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LAND USE AND OCCUPATION IN THE SEMIARID REGION OF BAHIA: A CASE STUDY IN THE MUNICIPALITY OF ANTÔNIO GONÇALVES - BA

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RESUMO
A técnica de mapeamento é uma das maneiras mais apropriadas de representação do espaço geográfico, e tem se constituído importante aliada na construção de cenários ambientais (JHON, 2009; WANG et al., 2010). Diante de tais constatações, este trabalho tem o objetivo de propor um mapeamento do uso e ocupação da terra do município de Antônio Gonçalves (BA), enquanto subsídio ao planejamento ambiental. Para tanto, o trabalho foi dividido em três principais etapas: a primeira composta de revisão bibliográfica; a segunda, composta pela aquisição das imagens Landsat-TM e a terceira etapa caracterizada pela integração dos dados levantados em ambiente SIG, com uso do software QGIS (versão 3.10.14) e pela redação final da pesquisa. Em se tratando dos resultados, constatou-se a predomínio da caatinga arbustiva, cuja existência se explica pelo contexto climático. Verificou-se também grande presença das áreas de florestas, enquanto as classes de vegetação herbácea, solos expostos, área urbana, cultivos agrícolas e água continental foram minoria no resultado espectral do uso e ocupação. De um modo geral, espera-se que este trabalho possa ser o ponto de partida para outros estudos que se proponham a diagnosticar melhor a dinâmica do uso e ocupação da terra do município de Antônio Gonçalves – BA.
Palavras-Chave: Dinâmica espacial; Sensoriamento remoto; Mapeamento.

ABSTRACT
The mapping technique is one of the most appropriate ways of representing the geographic space, and it has become an important ally in the construction of environmental scenarios (JHON, 2009; WANG et al., 2010). In view of these findings, this work aims to propose a mapping of land use and occupation in the municipality of Antônio Gonçalves (BA), as a subsidy for environmental planning. To this end, the work was divided into three main stages: the first consisted of a bibliographic review; the second, consisting of the acquisition of Landsat-TM images and the third stage characterized by the integration of the data collected in a GIS environment, using the QGIS software (version 3.10.14) and the final writing of the research. Regarding the results, the

predominance of shrubby caatinga was observed, whose existence is explained by the climatic context. There was also a large presence of forest areas, while the classes of herbaceous vegetation, exposed soils, urban areas, agricultural crops and continental water were a minority in the spectral result of use and occupation. In general, it is expected that this work can be the starting point for other studies that propose to better diagnose the dynamics of land use and occupation in the municipality of Antônio Gonçalves - BA.
Keywords: Spatial dynamics; Remote sensing; mapping.

INTRODUCTION

The advancement of technologies has enhanced the human ability to analyze natural environments (NUNES and ROIG, 2015). In contemporary times, in view of the accelerated anthropic modification of the environment, alternatives for representing the earth's surface are urgently needed, and yet they are enhanced from the spatial interpretations provided by the Geographic Information System (GIS) (SANO, et al., 2009).

In this scenario, the use and occupation mapping technique is one of the most appropriate ways of representing the geographic space, and it has become an important ally in the construction of environmental scenarios that serve as indicators of weaknesses, risks and potential of natural environments (JHON, 2009; WANG et al., 2010; AUGUSTIN, FONSECA and ROCHA, 2011). In fact, the geographic space has evolutionary characteristics (ROSS, 2006), however, these are not able to follow the sequence of functional imbalances provided by unplanned human action at its accelerated pace (CASSETI, 2005; QUEIROZ, 2012; TRENTIN; SANTOS; ROBAINA, 2012).

Within this context, one of the main ways of analyzing environments is through the diagnosis of land use and occupation mappings, which consists of a vast field of understanding of space, through the representation of the multiplicities of land cover and its particularities (CASSETI, 2005; JHON, 2009; IBGE, 2013). According to the Technical Manual for Land Use (IBGE, 2013), the information contained in the use and occupation maps allow the characterization of land use processes, a debate that has gained notoriety in recent years due to the pressing need for sustainable development.

