

LAND USE AND OCCUPATION IN THE SEMI-ARID REGION OF BAHIA: A CASE STUDY OF THE MUNICIPALITY OF SANTALUZ (BA)

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Resumo

A COMPREENSÃO DOS MÚLTIPLOS USOS E OCUPAÇÕES DO SOLO EM AMBIENTES SEMIÁRIDOS É UM ELEMENTO fundamental no que diz respeito à estruturação e organização do espaço. Diante disso, este trabalho tem como objetivo analisar a dinâmica de uso e ocupação do solo no município de Santaluz (BA) a partir de técnicas de sensoriamento remoto. Os procedimentos metodológicos deste trabalho foram baseados na análise de imagens orbitais do satélite CBERS 4A para o ano de 2020, que foram integradas e processadas em ambiente de Sistema de Informações Geográficas por meio de classificação supervisionada. Os resultados mostraram a preeminência da classe parque caatinga, ocupando mais de 50% da malha territorial da área em estudo, bem como permitiram a identificação dos mais diversos usos e ocupações do solo em Santaluz. Por fim, destaca-se a relevância deste estudo devido à carência de produção científica sobre o mapeamento do uso e ocupação do solo no município, além de subsidiar políticas voltadas ao planejamento ambiental e territorial.

Palavras-chave: Planejamento Ambiental; Semiárido; Sensoriamento remoto

ABSTRACT

The understanding of the multiple uses and occupations of land in semi-arid environments is a key element with regard to the structuring and organization of space. Given this, this work aims to analyze the dynamics of land use and occupation in the municipality of Santaluz (BA) from remote sensing techniques. The methodological procedures of this work were based on the analysis of orbital images from the CBERS 4A satellite for the year 2020, which were integrated and processed in a Geographic Information System environment through supervised classification. The results showed the preeminence of the class caatinga park, occupying more than 50% of the territorial mesh of the area under study as well as allowed the identification of the most diverse uses and occupation of land in Santaluz. Finally, it is noteworthy the relevance of this study due to the lack of scientific production on the mapping of the use and occupation of

land in the municipality, in addition to subsidizing policies aimed at environmental and territorial planning.

Keywords: Environmental Planning; Semi-arid; Remote Sensing

INTRODUCTION

The terrestrial landscape is an inheritance of remodeling processes by which physiographic, biological, and anthropic processes are responsible for these transformations in geographic space. In view of this, the reality that everyone has a share of responsibility with regard to the non-predatory use of the terrestrial landscape stands out. Therefore, the limitations on the use and occupation of land must be understood to maintain the physiographic and ecological balance (AB'SABER, 2003).

In this context, examples of imbalances in the use of environmental resources, such as deforestation of native vegetation, inappropriate agricultural practices, fires, and erosive processes can be considered severe consequences to the environment. The advancement of these degrading processes can cause irreversible impacts on the environmental scenario, since the soil remains increasingly vulnerable, especially due to anthropic action, which represents the main indicator of degradation in semi-arid environments (SAMPAIO, ARAÚJO E SAMPAIO 2005; BRASILEIRO, 2009).

Regarding the diagnosis of the alarming vectors mentioned above, it is worth highlighting the analytical study of the dynamics of land use and occupation as a tool to better understand these landscape transformations. In this sense, remote sensing, as a set of techniques for obtaining information about objects on the earth's surface without physical contact between sensor and object (NOVO & PONZONI, 2001; JENSEN & EPIPHANIO, 2009; MENESES & ALMEIDA, 2012), is an elementary source when it comes to understanding the spatial-temporal dynamics of land use and occupation through investigations based on orbital images (FOODY, 2010).

Considering the potentialities of land surface analysis from remote sensing, Assis et al. (2014), assert that these techniques contribute to environmental planning, considering the spatial repercussions can be understood through these analyses. In this perspective, it is noted that understanding the phenomena associated with the use and occupation of land is essential with regard to the perception of various environmental problems, since the use and occupation of land corresponds to the pressures and direct impacts on the environment (SEABRA et al. 2014).

According to the technical manual of land use prepared by the Brazilian Institute of Geography and Statistics (IBGE, 2013), land use is understood as the performance of substantially anthropic activities over a given area. Thus, land use can be described from the transformation of land for various purposes, singularly, as an effect of anthropic action, while land occupation relates to physical coverage distributed in space (YONABA et al., 2021).

