

Multiple data available to analyze the urbanization phenomenon in temporal and spatial scales

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Abstract. The purpose of this work is to analyze the dynamics of the land use to understand the reduction of natural and anthropic natural areas through urbanization for 60 years in the Região dos Lagos of Rio de Janeiro State, Brazil. It focuses on spatial analysis to generate hypotheses that determine the choices for localization of the residential lot subdivisions and then decide whether to promote or not, the urbanization around them. Two processes of the phenomena are in question: urban sprawl and densification. They lead to consumption of natural and anthropic natural areas at the regional scale, passing through the municipal one. The urban scale, with the most concrete example of Araruama city, will be analyzed as well to present the characteristics, in terms of density, of some residential lot subdivisions. These processes highlight the sustainability of the natural and anthropic natural areas in a region where the single-family housing for a temporary use is predominant. For centuries, natural resources are exploited for human consumption. However, their reduction is due to the space production in different dimensions: economic, social and cultural.

The main discussion is about the use of the cartography to represent the phenomena of urbanization through 60 years. The available sources to compose this representation were from various institutions, which made it difficult to calculate accurately the reduction of natural and anthropic natural areas. The understanding of urban sprawl and the densification phenomena was possible through spatial and historical comparisons.

Keywords: Urbanization, Dispersion, Densification

1. Introduction

The spreading at high speed of technical innovations twenty years after Second World War were increased two times faster than those introduced after the First World War and three times faster than those introduced between 1890 and 1919 (Santos 2006). The XX century is a step forward with the past, in reason to the world urbanization process (McNeill 2000), consolidated in the XXI century (Madden 2012). Humanity has modified its environment everywhere through cities and its impact has reached beyond the boundaries.

Several authors (McNeill 2000, Clark 2003, Spencer 2015) cite the population growth role on these changes. Urbanization is among some authors as the increase of the population proportion living in cities and villages. According to Clark (2003), the urbanization measure the passage of human settlement spreading to another one where the population is concentrated at urban centers. For him, urbanization has a beginning and an end, which it is very questionable from the point of view of the urbanization evolution characteristics. Known rather as a process, urbanization denotes an evolution, a transition from a period to another, but never a finished stage. Even in urbanized zones, urbanization can be retroactive. However, it depends on the meaning of this “retrocession” in relation to urbanization phenomenon.

So, urbanization appears as a phenomenon that modifies environmental aspects before in balance with humans. The imbalance, by which these relationships have passed since the history of societies, shows that the urbanization is the mode of change more damaging the nature. As the urban extension, as the densification, will be two categories of urbanization process, which impacts natural and anthropic-naturals areas of several cities.

George and Verger (2004) on their dictionaries of geography, sustain that urbanization is, “in a strict way, the development cities process, in a number of inhabitants, in territorial extension and in terms of lifestyle. The increasing concentration of population in cities have been reinforced the main urbanization form in the past (densification, filling of the built framework)”. The idea of urban densification appears as part of urbanization phenomenon.

They affirm the existence of a relation between the sprawling of urbanized zones and the land use in terms of space consummation: “urbanization, as urbanized areas extension, include many aspects of land use and space consummation: settlements development, the implementation of urban equipment (commercial, public, leisure, circulation), and wastelands awaiting an urban assignment” (p.435).

Lussault and Levy (2003), define urbanization as «a population concentration process and its economic activities in urban zones”. This definition is too general and it can undertake different conceptions according to the definition of “urban zones”. Each country has its own definitions that can be related either to the number of inhabitants, or to functional and administrative criteria, or to the three merged.

In Europe, the criteria concerns the base unity, the limits of population, the functional and economics criteria, the administrative statement and the urban region (Houillon et al. 2001). For example, in France, the urban unity represents the whole of settlements grouping at least 2000 inhabitants, so that the dwellings are not isolated from the nearest of over 200 meters; in Denmark, the urban agglomeration represents the urban unity as the whole of dwellings separated at least 200 meters and with 200 inhabitants (Houillon et al. 2001). Therefore, the analysis can be different as well, according to the criteria adopted.

