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Mapping and Classification of Use Only in the Municipality of Ulianópolis-PA: Dynamics of the Landscape in the Hydrographic Micro-basin of the Cabeludo River

Maiara dos Santos Sousa[1*], Letícia do Socorro Cunha[1], Renata Adelaide Pluta[1], Vanessa de Oliveira Faria[1], Karlene Fernandes de Almeida[1] and Fabiana Tonin[1]

[1]State University of Western Paraná, Agronomy, Brazil.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The search for economic development, in its most varied production models, anthropic actions have caused great environmental impacts, changing the environment and consequently causing environmental risks in different ways. In this sense, this work aimed to map the use and occupation of land through the spatial temporal dynamics of the hydrographic landscape of the Rio Cabeludo, in the municipality of Ulianópolis - PA, using integrated techniques of remote sensing and geoprocessing. Through the images, the supervised classification of the area was carried out, using the ENVI software for digital image processing and ArcGIS software for the elaboration of the thematic map. Some classes were investigated, such as urban area, exposed soil, temporary tillage, permanent tillage, dense vegetation, scrub, pasture, hydrography, cloud, shade, it is noteworthy that not all classes were repeated in the analyzed period. The evaluation of the studied area showed that there were significant changes in some classes. The identified classes reflect the dynamics of agricultural activity and not commercial plantation areas or large tracts of land. The work showed the possibility and importance of using geoprocessing techniques to monitor the territory and manage the environment, enabling better forms of land occupation and use of natural resources.

**Corresponding author: E-mail: maiaraifet@gmail.com;*

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1. INTRODUCTION

Over time, nature undergoes constant natural transformations in its landscape, which are necessary for the balance of space and its natural resources. However, in addition to natural changes, the search for economic development, in its most varied production models, anthropic actions have caused major environmental impacts, changing the environment and consequently causing environmental risks in various ways, such as: compromise of sources and sources of water, soil erosion, among others. As a result, the constant human interventions in space have been the subject of discussions and studies in various areas, aiming at planning and interventions for the establishment of environmental recovery actions.

Thus, in recent years, environmental conservation has become a major challenge for a large part of the authorities, as well as for the regional communities involved, because depending on the decisions taken and effectively applied to the quality of life of future generations, they will be guaranteed. In this sense, the use of geographic information systems (GIS) is essential, as it provides subsidies for decision-making for the rational and sustainable use of natural resources [1].

Because, among the existing natural resources, it is known to many individuals that the rational use of water resources has been one of the concerns of a large part of society in the 21st century, as this is finite, and in its absence, several regions suffer the consequences with problems in crops, animal husbandry, health problems and lack of food. Thus, remote sensing and geoprocessing techniques have been developed; which are used as effective tools to aid in watershed management [2].

Hydrographic basins, as well as other natural resources, are objects of discussion in various social spheres, as they are essential to guarantee human and biological survival, however these resources are targets of human actions, which often use nature inappropriately, causing environmental degradation.

The environmental degradation of a given location, as well as the understanding of the organization, and the changes that have taken place over the years, can be identified and observed through the mapping of land use and vegetation cover, as this enables knowledge of the entire the use, or characterization of the types and categories of vegetation covering the soil of a given space [3].

Therefore, Geoprocessing is a very important tool for monitoring biodiversity, due to its capacity to collect data for different studies, as well as perform complex analyses, by integrating data from different data sources. The GIS can also be considered as an important means of support and development of applications aimed at the environment, facilitating the integration of spatial data and allowing to propose alternatives to reduce identified impacts on the environment, including in the scope of hydrographic basins [4].

In this context, the study focused on the municipality of Ulianópolis in the State of Pará is inserted, which has been suffering an intense exploitation of its natural resources, especially since the 70s, with the arrival of entrepreneurs, timber industries and industrial production of monoculture.

At the same time, the mesoregion of Ulianópolis-PA, accompanying the process of economic insertion, experienced a rapid process of landscape transformation and currently presents itself as an important agro-industrial region of Pará for being a prominent center for sugarcane in the national scenario. With this many environmental problems of medium and large amplitude have appeared. There are vast studies found that indicate environmental problems related to soil contamination, contamination of water resources, change in the dynamics of the water table, decrease in biodiversity, among others.

