838269876	0,114891867		
Total	20	26,21888429			

The authors

Table 90 shows that the degree of freedom (*gl*) for Group 10 is 4 for regression, meaning that four explanatory variables will be used in the model and 16 for residuals, totaling 20. The sum of squares was higher for the regression analysis than for the residue analysis. This demonstrates that the independent variables chosen explain the possible changes in the dependent variable better than the calculated residuals. The value of the F-statistic of significance was 1.31282E-11, that is, very close to zero, being much lower than 0.05 or 5%, so that one can reject, in the case of Group 10, the null hypothesis that the regressors do not influence the returning.

Table 91 summarizes the values of the coefficients of the variables Extension of the CU (), Average Income (), Employed Population (), and Salary/Other Remuneration () calculated through the analysis of the data from Group 10. $X_1X_2X_3X_4$

Table 91 – Analysis of the variables of Group 10

	<i>Coefficients</i>	<i>Standard error</i>	<i>Stat t</i>	<i>P-value</i>
Intersection	9,017169344	0,493222	18,28219	3.8E-12
CU Extension	7.49009E-06	2.24E-05	0,333974	0,742737
Average income	0,001236697	0,000423	2,925742	0,009897
Employed Population	5.69249E-05	3.02E-05	1,883581	0,077928
Salary / Other remuneration	- 1.28888E-09	2.47E-09	-0,5214	0,609233

Source: The authors.

According to the results found, the value of the intersection is 9.01, that is, when the value of x is zero, the value of real GDP starts from 9.01%.

The variable Average Income in R\$ () presented a coefficient of 0.0012, so the increase of 1% in the Average Income Real GDP will cause an increase of Aproximately 0.12% in the real GDP of the municipalities of Group 10. X_2

The variables Extension of the CU (, Employed Population (), and Salaries/Other remuneration () presented coefficients with error, making it clear that the extension of the CU, the number of employed persons, and the total salaries and other remuneration paid to them do not influence, in the case of Group 10, the variation of real GDP. $X_1)X_3X_4$

The Standard Deviation and the mean of the independent variables were calculated for Group 10 and the results found are shown in Table 92:

Table 92 – Standard Deviation and Mean and Group 10

Variable	Standard deviation	Average
Average Income (R\$)	747,52	1.264,32
Extension of the CU (Km ²)	9.928,96	10.645,06
Employed Population (Hab.)	6.859	1.264
Salary / Other remuneration (R\$)	152.504.343,25	273.541.070,11

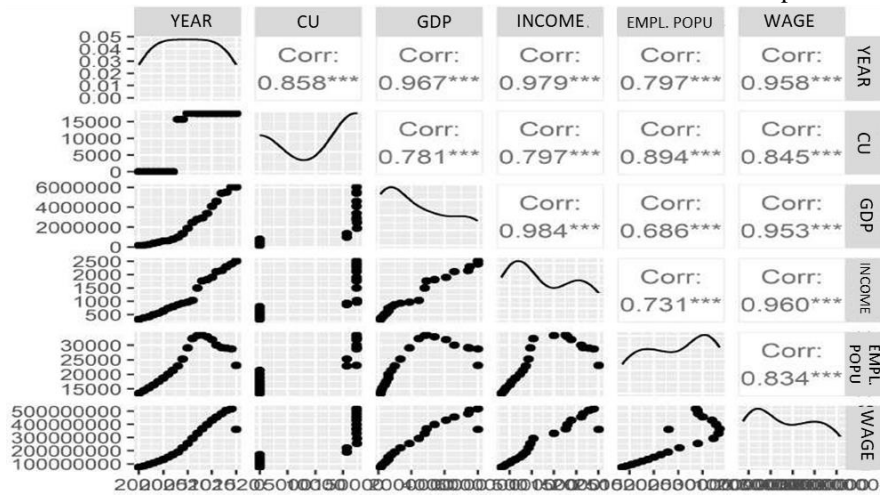
Source: The authors.