For IBGE (2013) the surveys of land use and land cover contribute to the analysis of environmental impacts, whether as a result of deforestation, climate change or even degradation through human action. In view of these potentialities, Souza and Reis (2020) also highlight the mapping of land use and occupation as a means of determining how

environmental fragilities can be mitigated through public planning policies in semi-arid environments.

Internationally, land use and land cover mapping research in semi-arid areas has highlighted the intensive growth of agricultural crops as well as land degradation as a result of the suppression of native vegetation. That said, such analyses can be inferred from the studies by Muriithi (2016), Roy and Inamdar (2019), and Yonaba et al. (2021), with research in Kenya, India, and Burkina Faso, in this followed order.

Still in this perspective, surveys of land use and occupation in the semi-arid region of Bahia showed, in the municipalities of Valente (BA) and Teofilândia (BA) that the ecosystemic deterioration is intrinsically associated with agricultural practices, whose occurrence has provided, in certain places, the induction of desertification processes, aggravated by intense soil exposure. Moreover, it is still notable the intense expansion of land use with regard to agricultural practices (LIMA, SANTOS and RODRIGUES, 2009; BATISTA and SANTOS, 2011).

Similarly, to the aforementioned studies, Souza and Reis (2020) analyzed land use in the municipality of Senhor do Bonfim (BA) by means of diagnosis based on orbital images, finding that in this municipality there is a predominance of the class of shrub caatinga. Furthermore, the study also indicated a gradual growth of deforestation of native vegetation, giving way to agricultural crops in recent years.

Considering the environmental characteristics denoted, this work is justified, in principle, by the lack of studies concerning the use and occupation of land throughout the territory of Santaluz (BA), as well as by the relevance of potential analysis of environmental impacts on multiple land uses through this diagnosis, with emphasis on the development of agricultural practices and activities of mineral extraction. In view of the above, this work aims to identify the classes of land use and land cover in the municipality of Santaluz (BA) from techniques of geoprocessing of orbital images from CBERS sensors for the year 2020.

METHODOLOGY

Characterization of the study area

The municipality of Santaluz - BA is part of the Sisal Identity Territory, a region that incorporates 19 other municipalities in Bahia, and is located between latitudes 11°10' 05" S and 11° 45' 15" S and longitudes 39° 23' 11" W and 40° 27' 10" W, It is limited to the east by the municipalities of Araci and Conceição do Coité, to the north by the municipalities of Cansanção and Nordestina, to the west by the municipalities of Capim Grosso, São José do Jacuípe and Queimadas, and to the south by the municipalities of Gavião, São Domingos and Valente, as shown in Figure 1 (SEI, 2016).