In this sense, changes in the surroundings of the Cabeludo River Microbasin were evaluated through a multitemporal analysis, using remote sensing tools and geoprocessing techniques.

2. MATERIALS AND METHODS

2.1 Delimitation of the Microbasin under Study

The study area is located exclusively in the State of Pará, the municipality of Ulianópolis - PA, located in the surrounding rectangle with geographic coordinates latitudes 03º3410 to 03º

75 08 south of the equator, and longitude 47º2927 at 47º4900 west of Greenwich at an altitude of 185.67 m, has an area of 5,081,061 Km². It belongs to the Capim River region, being limited to the municipalities of Dom Eliseu and Paragominas. on the margins of the BR-010 Highway, which connects Belém to Brasília. It has a population of 55.739 inhabitants [5].

The delimitation of the Hydrographic Microbasin area was carried out using a digital file in shapefile format of the orthocodified hydrographic base (Level 5 Orthobasins) available by the National Water Agency – ANA. For this, the image was masked using the tool: Masking – Build Mask, and after that, the Apply Mask command coupled to the 4.7 software was performed to cut the image according to the vector limits [6]. The limits of the microbasin were, therefore, defined by the topographic dividers that circumscribe the area that drains to this specific point.

2.2 Data Systematization

For the survey of land use and land cover, as well as for the detailing of the hydrographic network and road network of the study area, digital images from satellites of the Landsat series and the USGS satellite were used, aiming with this, the temporal analysis in a sample space totaling 29 years (1988 and 2017).

For 2017, a georeferenced image by a high precision process (MrSID) was used, corresponding to the 222/063 orbit, coming from the Landsat 8 satellite, from the B4, B5 and B6 of the Operational Land Imager (OLI) sensor, with planialtimetric base compiled and made available by the Research Center of the University of California (USGS), also containing the existing drainage networks and road network in the study area, among other elements. As for the software applied in the computational environment to conduct the processing of the database associated with the georeferenced information in the study areas for the different periods, it was the Enviroment For Visualizing Images – ENVI 4.7 for the treatment and digital processing of satellite images.

2.3 Land Remote Sensing Satellite – LANDSAT

To acquire satellite images, it was necessary to register on the INPE website (www.inpe.br). After completing the registration, the download of images from the LANDSAT 5 satellites was requested.

According to the release, spectral bands 3, 4 and 5 of the images covering the municipality of Ulianópolis –PA from the dates 07/06/1986 were downloaded, respectively, corresponding to the year 1988 analyzed in this work, with point 222/63 orbit.[7].

In order to acquire the LANDSAT 8 satellite images, it was necessary to register on the USGS platform and then open the Earth Explorer platform from which the download was requested, placing the image data and the period of remote sensing.

2.4 Image Registration

The image registration process becomes essential, as it provides a cartographic uniformity to the different images used, which becomes a necessity in this work for its objectives.

For two images to be perfectly coincident in space, it is necessary that they undergo a type of spatial transformation. Such transformation called image registration refers to the process of geometric alignment of two or more images, that is, the adjustment of the coordinate system of one image to the equivalent system of another, covering the same area. The recording of images is necessary in cases where you want to perform a comparative analysis of multitemporal images, combining images from different sensors, or even juxtaposing images [8].

2.5 Image Processing

According to [9] image pre-processing minimizes radiometric and geometric distortions. The first changes the gray levels of each image element and the second the spatial distribution of the image elements, affecting scale, affinity, orientation, among others.

Aiming to standardize land use patterns present in the selected images, a radiometric normalization process was carried out using the ENVI 4.7 program, involving the steps of transforming the digital numbers of the raw images into radiance values, and its subsequent conversion to apparent reflectance. For the geometric correction, the Universal Transverse Mercator coordinate system - UTM, zone 23 S, and datum of the Geocentric Reference System for the Americas – SIRGAS 2000 were used.

2.6 Supervised Image Classification

Image classification according to [9], as an extraction of information from images. Therefore, it is divided into two parts, image classification and filtering. Because it is a case of supervised character classification, object classification is performed by their spectral signatures. According to [6] the supervised method allows classification with any prior knowledge of the classifier about the attributes of the classes and the area of study. However, there is little control over the separation between classes.

In this type of classification, it is defined by definition that the algorithm is able to identify the classes of a data set, assuming that the number of classes and the amount of interaction are provided.

