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Mosaic of conservation units: a conservation strategy for the Seridó Potiguar biome

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ABSTRACT

This article aims to show the Seridó Potiguar - Brazil through the model of integrated management of conservation units and protected areas, known as area fragmentation mosaics. The loss of native vegetation, caused by anthropic destruction, is felt as one of the conditioning factors in the decrease of biodiversity almost everywhere on Earth, however, only with the creation of Conservation Units (UCs) will it be possible to establish a tool as a conservation strategy. The National System of Conservation Units (SNUC) began the structure in mosaics, where it could provide a participatory and social management of the territory of those involved, taking into account the conservation of biodiversity and geodiversity. In this way, this article observes to what extent a good management of UC mosaics can bring a better contribution to the conservation of biodiversity and geodiversity, taking into account particularly the Caatinga biome in the Seridó of the state of Rio Grande do Norte. As results, the project presents biophysical, socioeconomic and environmental elements.
Keywords: Mosaic. Conservation Unit. Protected Area. Protected Area. Environment.

1 INTRODUCTION

Approximately 90% of the Earth's surface has suffered or is suffering some kind of human impact, from the paleolithic period to the present day. This, as human populations have continued their migratory cycle, altering terrestrial landscapes to meet their needs. Interactions exist between natural processes and human activities to produce a constantly changing mosaic. In this way, terrestrial mosaics provide a spatial solution to meet society's land use objectives, thereby achieving a sustainable environment and protecting natural habitats.

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It is observed that this biodiversity presents, within a context, an immense potential for the conservation of environmental and sustainable services, since, if well exploited in a sustainable development, they will be decisive for the maintenance of the balance of this geosystem. The Catinga biome of the Brazilian semi-arid region is one of the most biodiverse in the world, unique to Brazil. The fight against the desertification process is associated with the conservation of Catinga, verifying that this process of environmental degradation occurs in arid, semi-arid and dry sub-humid areas, occupying an area of 62% of the areas susceptible to the desertification process within this space, noting that many are already very altered.

Occupying an area of approximately 862,818 km², the Brazilian Northeast represents 10.1% of the national territory, encompassing nine states and the north of Minas Gerais. It is, also home to 27 million people, with a good portion of its inhabitants depending on natural resources daily for survival. Several biomes coexist simultaneously and show signs of dilapidation throughout the country's history.

Regarding this picture, only about 9% of the Caatinga biome is covered by Conservation Units, UCs, with approximately 2% being fully protected units, such as parks, biological reserves and ecological stations, since these are the most restrictive to human intervention.

Within the United Nations, in an international context, this biome Caatinga is directly related to two of the three main environmental conventions, which are the Convention on Biological Diversity (CBD), the Convention to Combat Desertification (CCD), and the Convention on Climate Change (CCC).

The mosaics observation, among other conservation tools, are part of a historical evolution in the conception of protected areas, which converges towards an integrated vision between environmental conservation and socio-cultural, political-economic issues on a bioregional scale, emphasizing more participative processes in society.

The mosaic concept is related to what is called the management of close or juxtaposed UCs, which aims to stimulate an integrated management of UCs, thus contributing to the preservation and conservation of natural resources, as well as to the sustainable development of the region, in line with the UCs' management bodies. There is no clear definition of this concept on an international level, with scientific texts describing landscape mosaics, ecological corridors, or landscape corridors. It can also be said that a UC mosaic is defined as a

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management model for protected areas, which seeks the participation, integration and involvement of unit managers and the local population in their management, all with the objective of making compatible the presence of biodiversity, the appreciation of social diversity and sustainable development in a regional context. Law 9985/2000, known as the Law of the National System of Conservation Units (SNUC), states that the institutes of environmental mosaics are inserted and affirmed in this law. Environmental science is made up of living components, including human and non-living components within the ecosphere, constituting an interdependent character (BRASIL, 2000). In this way, as all the elements of the ecological systems, composed of biotic, abiotic and anthropic means, are integrated within a geosystemic perception. In this context, this integrated management will assume an interdisciplinary profile, where the so-called primary objects of the natural sciences, consisting of forests, soils, water resources, air, seek the satisfaction of fundamental human needs.

According to the SNUC Law, the nearby, juxtaposed or overlapping UCs should be managed together, as a mosaic. Thus, there will be the need for the creation of a joint mosaic council. Taking into account that there is planning and management within an integration with the other UCs, the SNUC established a strengthening of the role of these units. Thus, significant and ecologically viable samples of different ecosystems, populations and habitats will be adequately represented in the national territory and jurisdictional waters. To this end, the SNUC is managed by the three spheres of government (federal, state and municipal) (BRASIL, 2000).

In Brazil, according to the SNUC, there has been an institutionalization and standardization of protected areas - the UCs (BRASIL, 2000). Thus, the establishment of UCs alone will not guarantee the preservation of an area, an ecosystem or a species (TOSSULINO et al., 2006). There is a need to improve conservation in existing UCs. Measures must be put into practice as a whole, so that a UC should contribute since its conception to the conservation of nature and, also, to produce expressive results and stability of these UCs (CAMPOS; COSTA FILHO, 2006).

Among the criteria that would be necessary for a UC to make a real contribution to conservation is the formation of mosaics of protected areas (DAVEY; PHILLIPS, 1998; BRASIL, 2000; PHILLIPS, 2002; THOMAS; MIDDLETON, 2003; BENNETT; MULONGOY, 2006). According to SNUC, a mosaic is an area formed by a group of UCs of different management categories or not, that are close, juxtaposed or overlapping and whose

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management must be done jointly, in order to make compatible, within a regional context, the conservation of biodiversity (BRASIL, 2000).

The study of landscape constitutes a science in which the elements of landscapes are treated, establishing itself as an important tool, assisting in the establishment of conservation priorities, in the definition of new areas of protection and in the management of protected areas (MILANO, 1990). This denomination "landscape" is made up of a series of concepts among different authors, with different approaches being attributed to it (BIONDI, 2005). The landscape, therefore, is a heterogeneous land area, possessing in its composition a grouping of ecosystems that are interconnected in a similar way.