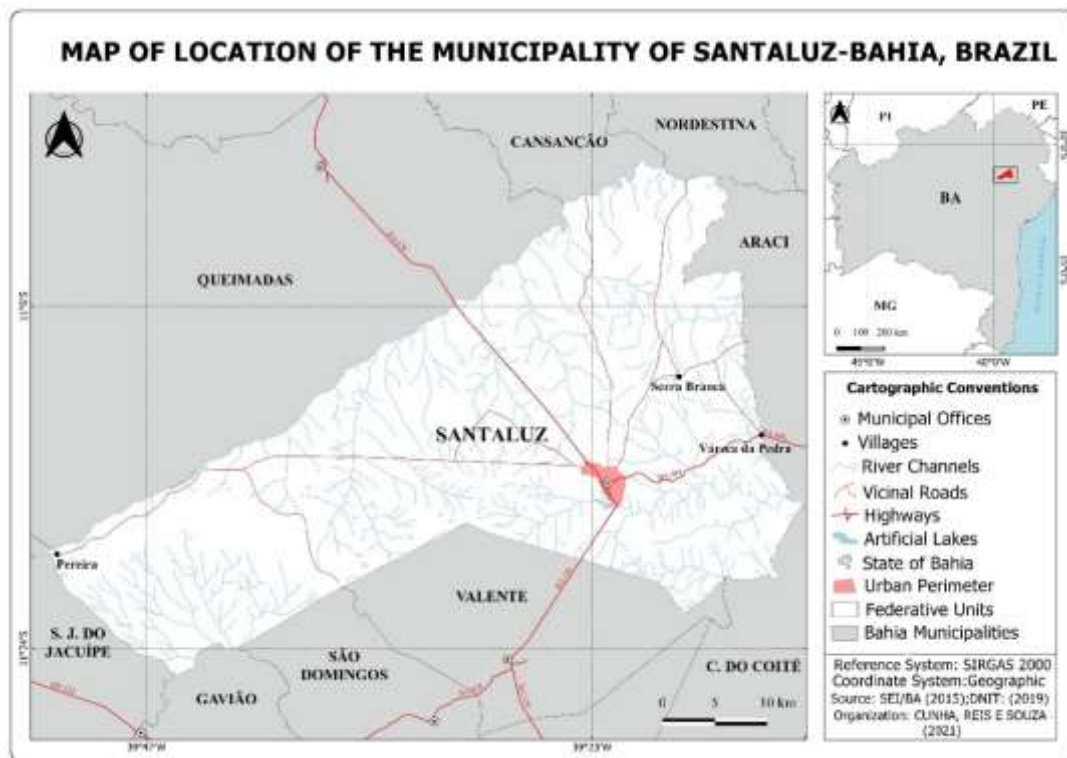


Figure 1: Location map of the municipality of Santaluz (BA)

Source: Authors

From the perspective of socioeconomic data, the municipality under study presents an estimated population of 37,531 inhabitants and has an area of 1,623.445 km², therefore, it configures a demographic density of 23.1 hab./km². (IBGE, 2020). Its economy is based on the activities of trade, services, industry and exploitation of mineral resources (IBGE, 2010; SEI, 2016).

Regarding the physical aspects of Santaluz, the climatic typology of the region is tropical semi-arid, with rainfall ranging between 400mm and 500mm and an average annual temperature around 24.2°C (SEI, 2016). Such climatic attributes contributed to the fact that the study area has a hydrography characterized mostly by intermittent rivers, especially the Saco, Espera, Itapuã, Bonsucesso, Onças, Camaíba, and Mulungu creeks. Whereas the existence of perennial river channels is much less present, occurring in the northeast of the municipality (Itapicuru River) and the southwest (Jacuípe River) (YAMANA GOLD, 2009).

Regarding the geological context, it is noticeable that the structure of the municipality is quite complex, encompassing rocks of various ages, from the Archean to the Quaternary period, being part of the geological context of the São Francisco Craton (YAMANA GOLD, 2009), highlighting the lithotypes of the Caraíbas complex to the west of the municipality, one of the Tanque Novo/Ipirá complex to the southwest of the municipality and one of the Santaluz complex in the central portion of the municipality, the latter with sedimentary volcanic basement of the Itapicuru *greenstone belt*. Such characteristics are associated with the enormous mineral potential found in Santaluz, and in particular by the occurrence of gold, chromite, and granite, as revealed by data from the Mineral Resources Research Company (CPRM, 2005; SEI, 2016).

Such lithological units impact morphologically on the landscape as a predominantly flat surface, with vast occurrence of pediments associated with the sertanejo pediplano, interrupted in some areas by the occurrence of inselbergs (CPRM, 2005; YAMANA GOLD, 2009). Such morphologies are occupied primarily by the phytophysionomies of the Caatinga vegetation domain, although a considerable portion of this native vegetation has been replaced by pastures and agricultural crops, especially for the cultivation of sisal (CPRM, 2005; SEI, 2016).

Methodological procedures

Based on the objectives of this research, the methodological procedures of this study were divided into four main stages: the first related to the literature review on the themes of use and occupation in the semi-arid region, environmental impacts due to the inappropriate use of the land, among others; the second, referring to the obtaining and classification of orbital images from the Sino-Brazilian Earth Resources satellite (CBERS 4A) in the databases of the National Institute for Space Research (INPE); and the third stage, composed of the data survey and elaboration of the use and occupation map. Finally, the last stage concerns the analysis and discussion of the results obtained. The main procedures used are presented below:

In principle, to prepare this mapping, images with cloud cover of less than 20% were acquired from the CBERS 4A satellite, which is a satellite resulting from a partnership between Brazil and China. These images, operated from the year 2020, are available, free of charge, through the INPE image catalog and obtained through the address: <http://www2.dgi.inpe.br/catalogo/explore>. Furthermore, it is noteworthy that the images were acquired from the Wide Scan Multispectral and Panchromatic Camera (WPF), which is characterized by providing images with multispectral resolution of 8 meters and 5 spectral bands, operating in the range 0.45 to 0.90 μ m (INPE, 2021).