In the case of the Mean Income of Group 10, the standard deviation was calculated at R\$ 747.52. The standard deviation of the CU Extension was 9,928.96 km². The variables Employed Population and Salary / Other Remuneration presented standard deviations estimated at 6,859 and R152,504,343.25, respectively.

The average, which is a statistical measure, was estimated at R\$ 1,264.32, 10,645.06 km², 1,264 employed persons, and R\$ 273,541,070.11, respectively, for the variables Average Income, Extension of the CU, Employed People, and Salary / Other Remuneration.

The correlations that show the forces of attraction between the variables involved in the estimates of the economic and legal effects of PADDD events in the municipalities belonging to Group 10 are listed in Table 93:

Table 93 – Correlation Coefficients between the variables of Group 10



Source: The authors.

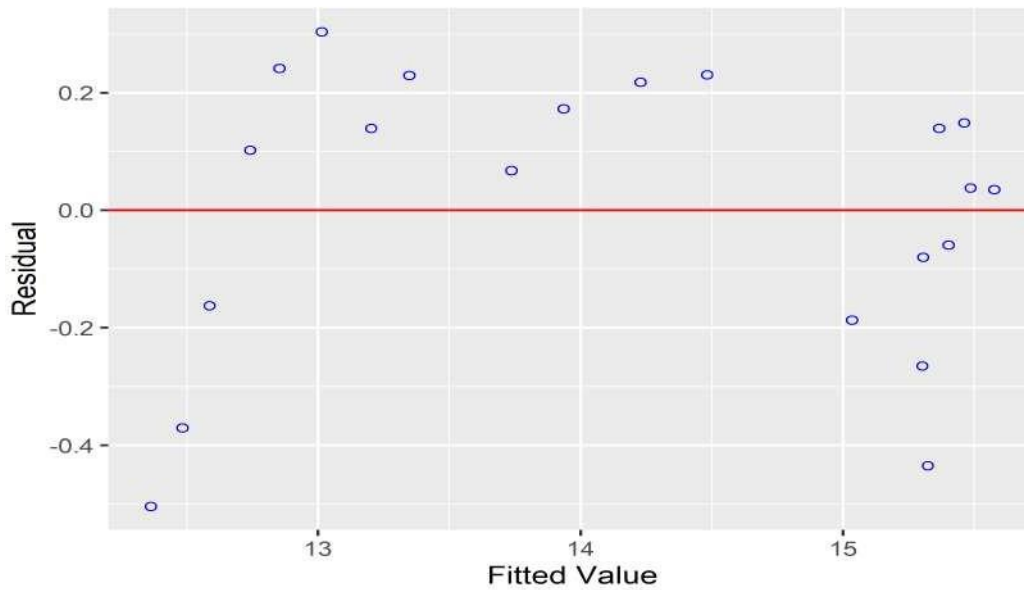
Table 93 shows that the variables Mean Income and real GDP presented the highest correlation coefficient of Group 10, which was 0.984. This denotes a high degree of attraction between them. The variables Average Income and Salary / Other Remuneration and InReal GDP and Average Income presented a relevant correlation coefficient, close to 1, of values 0.960 and 0.953, respectively.

Regarding the variable Extension of the CU, the highest correlation coefficient was with the variable Employed Population, with a value of 0.894. This indicates that they have a force of attraction considered high.

The lowest positive correlation coefficient was 0.686 and occurred between the variables InPIB real and Employed Population, indicating that there is a relatively moderate force of attraction between them.

Graph 12 expresses the degree of dispersion for Group 10, indicating that they are very dispersed about the mean.

Graph 12 – Graphic representation of Group 10 waste
Residual vs Fitted Values



Source: The authors.

The homoscedasticity test was also performed to determine the reliability of the model, the result of which is shown in Table 94:

Table 94 – Result of the homoscedasticity test of Group 10

TEST SUMMARY	
DF	1
Chi²	1.938162
Prob > Chi²	0.1638683

Source: The authors.

