MAPPING OF LANDSCAPE UNITS OF THE STATE OF RIO GRANDE DO NORTE, BRAZIL

MAPEAMENTO DAS UNIDADES DE PAISAGEM DO ESTADO DO RIO GRANDE DO NORTE, BRASIL

MAPEO DE LAS UNIDADES DE PAISAJE DEL ESTADO DE RIO GRANDE DO NORTE, BRASIL

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Abstract

The mapping of landscape units is fundamental for spatial planning, since this is the preliminary stage for the Ecological-Economic Zoning. The objective of this work was to map the landscape units on the scale of geocomplexes for the State of Rio Grande do Norte. The research was organized in the taxonomic system proposed by Bertrand (1972) and used by Ab'Sáber (2003) for the national territory and by Souza (2000) for the State of Ceará. The mapping was performed at a scale of 1: 250,000. Twenty geocomplexes, nine natural regions and two morphoclimatic domains were identified and mapped for the state of Rio Grande do Norte. It is hoped that this study will be used later as a basis for planning and planning of the territory.
Keywords: Landscape units, integrated landscape, geoenvironmental units.

Resumo

O mapeamento de unidades de paisagem é fundamental para o ordenamento do território, pois se trata de etapa preliminar para o zoneamento ecológico-econômico. O objetivo deste trabalho foi realizar o mapeamento das unidades de paisagem na escala dos geocomplexos para o estado do Rio Grande do Norte. A pesquisa foi organizada no sistema taxonômico proposto por Bertrand (1972) e utilizado por Ab'Sáber (2003) para o território nacional e por Souza (2000) para o estado do Ceará. O mapeamento foi realizado em escala de 1:250.000. Foram identificados e mapeados 20 geocomplexos, nove regiões naturais e dois domínios morfoclimáticos para o estado do Rio Grande do Norte. Espera-se que este estudo seja utilizado posteriormente como base para o planejamento e o ordenamento do território.
Palavras-chave: Unidades de paisagem, paisagem integrada, unidades geoambientais.

Resumen

El mapeamiento de unidades de paisaje es fundamental para el ordenamiento del territorio, pues se trata de etapa preliminar para la Zonificación Ecológico-Económica. El objetivo de este trabajo fue realizar el mapeo de las unidades de paisaje en la escala de los geocomplejos para el Estado de Rio Grande do Norte. La investigación fue organizada en el sistema taxonómico propuesto por Bertrand (1972) y utilizado por Ab'Sáber (2003) para el territorio nacional y por Souza (2000) para el Estado de CearáEl mapeo se realizó a una escala de 1: 250.000. Se identificaron y mapearon veinte geocomplejos, nueve regiones naturales y dos dominios morfoclimáticos para

el estado de Rio Grande do Norte. Se espera que este estudio sea utilizado posteriormente como base para la planificación y ordenación del territorio.
Palabras clave: Unidades de paisaje, paisaje integrado, unidades geoambientales.

Introduction

The compartmentalization of landscape units is part of studies on landscape dynamics, and is presented as an instrument of environmental and territorial planning based on techniques integrating environmental information.

The State of Rio Grande do Norte has a reference work based on the compartmentalization approach. This work is the result of technical work commissioned by the Institute for Sustainable Development and Environment (IDEMA). This work was carried out in 2006 with publication of a technical report this year (IDEMA, 2006) and later published in scientific / academic journals by Cestaro et al., (2007), the technical team that elaborated the map. This material refers to the mapping of geoenvironmental units of the aforementioned state. In Figure 1, it is possible to identify the mapping performed by IDEMA (2006).

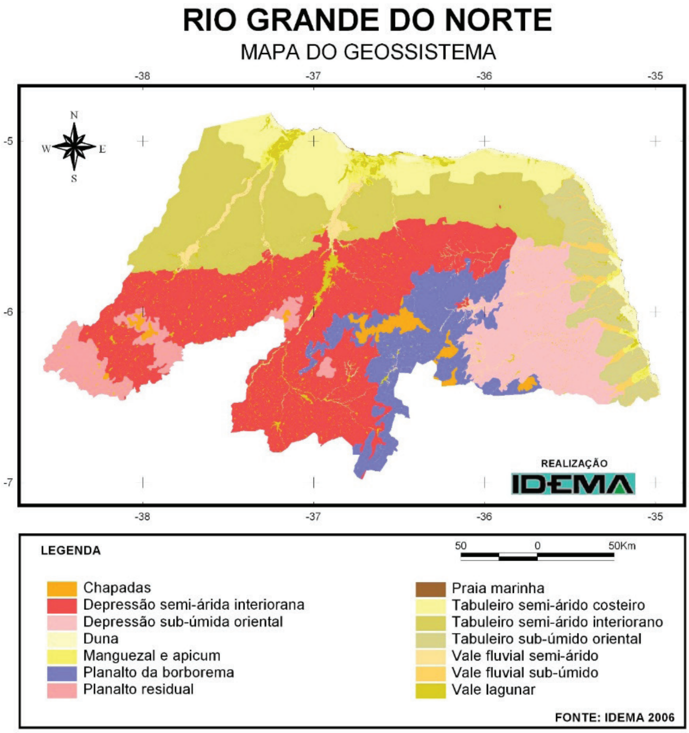


Figure 1 - Map of Rio Grande do Norte. Geosystem

Source: IDEMA, 2006.