The rural and urban definition, of dwellings and population, were considered in a different way in Brazilian census. In 1940 and 1950, IBGE defined as urban the population living in municipalities or districts, regardless of the size of its population or other characteristics. However, this criteria has some problems as it allows the inclusion, at the whole of cities and villages (urban zones), of insignificant urban cores. In 1991 and 2000, there are new criteria, and the census sectors were classified in two groups and seven sub-groups:

Urban status: it is the internal zone of the legal urban perimeter, divided in three sub-groups:

- Urbanized zones corresponding to the cities (municipal seats);
- Non urbanized zones corresponding to the cities (municipal seats);
- Villages, districts or isolated urban zones.

Rural Status: it is the external zone of the legal urban perimeter, divided in four sub-groups:

- Rural agglomerations characterized as urban extension;
- Isolated rural agglomerations forming little rural settlements;
- Isolated rural agglomerations forming rural cores;
- Other types of isolated rural agglomerations.

According to Dorier-Apprill (2001), in spite of the urban term is neutral and general, it is used to define the urbanization phenomenon and the national definitions are different according to the criteria. A phenomenon which is associated to the changes over humanity development in terms of the relationships between the city and the environment, between man and nature, culture and nature, society and nature.

Pumain (2006) defines urbanization as a transition from a structure to another: from the rural one, its little cores dispersed and homogeneous in dimension, which transformed itself in an urban one, concentrated and hierarchical, formed by cities. Urbanization as a changing process from agricultural economies to industrial ones has a relationship between men and nature, modified by society itself. The economic activities, which found the urbanization, represent the passage from agriculture to industrialization, which characterized the world-urbanized societies. At the same time that this transition is historical, it is spatial, where the city is the main form of living.

Gauthiez (2003) explores the idea of an extension of the agglomerations, with previous planning or not, establishing new buildings and new infrastructures. The urbanization is, for him, measured by the quantity of utilized space for new planning in different periods. Therefore, urbanization presents an approach associated to the space transformation whose consummation is unavoidable.

The notion of urban extension can be associated to dispersed urbanization for the space consummation understanding. This notion, adopted by Barattucci (2004) characterizes the discontinuity and the fragmentation of built areas: "the wide dispersion of built areas defines morphologically these urbanizations" (p.39). According to her, the main characteristic of these dispersed urbanizations is the predominance of individual houses "lived depending on the different ways of life and urban practices of European cities concentrated, and so the practices historically associated to rural world as well" (p.39).

In Brazil, according to Limonad (2006), urban dispersion assume different forms in terms of its spatial localization: either in metropolitan peripheral zones, through the multiplication dispersed of little urban agglomerations in employment areas, either in industrial clusters, of services or touristic ones, accompanied by *condominios* or *mega-condominios*, outside urban zones.

Studies about dispersed urbanization in Brazil are large, and they define it as: the territorial planning in benefit of the right to the city (Limonad 2006); the urbanization extensive with an environmental approach (Monte-Mór 1996); its conceptualization for urban phenomenon understanding and the urban, regional and environmental planning (Ojima 2008). They use expressions such as "extensive urbanization", "urban dispersion", "urban sprawl" and "urban extension" to explain the social and urban production process. In most cases, the motivation of these processes is the industrial deconcentration in the periphery.

Studies also reveal the characteristics of space consummation of this phenomenon. Monte-Mor (1996) reports that there is a disproportionate use of human and natural resources and its intense destruction because of consumption patterns, logic of industrial production, and its environmental impacts. He combines industrial development and its social and spatial models of production to the problems of extensive urbanization in peripheral zones. He points out that there are many reflections at agglomeration and metropolitan scale and not too much about cities and urban spaces, whose relations between city and countryside, city and region are sparsely studied.

2. The Região dos Lagos context

The Watershed Região dos Lagos São João is the reference area of study about this phenomenon. Better known as Região dos Lagos, six towns cover the entire study zone - Saquarema, Araruama, Iguaba Grande, São Pedro da Aldeia, Cabo Frio and Arraial do Cabo. The municipality of Araruama will be the case study on the phenomenon of urban densification, mainly horizontal one.