Analyzing the information already presented, we conclude that the hypothesis must be accepted. Thus, the variance between the chosen variables is constant, and a reliable model used for Group 10 is used. H_0

Finally, the following equation can be estimated for Group 10:

$$= Y_{\ln PIB_{real}} \text{Exp. } [9,01 + 0,0012.] X_{Average\ income} \quad (\text{Equation 12})$$

4 CONCLUSIONS

The study in question brought with it several reflections on the Brazilian Federal Integral Protection Conservation Units expressed in the significant economic and legal effects caused by the PADDD events. This occurred mainly in the variables inferred through the average income of the population of the municipalities where the territorial extension of these areas of nature preservation

overlaps the limits defined by the municipal Public Power, as a rule using it as an important legal instrument for the creation of the municipality, in addition to considering it in the variation of the quantity of the employed population, also in the total wages and other remuneration paid to persons who had some occupation in the group studied.

As a timely *locus* of response to the proposed objectives, we have:

- 1 The multiple inputs of variables in the various occurrences of PADDD events in the various conservation units chosen were measured and methodologically transformed into groups. This seemed to be the most viable way to find answers to the above-mentioned problem.
- 2 The historical and legal evolution of government strategies for the protection and preservation of nature through the creation of conservation units of the Integral Protection type was demonstrated in this work, narrating episodes from 1605, when the first law was created, called the "Pau-Brasil Regiment" to the present day.

Following the evolutionary trend of expansion of the mechanisms of preservation of national biodiversity, the Forest Map discusses in detail the description of the different biomes and their conservation states, in addition to aiming to subsidize the creation of a set of National Parks. Two decades later, in 1934, a year considered quite significant for advances in terms of public policies, especially the creation of mechanisms to defend the nature of anthropogenic actions of degradation, the first Brazilian Forest Code instituted by Federal Decree No. 23,793 was promulgated, innovating the country's environmental legal system by defining the concept and legal objectives of the first Permanent Protection Area (PPA). In this way, for the first time, it brought the idea of nature protection as a fundamental principle associated with the duty of the State as an active agent in the fight against acts of environmental degradation.

In 1965, another important environmental normative device was promulgated, which can be considered another advance in the conservation actions of our biodiversity, which was Federal Decree-Law No. 289 which gave rise to the Brazilian Institute of Forest Development.

In the mid-1970s, Federal Decree No. 73,030 emerged, creating the Special Secretariat for the Environment (SEMA) and four other protected areas, namely the Ecological Station, the Environmental Protection Area, the Ecological Reserve, and the Area of Relevant Ecological Interest. In the following decade, in 1980, the Environmental Protection Area was created, which allowed the permanence of resident populations, seeking, in a pioneering way, the conciliation of the activities and economic interests of these populations with the conservation of natural elements.

In October 1988, the new Constitution, in Chapter VII, article 225, brings, in its *caput*, the insignia that everyone has the right to an ecologically balanced environment, that this is good for the

common use of the people and essential to the healthy quality of life, and it is up to the public power and the population, in terms of collectivity, the duty to defend and preserve it for present and future generations. In item III of this normative provision, the Public Power must define, in all units of the Federation, certain territorial spaces and their components. In this case, they are specially protected, and the alteration and suppression are allowed only with the enactment of a law, with the prohibition of any use that compromises the integrity of the attributes that justify their protection.

A typology of nature preservation area emerged in 1990, called the Private Reserve of Natural Heritage (RPPN), which allowed the recognition of a protected area in the private domain, thus stimulating the voluntary creation of nature protection areas. In this study, an advanced theoretical typological spectrum of the PADDD type and its derivations was made.