2.7 Editing Classes

The edition of the classification of classes was carried out through visual interpretation according to the spectral behavior of each pixel, also due to the different formations of the delimited regions within the landscape; thus differentiating the areas with the same pixel reflectance, but which supposedly had their properties of different formations, such as: layout, cultivated species, tree structure, among others.

Afterwards, the file was transformed into a vector file (shapefile) and quantified using the Spatial Statistcs Tools extension of ArcGIS 10.1. The final classification was generated with the following classes: (1) Hydrography, (2) Dense vegetation, (3) Caponier, (4) Pasture, (5) Temporary tillage, (6) Permanent tillage, (7) Urban area, (8) Exposed Ground, (9) Shadow and (10) Clouds. The construction of the classification key was carried out from the analysis of the features present in the study area.

Classification, in remote sensing, is understood as the association of points in an image to a class or group of classes, which represent terrestrial aspects and targets such as: hydrology, vegetation, urban area, etc. Image classification can be defined as the technology that performs recognition of classes or groups whose members exhibit common characteristics [10].

Thus, according to [11] the concepts attributed to land cover and land use maintain a relationship with each other and are used to being used alternatively. Human activities are commonly directly relevant to the type of land cover, regardless of whether it is forest, agricultural, residential or industrial. Remote sensing data, such as aerial photographs and satellite imagery, can be correlated with the land cover and used to map the subject. However, as the remote sensing does not record activity specifically, but rather land surface characteristics that depict land cover, land use activities in relation to land cover need to be interpreted from patterns, tones, textures, shapes, spatial arrangements of activities and location on the ground, thus identifying the classes present in the space, which may be: Caponier; Pasture; urbanized areas; temporary culture; permanent cultures; Dense Vegetation and Hydrography.

2.8 Temporal Analysis of Images

The quantification of areas, vegetation classes and land use and so on for each of the years involved in the study was carried out considering the Class Statistics function, cited by [12]. The step referring to the analysis of the dynamics of land use in the periods considered was conducted through cross-tabulation between thematic images of consecutive dates, that is, from 1996 to 2017, using the change detection module of the ENVI 4.7 program.

To estimate the data obtained, the Confusion Matrix technique was used, which, according to [13],offers an effective measure of the classification model, by showing the number of correct classifications versus the predicted classifications for each class , about a set of training samples from each class.

From the inspection of change matrices, the corresponding percentage in an area of a class that was converted into another during the analyzed periods was verified, thus making it possible to analyze the transformations of the targets of interest.

3. RESULTS

From the multitemporal analysis of the data obtained in the unsupervised classification of land use and occupation of the Cabeludo River watershed in the period from 1988 to 2016, some classes were investigated, such as hydrography, dense vegetation, soil exposure, temporary tillage, permanent crop, dense vegetation, scrub, pasture, clouds and cloud shadow, it should be noted that there were classes that were not repeated in the analyzed period. Based on the values of the classes mentioned, a graph was made to demonstrate the percentage corresponding to each class previously identified (Fig 1 and Fig 2).

Based on the data (Fig. 1) it can be seen that most of the classified visual area is composed of dense vegetation corresponding to a percentage of 56.88%, this fact shows the low degree of anthropization in the area, as well as the expressive remnant forestry. The second class with the highest percentage was exposed soil, corresponding to 15.51% of the Cabeludo River watershed. In this analysis, the capoeira class corresponded to 11.51% of the total size of the hydrographic microbasin, while the identified hydrography corresponded to a percentage of 8.93%. The pasture class identified within the