Four centuries of human occupation and natural resources exploitation have highlighted the destruction of the natural environment, according to the economic cycles of production. The production of citrus, sugar cane, rice cultivation and livestock have changed the land use of the region. Since the last decades, there is a massive occupation by allotments with a primary sanitation system, which put in evidence the reduction of natural and anthropic-natural zones.

The region had at about 70% of forests nearest 1500 year. The flooded fields and wetlands on the flooded alluvial plain, sandbanks (*restinga*) and steppes occupied the remaining 30% (CILSJ 2006). European and the natives have been exploited the forests for wood. *Pau-brasil* is a tree, exploited up to its extinction. It supported the production of coffee, sugar cane, orange and livestock. It has supported, as well, the city development over the years. It is possible that at about 50% of the region's land were transformed on fields and on urban spaces over centuries.

Nowadays, there are forests fragments on different sizes surrounded by fields and crops. However, there are still intact forests in the municipalities of Silva Jardim (in the biological reserve Poço das Antas), Casimiro de Abreu and Rio Bonito. The southern part of the watershed in the study area was devastated and its forests were substituted by herbaceous vegetation or by allotments, especially in the rural zones in Araruama, Cabo Frio and São Pedro da Aldeia (CILSJ 2006), and in particular around Araruama lagoon.

This environmental diversity has attracted human occupation for natural resources exploitation. The main economic activities have known a deep change: from resources exploitation, such as vegetation, land and water, for agricultural activities and fishing, to exploitation of these resources for other economic activities like tourism, oil production, mineral extraction, etc. The most important activity currently is the tourism in which many infrastructures were developed to attract inhabitants.

In order to highlight the environmental diversity changes in the region towards urban occupation, we have used many sources, from different institutions, in different spatial and time levels. First, agricultural and demographical data were collected from different census of IBGE. These data were related to the number of population and urban surface to evaluate the anthropic-natural zones reduction in Região dos Lagos and in the municipality of Araruama.

Then, the elaboration of land occupation maps allow us to visualize spatially the urbanization phenomenon in all territory and the zones most affected by urban extension, mainly the most fragility areas. The analysis in a local scale, in the city of Araruama, allows an understanding about the densification process that has been started recently.

2.1. Land use in the region

The analysis induce that the agricultural diversity of the region, due to favorable local climate, allowed human occupation in agricultural activities in benefit of the local and regional supplying, livestock and forestry, main land exploitation in the region. The urban zones have been established around these rural activities in the beginning of the development. After that, it expands towards touristic zones in 50's. Local data demonstrate this strong agricultural reduction after 1940.

The land use data from IBGE (agricultural census) was associated with the rural and urban population number since 1940 (population census of IBGE) (Fig. 01). The chart below indicates an important population increase accompanied by a considerable agricultural reduction of its surface. We observe that urban surface do not increase in a proportional way with urban population increase. It can induce the existence of both two process: the densification and urban extension.