Brazilian landscapes have shown the multiplicity of uses accumulated over time, often resulting in very heterogeneous landscapes and generating major conflicts between social actors (BRITO, 2003). These territories are relevant for environmental planning (POLETTE, 2003) because they are complex landscapes that are extremely fragile and should be strongly conserved but have numerous interests of human uses (SANTOS; CALDEYRO, 2007).

The matrix, fragments and corridors consist of three spatial elements in which a landscape is structured, forming mosaics responsible for a diversification of landscapes, presenting spatial models with different components, which are elements of the natural framework, such as relief, lithology, climate, soil, water, vegetation and fauna (FORMAN, 1995; MARENZI, 2000), all of the above-mentioned indications compose a negative consequence of anthropic action, that is, artificial components are inserted, arising from human influence (BIONDI; LEAL, 2002). According to the spatial patterns of the landscape, there is a discussion regarding the landscape ecology as better ways of planning conservation areas for the protection of biological diversity, with the aim of understanding the composition of the structure of landscapes in ecological processes (METZGER, 2003).

Thus, the different UCs composed of mosaics form landscapes that require analysis of the concepts mentioned and their structure translates the dynamics of land cover and occupation, essential to their conservation. The maintenance of protected areas can be evaluated through the structural elements of the landscapes, as well as the development of management plans and conservation strategies, considering the mosaics of UCs not in isolation, but within a UC approach.

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Heterogeneity, rarely discrete in a territory and arising from a wide range of habitats (LOVETT et al., 2005), can be analyzed through the diversity of types and configuration of elements that compose the landscape, the intensity of interaction between these elements and the nature of the relationship between elements (MIMRA, 1993). It can also be observed by different types of pressure on natural fragments (TURNER; CARDILLE, 2007), the porosity of the matrix (COUSON et al., 1999) or by connectivity between elements (LI; REYNOLDS, 1995; MCGARIGAL; MARKS, 1995). It is important to note that one cannot directly relate landscape complexity to the presence of impacts. De Pablo (2000) showed that certain landscape structures may or may not cause negative impacts, depending on the types and amounts of interactions between their elements.

In Brazil, the expansion of the System of Conservation Units (SUC) is worrying, and it is estimated that the natural areas will be exhausted in a few decades, making it essential to identify strategies, on a large scale, that help maintain the system of remaining areas in a scenario of increasing pressure. The knowledge gained from studies of ecology and landscape management (FONSECA et al., 1997) are the strategies indicated for the equation of the alterations that animal and vegetal communities go through.

The use of remote sensing and geographic information system techniques are important in the study of the landscape, mainly because of their accessibility and adaptability (FORMAN, 1995), thus providing the means for a quantitative analysis of landscape structure.

The objective of this work is to verify, from the analysis of the structural elements of the landscape, the matrix and the fragments, the spatial functionality of UCs of the biome of the Seridó Potiguar. In this sense, integrated management assumes an interdisciplinary profile, as it seeks to reconcile what has constituted the main object of the natural sciences with participatory processes of political decision making, through popular participation. In these processes of creating mosaics, the participants have encountered several problems and the mosaics run the risk of remaining only on paper and having the same fate as many UCs that are created but not implemented (TAMBELLINI, 2007).

Based on these contributions, the Seridó Potiguar Region was chosen as a possible location for the creation of a mosaic of protected areas. Therefore, the objective of this study is to propose the implementation of a mosaic in the biome of the Seridó Potiguar in Rio Grande do Norte, based on the experiences of other studies already done on the subject. This research

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is an effort towards the analysis of the process of implementation of mosaics in protected areas in Brazil, aiming to contribute to its effectiveness.

2 MATERIALS AND METHODS

Predictions based on space use theory, using theories about fragmented environments (which are endowed with perfect knowledge and/or perfect location about the state of the landscape, follow the assumptions based on empirical data about:

(a) the size of the conservation area;

(a) the area size of fragmented spaces.

The study of mosaics favors knowing the size of the distribution area by shallow cuts. Through this methodology it is possible to know the depletion and/or the rapid recovery of the protection scenario - APA or fragmentation by deforestation.

Since no information was available on the depletion rates of the Serido we used the mapbiomas satellite as a prediction of the degraded proportions (but < 1.0), which includes the approach of comparing regions of old forest and nearby young forest (a habitat type with lower or less predictable maximum prey densities).

2.1 RESEARCH LOCATION

The largest continuous remnant of the Caatinga biome in the Northeast is located in the south of the state of Rio Grande do Norte, constituting one of the nuclei in the process of intense desertification in Brazil.

Firstly, a bibliographical survey and a document analysis was carried out from different sources (scientific articles, theses, dissertations, official *websites*, laws, decrees, among others), serving as a subsidy for the feasibility of the proposal for the creation of the Mosaic of Conservation Units of the Serido Potiguar in the state of Rio Grande do Norte.

From this preliminary analysis one can see a lack of publications on the subject, where it was possible to see that most of the published works address issues such as organizational management (SILVA et al, 2021), legislation (MACHADO; COSTA; VILANI, 2012), Brazilian mosaics (MACIEL, 2007), ecological corridors (LINO; ALBUQUERQUE; DIAS,

2007) and PAs (BURKOWSKI; BOAS, 2014), but very few have addressed the mosaics of PAs and protected areas (CAMPOS, 2011; DE MELO; IRVING, 2014).

The Serido Potiguar is a geographical and cultural region belonging to the state of Rio Grande do Norte, as shown in Figure 1.