After *downloading* the images, in a GIS environment, through the Qgis 3.14, the images were georeferenced through the UTM coordinate system, zone 24 South, SIRGAS Datum and then proceeded to cut the study area in all images used based on the vector file of the municipal boundary of Santaluz, obtained in the cartographic base of the Superintendence of Economic and Social Studies of Bahia (2015), and then the application of the mosaic of the bands of CBERS 4A images, grouping thus, all bands in a single image through the menus raster<miscellaneous<clear. Subsequently, it was chosen the radiometric correction of the images and the RGB color composition of the spectral bands, being chosen the R2G1B3 composition, because this was the one that best represented the area under study.

Continuing the processing, the vector layer was structured to generate the sample polygons and a field was created in the attribute table to identify the classes. In this sense, it is worth emphasizing that the determinations of these classes were guided according to the guidelines of the Technical Manual of Land Use and Occupancy (IBGE, 2013). Then began the process of supervised classification of the composition in false color, which according to INPE (2021), consists of the process of extraction of information in images in order to recognize equivalent patterns, performed through the complement *Orpheu Toolbox* (OTB), referring to the Maximum Likelihood classification.

Next, a command was processed with the purpose of training the classification algorithm using the inserted samples. This procedure was done through the

OTB>Learning>TrainImagesClassifier menus. Then, the supervised image classification was performed through the menu OTB>Learning> ImagesClassifier. With the result of this last process, the *raster* image vectorization became indispensable, *since it* was crucial to calculate the area in km² of each polygon. Finally, we proceeded to some manual corrections of the polygons as well as the computation of the relative values in area of each class, both via editing in the attributes table, providing an interpretation of the data of this study.

RESULTS AND DISCUSSIONS

The municipality of Santaluz, inserted in the semi-arid region of Bahia, has a diverse and heterogeneous natural landscape both in terms of its structure and its coverage, thus reflecting unique environmental patterns with profiles of anthropic occupation and evidence of a region marked by agricultural and mineral exploration activities (CERQUEIRA, 2015). In view of this, through the map of land use and occupation in the municipality of Santaluz - BA, it was possible to verify how the established classes are spatially distributed by the municipal area, as can be seen in Figure 2 and Table 1.

Figure 2: Map of land use and occupation in the municipality of Santaluz - BA (2020)

