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Remote sensing applied in the vegetation cover analysis in the municipality of Taperoá – Paraíba

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ABSTRACT

The objective of this work was to identify and analyze the different vegetation cover classes in the municipality of Taperoá - Paraíba for the years 1990 and 2015. The images used were acquired in the INPE (National Institute of Space Research) catalog. The image selection criterion was based mainly on the number and distribution of clouds in the study area, TM images (Thematic Mapper) Landsat 5 and Landsat 8 Operational Land Imager (OLI) were selected with the release date of March 3, 1990 and May 6, 2015. The system used for the processing of georeferenced information was SPRING. It was possible to analyze that between 1990 and 2015 there was a reduction of areas covered by dense, sparse semi-dense, sparse + exposed soil and exposed soil; while areas of semi-dense and sparse vegetation showed a progressive increase. Population reports show that in 10 years the lack of rainfall intensified, causing greater exploration of activities such as extensive livestock farming and the exploration of previously abandoned areas. In the area studied, it was observed laminar erosion, with the presence of ravines, furrows and gullies; cattle and goat livestock activity; deforestation for pasture installation; variable population density in the different geographic limits, as well as the implementation of civil construction.

Keywords: Geotechnology, Caatinga, vegetation reduction.

Sensoriamento remoto aplicado na análise da cobertura vegetal no município de Taperoá - Paraíba

RESUMO

Este trabalho objetivou identificar e analisar as diferentes classes de cobertura vegetal no município de Taperoá – Paraíba para os anos de 1990 e 2015. As imagens utilizadas foram adquiridas a partir do catálogo de imagens do INPE (Instituto nacional de Pesquisas Espaciais). O critério de seleção das imagens baseou-se principalmente na quantidade e distribuição de nuvens na área de estudo, as imagens TM (*Thematic Mapper*) Landsat 5 e OLI (*Operational Land Imager*) Landsat 8 foram selecionados com data de passagem de 14/03/1990 e 06/05/2015. O sistema utilizado para o processamento de informações georreferenciadas foi o SPRING. Foi possível analisar que, no período de 1990 e 2015 houve uma redução das áreas cobertas por vegetação densa, semidensa rala, rala + solo exposto e solo exposto; enquanto as áreas de vegetação semidensa e rala, obtiveram progressivo aumento. Relatos da população mostram que em 10 anos intensificou a falta de chuvas, fazendo com que atividades fossem exploradas em número maior como a pecuária extensiva e outras áreas totalmente abandonadas. Observou-se então erosão laminar, com presença de ravinas, sulcos e voçorocas; exploração bovina e caprina; desmatamento para pastagem; densidade populacional variável nos diferentes limites geográficos, além de implantação de loteamentos da construção civil.

Palavras-chave: Geotecnologias, caatinga, redução da vegetação.

Introduction

A biome is a set of plant and animal life, constituted by the grouping of contiguous vegetation types that can be identified at a regional level, with similar geology and climate conditions, and which historically have undergone the same processes of landscape formation, resulting in a particular diversity of flora and fauna (IBGE, 2011).

The Caatinga climate is called semi-arid, which is characterized by low humidity and pluviometric regime, that is, reduced rainfall. This irregular rainfall climate influences the rivers course, which suffers from drought at certain times; reduces water availability for plants, animals and men; increases the aridity of the environment. The climate is then a determining factor in the Caatinga biome: it defines the landscape and the inhabitants routine (Moraes, 2017).

The ongoing environmental degradation process of the Caatinga biome is due to several factors. Thomaz and Costa et al. (2009) state that the main factors that contribute to the degradation of this biome are: inadequate agricultural practices, deforestation, infertility and soil compaction, erosion processes and salinization. Thus, the environmental degradation of the semi-arid regions is related to a series of intrinsic factors, among which we can mention the anthropic action, as a direct consequence of the lack of sustainability, high evapotranspiration rates, low rainfall indexes and misuse of the arable land.

Obtaining information on vegetation classes is an important tool for management and decision making. The knowledge of the vegetal cover classes allows to anticipate protection practices that can reduce the negative impacts to which these environments are subjected, such as emergency measures and corrective actions (Farias, 2013).

The present study aimed to identify and analyze the different vegetation cover classes in the municipality of Taperoá, state of Paraíba, for the years 1990 and 2015.