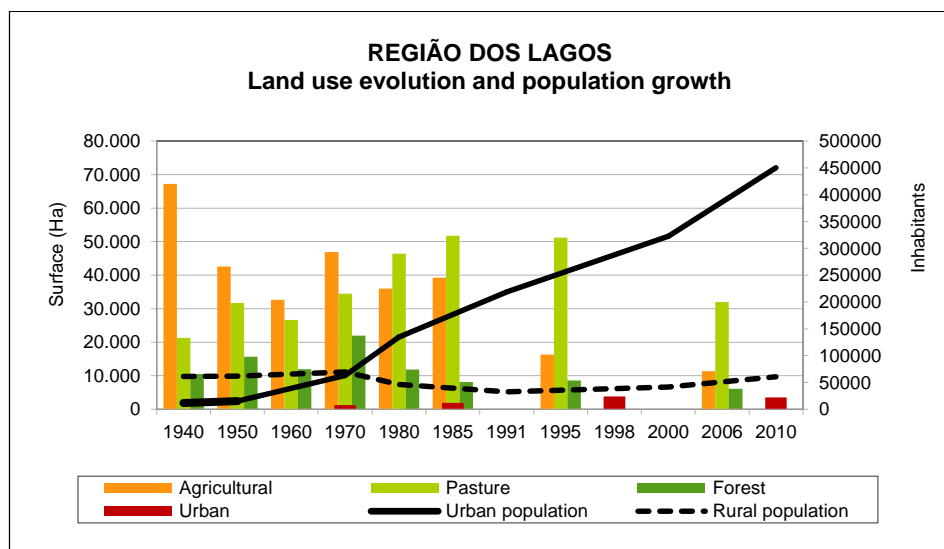


Figure 01. Land use evolution and population growth. Source : Census IBGE

Statistics data of IBGE presented above were an important overview about the land use of the region. These data do not include the surfaces occupied by saltmarshes and wetlands, neither urban surfaces which difficult a precisely analysis of the urban development direction. For example, the substitution of agricultural or forests zones into pasture, can induce an urban

development of these areas of pasture. Therefore, a spatial analysis along the time is an instrument that can help to visualize these changes.

A spatial approach will highlight the urban development direction through its shape and surface. It will also be exploited which percent of all land occupation was occupied by urban surface, around of its nearest landscape.

Four periods design the occupation land maps – 1969, 1986, 1998 and 2010. A gap of 12 and 15 years represent important periods of regional development. Each map came from a different institution, which was in a different file format. The table 01 associate the map, the year, the source, the file format and the conversion into file format *.shp* to apply in a GIS software.

Year	Original classes	Source	Original file	Conversion process into
1969	12	IBGE	.dgn > .shp	Conversion into Arc Gis
1986		INPE	Satellite image	Remote sensing with
1998	14	CILSJ	.shp	Re-classification
2010	20	INEA	.shp	Re-classification

Table 01. Data analysis

The analysis of these four maps (Figures 02, 03, 04, 05) allowed us to measure the consummation of natural and anthropic-natural areas by urban zones. Therefore, a homogenous classification of the occupation land was necessaire. Many phases of the maps elaboration to put in place this classification were necessary, mainly for the file format transformations.

The choice of the classification process considered the existence of similar classes, which has obliged the reduction of the number of classes. For example, data from IBGE (1969) had 12 classes, which were converted into 7 classes; data from CILSJ (1998) had 14 classes converted into 7; data from INEA had 20 classes converted into 7. These maps reflect the urban extension process in the region and the consummation of natural and anthropic-natural zones through the time.

2.2. Maps of land occupation – 1969, 1986, 1998, 2010

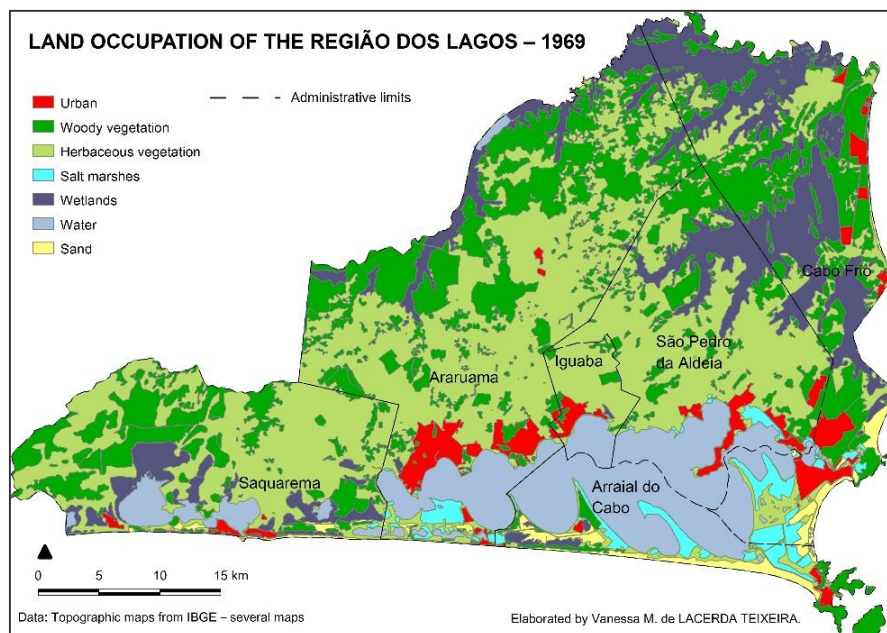


Figure 02. Map of land occupation in 1969.