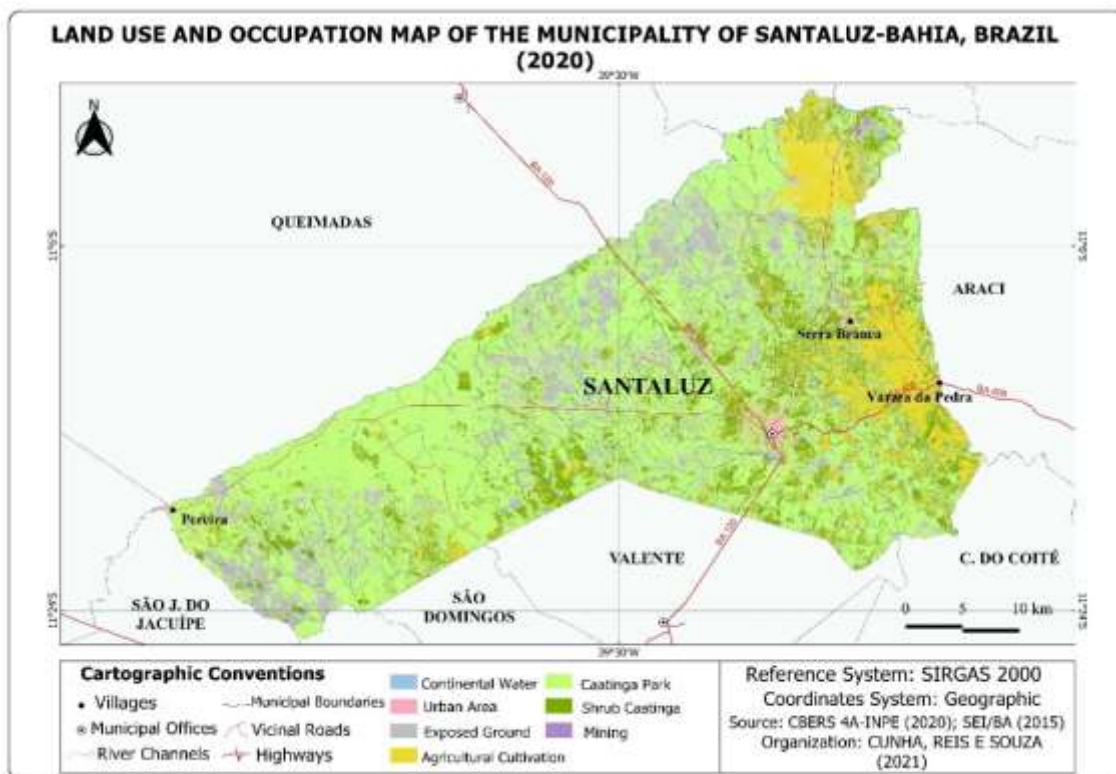


Table 1: Categories of use and occupation in Santaluz - BA (2020)

CATEGORIES OF USE AND OCCUPATION IN SANTALUZ -BA, BRAZIL (2020)		
CLASSE	ÁREA km ²	ÁREA %
Continental Water	4.48	0.28
Urban Area	11.90	0.73
Exposed Ground	251.14	15.47
Agricultural Cultivation	178.28	10.98
Caatinga Park	892.91	55.00
Shrub Caatinga	282.59	17.41
Mining	2.15	0.13
Total	1623.45	100.00

Source: Authors.

The caatinga park class was the class with the highest expression in the whole study area, occupying 892.91 km², equivalent to 55% of the municipal territory, and is characterized by the presence of small xerophytic plants in the midst of some tree species and are distributed openly with the presence of xerophytic plants, like cacti (SEI, 2006).

Moreover, this typology can be identified by the presence of a grassy-leny extract while denoting an absence of many tree species. Such coverage, although very common, is a reflection of degrading processes as a result of the massive removal of native vegetation through pruning and clearing for firewood extraction, pastures and sisal fields (EVANGELISTA, 2010).

Regarding the shrub caatinga class, it can be seen that it is spatially distributed in the territory of Santaluz in 282.59 km² of area, corresponding to 17.41% of the municipal area. This patch is characterized by being of the arboreal-shrub type, sometimes dense and with the presence of palm trees (*Syagrus coronata*), and generally comprise fragments of conserved biome (SEI, 2006). These more concentrated forest patches are mostly distributed in the eastern region of the municipality and consist of areas of pressing need for preservation of native caatinga vegetation.

In relation to the class of exposed soil, the existence of this class is observed in about 251.14 km², filling about 15.47% of the territorial mesh. These areas correspond to the denuded surfaces with soil exposure, rocky outcrops, and slabs, and are related to the levels of environmental degradation due to indiscriminate deforestation, abandoned pasture areas and the use of successive burnings that provided for a denudation of certain areas, contributing to a gradual increase in areas susceptible to soil erosion.

In this perspective, Sampaio, Araújo, and Sampaio (2015), show that soil erosion in semi-arid environments, due to its irreversibility, constitutes severe impacts to the environment, and especially in areas of large extensions of exposed soil, excessively shallow, with low and irregular rainfall rates and through inappropriate farming activities.

With regard to the class of agricultural cultivation, it is possible to verify the occupation in an area of 178.28 km², equivalent to 10.98% of the municipal territory. Agricultural production in Santaluz, according to data from IBGE (2020), is predominantly

characterized by the cultivation of *sisal* (*Agave sisalana*), representing more than 90% of all temporary or permanent agricultural production throughout the municipality. This relevant production occurs because the climatic characteristics of the semi-arid region of Bahia have favored an adaptation of these plantations, Santaluz being the precursor municipality of the planting of the first sisal seedlings in Bahia, which from then on, was spreading throughout the region, today, known as the sisaleira region (SEI, 2016; COMPANHIA SISAL DO BRASIL, 2021).