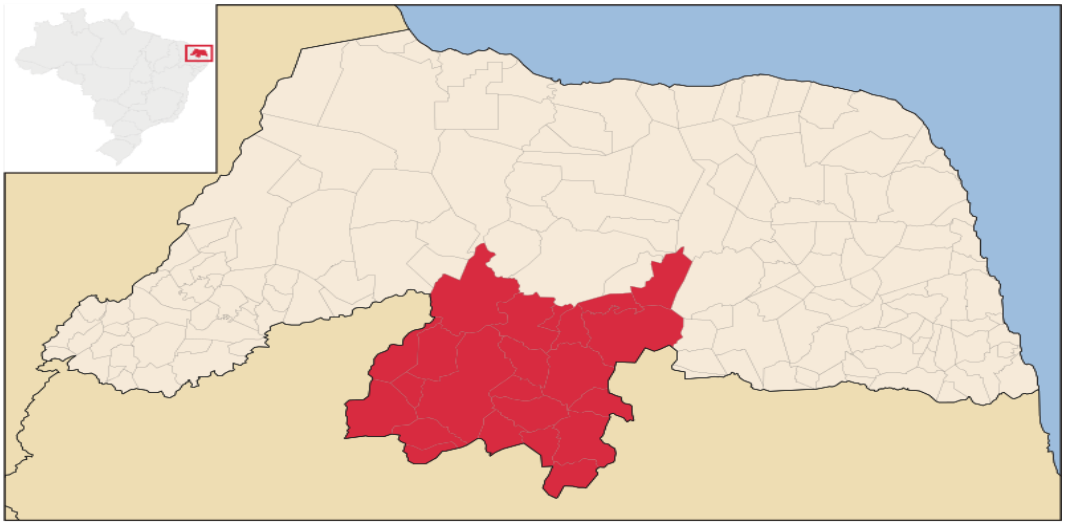

Figure 1 - Location of the Seridó Potiguar.
Source: IBGE, 2023.

Its territory covers the microregions of the Western Seridó, Eastern Seridó, and part of the Vale do Açu and Serra de Santana microregions[1] , as shown in Figure 2.

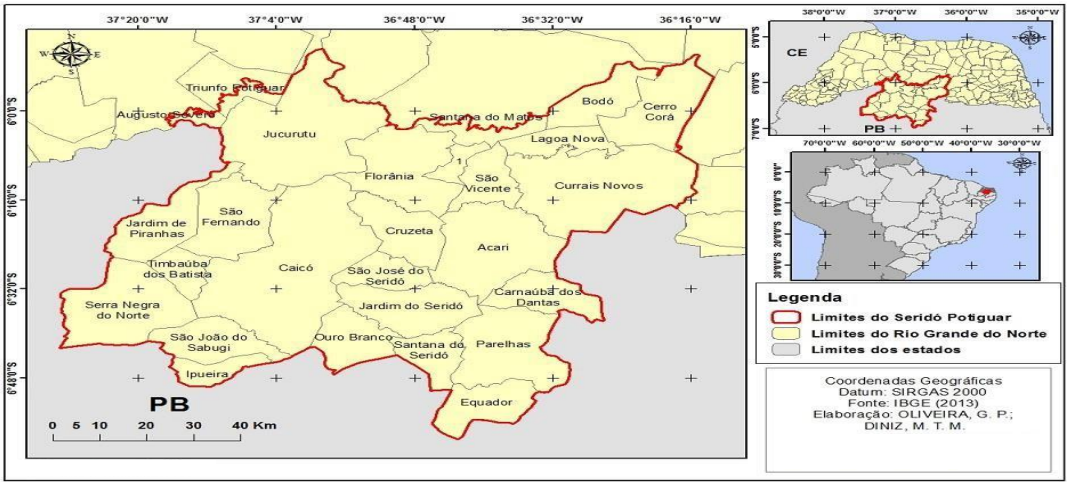

Figure 2 - Location of the Seridó Potiguar.
Source: IBGE (2013).

[1] Demarcation of the Seridó territory. Available at: http://sit.mda.gov.br/download/ptdrs/ptdrs_qua_territorio076.pdf. Accessed on: 16 mar. 2023.

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The region has unique cultural and geographic characteristics, when compared to other portions of the state, and it is very popular for tourism to enjoy the local cuisine, its cultural events and for the practice of extreme sports, and still presents the highest concentration of municipalities with high or medium-high Human Development Index (HDI) of the North and Northeast regions of the country[2] . Such characteristics were taken into account for the creation of the Geoparque Seridó, by the United Nations Educational, Scientific and Cultural Organization (UNESCO), which would reconcile development with environmental preservation and would have a significant impact on tourism[3] .

From the geological point of view, the Seridó Potiguar is located in the Borborema Province, Piranhas-Serido River Domain, being its western portion formed by a paleoproterozoic metamorphic basement corresponding to the Caicó Complex (orthogneisses and metavulcanosedimentary sequences), while in the eastern portion predominate supracrustal Neoproterozoic rocks of the Serido Group (gneisses, marbles, quartzites, schists, among others), also of metamorphic nature (ANGELIM; MEDEIROS; NESI, 2006).

> The Exposed Cristaline Shield corresponds to Proterozoic crystalline terrains, mostly metamorphic bands, involved in ancient orogenic events. It is the largest of the units that occur in the Seridó Potiguar. Inside this shield, a single Morphospheric Unit was discriminated, named Superfície ou Depressão Sertaneja. This is an immense peripheral depression derived from denudational processes, mainly pediplanation, which prevailed during the Quaternary (ANGELIM; MEDEIROS; NESI, 2006).

Based on the analysis of the geological information, planialtimetric and digital elevation models, three Morphostructural Units were identified in the Serido Potiguar, which are subdivided into four Morphosculptural Units. These last ones, in turn, are subdivided into six Morphostructural Subunits. These relief compartments and their respective nomenclatures can be seen in Figure 3.

[2] Atlas of HDI, 2013. Available at: http://atlasbrasil.org.br/2013/consulta/. Accessed on: 16 mar. 2023.
[3] See what to do in Geoparque Seridó (RN), recognized by Unesco | Metrópoles. Available at: https://www.metropoles.com/vida-e-estilo/turismo/veja-o-que-fazer-no-geoparque-serido-rn-reconhecido-pela-unesco. Access on: 16 mar. 2023.