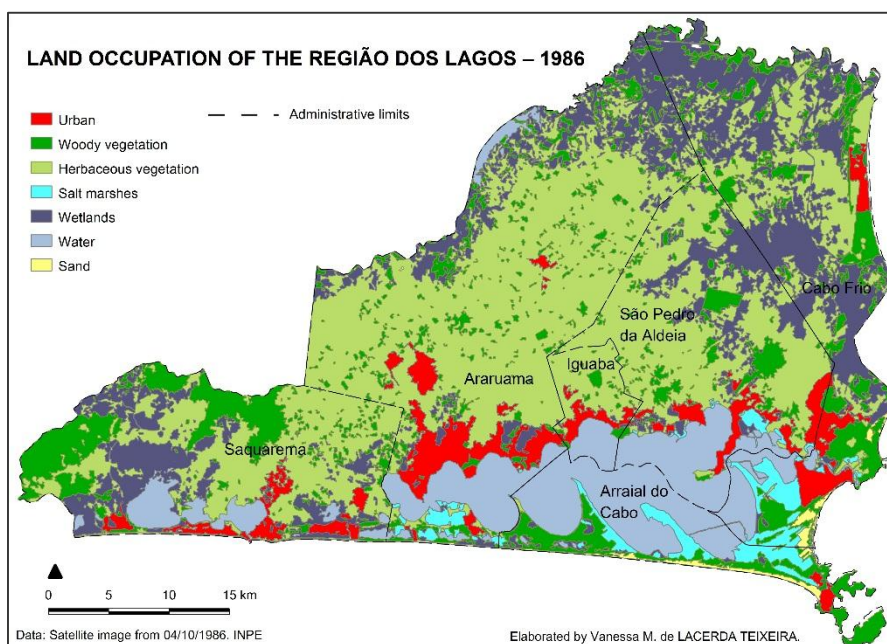


Figure 03. Map of land occupation in 1986.

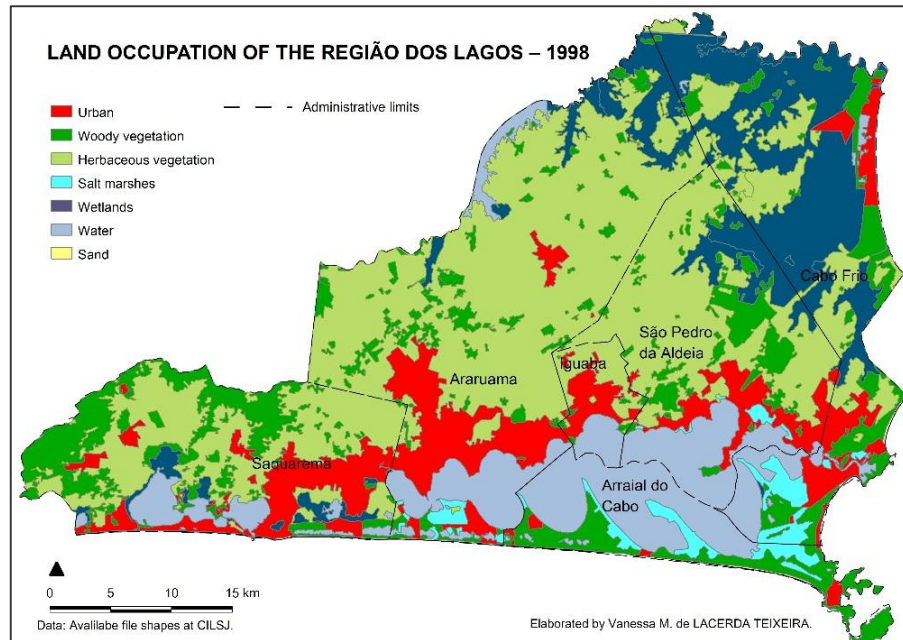


Figure 04. Map of land occupation in 1998.