It should be noted that recent years have been marked by an intense cause and effect relationship in the process of exploring natural environments, because as society spreads over the Earth, resources are used and modified (MEIRELES et al., 2007) and this action, when not planned, causes a series of functional imbalances that, regularly, cause drastic consequences to society (R0SS, 2006). A worrying scenario is generated, as data indicate that the current form of land use and occupation has instigated multiple types of impacts at different levels on the environment (DE ASSIS et al., 2014; SOUZA and REIS, 2020). In view of the above, we highlight the use of geoprocessing as a means of building graphic representations of space, in order to recognize the phenomena and associated processes, a technique made possible through Remote Sensing, which consists of obtaining images, and other types of terrestrial surface data, through the emitted and reflected energy (RODRIGUES, 2000; FLORENZANO, 2007). Similarly, scientific investigations based on changes in the landscape and potential risks have stood out in serving as a basis for planning proposals (RODRIGUES, 2000).
As for the diagnoses of use and occupation mapping in a semi-arid environment at the international level, it is worth citing the analysis of authors such as Conway and

Nordstrom (2003), who identified areas of vegetation in residential lots in the city of New Jersey, United States. We can also mention authors such as Bustos, Perillo and Piccolo (2016) who studied the use and coverage of the municipality of Pehuen - CO, southwest of Buenos Aires, Argentina, with emphasis on the analysis of the evolution of dune covers. Similarly, Pais, Ribeiro and Santos, who analyzed, from three Landsat-8 images, six types of use and occupation in the savannas of Mozambique, in southern Africa.

In the context of the Brazilian semiarid region, Folharini and Souza (2019) mapped the use and occupation of the municipality of Petrolina (BA), using the Normalized Difference Vegetation Index (NDVI) derived from LANDSAT-8 images (OLI), diagnosing the high occupation by the region. vegetation of Caatinga, followed by agricultural areas and urban areas close to the São Francisco River. It is also worth mentioning the authors Lima et al., (2019) who analyzed the use and occupation of the Paraíba and Taperoá river basins based on MSI images from the SENTINEL-2 satellite, in the state of Paraíba, and also evidenced the greater occurrence of Caatinga Arbustiva. Similarly, Souza and Reis (2020) mapped the use and occupation of the municipality of Senhor do Bonfim (BA), using images from the LANDSAT-8 and the hybrid classification method, these authors diagnosed seven classes, highlighting the existence of the class of Caatinga Arbustiva in an accentuated way, followed by the Forests class.

Considering the importance of mapping for the planning of territories, it can be said that this work is legitimized, firstly, by the scarcity of studies dealing with mapping the use and occupation of land in tropical semi-arid environments, as pointed out by Souza and Reis (2020).). In addition, understanding the use and occupation of the area under study may legitimize the proposal for the Serra de Jacobina Environmental Protection Area (BA) (BAHIA, 2019) in addition to contributing to the decision-making implicit in the planning and environmental planning of other areas. conservation units associated with the study area, such as the Chapada Diamantina National Park and the Sete Passages State Park (CONCEIÇÃO, et al., 2007).

In view of these findings, this work aims to propose a mapping of land use and occupation in the municipality of Antônio Gonçalves (BA) for the year 2020, as a subsidy for environmental planning.