Material e methods

The municipality of Taperoá (7° 12 '23 "South - 36° 49' 25" West), state of Paraíba (Brazil), is located in the Western Cariri

microregion. It is limited to the North with Sand of Baraúna, Salgadinho and Assunção, East with Santo André and São José dos Cordeiros, South, with São José dos Cordeiros and Livramento, West, with Cacimbas and Passage. It has an area of 644,155 km² and an estimated population of 15,193 people (IBGE, 2016).

According to Köppen's climate classification, the Bsh climate type predominates in the municipality of Taperoá: hot semiarid, that covers the driest area of the Paraíba state. In its climatic aspects, the region is characterized by rains concentrated in a single period (3 to 5 months), with the annual rainfall averages varying between 400 to 800 mm. The mean annual temperatures are high (23 to 27 °C). Is located in the areas of the Paraíba river basin, a sub-basin of the Taperoá river, where it has limitations due to high evapotranspiration rates. The pluviometric oscillations should receive more attention, since almost all the rural activities developed in the area depend on it, with a direct influence on the region's economy. The Paraíba's semi-arid is known as a low rainfall incidence region. This fact has a socio-environmental consequence that justifies any study that aims to develop policies to improve local conditions.

The main water accumulation bodies are the weirs: Manoel Marcionilo, with a maximum capacity of 15,148,900 m³ of water; Lagoa do Meio (Municipal) with a capacity of 6,647,875 m³ of water (both managed by the State) and the following ponds: Do Escuro, Fernando, Panati and Canga.

For this study, the evaluation of the vegetation classes was observed, being as follow: dense, semi-dense, sparse semi-dense, sparse, sparse + exposed soil and exposed soil. The images used were from the years 1990 and 2015, obtained from the TM / Landsat - 5 satellite, with transit date 03/14/1990, and OLI / Landsat - 8, with transit date 06/05/2015, referring to the 215 orbit and point 65. These images cover the municipality of Taperoá, state of Paraíba, and its geographical limits. For computer support the following hardware resources were used: software SPRING 5.4.2 and Microsoft Office Excel.

The visual analysis of images proceeded from a comparative study between the spectral and textural properties that each spatial phenomenon assumes in the several recorded scenes, associating different levels of reflectance to the various phenomena, the time of acquisition of images related to the spectral targets.

The digital image processing techniques can be divided into 3 stages according to Santos et al. (2010) in the following scheme:

- Pre-processing of images: it is the set of processes through which the images pass, in order to minimize their distortions to the maximum. The distortions can be classified as radiometric and geometric. Radiometric distortions change the gray levels of each element of the image. Geometric distortions alter the spatial distribution of image elements, affecting scale, affinity, orientation, among others aspects.

- Images enhancement: this technique aims to modify, through mathematical functions, the gray levels or other digital values of an image, in order to highlight certain spectral information, improving its visual quality and facilitating the later analysis by the photointerpreter.

- Image analysis: it is related to the extraction of information in the images. Includes image segmentation and classification. The segmentation has the objective of fragmenting a region into homogeneous units, considering some of its intrinsic characteristics, such as pixel gray level, texture and contrast. The classification of images aims to categorize the land cover, distinguishing the compositions of different surface materials, being a specific segmentation using patterns recognition techniques.

After the determination of the physical values of the Landsat images, it was proceeded the NDVI calculation proposed by Rouse et al. (1973). The values obtained with the NDVI calculation are contained in a scale of -1 to 1. For this index, the following expression was adopted:

$$NDVI = \left(\frac{\rho_{IVP} - \rho_V}{\rho_{IVP} + \rho_V} \right)$$

in which: IVP is the reflectance value in the 'near infrared' band; V is the reflectance value in the 'visible red' band.

In order to increase the contrast between soil and vegetation, the ratio between red and near infrared bands can be used, thus forming the so-called vegetation indexes (NDVI). The multispectral composition set in Landsat 5 involves the following bands (b3 + NDVI + b1) and in Landsat 8 (b4 + IVDN + b3) to an RGB transformation in whose the red light source (R) will be positioned in the band 3, in the green source (G) the NDVI image and in the blue source (B) the band 1. In this combination, areas of high NDVI value will appear in green (occurrence of vegetation) and areas of low occurrence of NDVI will appear in red or blue (magenta or cyan), indicating the presence of exposed soils.