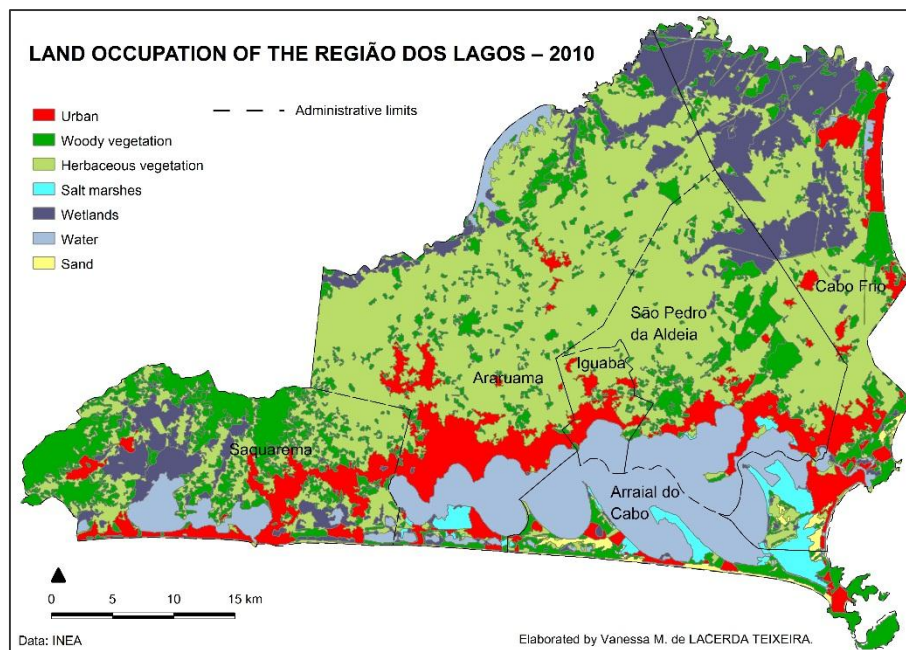


Figure 05. Map of land occupation in 2010.

3. Urban extension process in the region

It is verified a dominance of the herbaceous vegetation class in all periods and a strong urban concentration after 1986. Maps show an important spatial growth of the urban zone after 80's, mainly towards wetlands, saltmarshes, dunes and sandbank (*restinga*).

The land use maps of the four years reveals that the urban area has concentrated particularly in the coastline around the lagoon showing that land management has valued the front of the lagoon by putting back the development of the peripheral areas. The linear development along the lagoon is a result of production relations made since the seventeenth century, with the arrival of Europeans, and later, the results of changes implemented by local and regional policies. Highway Amaral Peixoto is in the 50's, the infrastructure that guides this development.

The results of these analysis attested that a great part of the territory composed of herbaceous and woody vegetation was consumed by urban zones. The table below displays the percentage of natural and anthropic-natural surfaces consumed by urban surface:

Land use	Natural and anthropic-natural zones consumed by urban surface between 1960 and 2010.		
	1969 – 1986	1986 – 1998	1998 – 2010
Herbaceous vegetation	30,92%	36,87%	2,62%
Woody vegetation	16,63%	6,98%	5,65%
Wetlands	1,72%	9,68%	2,34%
Sand	2,83%	0,36%	0,27%
Saltmarshes	1,00%	0,86%	1,34%

Table 02. Natural and anthropic-natural zones consummation

All these analysis, in a statistics, spatial and historical way, present the dynamics of the urban development along the years. In each period, urban zones were developed near from the urban surface of the previous period, as exhibited on the maps. The aggregation of urban fragments formed a large urban surface along the lagoon, and consequently, they consumed a certain percentage of natural and anthropic-natural surfaces.

4. Densification process

All these data reveal a spatial dynamics over the time, which is determined according to population growth and, therefore, the need for housing, either as a main residence or as a secondary one. These dynamics have changed the way of space consumption, mainly for habitat. Firstly extensively beyond the city center, sprawling the rural areas and, secondly, densely, in the center-town or periphery, along the lagoon.