In terms of units of conservation, the year 2000 can be considered a historical milestone, because it was in that year, the beginning of a new century, that Federal Law No. 9,865 emerged, which created the National System of Conservation Units. This set of normative devices for the protection of the environment, in addition to bringing together all the typologies of protected areas existing until then, also opened space for new typologies to be created or incorporated from original experiences developed in the country, being remarkable the advance that has been processed in Brazil about the theme of protection of Brazilian biodiversity from human actions of modification or extinction of fauna and flora.

Likewise, the analysis of the historical-legal evolution of public policies aimed at the preservation of green areas was made. That said, let's talk about what happened in 2012, the year in which Federal Law No. 12,651 was enacted, which established the new Brazilian Forest Code. This brought novelties changes as to the conditions for the limits of the Permanent Preservation Areas (PPA).

- 3 The PADDD effects allied to the econometric technique were studied using the Multiple Linear Regression Model (MLR) and the Ordinary Least Squares Method (OQM). This model was extremely relevant for the final rounds, regarding the satisfactory and reliable answers to the problems mentioned above.
- 4 The absolute data and the territorial extension of the Brazilian federal conservation units of full protection existing in the period from 2000 to 2020 were related. In this work, it was seen that 59 Conservation Units were created that protect a total territorial area of 309,548.33 km², accounting for 3.49% of the Brazilian territory, and 115,763.88 km² of the marine protected area, that is, 3.18% of the total marine area existing in the country, and these units belong to the following typologies, according to Federal Law No. 9,865 of 2000:

- a) National Parks (PARNA) that aim at the integral preservation of the biota and other natural attributes existing within its limits, without direct human interference or environmental modifications, except for the recovery measures of their altered ecosystems and the management actions necessary to recover and preserve the natural balance, biological diversity, and natural ecological processes, with 30 protected areas covering an approximate area of 142,336.20 km², equivalent to 45.98% of the total areas protected by conservation units in Brazil, and 1.67% of the Brazilian territory;
- b) Ecological Stations (ESEC), which aims to preserve nature and conduct scientific research, with 10 conservation units, which are responsible for covering an area of 40,780.38 km², accounting for 13.17% of the total areas protected by conservation units in Brazil and approximately 0.47% of the Brazilian territory;
- c) Natural Monuments (MONAT), whose basic objective is to preserve rare, singular, or great scenic natural sites, with seven conservation units that protect an area of 115,313.22 km², which represents 37.26% of the total areas protected by conservation units in Brazil and corresponds to 1.35% of the national territory;
- d) Reserva da Biológica (REBIO), which aims at the integral preservation of the biota and other natural attributes existing within its limits, without direct human interference or environmental modifications, except for the recovery measures of its altered ecosystems and the management actions necessary to recover and preserve the natural balance, biological diversity, and natural ecological processes, with eight conservation units, which are responsible for the protection of an area of 8134.70 km², which corresponds to 2.63% of the total area protected by conservation units in Brazil and 0.00001% of the national territory;
- e) Wildlife Refuge (RSV), which aims to protect natural environments where conditions are ensured for the existence or reproduction of species or communities of local flora and resident or migratory fauna, with eight conservation units that protect an area of 2,983.83 km², which corresponds to 0.96% of the total area protected by conservation units in Brazil and 0.00001% of the national territory.

In the analysis of the biomes, it was observed that, in the Amazon, 16 federal conservation units of the integral protection type are located, which were created in the period from 2000 to 2020 and protect an area of 173,748.69 km² or 0.67% of the total area of the biome. In the Caatinga biome, eight conservation units are located that protect an area of 5,045.86 km² or 0.61% of the total area of the biome.

The Atlantic Forest biome was contemplated with acts of the Federal Public Power that

created 24 federal conservation units of full protection between 2000 and 2020. These units, added to their areas, protect a territorial extension of about 4,494.98 km² or 0.40% of the total area of the biome.

In the case of the Cerrado biome, in the same period, only seven nature protection areas were created, which do not allow any human intervention and are under the governance of the Federal Public Power, which preserves 19,493.94 km² or 0.95% of the total area of this biome.