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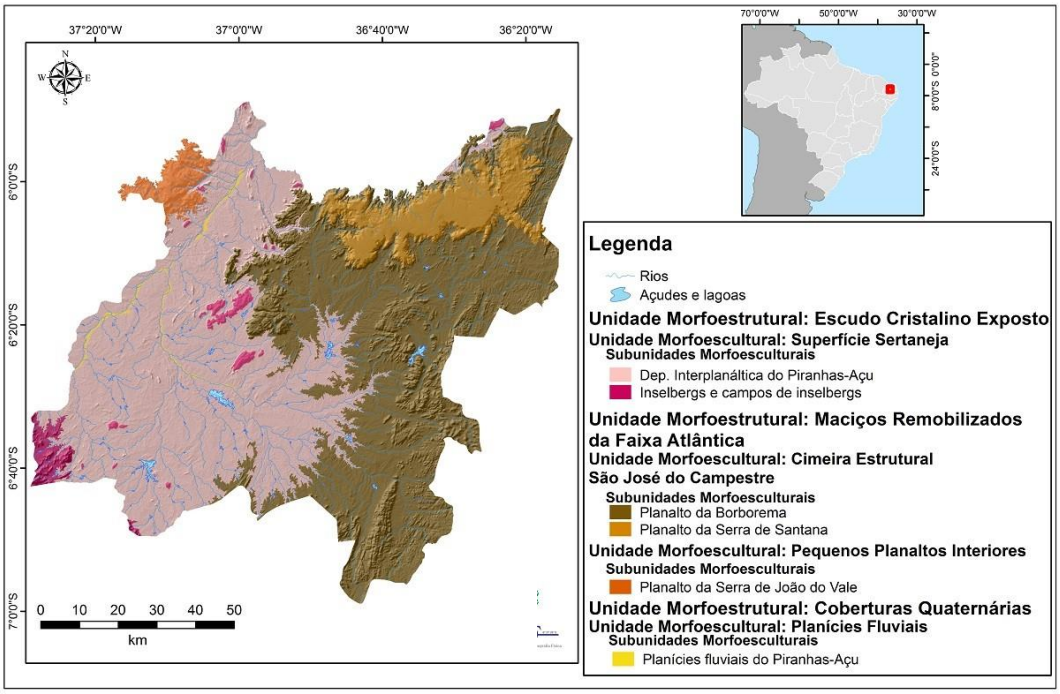

Figure 3 - Morphostructural and morphosculptural units of the Seridó Potiguar.
Source: Authors

The hydrographic region of the Eastern Northeast Atlantic has a huge range of small and medium-sized dams that are used to store water used in agriculture and for human consumption. The Serido River is a watercourse that bathes the states of Rio Grande do Norte and Paraíba. It is the main sub-basin of the Piranhas-Açu basin. The bordering areas of the basin are inserted in the geographical coordinates 6°02' to 6°58' South latitude and 36°15' to 37°17' West longitude. Its basin encompasses 17 municipalities. Its source is located at the foot of the Serra dos Cariris or Serra do Alagamar, in the Paraíba municipality of Cubati. Still in Paraíba, the Seridó River is dammed in the municipality of the same name and for a long time was the source of supply for the city of Saint Vicent of Serido. Soon after the flood season, when the river overflows the dam, natural pools are formed in the Serra Branca, which is located in the municipality of Serido, near the border between the municipalities of Pedra Lavrada and Parelhas. Afterwards, the river enters the Potiguar territory through the municipality of Parelhas, where it is dammed, forming the Boqueirão Dam. After that, its bed runs through the towns of Jardim do Seridó, São José do Seridó, Caicó and São Fernando, in the latter, about four leagues north of the town, the river flows into the Piranhas River. The Geomorphologic Map of the Rio Serido/PB Basin is identified through Figure 4.

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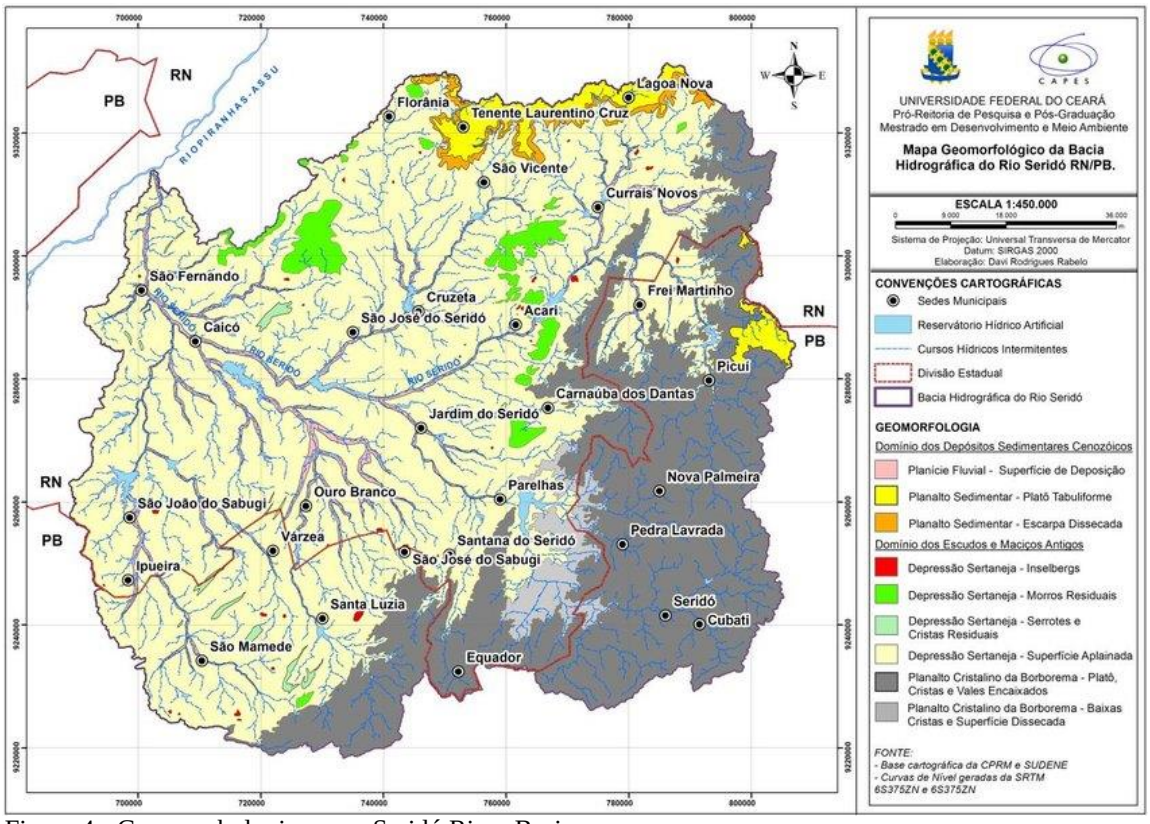

Figure 4 - Geomorphologic map - Seridó River Basin.
Source: Rabelo (2016).