Thus, considering that some specific points were not in agreement with the main reference works on the theme, this research aimed to update and improve, a decade later, the mapping developed by IDEMA (2006) and Cestaro et. al. (2007). In this sense, to guide the research that resulted in this article, the following assumptions were considered as advances in relation to the previous mapping:

1. To use the geosystem as a category of analysis and the geocomplex as a taxonomic unit as pointed out by BeroutchachvillI and Bertrand (1978);

2. To consider the existence of two morphoclimatic domains in the state, according to Ab'Sáber (2003) and not considered in the previous mapping;
3. To divide the morphoclimatic domains into natural regions, not previously presented;
4. To divide the natural regions into geocomplexes;
5. To resize some apparently overestimated units - such as the semiarid interior depression geosystem - subdivided them (into smaller geocomplexes); or grouping them into other units - as in the case of the mangrove and apicum geosystem (Cestaro et al., 2007; Figure 1);
6. To create an information database necessary for the subsequent ecological-economic zoning (EEZ) of the state, since it does not exist.

Thus, the aim of this work was to map landscape units of Rio Grande do Norte in the 1: 250,000 scale.

Methodology

The state of Rio Grande do Norte is located in extreme northeastern Brazil (Figure 2), approximately between coordinates 4° 50 'S and 6 ° 59' S; and 34 ° 58'W and 38 ° 34'W. It is one of the nine states in the northeastern region of Brazil and is limited to the west with Ceará, to the south with Paraíba and to the north and east with the Atlantic Ocean. In 2013, the estimated population for the state was 3,373,959 inhabitants (IBGE, 2013).

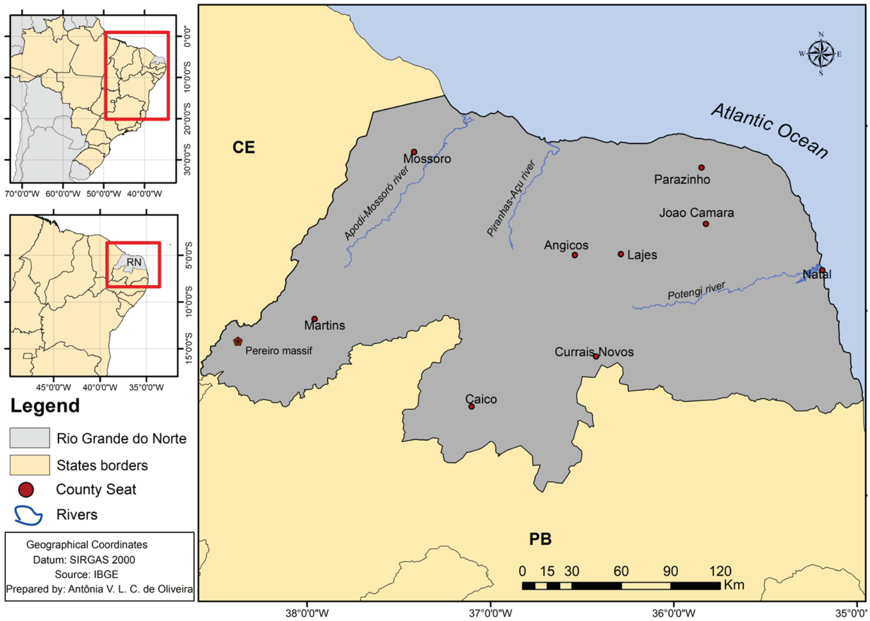


Figure 2 - Location map of the State of Rio Grande do Norte

Source: Elaborated by the authors (2018).

George Bertrand (1972) presented a reference text with great repercussion in Brazilian Geography, the work had as its major contribution the elaboration of a universal taxonomic system that allows classifying landscapes in the double perspective of space and time. The author points out that the notion of scale is inseparable from the study of landscapes, and uses the temporal-spatial scales of Cailleux and Tricart (1956) in their work methodology.

According to Bertrand (1972), in the delimitation of landscapes, the upper units are: zone, domain and natural region; and the lower ones are: geosystem, geofacies and geotope.

It should be noted that contrary to Bertrand's original conception, the idea of a geosystem is beyond a simple hierarchical level, a fact that had already been shown by V. Sochava (1977). Bertrand (Beroutchachvilli; Bertrand, 1978), in an attempt to create a consensus regarding the terminologies used by landscape scholars, admits that the most logical definition of geosystems is proposed by Sochava (1977), which defines geosystem, in the same way as the ecosystem, as an abstraction and category of analysis that is not only a mere arbitrary spatial scale, so that the geocomplex became a scale of geographic analysis and the geosystem the very concept base of its theory, that is, studies of global physical geography. It could be even inferred that the geosystem is for Global Physical Geography just as the ecosystem is for Ecology.

Thus, as a taxonomic level that could replace the geosystem nomenclature, the concept of geocomplex or geographic complex emerges, this is well defined in the temporal-spatial scale (4th and 5th magnitude). On this scale, the most interesting dialectical combinations for the geographer evolve (Bertrand, 1972), which are compatible with the human scale. Man, the ecological potential (abiotic factors: geomorphology, climate, hydrology) and biological exploration (biotic factors: vegetation, soil, fauna) produce the synthesis of the landscape dialectics.