The final maps of the vegetation classes were created in the SCARTA module of the SPRING software.

Results and discussion

The results were obtained with the points of information georeferenced and scanned in the SPRING program. Regarding the normalized difference vegetation index - NDVI, it was observed differences in the vegetation cover in the images dated from 1990 and 2015. It shows a very advanced vegetation loss in the landscape, where the lighter gray shade has a higher vegetation cover and the darker shade of gray tends to the exposed soil (Figures 1 and 2), with the use of two bands of the electromagnetic spectrum (bands corresponding to red and near infrared).

According to Neto et al. (2009), the arithmetic operations - ratio between bands - NDVI (Normalized Vegetation Indexes) were created to reduce the work of orbital data analysis, by maximizing vegetation spectral information in a lower number of operation bands of the sensors. These operations highlight the spectral behavior of the vegetation in relation to the soil, which reduces the size of the multispectral information obtained, even when providing a highly correlated number of agronomic parameters.

The figures below show this clear vegetation difference, and it also shows the

great water decrease in the Manoel Marcionilo reservoir, Taperoá - PB.

Figure 1. Normalized Difference Vegetation Index (NDVI) - Taperoá/PB in 14/03/1990. Source: Silva, Miguel José 2017.

Figure 2. Normalized Difference Vegetation Index (NDVI) - Taperoá/PB in 06/05/2015. Source: Silva, Miguel José 2017.

Farias et al. (2013), when performing a study in the microbasin of the municipality of Taperoá - PB, found that the degradation advance in the region is partly attributed to the lack of conservation practices in the agriculture, as well as the exploitation of forest resources for energy and income making. In addition, the disorderly growth of cities and the industries establishment have also aggravated the environmental problems of the microbasin, either by the lack of basic sanitation facilities, which leads to water pollution, or by the pressure that these anthropic activities exert on natural resources. It should be noted that the

basins, sub-basins and hydrographic basins have suffered numerous impacts with agriculture and livestock activities, the implantation of industries, the disorderly growth of cities, clandestine hunting of the fauna and the extraction of plant species. All of these activities have caused serious environmental degradation, confirmed by Duarte (2008) and Silva (2011).

After plotting the data, a comparative analysis of the Adjusted Multispectral Composition (AMC) was performed for the same dates of NDVI, 03/14/1990 and 05/6/2015, where it was possible to observe the

behavior of the targets, vegetation and soil. It shows high levels of degradation by the

removal of its vegetation in some points (Figures 3 and 4).

Figure 3: Adjusted Multispectral Composition (AMC) - Taperoá/PB in 14/03/1990. Source: Silva, Miguel José 2017.

Figure 4: Adjusted Multispectral Composition (AMC) - Taperoá/PB in 06/05/2015. Source: Silva, Miguel José 2017.

The Adjusted Multispectral Compositions are efficient and practical for the study and space-time monitoring of anthropic actions, in this specific case of the dynamics involving deforestation and native vegetation recomposition, as well as of the water mirrors in the most representative water springs of the region studied. The degraded areas are differentiated by the magenta color. The green color indicates vegetation covering, and the lighter the green, the higher the level of preservation of the native vegetation. The darker green areas represent high levels of degradation (Neto et al., 2009).

Through the photographic record, the same characteristics were observed in the field, in 2016, in a comparative analysis of the images generated in the digital image processing. Areas with soft to wavy reliefs; exposed soil with high stoniness; sparse shrub vegetation; specimens with presence of cactus, macambira, jurema and pereiro; presence of algaroba; very serious environmental degradation; laminar erosion, with presence of ravines, furrows and gullies; cattle and goat livestock; deforestation (Figure 5). As well as areas with land abandonment profile and natural regeneration (Figure 6).

Figure 5: Southern limit of the city of Taperoá - PB. Coordinate: $07^{\circ} 18' 32,9''$ S $36^{\circ} 45' 27,9''$ W. Source: Author, year 2016.

Figure 6: East limit of the city of Taperoá - PB. Coordinate: $07^{\circ} 09' 43,3''$ S $36^{\circ} 46' 20,0''$ W. Source: Author, year 2016.

The vegetation classes: dense, sparse semi-dense, sparse + exposed soil and exposed soil had their values reduced between 1990 and 2015, whereas the semi-dense and sparse

vegetation classes increased, as shown by the maps that represent the spatio-temporal distribution of the six vegetation classes established in the area (Figures 7 and 8).