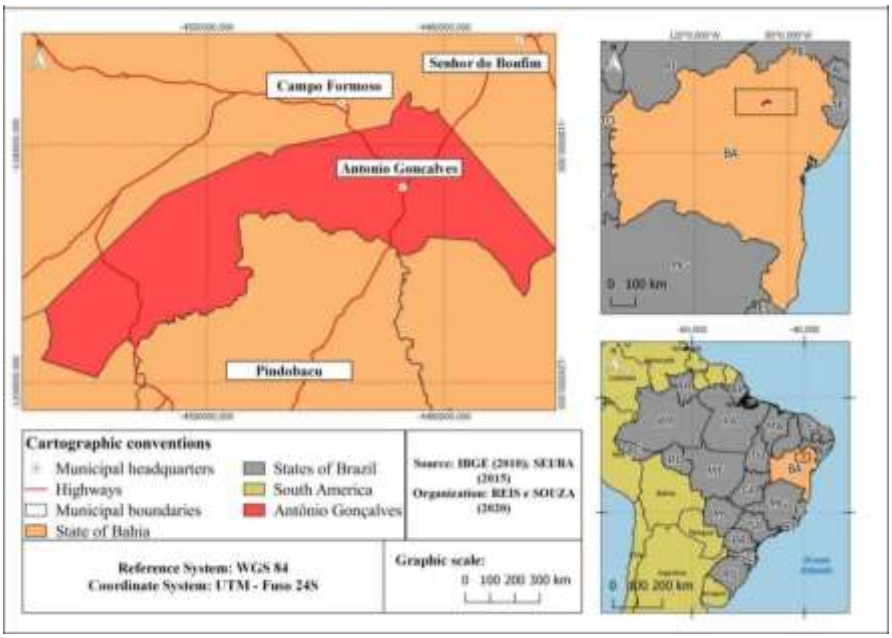
METHODOLOGY

Characterization of the area

In order to generate a cartographic and analytical product of tropical semi-arid environments, it was decided to study the municipality of Antônio Gonçalves – Bahia, located between the parallels 10º 34' 22" S and 10° 34′ 12″ S and the 40º meridians. 16' 31" and 40° 16′ 20″ W, located in the north center of the state of Bahia (Figure 1), integrating the Piemonte Norte do Itapicuru Identity Territory (SEI, 2018).

Figura 1: Location map of the municipality of Antônio Gonçalves, Bahia - Brazil.

Source: authors.



Depending on the natural scenario, the area under study has a semi-arid tropical climate (IBGE, 2018), which is characterized by irregular rainfall, low rainfall and high average annual temperature. While, due to its topographical diversity, the municipality also has sub-humid patches (RADAMBRASIL, 1983; SEI, 2018). In this sense, the area has average rainfall of 800 mm/year, in addition to high average temperatures, around 27º C and average annual thermal amplitude around 5º C, which contributes to the existence of Caatinga vegetation (RADAMBRASIL, 1983; IBGE, 2012; INMET, 2019).

As for the geological characteristics, Antônio Gonçalves is structured on the geotectonic domain of Bahia Oriental, inserted in the São Francisco Craton (CBPM, 2003; CPRM, 2005). In addition to belonging to three main lithological units, Complexo Saúde, Complexo Itapicuru, and Complexo Campo Formoso (RADAMBRASIL, 1983). In the regional modeling, morphologically moved forms predominate, as a result of the lithological characteristics of textural maturity conditioned to the São Francisco Cratron, and by the wavy forms of the Jacobina Group, which offer unique clinographic characteristics to the territory of Antônio Gonçalves.

Also, the municipality is drained by the Itapicuru river basin (SEI, 2018), represented in the area by the presence of the Água Branca river, in the northwest municipal region, and the Aipim river, inserted in the territorial border in the southeast region, with the two channels being of intermittent characteristics and originating from the backs of the Diamantina Plateau (RADAMBRASIL, 1983; CPRM, 2005). Indeed, it is worth mentioning that intermittent channels are river bodies that have a greater load in rainy periods, due to the continuous flow of rain and the rise of the water table at the level of the channel, reducing its load in the dry seasons (LIMA, 2014; FARIA, 2014).).

Regarding the vegetation of the area under study, the characteristics vary from the contact of caatinga-seasonal forest, to cerrado-caatinga and cerrado-seasonal forest (CPRM,

2005). According to IBGE data (2012), there is a predominance of xerophilous deciduous plants, mainly the Anacardiaceae and Fabaceae families (IBGE; 2012; SEI, 2018).

Historically, Antônio Goncalves was, along with surrounding municipalities, an important ally in the historic interiorization of Brazil, in the cattle cycles, and a place of passage for drovers and miners who headed towards the city of Jacobina (MACHADO, 1993). Currently, with a GDP per capita of 5,916.84, an estimated population of 11,878 inhabitants and a population density of 35.09 inhab/km², according to the IBGE (2020), the municipality reveals an economic prominence for the extraction of umbu, tobacco, wood and oilseeds, like licuri.

Methodological procedures

To achieve the objectives proposed in this study, it was divided into three main stages: the first consisted of a bibliographic review about land use and occupation in tropical semi-arid environments; the second, consisting of the acquisition of Landsat-TM images and the third stage was characterized by the integration of data collected in the field with data from the Thematic Mapper (TM) sensor, belonging to the Landsat-8 satellite, in a GIS environment using QGIS software. (version 3.10.14) and for the final writing of the research. The details of the main procedures related to the second and third stages are presented below.

The land use and occupation map of the municipality of Antônio Gonçalves was made from the hybrid classification of orbital images, where each pixel in the image is labeled according to a type of use and occupation. This classification method performs its activity through the thematic knowledge of who is analyzing the statistical classes, the classification, in this way, must spectrally express the use of each chosen class (AZEVEDO and MANGABEIRA, 2001).