The main criterion for the definition of geocomplex is the same one proposed by Bertrand (1972) for the definition of geosystem, that is, the vegetation. However, he reports that for some cases, the dominant element may turn out to be geomorphology. This criterion is widely adopted in the researches of Aziz Nacib Ab'Sáber (1969) and Marcos José Nogueira de Souza (2000), who use the hierarchy proposed by Bertrand (1972).

Souza (2000) was responsible for the delimitation of landscape units of the state of Ceará. The author considers the geomorphology more constant for the delimitation of environmental systems, since the Brazilian semiarid vegetation (the most populated in the world) has been, and still is, heavily altered by man. In turn, Ab'Sáber was Souza's advisor, and was concerned with the classification of landscapes at national level, proposing the Morphoclimatic and Phytogeographic Domains of Brazil in a series of works compiled in Ab'Sáber (2003). Both works had their mappings as references for this work.

The Bertrand's (1972) taxonomic system was used due to its universal application, so that it can be used for mapping landscape units across the globe according to the detailing scale chosen by the researcher. As already mentioned, the system considers from the largest to the smallest unit, proposed units Zone, Domain, Natural Region, Geocomplexes, Geofacies and Geotopes. This mapping was performed in the 1: 250,000 scale, advancing to the level of geocomplexes.

The morphoclimatic and phytogeographic domains pointed out by Ab'Sáber (2003) that occupy the territory of Rio Grande do Norte were mapped, as well as a transition area between these two domains, commonly known as *Agreste* (wild landscape). The Domain of semiarid intertidal depressions of northeastern Brazil (vegetated by *caatinga*) or Domain of *Caatinga* was mapped in shades of yellow, brown and gray and the Domain of the *Mares de Morros Florestados* or Domain of the Atlantic Forest had shades of green. These two domains were separated based on the average rainfall mapped by Diniz and Pereira (2015). The natural regions are divisions of these domains based on the geological units of Angelim, Medeiros and Nesi (2006) and on the morphoescultural domains of Diniz et. al. (2017).

The Atlantic Forest domain is located in the extreme eastern part of the state involved by the 1000 mm isohyet that practically coincides with the delimitation of the humid and semi-humid climate subtypes of the state. There is an area of transition from mild semi-arid climate (6 dry months) immediately to the west of the previous domain that was delimited between 800 and 1000 mm isohyets. The *Caatinga* Domain is positioned to the west of the transition area, under a semiarid climate that varies from mild (6 dry months) to strong (7 to 8 dry months), mostly within the 800 mm isohyet, except for higher areas of the western part of the state.

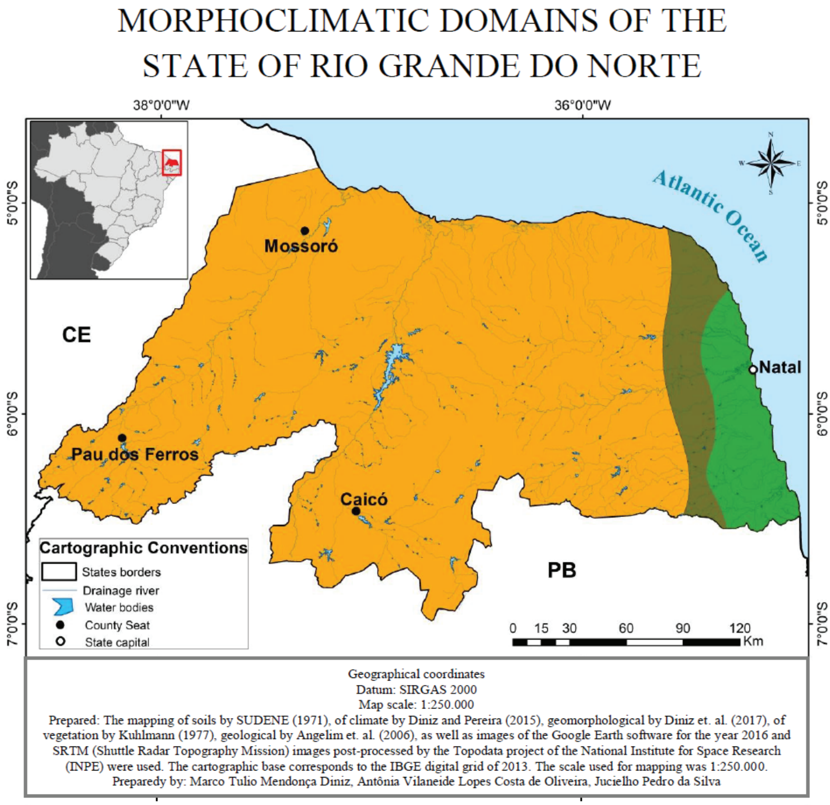
Average temperatures throughout the state have little variation, with values between 23ºC and 26ºC, since the longitudinal variation is minimal and the altitude exceeds 700m only in restricted areas, so the temperature is not a relevant component for the delimitation of Morphoclimatic Domains.