Figure 7. Vegetation cover classes in the municipality of Taperoá – Paraíba, year 1990.

Figure 8. Vegetation cover classes in the municipality of Taperoá – Paraíba, year 2015.

The data indicate that in 1990 the area covered by dense, semi-dense, sparse semi-

dense, sparse, sparse + exposed soil and exposed soil was, respectively, 8.3 km²; 13.9 km²; 140.8 km²; 159.3 km²; 228.5 km² and 107.6 km². In 2015, 3.8 km²; 77.8 km²; 32,7 km²; 264.9 km²; 218.2 km² and 65.3 km² were the areas covered by dense, semi-dense, sparse semi-dense, sparse, sparse + exposed soil and exposed soil, respectively.

Semi-arid climate regions present vegetation more susceptible to changes, responding quickly to the presence or lack of rainfall. Thus, in the municipality of Taperoá, its was observed deforestation with exposed soil spots that were present in all areas, besides the presence of extensive livestock farming, such as goats and cattle (Figures 9 and 10).

Figure 9. Abandonment of the land, allowing natural vegetation restoration. Source: Author, year 2016.

Figure 10. Soil preparation system for extensive livestock activity. Source: Author, year 2016.

The Caatinga vegetation is composed of xerophytic plants, species that developed mechanisms to survive in a low rainfall and humidity environment. In the Caatinga biome shrubs and small trees are common, as well as

thorns are present in many plant species. In the cactuses, for example, the thorns are leaves that have been modified throughout the evolution, which reduces water loss by evapotranspiration (FIOCRUZ, 2012).

The flora consists of xerophytic species (dry and thorny formation resistant to fire and with practically no leaves) and deciduous species (which lose their leaves during the dry season) with a predominance of cactaceae and bromeliads, so that the species do not exceed 12 meters height, the shrubs 5 meters and the herbaceous extract vegetation 2 meters. The main species are: aroeira, mandacaru, xique-xique, juazeiro and amburana. The fauna consists of 47 species of lizards, 45 species of snakes, 4 of chelonians (family of turtles) and 44 species of anurans (frogs and toads). Among these species we can mention: Ararinha-azul, Sapo-cururu, Cutia, Asa-branca, Preá, Gambá, Veado-catingueiro, Tatu-peba, Cascavel and Cobra-bicuda (CAATINGA, 2017).

According to Moreira (2004), part of the deforestation occurs due to the system adopted since the colonization period that was based on the exploitation of the natural resources, in particular of the natural vegetation, that was replaced by a very intensive agriculture and livestock activity.

Sousa et al. (2007), studying the semi-arid vegetation of the municipality of Boa Vista, state of Paraíba, observed that the forest cover was also reduced during the years studied. The deforestation in this case is related to the large use of the land for extensive livestock farming and the extraction of firewood from the native vegetation by the low income rural population, that has no better energy alternatives. Barbosa et al. (2007), when studying the vegetation cover evolution and agricultural land use in the semi-arid region of Lagoa Seca city, state of Paraíba, observed that the significant increase in areas under livestock farming activity in the region can be seen from two aspects: substitution of the exploitation type, because of the economically positive response in areas where commercial crops such as fruit and vegetables were previously cultivated, and replacement of native vegetation by pasture, due to the possibility of economic exploitation.

The rural population reduction causes less anthropic pressure to the environment, due to reduced agricultural and livestock activities. The less productive lands are abandoned, allowing the native vegetation to grown in these areas again. The vegetation cover

permanence and intensification in higher and sloping areas indicate lower anthropogenic pressure on this environment, since these fields are more remote and difficult to reach.

The anthropic activities result from an erroneous perception generated by a failed environmental education, with prejudiced and generalist point of views, which end up making the Caatinga one of the most degraded biomes, where 45% of its original vegetation has already been replaced by pastures and crops, and the remains are extremely fragmented areas (Alves, 2009).

Conclusions

According to the data obtained in the area studied and population reports in more than 10 years, the low productivity of the soil caused land abandonment, giving priority to subsistence agriculture, resulting in increased semi-dense vegetation. On the other hand, the dense vegetation reduction and the exposition of the soil resulted from extensive livestock farming, deforestation, implementation of construction sites and the population density increase. These activities have caused biodiversity loss, erosion processes and reservoirs silting.

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