With respect to climate, the region is divided into three homogeneous areas. The dry humid climate, or mild semi-arid extends from the municipality of Caicó to the municipality of Serra Negra do Norte, with precipitation ranging from 800 to 1000 mm per year and an average annual temperature of 27.5ºC. In the other region, the climate is medium semi-arid, with precipitation varying from 600 to 800 mm per year and an average temperature of 26ºC. In the other areas of the Oriental Serido, the climate is defined as rigorous semi-arid, with precipitation varying between 400 and 600 mm/year and milder temperatures due to the altitude, with temperatures that can reach a minimum of 10ºC in the winter and a maximum of 30ºC in the summer. Such characteristics are being taken into account for the creation of the Geopark Serido, by UNESCO, which would reconcile development with environmental preservation and would have a significant impact on tourism (SANTOS; GARCIA, 2017; IBGE, 2018; UNESCO, 2014).

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Taking into account the fragments and the matrix, as well as their attributes and their inter-relationships, the legal aspects of the total area of this UC, when analyzed, will make it possible to measure its functionality in the Caatinga biome of the Serido Potiguar.

3 RESULTS AND DISCUSSION

Protected areas protect natural resources that are essential to many people on Earth. Within these areas, the genetic diversity of the biome can evolve in response to natural selection pressures (MATOS; SERRA, 2020). Preserving natural areas offers many practical benefits. For example, natural areas contain the biological raw material needed to develop products that can greatly benefit human genetic health, diversity, and well-being (GRISE, 2013).

In addition, they provide safe havens for endangered species, store carbon, generate much of our clean air and water, shelter sites of cultural and spiritual importance, and sustain the livelihoods of millions of people. Protected areas have a critical role to play in addressing the global nature crisis (HONORA, 2018; DUARTE, 2012).

Rio Grande do Norte is one of the states that has not yet been contemplated with the *Rapid Assessment and Prioritization of Protected Area* Management (RAPPAM) method. Therefore, it is essential to apply RAPPAM to identify the weaknesses and strengths in the implementation of the Potiguar UC System. The weaknesses of the Potiguar UC System are reflected mainly in the lack of investment in human, financial and research resources, the lack of application of the principles of sustainability in the use of resources, and the little social and political commitment to maintain a system of connected protected areas. However, it finds potential at the moment when it has an operational planning, which covers social as well as economic and environmental values, which is optimized with the implementation of a good physical infrastructure of the UC, ease of communication between the different social actors involved in management and community participation represented by management councils (TEIXEIRA; VENTICINQUE, 2014).

Destruction and modification of habitats are inherent consequences of activities related to anthropic occupation (BURKOWSKI; BOAS, 2014). The results obtained indicate that areas subjected to anthropic activities, despite being disturbed, can be very important for the

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preservation of biomes (DOMENICO, 2008). Therefore, intensive field studies are fundamental, as well as the improvement and standardization of methods and techniques.

The mosaics should have the support of advisory councils, which should act as an instance of integrated management of the UCs. The strengthening of Ecological Corridors and the creation of Mosaics of CUs and protected areas were defined in the Strategic Planning of the Atlantic Forest Biosphere Reserve as a priority line of conservation, which presupposes the consolidation, strengthening and creation of CUs and their management instruments, in a vision of articulation between them and their surroundings (LINO; ALBUQUERQUE; DIAS, 2007).

Law No. 9.985 of 2000, known as the SNUC Law, is the legal instrument that provides for the implementation and management of UCs in Brazil, establishing the National System of UCs. According to this law, a UC is:

> Territorial space and its environmental resources, including jurisdictional waters, with relevant natural characteristics, legally established by the Public Power, with conservation objectives and defined limits, under a special administration regime, to which adequate protection guarantees apply (BRASIL, 2000).

Another positive factor with regard to the creation of the SNUC law is that it brought into the sphere of a single normative instrument practically all the dynamics of the creation and management of Conservation Units in Brazil. It is also worth noting that, despite the advances, some considerations must be made. Many specially protected territorial spaces, which are of utmost importance for the effective guarantee of the system's operation, are not mentioned in the SNUC, such as indigenous and quilombola lands, legal reserves, environmental protection areas (APAs), areas of special tourist interest, caves, among others (SCALCO; GONTIJO, 2009).

Discussions about environmental issues and the importance of preserving and conserving certain areas, increasingly frequent in various social spaces, highlight the exacerbated exploitation of natural resources as an activity that needs to be controlled (CAMPOS, 2011). Moreover, this type of knowledge could provide concrete information for the development of efficient conservationist measures.

According to Tambellini (2007), environmental governance is intrinsically linked to territorial planning and sustainable development issues. For the author, a differentiated development project for a given "place" or "region" triggers a new way of thinking about the appropriation of territory and its resources.

In this vision, we have that the rapid growth of human populations is causing great damage to the environment and, consequently, resulting in a considerable loss of biological diversity due to the irreversible extinction of species caused by the destruction of their natural habitats (CAMPOS, 2011).

Thus, it is urgent to create projects and programs aimed at reducing these impacts and environmental degradation, and the implementation of mosaics in UCs and protected areas is a good solution.

According to Figure 5, of land use and occupation extracted from Mapbiomas (2023), it is observed that this mosaic of vegetation and land use was still little explored, occupying a considerable percentage of dense and sparse vegetation in its space, with few areas of pasture.