The Marine biome has been protected 115,763.88 km² by federal conservation units of full protection that were created in the last 20 years, which corresponds to 3.18% of the total area of this biome.

However, these federally protected conservation units suffered the effects of networking, recategorization, and demotion events in the period between 2000 and 2020. This work contains absolute data on the quantity and territorial extent of these events known as PADDD, demonstrating that, in the period under study, 10 federal conservation units of full protection, whose protected areas are superimposed on the territorial extensions of 40 Brazilian municipalities, suffered 13 PADDD events. 12 of these events were rebounding, which can be considered a decrease in the size of a protected area as a result of the excision of land or sea area through a change of legal boundary; and, on the other hand, only one PADDD event of recategorization, that is, events that cause a decrease in restrictions on the number, magnitude or extent of human activities within a natural protection area due to an enactment of a legal authorization from the Public Power managing the area to increase the use of this area for human activities.

These conservation units had a total area of 43,876 km² and are located in the Caatinga biome, four in the Atlantic Forest biome, two in the Cerrado biome, and four in the Amazon biome. However, due to nine positive effects of PADDD events, which caused increases in the original areas of the conservation units under study, two negative effects decreased the protected areas and two were neutral, keeping the same protected area constant in the legal document of creation of the conservation unit. There was an increase in the total area of the federal conservation units of full protection under the study of about 5,744 km², totaling Approximately 49,620 km² in 2020.

- 5 Absolute data were collected from the IBGE – Cities website regarding the average income of the population, the number of the employed population, the total salaries and other remuneration paid to the employed population, and the nominal GDP of all municipalities that had federal conservation units of full protection created by the Government and that suffered some type of PADDD event in the period from 2000 to 2020. The municipalities were grouped into 10 groups, according to the conservation unit in which their territory overlaps and the estimation of those for those years in which the

data were not recorded was performed. As a continuous act, the arithmetic means of these data were calculated, to produce a Table in which they would be organized and would serve for the application of econometric formulas for estimating Multiple Linear Regression models, using the method of Ordinary Least Squares (OLS).

The total average income of the population of the groups, adding the average income of each group, increased from R\$2,929 in 2000 to R\$22,367 in 2020. The employed population increased from 251,118 in 2000 to 429,725 in 2020. In the case of real GDP, in 2000, adding up the real GDP of all groups, we arrived at the amount of R\$629,818. This amount increased almost 35 times in 2020, totaling R\$21,968,090. The same increase was observed by comparing the total salaries and other remuneration paid to the economically employed population of the groups in the year 2000 with the amount paid in 2020 because in that year the amount was R\$ 1,758,800,983 and in this year it increased to R\$ 10,308,380,222.

After collecting the data and treating them for the selection of the variables that would be the dependent and the independent, the Multiple Linear Regression Model was applied, with the dependent variable the real GDP, calculated after the removal of the inflationary effects of the period in studies on the value of the nominal GDP of each group, receiving this variable the application of the LogN function. The independent variables were defined as the extent of the conservation unit in km² (X1), the average income in R\$ (X2), the employed population (X3), and the salary/other remuneration in R\$ (X4).

6 The econometric models estimated for the groups presented in this study investigated the influence of PADD events on variations in average income, the quantity of the employed population, the total wages and other remuneration paid to the employed population, and the real GDP of the municipalities where the fully protected conservation units that were affected in the period between 2000 and 2020 are located. This shows that, in all groups, the value of R² was quite close to 1 and that the variables chosen explain the phenomenon studied more than the residues calculated econometrically for the groups.

7 The Homoscedasticity tests performed for each group showed that the variance between the chosen variables is constant, and the model was used for the reliable groups. The results of the *t*- and *P*-value statistics were lower than 5%, indicating that the independent variables chosen to explain the variation in real GDP are adequate.