Moreover, other crops such as beans (*Phaseolus vulgaris*), cassava (*Manihot esculenta*), corn (*Zea mays*) and forage palm (*Opuntia cochenillifera*) also stand out in terms of uses, justifying their identity in the territory (IBGE, 2020). These, predominantly in small farms, and mostly at subsistence level, are practiced in the rainy periods, becoming sometimes risky activities, given that they are dependent on rainfall in the wettest periods (SEI, 2006). Still with regard to the context of agricultural crops, the map of use and occupation reveals that these areas are more identified in the eastern and northeastern regions of Santaluz, especially with regard to sisal crops. In view of this, it is notable that the dynamics of occupation is linked to natural and socioeconomic aspects, thus, the production of this fiber played a key role in the economic base of the municipalities that had good rates of sisal cultivation.

Regarding the occurrence of urbanized areas, these correspond to about 11.90 km², which are subdivided into city, towns and villages, representing 0.73% of the territory. Given this, it is possible to verify on the map that the most notable urban spot comprises the urban perimeter of Santaluz, denoting the areas of intensive use involved by buildings, non-agricultural artificial surfaces, road areas, services, transport, energy and communications (IBGE, 2013).

The continental water class, in turn, with little occurrence in the municipality, corresponds to 4.48 km² of the municipal area, configuring 0.28% of the entire area under study. It is translated by the presence of dams and reservoirs, especially the Tapera dam and the Cruz dam, as well as by intermittent and perennial fluvial channels, especially the Itapicuru, Jacuípe and Bonsucesso rivers.

Considering the multiple uses of the continental water class in the area under study, the most noteworthy are the abstraction of water for domestic, industrial, and agricultural supply, as well as for animal watering. On the other hand, the discharge of waste as domestic effluents into some river channels, with emphasis on intermittent channels, is also noticeable. The banks of these channels can derive a certain degree of instability in the accommodation of the detritic material, potentially causing periodic flooding, especially due to irregular and concentrated rainfall. Thus, these are areas that should be appreciated in order to preserve this class (LIMA, CUNHA e FILHO, 2014).

The class less present, but no less important, is the mining class, represented by 2.15 km² in area, equivalent to about 0.13% of the territory of Luzense. These concern areas where mineral substances are exploited, either by means of mining or prospecting. Although they are not such expressive units, the mining areas in Santaluz are points of urgent analysis, since they translate a significant economic activity of the municipality, at the same time that they also reproduce several environmental impacts.

In this sense, among the various environmental impacts, one problem concerns the fact of the distance of the chromite mine with the urban area of Santaluz, approximately 3 km from the city center. Because of this, the detonations have had an intense impact, causing cracks in the structures of hundreds of homes and cisterns after the explosions. Moreover, the deforestation of the caatinga, soil degradation and water pollution have been some of the problems that have affected the quality of life of some inhabitants, especially those who live near the extraction sites (CETEM, 2013a; CETEM, 2013b).

On the other hand, it is relevant to note that the enormous potential of granite mineral deposits has provided Santaluz the condition of largest producer of granite stone in the entire state of Bahia (MATTOS, 2009). In view of this, as well as by the significant explorations of gold and chromite, it can be said that this use is a key element for local economic development because of the generation of formal and informal jobs for the local population.

FINAL REMARKS

Through the analyses carried out throughout this study, it was possible to understand the configuration of the landscape and the result of intense land use, providing subsidies for policies aimed at environmental and territorial planning. In relation to the use and occupation, the preeminence of the class corresponding to the caatinga park was evident, whose occurrence is present in practically the entire municipal network. On the other hand, the class of agricultural crops also stood out, and in special, for the intense agricultural production of sisal in the municipality. In view of the above, the study reached the proposed objective, as it allowed to verify the distribution of the use and occupation of the land in the municipality of Santaluz (BA).

However, it is worth emphasizing that, although the study has provided the understanding of the general context of the area under study, it is necessary to develop further research focused on the weaknesses and potentialities of the environment, since the scarcity of scientific production, especially in semi-arid environments, makes it difficult to access detailed information about the use and occupation of land in these locations. In this perspective, more detailed studies, based on orbital images with better spatial resolution in order to delimit land use more precisely, are fundamental to obtain more accurate results.

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