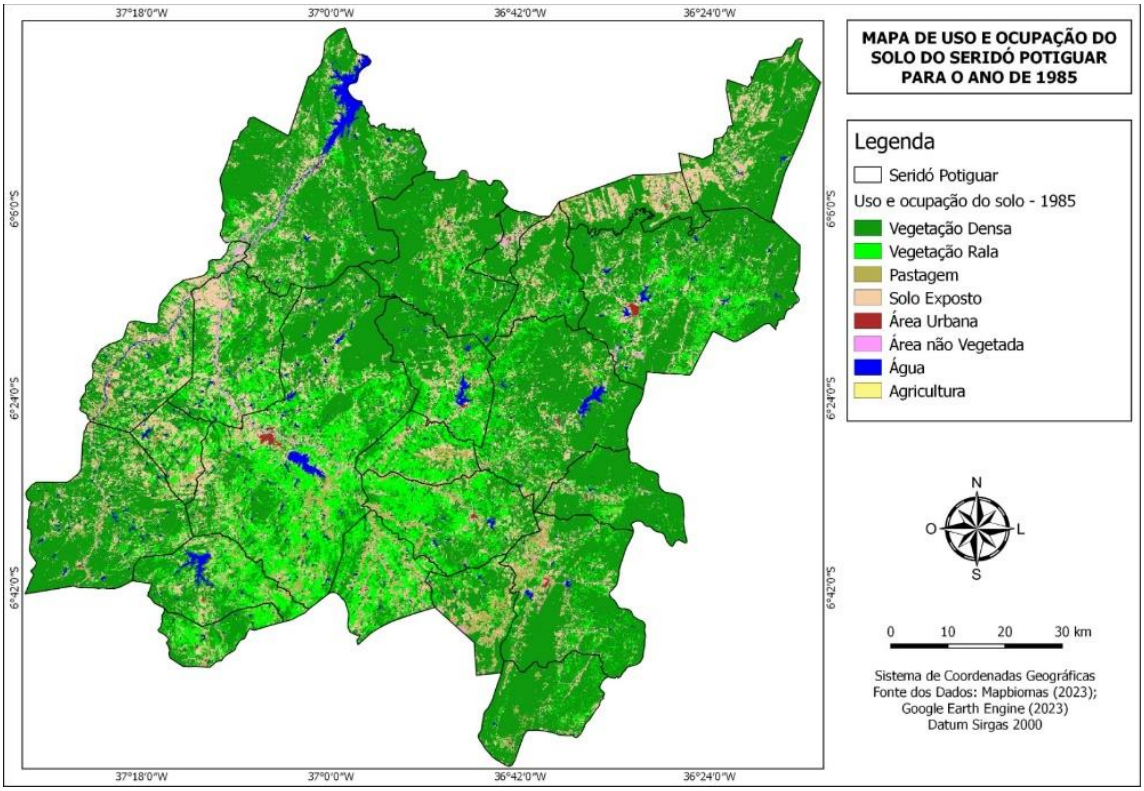

Figure 5 - Land use and occupation map of the Seridó Potiguar
Source: Authors from Mapbiomas (2023).

After a period of about 15 years, agricultural activities have intensified to the north of this region, especially near the Serra do Doutor, where edaphic conditions are more favorable for these activities, observing that there is already a decrease in the dense caatinga vegetation

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and a small increase in pastures, exposing the soil, with the introduction of small cattle ranches. These changes can be seen in Figure 6, below.

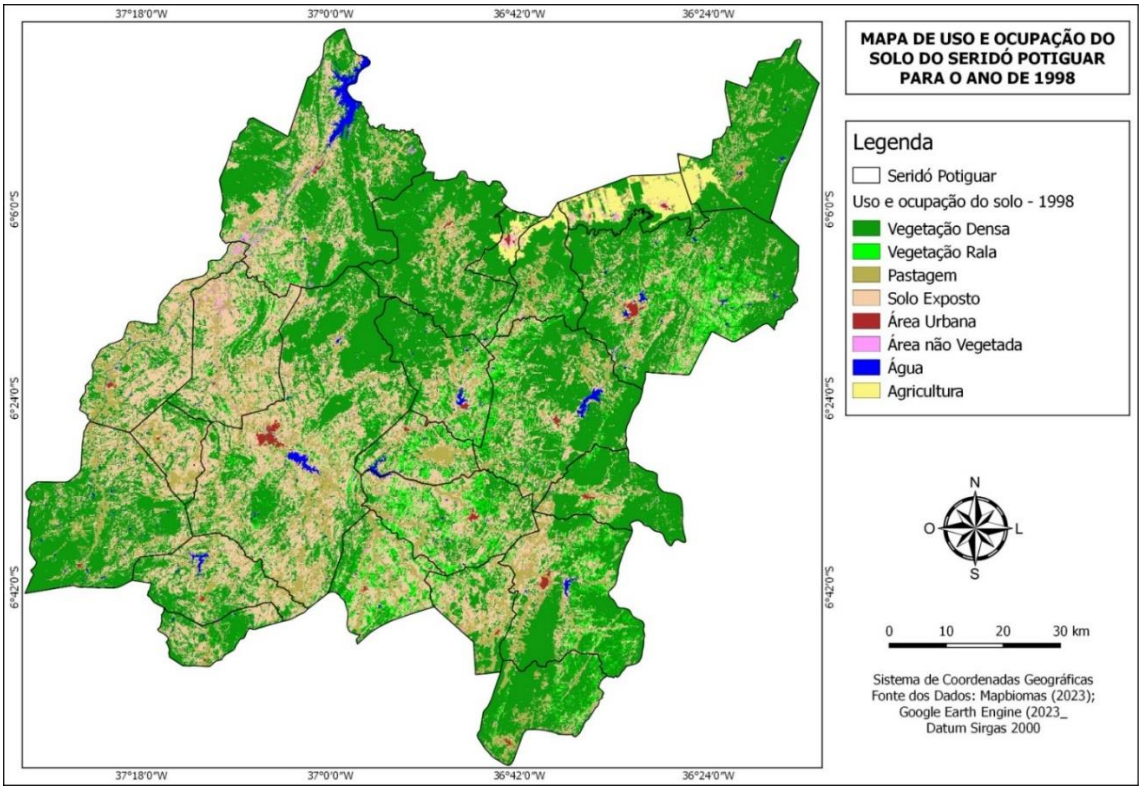

Figure 6 - Map of land use and occupation of the Seridó Potiguar - 1998.
Source: Authors from Mapbiomas (2023).