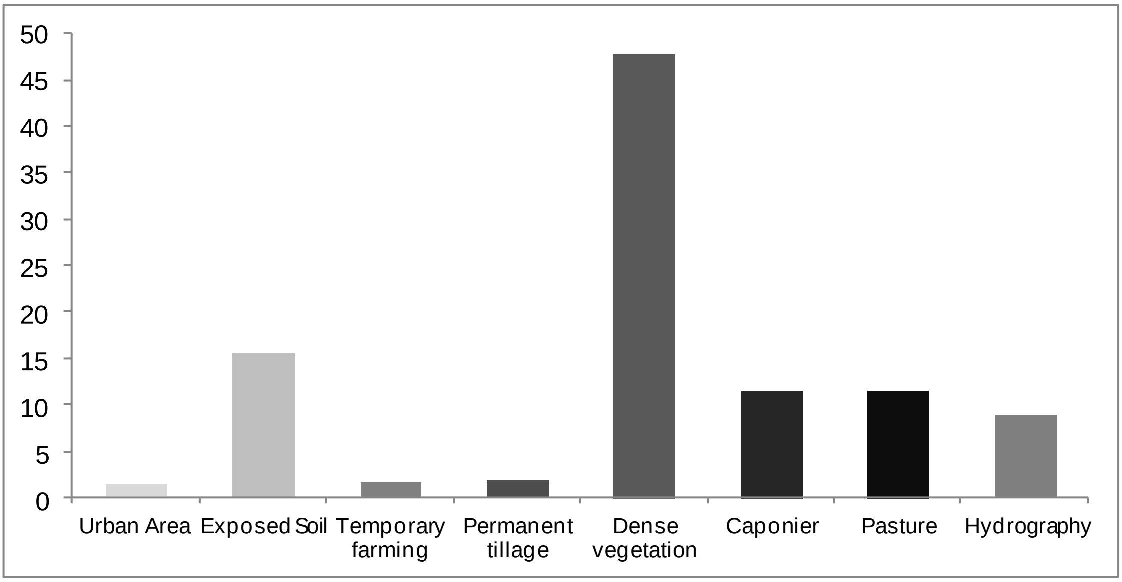

Fig. 1. Distribution of land use and land cover classes in the Cabeludo River Watershed in 1988

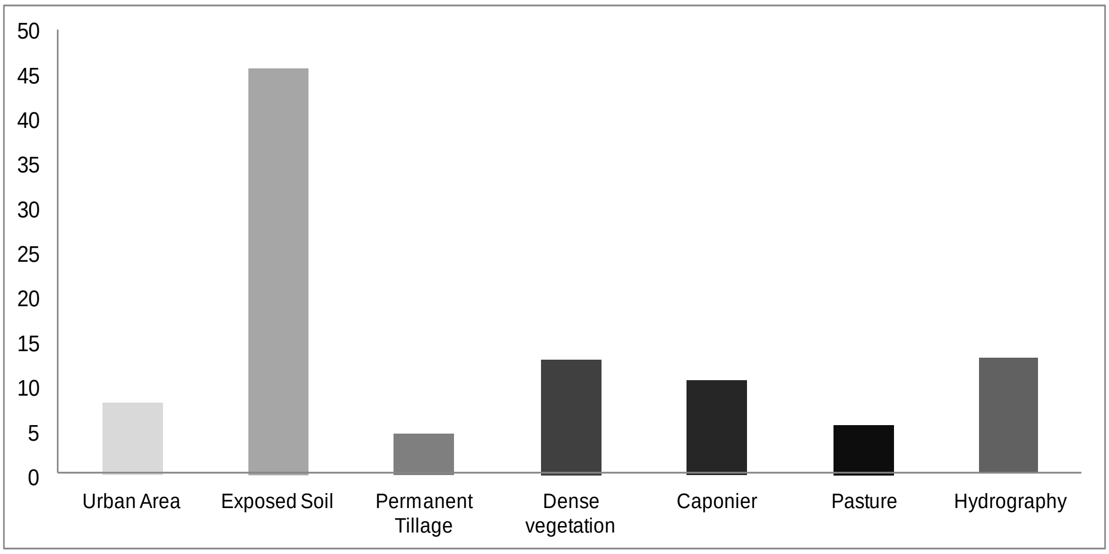

Fig. 2. Distribution of land use and land cover classes in the Cabeludo River Watershed in 2017

area covered by the Cabeludo River Basin corresponded in 1988 to 2.43% of the analyzed area. The class of crops both temporary and permanent the percentage obtained low percentages with respectively 1.61% and 1.79%. And urban area was the class with the lowest percentage, correlating to 1.34% of the total size of the area, a factor related to the beginning of the colonization of the city.