The mapping of soils by SUDENE (1971), of climate by Diniz and Pereira (2015), geomorphological by Diniz et. al. (2017), of vegetation by Kuhlmann (1977), geological by Angelim et. al. (2006), as well as images of the Google Earth software for the year 2016 and SRTM (Shuttle Radar Topography Mission) images post-processed by the Topodata project of the National Institute for Space Research (INPE) were used. The entire database was georeferenced in geographic coordinates in the SIRGAS Datum 2000. For mapping, ENVI 5.1 and ArcGIS 10.2 computer programs were used, both with academic licenses. Throughout the years 2016 and 2017, several field expeditions were carried out to validate the mapping, which was funded by the National Council for Scientific and Technological Development (CNPq).

Results and discussion

Morphoclimatic domains

Two morphoclimatic domains and a transition area identified by Ab'Sáber (2003) were delimited. The two domains were named by the author as Domain of the semiarid intertidal depressions of northeastern Brazil (vegetated by *caatinga*) or Domain of Caatingas and Domain of *Mares de Morros Florestados* or Domain of the Atlantic Forest (Figure 3).



Morphoclimatic Domains	
Domain of the semiarid intertidal depressions of northeastern Brazil (vegetated by *caatinga*)	
(Transition area)	
Domain of the Atlantic Forest	

Figure 3 - Morphoclimatic domains of the State of Rio Grande do Norte.

Source: Elaborated by the authors (2018).

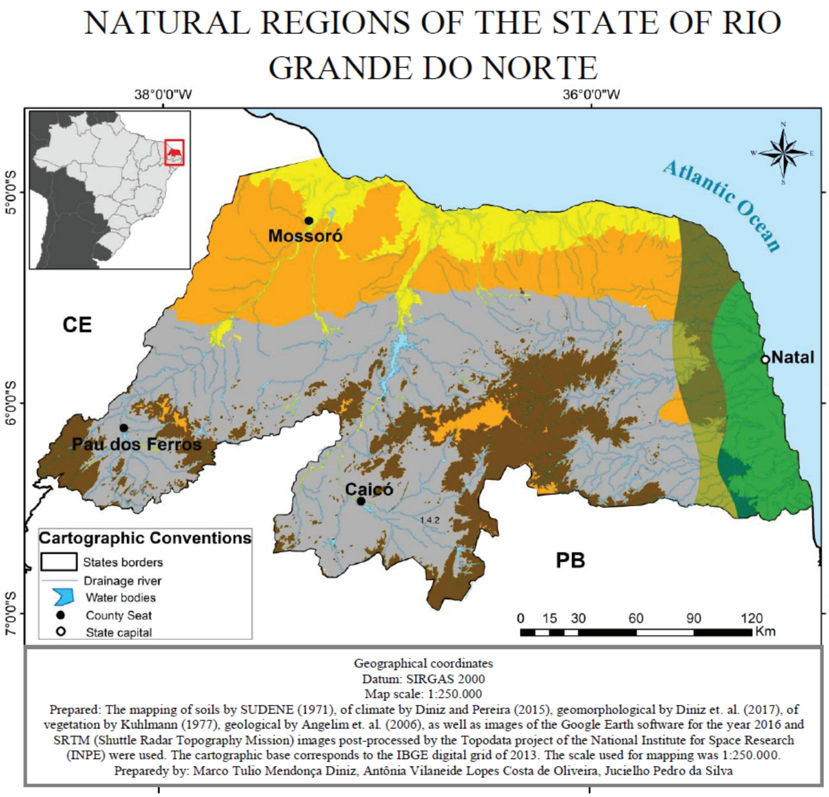
The Domain of the Atlantic Forest of Rio Grande do Norte is predominantly occupied by vegetation with marine influence (*restinga*), being restricted the occurrence of Dense Ombrophylous Forest (Rain Forest), which characterizes most of the Atlantic Forest Domain along the eastern coast of the country, there are also remnants of Semideciduous Seasonal Forest. There are areas with a certain predominance of Caatinga, especially in the proximities of the transition area, where characteristic species of Cerrados, Caatingas and Tropical Forests are mixed. The Domain of Caatingas is characterized by the predominance of the Steppe Savannah, except for higher areas where relics of the Semidecicual Forest occur.

Natural Regions

The state of Rio Grande do Norte has altogether 8 natural regions (Figure 4). At this taxonomic level, greater participation of the relief and the geological base in the delimitation of units was identified.

The Domain of Caatingas was subdivided into four natural regions: semiarid coastal tablelands and plains, sedimentary plateaus, crystalline plateaus and semiarid depressions.

Semiarid coastal tablelands and plains are areas that correspond to the extreme northern state, where, despite the predominance of sedimentary rocks, there are also several forms of young soils such as quartzarenic neosols, fluvic neosols and regolithic neosols, this high rate of renewal is due to the aggressiveness of the semiarid subtype Equatorial Zone tropical climate, which has in torrentiality and rainfall concentration some of its main characteristics. These are flat lands, in the form of a gentle slope from the interior to the coastline of about 50 m of altitude to quota 0 m next to the ocean.



Morphoclimatic Domain	Natural Regions	
Domain of the semiarid intertidal depressions of northeastern Brazil (vegetated by *caatinga*) (1)	Semiarid Coastal Tablelands and Plains (1.1)	
	Sedimentary Plateaus (1.2)	
	Crystalline Plateaus (1.3)	
	Semiarid Depressions (1.4)	
(Transition Area) (2)	Plains and Tablelands of Agreste (2.1)	
	Agreste Depression (2.2)	
Domain of the Atlantic Forest (3)	Humid and Semi-humid Sedimentary Plains and Plateaus (3.1)	
	Humid Depression (3.2)	

Figure 4 - Natural regions of the State of Rio Grande do Norte

Source: Elaborated by the authors (2018).