The densification process will be explained through the example in Araruama. The density of the number of settlements related to the urban surface will highlight the densification process, mainly between 1998 and 2010. Firstly, we put in relation the number of population with the number of settlements.

The relation of settlements actually occupied with the population growth, between 1950 and 2010, indicates a linear evolution. Housing supply has following growth population, even staying beyond the actual need for housing. It indicates a surplus of population related to the number of existing homes.

It infers an aggregation process of several people in the same dwelling. From a familial aggregation to the collective rental housing. In 2010 the number of population and the number of housing intersect, indicating a population density reduction per unit of dwelling.

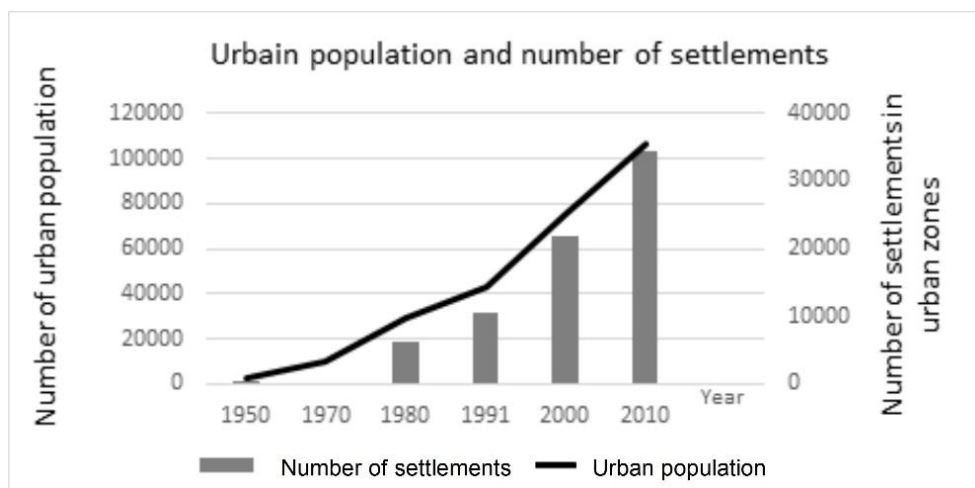


Fig. 06. Urban population and number of settlements between 1950 and 2010. Source: IBGE. Elaborated by Vanessa M. de Lacerda Teixeira

However, the evolution of settlements density, represented through the relation between the number of settlements and the urbanized surface, reveals that the urban densification process is present in 2010 (Table 03).

Evolution of settlements density	1986	2000¹	2010
Settlements density effectively occupied in the urban zone (Settlements / hectare)	2,34	2,78	5,06
Total settlements density (built), in the urban zone (Settlements /hectare) ²	-	5,20	8,56

Table 03 Evolution of settlements density. Source: Vanessa M. de Lacerda Teixeira, IBGE.

Taking the settlements effectively occupied, there is a slight increase between 1986 and 2000, while between 2000 and 2010, this density increases at about 1,8 times. This puts in evidence the need for housing in relation to population growth. Similarly, taking into account the total number of dwellings in the urban area in 2000 and 2010, it is verified an increase of 1,6 times. However, the density of total settlements in the urban zone is higher than the density of the settlements effectively occupied, which can infer a number of settlements empty, in reason to the seasonality of population in a period of the year.

The number of occasional and vacant settlements between 2000 and 2010, according to IBGE census shows an increase of 4.205 units and 1.302 units respectively. The number of non-occupied dwellings (closed) was 23.635 in 2010, which represents almost the half of the total settlements in the urban zone.

¹ The urban surface used was from 1998.

² The total occupied settlements units added to the number of non-occupied settlements is defined by IBGE as the housing, which correspond to the residential ones built in the city. Non-occupied settlement is only counted by IBGE and are not part of the population census. These data are obtained when disseminating the results of the Preliminary Synopsis of each census. According to IBGE : Non-occupied settlements (closed): it's the settlements whose residents were temporarily away throughout the census period. The vacant settlement: it's the one that there wasn't inhabitants in the reference date, although later, during the census period, it was occupied.