Correlating the data obtained between Fig. 1 and Fig. 2, there were significant differences between the studied classes, there was a reduction in dense vegetation, which went from 47.89% to 12.87%, totaling a reduction of approximately 73%. Considering the 2017 data, there was also a reduction in the pasture area, which in 1988 corresponded to 11.47% of the total area analyzed, rising to 5.48% in 2017. The most significant values regarding the representations of features in the images occurred in the Solo Exposto class, which suffered a considerable increase, and in 1988 this class represented 15.51%. In the 2017 image analysis, it rose to 45.64%, symbolizing an increase of more than 100%.

4. DISCUSSIONS

According to [14], exposed soil in general is an area that presents small spectral responses of vegetation cover in relation to the soil. According to [13], the forest is responsible for numerous ecological functions that are important for the functioning of ecosystems, including the protection of vegetation that covers mountainous regions or any natural area with the purpose of producing good quality water.

[15], mention in their work that secondary forests also known as capoeiras are the result of a succession process in areas where, in the past, there was clear cut of primary forest. The main examples of capoeira in the Amazon region are: fallow areas in the slash and burn agricultural system; vegetation formed after abandonment of degraded pasture areas and vegetation after abandonment of semi-perennial (i.e. black pepper) and perennial (i.e. cocoa) agricultural crops.

An important assessment regarding hydrography was raised by Mosca [16] where it is considered the smallest unit of the ecosystem, where the delicate interdependence relationship between biotic and abiotic factors can be observed, and disturbances can compromise the dynamics of its functioning.

According to [17], pasture is one of the causes of the fragmentation of areas of natural vegetation that lead to results such as loss of biodiversity, changes in biogeochemical cycles, which are presented as the main consequences for the causes of deforestation. On the other hand, it is noteworthy that the agricultural development of the Amazon in general, was encouraged by the Federal Government, first with the aim of guaranteeing the occupation of geographic space and later, regional development through tax incentives, subsidy and project financing [18].

According to [19], the formation of pasture occurs through the conversion of the forest, based on the process of cutting, felling and burning, although this practice is degrading, it is the lowest cost for the producer, however after the farmer ends up abandoning the area because it does not present satisfactory levels of production without the use of technologies, as there is a drop in soil fertility. As a result of this practice, new areas are opened.

According to [18] detected 70 square kilometers of deforestation in the Legal Amazon, and in Pará the municipality of Ulianópolis is in 5th place in the Rank of Critical State Municipalities, losing only to Alenquer (PA), Altamira (PA), Senator José Porfírio (PA), and Óbidos (PA), respectively [20].

According to the [20], the production of sugarcane, the second largest among the temporary crops in the state, had a production of 935,020 T, coming from a harvested area of 13,801 ha. In the period 2012-2013, the harvested area remained practically stable, with a variation of only 3.26%. It should be noted that the expansion of this crop in the state is restricted by Federal Decree No. 6961, of 07/17/2009, which prohibited the planting of sugarcane in the Amazon and Pantanal biomes. Thus, the production of this crop in the state is concentrated in the municipality of Ulianópolis (95.19%). Another important data is related to soy production, since, of the three municipalities that cover more than 60% of state production, Paragominas is in first place, with just over 24%, as it was the one that produced the most in 2013, followed by Santana do Araguaia (20.92%) and Ulianópolis (15.95%).

5. CONCLUSION

The classification methodology supervised by the maximum likelihood method of LANDSAT and USGS satellite images, used to analyze and monitor the evolution of land use and land cover in the Cabeludo river basin in the municipality of Ulianópolis over the years studied, proved to be valid for to portray the distribution of land uses in different periods, as well as to analyze the changes that have occurred and their main conditioning factors.

In the evaluation of the studied area, it was possible to verify significant changes in some classes. However, it was noticed that these changes are related to basic survival needs of man on earth. The identified classes reflect the dynamics of small farming and not commercial plantation areas or large tracts of land.

In this aspect, the mapping of land use and land cover was of great importance, since unplanned use can degrade the environment. With the recognition of the area, detection and intervention in critical points of degradation is facilitated, providing the precise location of these areas; therefore, the use of geotechnologies contributes to the management and monitoring process of areas.

The work showed that it is possible to use geoprocessing techniques to monitor the territory and manage the environment, enabling better forms of land occupation and use of natural resources.

Therefore, this evaluation proved that the dynamics of land use and land cover classes are based on the consolidation of agriculture and livestock as one of the variables in the economic matrix of the municipalities.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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