Sedimentary Plateaus: This natural region includes inner tableland areas and plateau areas of the semiarid climate of Rio Grande do Norte. Altitudes are variable, exceeding 700 m in plateaus areas overlapping the basement, which are landscapes that develop over the capping of the Serra do Martins formation above the crystalline basement. In these "serranas" areas of Rio Grande do Norte, average temperatures are milder, with annual averages of 23.2ºC in Martins, more than 3ºC less than Caicó (26.7ºC) located at 143 m above sea level in the *Piranhas Hinterland*. In addition to the mild temperature, precipitation is higher, with average of 1,106.8 mm / year in the same location (Diniz; Pereira, 2015), which provides the occurrence of relict of Seasonal Semideciduous Forest (Pluvial-Nebular Forest) in this plateau. In the rest of the area, vegetation varies according to climate, predominating Steppe Savannah (caatingas) in the strong semi-arid climate.

Crystalline Plateaus: this natural region is composed of the highest areas on the crystalline rocks in the state, ranging from about 200 m altitude at the foot of *Borborema* to 868 m at the west end, in the *Pereiro* massif. These terrains have characteristics that vary according to altitude and planimetry, in the more flattened areas, there are true suspended backlands, such as the Eastern *Seridó*, near *Currais Novos*, where the dominant human activities are the same as in *hinterland*, but in the steepest areas, the occupation is rarefied and there are true relics of arboreal *caatinga*, because it shows greater preservation of natural conditions. The climate is mild semiarid in the elevated areas of the western state and drier near the windward slope of *Borborema*.

Semiarid depressions: the natural region of the backlands of Rio Grande do Norte concentrates a large part of the population and until a few decades was the most important economic region of the state (Gomes, 1997; Diniz; Bernardino; Oliveira, 2015). Spatially, it is the most representative natural region. It is one of the core areas of the Domain of Caatingas, especially in *Seridó Hinterland*. The most striking characteristics of the domain are present in this area, as human occupation based on archaic agropastoral systems that have been degrading caatingas since the 18th century, resulting in the predominance of herbaceous vegetation with spaced shrubs such as the *Caatinga Seridó*, so called by Kuhlmann (1977). The climate is Equatorial Zone Tropical, which is milder (6 dry months), as far as it goes away from the windward slope of Borborema, where it reaches 9 dry months (Diniz; Pereira, 2015).

Plains and Tablelands of Agreste: This natural transition region had not been previously mapped. The region has characteristics common to both semiarid plains and coastal plains and to the humid and semi-humid sedimentary plains and plateaus.

Agreste Depression, also with transitory characteristics between Semiarid Depressions and Humid Depressions.

In the Domain of the Atlantic Forest, there are two natural regions:

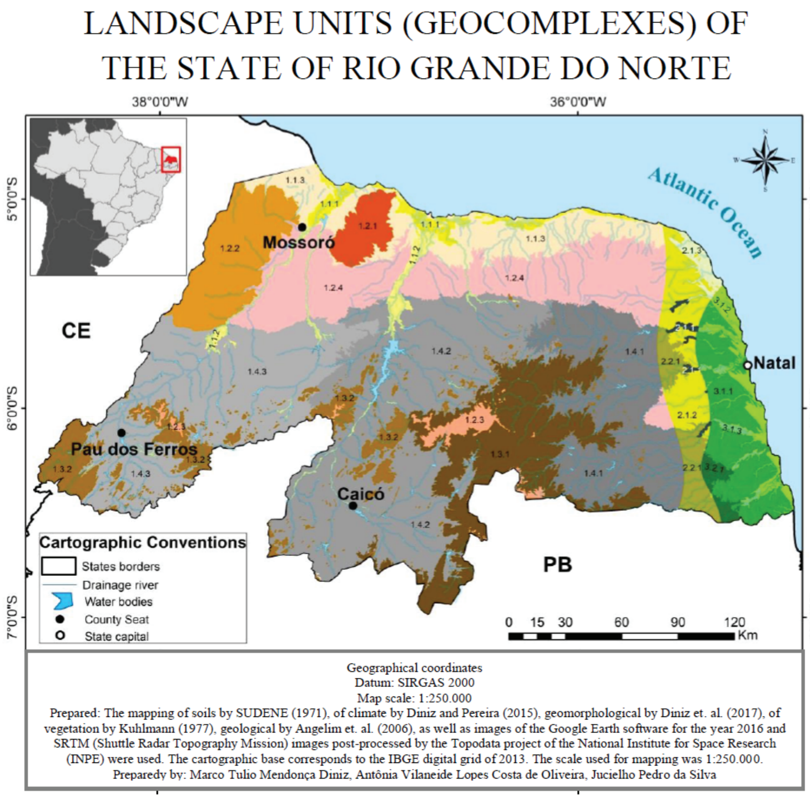
The Humid and Semi-humid Sedimentary Plains and Plateaus are positioned at the eastern end of the state. Its common characteristics is the presence of sedimentary terrains in climate that varies from humid to the east to sub-humid in contact with the *agreste*, which shows the strong influence of the marine climate in the eastern part of the state (Diniz; Pereira, 2015).