In the case of Group 1, consisting of the municipalities of Jijoca de Jericoacoara, Cruz, and Camorim, where the Federal Conservation Unit of Integral Protection of Jericoacoara National Park is located, which is inserted in the Cerrado biome, the effects of a PADD event of relimitation,

which added 4 km² to the established CU, occurred. The estimated model presented a value of 0.9776 for the R² and, as independent variables influence the value of real GDP, the extent of the conservation unit, the average income of the population, and the quantity of the employed population. Thus, a variation of 0.22% in the extension of the conservation unit in km² would cause a variation of 1% in real GDP. A variation of 0.18% in the average income and 0.01% in the quantity of the employed population would cause the same effect. For this group, the variables that presented the greatest force of attraction, because the correlation coefficient is close to +1, were the average income and the salary / other remuneration paid to the employed population, so that, if the variation occurs in one, the other also varies. On the other hand, the variation in the extension of the conservation unit, caused by a PADDD event, will cause a greater variation in the quantity of the employed population, due to the force of attraction being greater among these variables.

Group 2, consisting of the municipalities of Euclides da Cunha, Teodoro Sampaio, Marabá Paulista, and Presidente Epitácio, is located in the Federal Conservation Unit of Integral Protection Mico Leão Preto Ecological Station and is inserted in the Cerrado biome. This suffered the effects of a PADDD event of rebounding that added 55 km². The estimated model presented a value of 0.99 for R², as an independent variable that influences the value of real GDP, the extent of the conservation unit, and the average income of the population. Thus, there is a variation of 0.64% in the extension of the conservation unit in km² would cause a variation of 1% in real GDP. A 0.04% change in average income would cause the same effect. For this group, the variables that presented the greatest strength of attraction, because the correlation coefficient is close to +1, were the average income and real GDP, so that, if the variation occurs in one, the other also varies. On the other hand, the variation in the extension of the conservation unit, caused by a PADDD event, will also cause a greater variation in the quantity of the employed population, due to the force of attraction being greater among these variables.

Group 3, consisting of the municipalities of Indaial, Apiúna, Blumenau, Botuverá, Guabiruba, Presidente Nereu, Vidal Ramos, and Gaspar, all from the interior of Santa Catarina, is located in the Federal Conservation Unit of Integral Protection Serra de Itajaí National Park and is inserted in the Atlantic Forest biome, suffering the effects of a PADDD of networking, where 4 km² were added. The estimated model presented a value of 0.9947 for R², as the independent variable influences the value of real GDP. As with Group 2, the extent of the conservation unit and the average income of the population were observed. A variation of 0.04% in the extent of the conservation unit in km² would cause a variation of 1% in real GDP. A 0.05% change in average income would cause the same effect. For this group, the variables that presented the greatest force of attraction, because the correlation coefficient is close to +1, were the average income and the salary / other remuneration

paid to the employed population, so that, if the variation occurs in one, the other also varies. On the other hand, the variation in the extension of the conservation unit, caused by a PADDD event, will also cause a greater variation in the quantity of the employed population, due to the force of attraction being greater among these variables.

In Group 4, consisting of the municipalities of Pancas and Agua Branca, the Federal Conservation Unit of Integral Protection of the Pontões Capixabas Natural Monument is located, which is inserted in the Atlantic Forest biome and suffered the effects of a PADDD recategorization event. The estimated model presented a value of 0.9483 for the R^2 and as an independent variable that influences the value of real GDP, the extent of the conservation unit, and the average income of the population. A variation of 0.19% in the extent of the conservation unit in km^2 would cause a variation of 1% in real GDP. A 0.02% change in average income would cause the same effect. For this group, the variables that presented the greatest strength of attraction, because the correlation coefficient was close to +1, were the average income and salary/other wages paid to the employed population. Thus, if the variation occurs in one, the other also varies. On the other hand, the variation in the extension of the conservation unit, caused by a PADDD event, will also cause a greater variation in the quantity of the employed population, due to the force of attraction being greater among these variables.