Images from the Landsat 8-TM satellite were used, referring to orbit number 217 and point 067, with a date of passage referring to the year 2020. Chosen based on the smallest possible amount of clouds, less excess brightness and greater spectral normality. It is worth mentioning that this type of image is freely available through the image catalog of the National Institute for Space Research (INPE).

In a GIS environment, the composition in raster format was prepared using bands 5, 6 and 7 of the aforementioned satellite, through the command raster>miscellaneous>mosaic, an important step in the execution of the hybrid supervised classification method. After the composition, the contrast was changed, in order to help in the differentiation and identification of the places that will later be classified. For this change in contrast, the 'histogram' was used, within the 'properties' option.

The next step was the collection of samples through polygons. To collect them it was necessary to activate the ‘SCP Dock’ plugin. Next, the option ‘Semi-automatic Classification plugin’ was selected. The land use and occupation classes present in the study area were observed in the images and recorded during the fieldwork carried out. Subsequently, based on the Technical Manual of Land Use of the Brazilian Institute of Geography and Statistics (IBGE, 2013), the construction of sample keys for the classes shown in Figure 2 was followed.

Class	Satellite image	Field photography	Color referring to category
Continental water			
Urban area			
Shrubby caatinga			
Agricultural crops			
Forests			
Exposed soil			
Herbaceous vegetation			

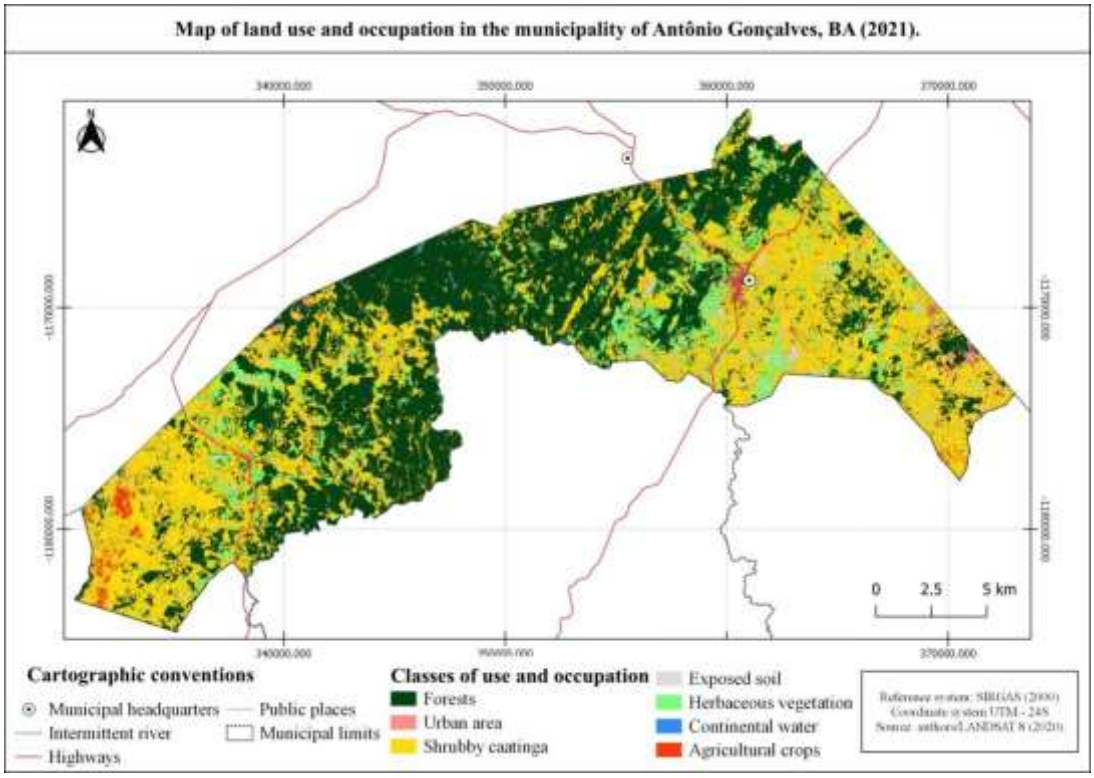
Figura 2: Identification of areas that correspond to the categories of use and occupation
Source: authors.