The natural *Humid Depression* region had not been previously mapped. It is an area of crystalline terrains in the southeastern part of the state with semi-humid climate (4 to 5 dry months).

Geocomplexes

The semiarid plains and coastal tablelands have three geocomplexes (Figure 5):

The **Semiarid Coastal Plain** is a subdivision of the "dune" unit of Cestaro et al. (2007). In this work, three coastal plains were considered, one semiarid, the other from the agreste and the other humid. The area is composed of sandy beaches with no soils. Quartzic nanosols occur in semi-fixed dunes of this geocomplex, and there are also extensive fluvial-marine plains. The largest estuarine area is the *Açú* delta, which has more than 220 km^2 (Diniz; Vasconcelos, 2017).



Morphoclimatic Domains	Natural Regions	Geocomplexes	
Domain of the semiarid intertidal depressions of northeastern Brazil (vegetated by caatinga) (1)	Semiarid Coastal Tablelands and Plains (1.1)	Semiarid Coastal Plain	(1.1.1)
		Semiarid Fluvial Plains	(1.1.2)
		Semiarid Coastal Tablelands	(1.1.3)
	Sedimentary Plateaus (1.2)	Serra do Mel Tableland	(1.2.1)
		Tableland Apodi	(1.2.2)
		Tablelands Overlapping the Basement	(1.2.3)
		Inner Tablelands	(1.2.4)
	Crystalline Plateaus (1.3)	Borborema Plateau	(1.3.1)
		Residual Crystalline Plateaus	(1.3.2)
	Semiarid Depressions (1.4)	Eastern Depression	(1.4.1)
		Piranhas Hinterland	(1.4.2)
		Apodi-Mossoró Hinterland	(1.4.3)
(Transition area) (2)	Plains and Tablelands of Agreste (2.1)	Fluvial Plains of Agreste Potiguar	(2.1.1)
		Agreste Potiguar Tablelands	(2.1.2)
		Agreste Potiguar Coastal Plain	(2.1.3)
	Agreste Depression (2.2)	Agreste Potiguar Depression	(2.2.1)
Domain of the Atlantic Forest (3)	Humid and Semi-humid Sedimentary Plains and Plateaus (3.1)	Humid Coastal Tablelands	(3.1.1)
		Humid Coastal Plains	(3.1.2)
		Humid Fluvial Plains	(3.1.3)
	Humid Depression (3.2)	Humid Depression	(3.2.1)

Figure 5 - Landscape units (geocomplexes) of the State of Rio Grande do Norte. Source: Prepared by the authors.

Source: Elaborated by the authors (2018).

The second geocomplex is the **Semiarid Fluvial Plains**, which is the junction of "lagunar valley" and "semiarid river valley" units of Cestaro et al. (2007), since it was considered that these plains have identical climate, soil and vegetation characteristics. They are originally colonized by a riparian forest where Carnaúba (*Copernicia prunifera*) was abundant and is still very present in the region, but nowadays Carnaúba crops are interspersed by floodplain crops in the area's fluvic neosols. These cultures have a major spatial separation framework in the Açu Valley. Upstream of the Armando Ribeiro Gonçalvez Dam, they are traditional and of rudimentary techniques, while at the downstream of this dam, activities are highly technified and carried out by transnational companies for the export of fruit products produced there.

The third geocomplex is that of the **Semiarid Coastal Tablelands**, which borders practically coincident with the "semiarid coastal tableland" of the previous classification (Cestaro et al., 2007), areas of gentle relief in the form of slope that inclines from 50 m above sea level to contact with the coastal plain, which is almost all in heights below 3 m. These are areas that have quartzarenic neosols in the more sandy facies of the *Barreiras* Formation; these soils are renewed by the climate torrentiality. In general, yellow and red-yellow latosols formed in past wet climates predominate.

These tablelands have scarce occupancy, since, except for the Apodi-Mossoró and Açú rivers, there is no other surface water source that sustains an expressive human occupation on the northern coast of the state.

The water source for the local populations are artesian wells, there are no cities with their exclusive territory in this geocomplex, except for Parazinho, a small town with little more than five thousand inhabitants, which is due to the almost absence of surface water.

Sedimentary plateaus have four geocomplexes (Figure 5):

The **Serra do Mel Tableland** that had not been mapped by Cestaro et al. (2007), is composed of the "semiarid coastal tableland" unit of these authors, it is a saline dome (Maia, 2012). In this area, the *Barreiras* Formation was elevated up to 280 m above sea level, would be suspended tablelands with the same red-yellow latosols and other similar geoenvironmental characteristics. Its distinction is due to the marked topographic difference.

The second geocomplex is the **Tableland Apodi**, which had not been mapped by Cestaro et al. (2007). It comprised the "semiarid interior tableland" of these authors in the form of a gentle slope that decreases from 270 to 40 m of altitude near the Apodi-Mossoró river valley, are tabular areas formed mainly by the Jandaíra limestone, with some capping of the Barreiras Formation where vertisols and cambisols occur (SUDENE, 1971). In these areas, there is irrigated fruit growing in medium-sized properties, mainly in the municipality of Baraúnas.