Group 5 consists of the Maranhão municipalities of Carolina, Estreito, and Riachão, where the Federal Conservation Unit of Integral Protection of the Chapada das Mesas National Park is located, inserted in the Cerrado biome. This Unit suffered the effects of a PADDD of networking, not presenting additions as to the territorial extension contained in the legal document of creation of the preservation area. The estimated model presented a value of 0.9803 for R^2 and as an independent variable that influences the value of real GDP only the average income of the population. A 0.21% change in the value of average income would cause a 1% change in real GDP. For this group, the variables that presented the greatest strength of attraction, because the correlation coefficient was close to +1, were the quantity of the employed population and the salary/other remuneration paid to it. Thus, if the variation occurs in one, the other also varies. The variation in the extent of the conservation unit, caused by a PADDD event, will also cause a greater variation in the total value of wages / other remuneration paid to the employed population, due to the force of attraction being greater among these variables.

In Group 5, two situations were also verified in which the correlation coefficients presented a value closer to -1, indicating that there was a force of attraction where it acted inversely. Thus, the variables extension of the conservation unit and salary / other remuneration and the quantity of the employed population of salary / other remuneration paid to this contingent of people decreased,

informing that they had some occupation in the municipalities belonging to the group.

Group 6 consists of the municipalities of Porto Velho, in Rondônia; and Canatuma, in Amazonas, where the Federal Conservation Unit of Integral Protection of the Cuniã Ecological Station is located, which is inserted in the Amazon biome and suffered the effects of three PADDD events of relimitation. These events added to the total 1,365 km² of the territorial extension contained in the legal document of creation of the preservation area. The estimated model presented a value of 0.9689 for R² and as an independent variable that influences the value of real GDP only the average income of the population. A change of 0.03% in the value of average income would cause a change of 1% in real GDP. For this group, the variables that presented the greatest strength of attraction, because the correlation coefficient was close to +1, were the value of the average income of the population and the salary/other remuneration paid to it. Thus, if there is variation in one, the other also varies in the same direction. On the other hand, the variation in the extension of the conservation unit, caused by a PADDD event, will also cause a greater variation in the quantity of the employed population, due to the force of attraction being greater among these variables.

Group 7 consists of the municipalities of Alto Paraíba (MA), Barreira do Piauí (PI), Corrente (PI), Gilbués (PI), São Gonçalo (PI), Mateiros (TO), São Félix do Tocantins (TO), Lizarda (TO) and Formosa do Rio Preto (BA), where the Federal Conservation Unit of Integral Protection of the Parnaíba River Springs National Park is located, which is inserted in the Cerrado biome and suffered the effects of a PADDD event of relimitation that added 200 km² of the territorial extension contained in the legal document of creation of the preservation area. The estimated model presented a value of 0.9690 for the R² and, as independent variables that influence the value of real GDP, only the average income of the population and the quantity of the employed population. A variation of 0.49% in the value of average income would cause a change of 1% in real GDP, while a variation of 0.41% in the quantity of the employed population of the group will cause the same effect. For this group, the variables that presented the greatest strength of attraction, because the correlation coefficient was close to +1, were the value of the average income of the population and the salary/other remuneration paid to it. Thus, if the variation occurs in one, the other also varies. On the other hand, the variation in the extension of the conservation unit, caused by a PADDD event, will also cause a greater variation in the quantity of the employed population, due to the force of attraction being greater among these variables. It is important to emphasize that the region where the municipalities belonging to Group 7 are inserted is known by the acronym MATOPIBA (MA + TO + PI + BA), formed by the abbreviation of the name of the states of Maranhão, Tocantins, and Bahia, considered prominent regions in Brazilian agribusiness, mainly in the production of soybeans, corn, and cotton.