Based on the determination of the aforementioned classes in the Semi-automatic Classification plugin option, the SCP DOCK tab used the following commands: Create a new training input and Create a ROI polygon. Subsequently, the class nomenclature and the respective colors were edited in 'C Info'. To finalize the classification, the 'Classification Output' option was used, through the 'Create Vector' and 'Run' commands. In the last step, with a vector file, some necessary corrections were made by editing the attribute table, with the help of data recorded in the field. Finally, the respective values in area were calculated using the field calculator of the attributes table, through the command geometry>$area.

RESULTS AND DISCUSSIONS

Regarding the spectral behavior of the targets, and field diagnosis, it became possible to verify the use and occupation of land in Antônio Gonçalves (Figure 3), evidencing the predominance of shrubby caatinga, forests, herbaceous vegetation, exposed soil, urban, agricultural crops and inland water (Table 3).

Figura 3: Map of land use and occupation in the municipality of Antônio Gonçalves - BA, 2021.



Source: authors.

Tabela 3: Antônio Gonçalves (BA): Land use and ocupation classes, 2021.

Classe	Área km²	Área (%)
Caatinga	149,76	43,37
Forest	148,35	42,97
Herbaceous vegetation	31,14	9,02
Exposed soil	6,30	1,83
Urban area	5,57	1,61
Agricultural crops	3,73	1,08
Continental water	0,41	0,12
Total =	**345,26**	**100**

Source: authors.

Based on the aforementioned categories, there is an abundant presence of shrubby caatinga, a fact that is explained by the climatic context in which the area under study is located, the semi-arid region. This unit occupies an area of 149.76 km², about 43.37% of the municipality, with emphasis on the occurrence of plants from the Anacardiaceae families; Vachellia, Senegalia, Mimosa, Chamaecrista and others from the Fabaceae family (IBGE, 2012). It is verified that the caatinga vegetation follows the pattern of the flatter areas, in the pediment, an area belonging to the region of the Pediplano Sertanejo (RADAMBRASIL, 1986).

However, added to its presence in almost the entire northeastern territory, the caatinga has presented a worrying factor in recent years; degradation associated with extraction. In this scenario, it is estimated that 80% of the vegetation is entirely modified, an indication of alert for this exclusively Brazilian domain (ARAÚJO FILHO, 1996; LEAL; TABARELLI; SILVA, 2003).

It is observed that one of the causes for this trend is the extractive potential of this class, such as medicinal, forage, and wood cutting for firewood and/or charcoal, which makes it susceptible to large-scale extraction (LEAL; TABARELLI; SILVA). , 2003). Considering, then, the dynamics of the studied municipality, it can be said that the degree of risk increases when checking areas deforested for pastures for goats and sheep, as well as areas of fire, a common practice in the semi-arid regions of Bahia (SAMPAIO; SOCORRO; SAMPAIO, 2008). From the perspective of environmental planning, there is a need for management practices that mitigate degrading scenarios, according to the Brazilian Agricultural Research Corporation (EMBRAPA, 2007), the simplification of bureaucratic procedures in the management of caatinga areas, as well as the delimitation of priority regions for species replacement would be one of the alternatives for the sustainable use of the caatinga (ARAÚJO FILHO E CARVALHO, 1997; SOUZA; ARTIGAS; LIMA, 2015).

There is also the presence of forests, totaling 148.35 km², or 42.97% of the total area of the municipality. Data from the IBGE Technical Manual on Vegetation indicate that forests are large vegetational formations with similar or related phytophysiognomy (IBGE, 2012), in the case of this study, the forests are mostly found in the Serra da Jacobina area, an area represented by an elongated valley and which exhibits considerable altitudes and intense erosive characteristics, in addition to fractured and faulted rock outcrops (RADAMBRASIL, 1986). As they occur in areas associated with the busy relief of mountain ranges, the forests have different orientations, bordering the aforementioned geomorphological features (RADAMBRASIL, 1986; CPRM, 2005; EMBRAPA, 2015).

Due to the geological and geomorphological evidence, as well as associated with the microclimate, the forests in the municipality of Antônio Gonçalves are long and spaced, and are positioned in hydroly-favorable zones (CPRM, 2005). In terms of environmental planning, a certain degree of preservation of these areas was perceived. In these environments, compliance with the Forest Code (BRASIL, 2012) is also suggested, and given the location on the Serra da Jacobina, it is recommended to follow the rules of Permanent Preservation Areas (APP), which establish general protection standards. and soil conversation, as well as sustaining water recharge. In addition, it should be noted that adherence to the proposal for the Serra de Jacobina Environmental Protection Area (BA) in areas belonging to this class is essential (BAHIA, 2019).