The third unit is the **Tablelands Overlapping the Basement**, with limits almost coincident with that of the "tablelands" unit of the previous mapping (Cestaro et al., 2007). These areas are called "serranas" in Rio Grande do Norte. These are the *Monte das Gameleiras*, *Serra de Santana*, *Serra de João do Vale* and *Serras de Portalegre* and *Martins* tablelands, the latter are more humid, since as identified by Diniz and Pereira (2015), the humidity in the inner areas of Rio Grande do North tends to be higher the more these areas are far from the windward slope of Borborema. Average annual temperature is around 23ºC, but it is common to lower below 20ºC on winter nights.

These plains are mainly composed of red-yellow latosols, such as those of the Barreiras Formation, but in these areas, semideciduous and deciduous forests predominate, different from steppe savannahs of the semiarid tablelands, due to the greater rainfall humidity and the fog itself, which allows naming these forests as pluvial-nebular.

The fourth geocomplex of this natural region is that of the **Inner Tablelands**, which have the same limits as the "semiarid inner tableland" unit (CESTARO et al., 2007), except for the **Tableland Apodi**, which had not been mapped. These tablelands are similar in shape to semiarid coastal tablelands, with tabular flattened areas sloping from 200 to about 50 m from south to north, as well as the semiarid coastal tablelands, presenting surface water in fluvial plain areas. The aggravating factor for these tablelands is that unlike the others, Jandaíra limestone predominates on the surface, a fairly soluble rock that does not accumulate water in subsurface, except in subterranean lakes. Thus, in addition to the absence of surface water, the subsurface is rare, which makes the occurrence of human populations difficult. Limestone is also responsible for the occurrence of vertisols, cambisols and argisols in this area.

The human occupation that deserves mention is the city of João Câmara, with a little more than 34 thousand inhabitants (IBGE, online, 2017), with economic dynamics more linked to the highway BR-406 that connects Natal to the salt producing region of Macau than to local productive activities. In addition, there are semi-desert cities such as the surroundings of Angicos and Lajes.

The crystalline Plateau region has two geocomplexes (Figure 5):

The **Borborema Plateau** (using the same name and practically the same limits of the CESTARO et al., 2007 mapping) and **Residual Crystalline Plateaus** (limits similar to those of the "residual plateau" unit of CESTARO et al., 2007), both of which are in semiarid climates that are more severe to the windward of Borborema and milder in the Pereiro Massif in the extreme west. These landscapes have at least two types of facies, one in areas most affected by secular livestock activity, and the inselbergs and montane scarp, where man has not yet interfered in the natural dynamics in a decisive way. The Gramineous-Woody Steppe Savannahs (shrub-herbaceous) colonize areas of chromic luvisols associated with litholic neosols in Borborema. In the western highlands of the state, red argisols that support Tree- Steppe Savannahs (shrub-trees) predominate. These western highlands have mild semiarid climate (6 dry months) in the highest areas (more than 500 m a.s.l.).

The region of semiarid depressions has three geocomplexes (Figure 5):

The **Eastern Depression** in the previous mapping (Cestaro et al., 2007) was called "Eastern sub-humid depression", and had its limits altered according to water dividers that drain the area and the sub-humid term was rejected because it is a semiarid climate. The area drains waters to rivers that flow into the eastern seaboard, and are drier the more distant from the Atlantic Ocean, since the effect of the sea is felt to areas 80 to 100 km away from the Atlantic Ocean. In this unit (Diniz; Pereira, 2015), lithoidal neosols occur at the foot of Borborema and planosols associated with chromic luvisols in less dry areas, more to the east.

The **Piranhas hinterlands** is parts of the "inner semiarid depression" of the previous mapping (Cestaro et al., 2007), is the depressed surfaces that drain waters for the Piranhas River and its tributaries such as the Seridó river, inner area of older occupation, which began even in the eighteenth century, and therefore, the most degraded portion of crystalline land in the state.

The climate is drier in these hinterlands near the windward slope of Borborema as in Acari and Parelhas, predominating Litololic neosols associated with spots of chromic luvisols in the less degraded areas, colonized by grassy-woody savannah, the Seridó Caatinga (Kuhlmann, 1977).

The **Apodi-Mossoró Hinterland** (another part of the "inner semiarid depression" of the previous mapping of Cestaro et al., (2007)) has more preserved soils, with large areas of red argisols associated with chromic luvisols, and profiles of more than 2 m in depth are often found. The surface drainage in the Upper West of the state (most southwestern part of the territory) is basically of high river flow, where declivities are larger. There are *Hinterlands* at 400 m of altitude, reason why the availability for dam is more restricted, which would probably have been the factor responsible for the greater conservation of these lands.

The three geocomplexes have intense surface runoff when torrential rains of the rainy season occur, due to the presence of soil of B horizon textural or even rocky outcrops that are naturally impermeable, favoring this flow.

For the *agreste* plains and tablelands, three geocomplexes, previously unmapped to this transition area between the two large morphoclimatic domains of the state (Figure 5) were proposed, since the transition area between the two morphoclimatic domains was delimited for the first time on this occasion:

The **Fluvial Plains of Agreste Potiguar** is area widely used by human activity. The Ceará-Mirim and Potengi plains are the most expressive, yet much lower in extent compared to the *sertão* plains. Throughout the occupation of Rio Grande do Norte, the *agreste* has been dedicated to food production, with areas of crops such as cassava, corn and beans.