After more 15 years, it is observed that this space is already with significant alterations, pointing an increase of small agricultural and cattle raising activities, with a good part of its soil becoming bare, due, mainly, to the extraction of firewood to serve the ceramic activities and kaolin decantation furnaces, more specifically in the municipalities of Carnauba dos Dantas, Parelhas and Equador. The above-mentioned alterations are well defined in Figure 7, below.

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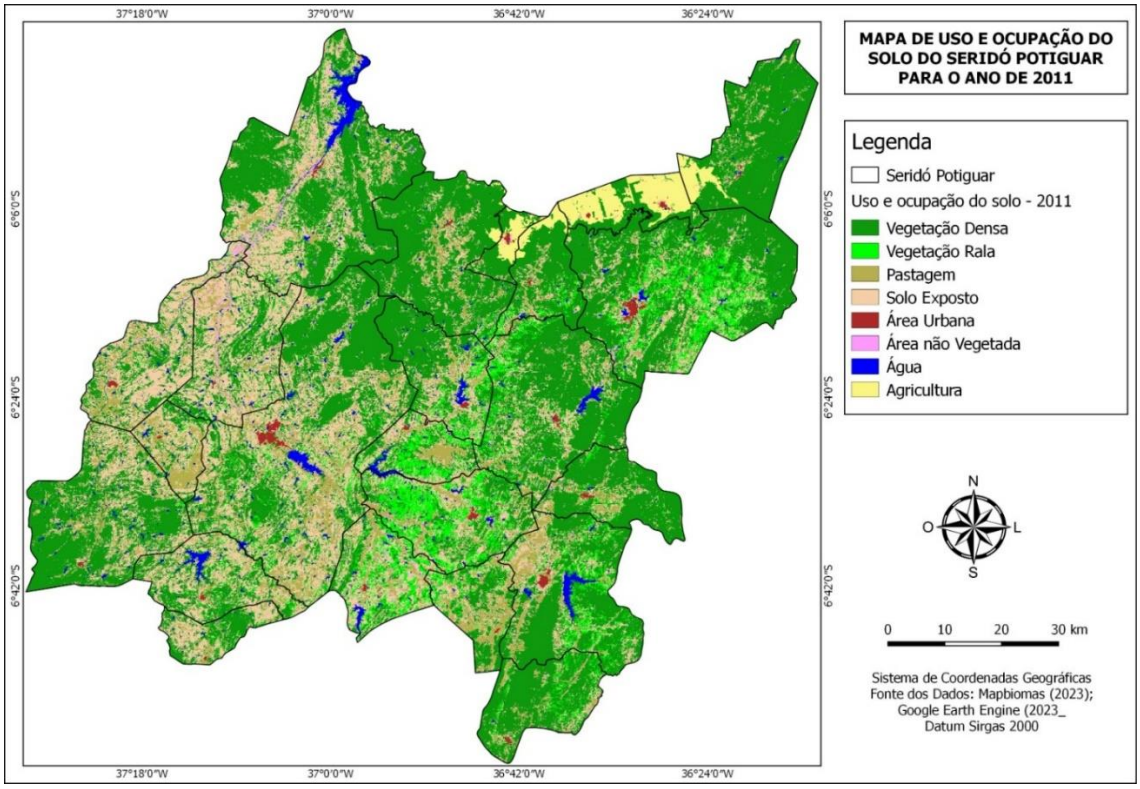

Figure 7 - Map of land use and occupation of the Seridó Potiguar - 2011.
Source: Authors from Mapbiomas (2023).

In 2021, this biome is already undergoing a significant change in almost all of its space, observing that, due to the expansion of agriculture, farming, and intensification of mineral extraction activities, this fragile Caatinga biome of the Seridó Potiguar has been suffering a significant impact on its natural framework, above all, becoming an intense nucleus in the desertification process, according to the United Nations Organization (UNO).

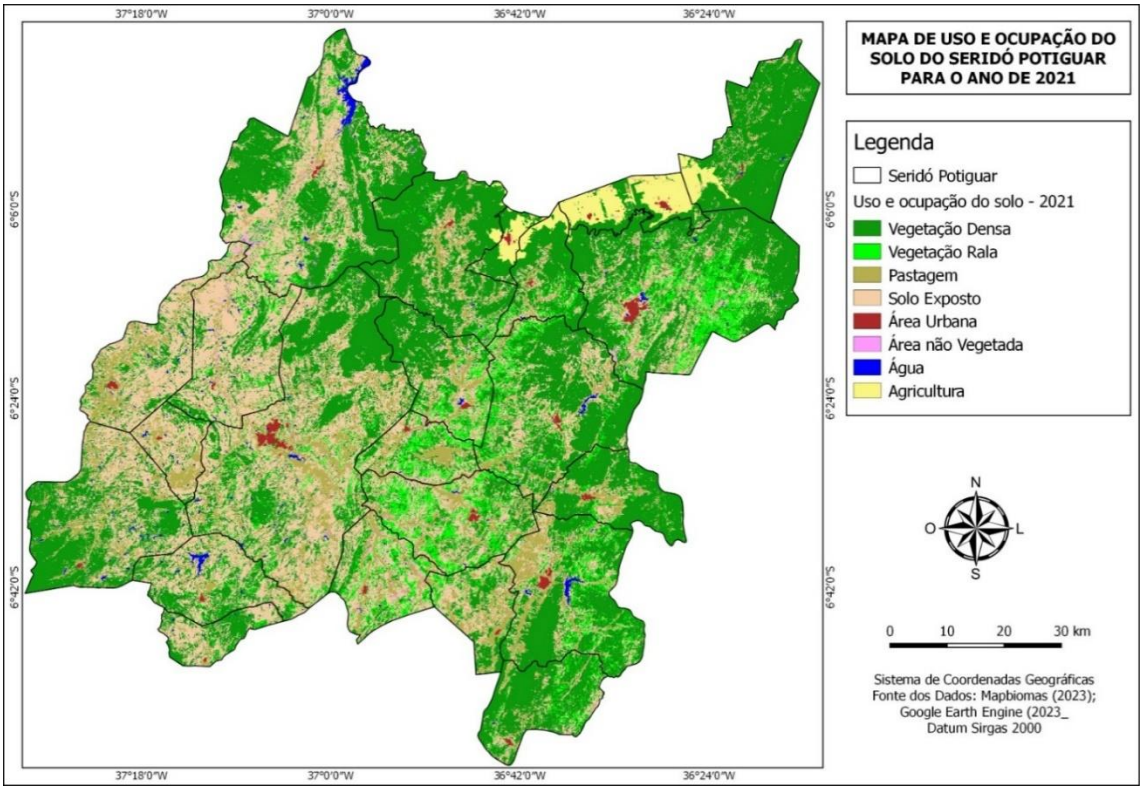

Figure 8 - Map of land use and occupation of the Seridó Potiguar - 2021.
Source: Authors from Mapbiomas (2023).