Still through the analysis of the spectral performance of the targets, the herbaceous vegetation category showed 31.14 km², or 9.02% of the municipal territory. For the IBGE (2012), herbaceous vegetation are plants that have flexible stems, usually 35 cm or more in height, and are of fundamental importance in maintaining the woody layer of the Caatinga (SILVA et al., 2009). Lima (2011) states that in addition to influencing the phytophysionomic aspects of the Caatinga, herbaceous vegetation also maintains germination conditions for the woody stratum, since it provides a kind of protection and shading to the soil (IBGE, 2012; SILVA, 2011).

In Antônio Gonçalves, the herbaceous vegetation class follows, for the most part, the orientation of the river courses, as it also assumes directions from the areas of the structural valleys of the municipality (RADAMBRASIL, 1986). There was a certain state of preservation of these environments, which may be linked to the factors of mild climate and water richness (CPRM, 2005). As intrinsic characteristics of planning, the occurrence zones are of extreme importance for the soil biota and water cycle, due to the proximity to intermittent channels, and soil cover, being necessary to follow the specific legislation for these areas (IBGE, 2012). ; SILVA, 2011; BRAZIL, 2012).

The exposed soils had a coverage of 6.30 km² or 1.83% of the territory. These areas, according to IBGE (2013) are abandoned extraction lands without exposed vegetation, or areas managed or prepared for agriculture, rocky outcrops or deforested areas for human use. On the main map (Figure 2), the exposed soil class is denuded areas such as soccer fields, highways, agricultural preparation areas, etc. It is suggested the observation and geotechnical monitoring of these environments, with the aim of mitigating possible impacts on the biota, as well as aiming at reducing erosive risks (LIMA, 2007; SILVA et al., 2009; IBGE, 2013).

As for the class of urban area, it represented in the municipality the sum of 5.57 km², a total of 1.61% of municipal extension, associated with the urban-population context of the municipal headquarters and the districts, such as Caldeirão do Mulato, Brejão da Grota and Jiboia (IBGE, 2020). Evaluating the urbanized areas, distributed in the mentioned locations, it is suggested that measures of sectorial policies and planning be reviewed, with the aim of balanced urban development (HONDA et al., 2015); In the field, inappropriate use was observed in areas south of the municipal headquarters, in areas of alluvial plains, also close to herbaceous vegetation, which culminates in a worrying spatial behavior, as it increases the risks of events, such as periodic floods (IBGE, 2009; CHRISTOPHERSON, 2012; LIMA and LUPINACCI, 2019), and generates negative impacts on the vegetation formations of the terrain. It is recommended to follow the guidelines of the National Policy for Civil Defense and Protection, established by Law No. 2012; HONDA et al., 2015).

The class of agricultural crops and continental water represented 3.73 km² and 0.41 km², or 1.08% and 0.12% of the territory, respectively. According to the IBGE (2020), the municipality shows economic prominence for the extraction of umbu and oilseeds, such as licuri, as well as for the cultivation of palm, a species widely used for animal consumption. In the field, the presence of corn was also observed and, in the areas of Serra da Jacobina, grapes. Regarding the continental water class, the Aipim dam, in Serra da Bananeira, stands out, which occurs in the center-south of the municipality and supplies the surrounding districts, in addition to being directly responsible for irrigating the plantations of nearby family farmers, such as residents of the village of Bananeira dos Pretos.

FINAL REMARKS

This work was guided, essentially, by the interest in contributing to the development of research on land use and occupation in the northeastern semi-arid region. In this sense, it can be said that the procedures used in this work, based on GIS routines and spectral analysis, did not dispense with the practice of fieldwork, while the use of the QGIS software version 3.10.14 proved to be effective.

As for the analysis of land use and occupation, the predominance of shrubby caatinga was found, whose existence is explained by the climatic context in which the municipality is inserted. There was a large presence of forest areas. Next, the class of herbaceous vegetation was quite expressive, and follows, for the most part, the orientation of the fluvial courses. The class of exposed soils, urban area, agricultural crops and continental water were a minority in the spectral result of use and occupation.

In general, it is hoped that this work can be the starting point for other studies, and that it provides an initial basis for different cartographic proposals in tropical semi-arid environments, or for research that proposes to better diagnose the dynamics of use and occupation of land in the municipality of Antônio Gonçalves – BA, Brazil.

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