The **Agreste Potiguar Tablelands** have basically the same human activities performed in the previous unit. Latosols are associated to quartzarenic neosols, which evolved over the Barreiras Formation and are colonized by grassy-woody, grassy savannah with deciduous forests, a typical combination of these transition areas. The secular agriculture practiced is of low production.

The **Agreste Potiguar Coastal Plain** is located in the extreme northeastern portion of the state, has extensive dune fields formed by the constant trade winds from the southeast. The mild semiarid climate of this area favors the intense wind transport, since the sediments of the post-beach area have less cohesion during the six months of dry season. The semi-fixed dunes present vegetation of young restingas on quartzarenic neosols, the rest of the area has absence of soils and vegetation. They are landscapes dominated by the activity of wind transport and the action of waves and tides, therefore, very unstable.

The natural region of the Agreste Depression has only one geocomplex, the **agreste potiguar depression** (Figure 5), a landscape also dedicated to extensive livestock and food polyculture in the planosolos that predominate in the area (SUDENE, 1971). This difference to the other agreste geocomplexes occurs in the crystalline geological basement and in the soil type (planosols) differentiated thanks to this basement, since the climate is Tropical of the Eastern Northeastern region, semiarid subtype mild (6 dry months). The human occupation is also similar to the other *agreste* geocomplexes.

The natural region of the humid and semi-humid plains and sedimentary plateaus presents three geocomplexes (Figure 5):

The **Humid Coastal Tablelands** are a redefinition of the limits of the “eastern sub-humid tableland” of the previous mapping (CESTARO et al., 2007), mainly according to climate aspects. They are areas of the Barreiras Formation in humid and semi-humid climate. To the north of the Ceará-Mirim River, it has tabular form and is defined as dissected tablelands to the south of this river. Soils vary from Red-Yellow Oxisols in the most western part to Red-Yellow Argisols in the more humid areas to the south, where Semi-deciduous Forest very degraded by the centuries-old sugarcane activity occurs. Quartz-like neosols occur in the sandiest facies, which are found in paleodunes in the northernmost part, colonized by savannahs (SUDENE, 1971).

The **Humid Coastal Plains** are part of the “dune” and “mangrove and apicum” units of the previous mapping. They belong to the Mixed Coast of Dunes and Cliffs in the compartmentalization of the northeastern coast of Brazil (Diniz; Oliveira, 2016), so that in the area, these plains are formed by dunes interspersed by cliffs. Dunes migrate to the northwest, loaded by the constant trade winds coming from the southeast, which vary from moving as in Genipabu to fixed as in Natal.

The **humid fluvial plains**, formerly known as the “sub-humid river valley” (Cestaro et al., 2007), are areas similar to the fluvial plains of the agreste, with small spatial expression, but important in sugarcane production, where the fluvial neosols had almost all vegetation replaced by agriculture.

The natural region of Humid Depressions had not been previously mapped and has only one geocomplex, the **Humid Depression** (Figure 5), an area of crystalline terrain, to the southeast of the state with semi-humid climate. It has the same planosolos of the agreste depression and is also an extensive agricultural area.

Concluding remarks

In this work, the landscapes of the state of Rio Grande do Norte in the 1: 250.000 scale were delimited, this study should serve as a basis for the planning and ordering of the state territory. It is hoped that this may be the initial step towards the Geo-Environmental and Ecological-Economic Zoning of the state (EEZ).

The twenty geocomplexes, eight natural regions and two morphoclimatic domains show the great diversity of landscapes in one of the smallest units of the Federation. This is due to its position in the extreme Northeastern boundary of the South American continent, which gives it the occurrence of two quite distinct climatic types in a contiguous area, part more influenced by climates that dominate the Semiarid Brazilian Coast (Northern of the Northeastern region) and those that dominate the Reef Coast (Eastern of the Northeastern region).

Another decisive feature for this landscape diversity is the occurrence of two geological provinces, Borborema and Bacias Marginais. The changes of altitude and erosive and depositional processes are also responsible for landscape variations, which in turn have different vegetative groups as a response to the interaction of the aforementioned elements.

Human occupation is also diverse, largely adapting to natural conditions, since most human activities are of poor technical development over much of the state's territory.

This research is expected to unify a taxonomic system, which in turn create a hierarchy of geoenvironmental units of the state and neighboring states, since this mapping has boundaries coinciding with the units of Souza (2000) in the areas bordering on the state of Ceará. The creation of this hierarchical system in different scales is intended to serve as a basis for the various large-scale cartographic surveys.

Acknowledgments

The authors would like to thank CNPq for the funding of this research through CNPq / MCTI Call No. 25/2015 Humanities, Social and Applied Social Sciences. They are also grateful for the reading and suggestions of Professor Luiz Antônio Cestaro from UFRN.

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The Authors' contributions

The two authors contributed jointly to the development of the research. The author Marco Túlio Mendonça Diniz was the idealizer of the research project that resulted in this article. His contributions were of the scientific and intellectual order, besides cartographic base survey, field work, structuring and textual revision. For the author Antônia Vilaneide Lopes Costa de Oliveira, it was the task of contributing to the scientific and intellectual discussions, mapping the landscape units, structuring and revising the presented text.

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Received for publication on 21 April 2018
Accepted for publication on 29 May, 2018