Group 8 consists of the municipalities of Itaituba and Trairão in Pará, where the Federal Conservation Unit of Integral Protection of Jamanxim National Park is located, which is inserted in the Amazon biome and suffered the effects of a PADDD event of relimitation with negative effects that reduced 511 km² of the territorial extension contained in the legal document of creation of the preservation area. The estimated model presented a value of 0.9799 for R² and, as an independent variable that influences the value of real GDP, only the average income of the population. A 0.37% change in the value of average income would cause a 1% change in real GDP. For this group, the variables that presented the greatest strength of attraction, because the correlation coefficient was close to +1, were the value of the average income of the population and the salary/other remuneration paid to it. Thus, if the variation occurs in one, the other also varies. On the other hand, the variation in the extension of the conservation unit, caused by a PADDD event, will also cause a greater variation in the quantity of the employed population, due to the force of attraction being greater among these variables.

Group 9 consists of the municipalities of Nova Aripuanã (AM), Manicoré (AM), Humaitá (AM), Machadinha D'Oeste (RO), and Colniza (MT), where the Federal Conservation Unit of Integral Protection of the Amazon Fields National Park is located, which is inserted in the Amazon biome and suffered the positive effects of a PADDD event of networking. This event increased 878 km² of the territorial extension contained in the legal document of creation of the preservation area, the estimated model presented a value of 0.9667 for the R² and, as an independent variable that influences the value of the real GDP, only the average income of the population, that is, a variation of 0.21% in the value of the average income would cause a variation of 1% in the real GDP. For this group, the variables that presented the greatest strength of attraction, because the correlation coefficient was close to +1, were the value of the average income of the population and the salary/other remuneration paid to it. Thus, if the variation occurs in one, the other also varies. The variation in the extension of the conservation unit, caused by a PADDD event, will also cause a greater variation in the quantity of the employed population, due to the force of attraction being greater among these variables.

Finally, Group 10, which consists of the municipalities of Lábrea (AM), Canitama (AM), and Porto Velho (RO), is where the Federal Conservation Unit of Integral Protection Mapinguari National Park is located, which is inserted in the Amazon biome and suffered two effects of PADDD events of relimitation. The first event of addition and the second of reduction of the preserved area, more that, in the end, ended up increasing by 1,724 km² of the territorial extension contained in the legal document of creation of the preservation area. The estimated model presented a value of 0.9298 for R² and, as an independent variable, which influences the value of real GDP only the average income of the population. A 0.12% change in the value of average income would cause a 1% change in real

GDP. For this group, the variables that presented the greatest strength of attraction, because the correlation coefficient was close to +1, were the value of real GDP and the quantity of the employed population. Thus, if the variation occurs in one, the other also varies. On the other hand, the variation in the extension of the conservation unit, caused by a PADDD event, will also cause a greater variation in the quantity of the employed population, due to the force of attraction being greater among these variables.

Thus, it was noticed that the PADDD events that affected the conservation units belonging to the 10 groups caused effects directly on the real GDP in Groups 1, 2, 3, and 4, considering that the extension variable referring to the conservation units is inserted in the econometric models estimated for these groups.

The income variable PPAeared in all estimated models, indicating that there is a strong relationship with real GDP. In the case of the variable salary / other remuneration, it did not PPAear in any estimated model as an explanatory variable of the variation of real GDP.

The econometric models estimated for Groups 7 and 1 indicated that the variable employed population, in these cases, had explanatory power over the variations in the value of the real GDP of the municipalities belonging to these groups.

The data used in this work were collected through numerous sources, such as IBGE – Cities, Ministry of the Environment, Chico Mendes Institute, and Socioenvironmental Institute. Likewise, the literature review combined more than 70 scientific articles, books, and websites focused on environmental issues.

Finally, it is asserted that the study in question contributes to the dissemination of events of the PADDD type (relimitation, recategorization, and extinction), related to the exploitation made in the various conservation units, are better understood, both from the economic and legal point of view. The opportunity was valid, given the opportunity to be a rich and complex topic, through which the researcher is faced with many unusual tools of scientific power, sometimes not conclusive.

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