Occasional settlement: it's the one which on the reference date of the census, was used as occasional, for weekends, holidays or other temporary purpose even if in the days of the passage the IBGE's enumerator, occasional residents were present.

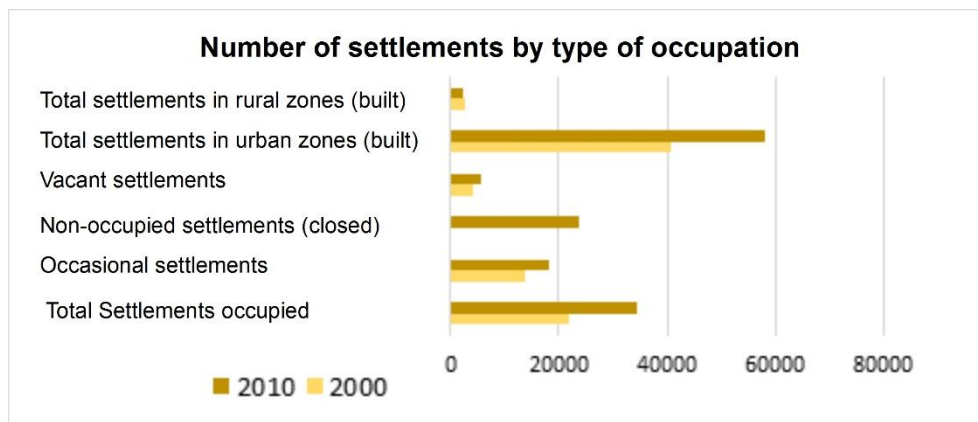


Fig. 07 Source: IBGE. Obs.: The number of non-occupied settlements (closed) was not informed by IBGE in 2000.

The increase of settlements density per hectare of urban surface reveals a beginning of the densification process. This new dynamic, put in discussion the distribution of allotments implemented 40 years ago. The grouping of dwellings, the implementation of residential *condominios*, collective buildings, and popular allotments are representative examples of this new way of building the city. The parcels of land had a change on their morphology, according to the planning regulations and, consequently, natural areas of the parcels (domestic gardens, for example), are consumed by urban dynamics, as well.

5. Conclusions

The analysis has taken into account the regional and communal space, specifying natural and natural anthropic zones the most consumed by urbanization. This scale of analysis revealed the phenomenon of urban sprawl designating a regular spatial extension from its city center towards the coast, and inland. A phenomenon that has been following by successive conversion of land, sometimes favoring the consumption of woody vegetation, initially converted into herbaceous vegetation. The land use is put in question, as well as their management and ownership status.

Some consumption and regressions in how to use the land, including natural, agricultural and forestry make part of local policies and real estate agencies, which subsidize and enhance the construction. The lack of strong policies that enhance the natural and anthropic-natural zones, especially from the 60's, when tourism growth is more important, has put in dialogue the land use and its consummation.

The data from different institutions, periods and sources, put in discussion its use to elaborate the urban production discourse during the time. How to

use these available multiple data to analyze the urbanization phenomenon at several temporal and spatial scales?

The lack of works about the urban and regional production of the Região dos Lagos, put in evidence the available data to compose this discourse. The available data reveals by its diversity, a major difficult to develop this problematic dialog. We could restrict the number of data sources. However, the possibilities of analysis would have also been reduced or impossible.

The major challenge of this work has been to organize the data both spatially and historically, as soon as they were available and to make a judicious criticism on their real utility. However, the lack of data that correspond to the space and time analysis, made it necessary to use some data that were less relevant, such as satellite images, which took time to get it in shape.

The applicability of the data collected in a GIS has been very important in this multivariate context, because of the possibility of its reuse for other periods (its updating from recent orthophotos), and especially the possibility of spatial and historical comparisons. The deployment of the phenomenon of urban sprawl and densification was possible in this multivariate context applied to several scales and years. The grouping of data in a unique format allows articulating the temporal and spatial aspects in order to highlight the urban processes and its responsibilities on natural areas and anthropic natural reduction.

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