Rêgo (2012) attributes the beginning of discussions about desertification to three strands. First, in 1927, the Frenchman Louis Lavaudeu reported in an article the impoverishment of trees in southern Tunisia, stating that desertification was an anthropogenic process. Another Frenchman, André Aubréville, in his 1949 book "*Climats, Forêts et Desértification* de *l'Afrique tropicale*", characterized the substitution of tropical and subtropical forests by savannas, believing that the degradation process was the result of the predatory use of resources. The third strand credits North American studies on desertification, based on degradation processes that occurred in the Midwest of that country, as the origin of the debate on this issue. In this region, deforestation and the intensification of soil exploitation for agriculture and cattle-raising, aggravated by a strong drought between 1929 and 1932, would have caused the dust storm phenomenon known as the Dust *Bowl*.

Figure 9 shows the desertification centers of the Brazilian semi-arid region, in which the Serido Potiguar is inserted.

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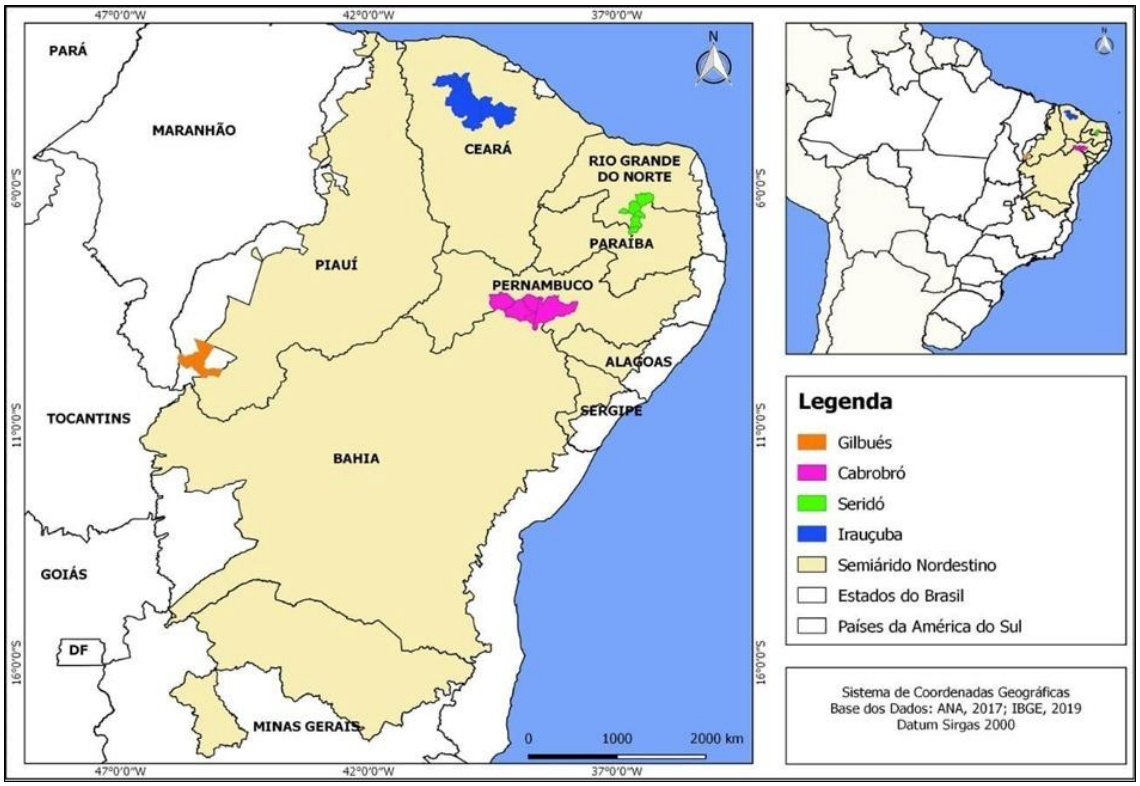

Figure 9 - Centers of desertification in the Brazilian semi-arid region.
Source: Silva (2017, p. 31).

3 FINAL CONSIDERATIONS

Participation and integrated management are considered sufficient to ensure preservation and conservation. What is needed to ensure integrated management in mosaics of protected areas? Is participation and integrated management sufficient to ensure the preservation/conservation of biodiversity in mosaics? The owners of the areas between UCs can have access to the management councils of the mosaics, but how to guarantee that they have effective participation? These are questions that are intended to be answered by a proposal for the implementation of a mosaic of CUs in the Serido Potiguar.

PAs or protected areas help mitigate extreme weather events, increase carbon storage, and provide space for plants and animals to adapt to a changing climate to maintain functioning ecosystems and the benefits they provide. Protected areas provide clean air and water, healthy soils, wild foods, and medicines.

However, to understand the landscape it is necessary to deal with large spatial and temporal scales, since man acts over large extensions of his territory. By analyzing these

interactive sets and their limits, it is possible to recognize the existence of a spatial dependence among the landscape units.

We conclude that, in order to make land use compatible with environmental, social and economic sustainability, it is necessary to plan the occupation and conservation of the landscape as a whole. To this end, the integrated way of viewing the landscape, as a mosaic, facilitates the understanding of the structural, and therefore functional, modifications brought about by man in the mosaic as a whole, explicitly incorporating all the complexity of the spatial interrelationships of its components, both natural and cultural.

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