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Cientific Paper

Abstract

Forests have been increasingly degraded by man. Therefore, in this context, arises the need to assess the model of occupation and land use in order to identify its relations with different levels of local resource degradation and thus organize methods of recovery of these areas. This study aims at the integration of remote sensing technique and TM/Landsat 5 images processing for classification of the land cover and land use in the Peixe-Boi basin, Pará, Brazil in 2008. The land cover and land use analysis of the basin shows that exists a great exploitation of the natural resources. The pasture class was the more significant vegetation cover in the region, characteristic of the Amazonian area by the implantation of this on great areas of forests and scrub.

Keywords: Vegetation cover; land use; Peixe-Boi watershed.

Analysis of vegetation cover and land use of the river basin Peixe – Boi - Pará through Landsat 5 satellite images

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Análise da cobertura vegetal e do uso do solo da bacia do Rio Peixe-Boi por meio de imagens do satélite Landsat 5

Resumo

As florestas vêm cada vez mais sendo degradada pela ação predatória do homem. Assim, surge à necessidade de avaliar o modelo de ocupação e uso do solo a fim de identificar suas relações com diferentes níveis de degradação dos recursos locais e assim estruturar métodos de recuperação destas áreas. O trabalho teve por finalidade a integração de técnica de sensoriamento remoto e processamento de imagens TM/landsat 5 para classificação da cobertura vegetal e uso do solo na bacia de Peixe-Boi, Pará, Brasil em 2008. A análise da cobertura vegetal e do uso do solo da bacia mostrou que existe uma grande exploração dos recursos naturais. A classe pastagem foi a cobertura vegetal mais significativa na região, característica da região amazônica pela implantação desta sobre grandes áreas de florestas e capoeiras.

Palavras-chave: cobertura vegetal; uso do solo; bacia hidrográfica de Peixe-Boi.

Análisis de la cubierta vegetal y uso del suelo de la cuenca del Rio Peixe-Boi través de imágenes del satélite Landsat 5

Resumen

Los bosques están sufriendo cada vez más por acciones de depredación por el hombre. En este contexto, surge la necesidad de evaluar el modelo de ocupación y uso del suelo a fin de determinar sus relaciones con los diferentes niveles de degradación de los recursos locales y así estructurar métodos de recuperación de estas áreas. El trabajo tiene como objetivo la integración de la técnica de sensoriamento remoto y procesamiento de imágenes TM/landsat 5 para la clasificación de la cubierta vegetal y uso del suelo en la cuenca del Rio Peixe-Boi, Pará, Brasil, en 2008. Mediante el análisis de campo y de laboratorio se observó un mosaico de usos del suelo, por lo que es evidente a través del mapa desarrollado, por lo tanto, se verifica que existe una gran explotación de los recursos naturales. Entre las clases, se destaca el predominio de pastos y matorrales en la región. Como reflejo general de la ocupación de la Amazonia oriental, especialmente en el noreste de Pará.

Palabras clave: cubierta vegetal; uso del suelo; cuenca del Peixe-Boi.

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Introduction

Forests have been increasingly degraded by man, its areas are constantly being incorporated both by the productive processes as also by the urban expansion, being that most of the times, the landscape transformations occur without planning, increasing the environmental issues in the Amazonia.

Such issue shows the need of judging the occupation model and land use in the landscape, noting its relations with the increase in the degradation levels of natural resources. As stated by BERNARDI et al. (2007) "the survey of land use, in a certain region, became an aspect of fundamental interest for the comprehension of the space organizational patterns¹."

The information survey about the landscape is of fundamental importance for the development of practices destined to solve the disorders caused by uncontrolled growth on the environment. According to PEREIRA et al. (1989), "the landscape conventional analysis techniques are characterized by the high cost and by the difficulty of obtaining data in a short period⁵."

The remote sensing arises as a more accessible option for the environmental planning and for the supervision of large areas, with time reduction in the information acquisition. VETURIERI (1998) states that "the great dimensions of the Brazilian territory and the need of information obtaining at low cost, in a shorter time are, among others, some of the responsible factors by the growth of this technology⁵."

The Para northeast, specially the region of the Bragantina zone, is characterized by a high degree of anthropization, being that it is an old area of colonization, suffering constant exploitation to attend the demands of the metropolitan region of Belem and of projects implanted along the years.

According to VIEIRA et al. (2007) it is important to point out that the deforestation of large areas of native forest in the Bragantina zone is related to three historical facts. The first occurred in 1616, with the opening of the Royal Road, which connected Belem to Maranhão, passing through the Caeté region. The second impact occurred at late XIX century, with the construction of Railways (1883-1908) and the advance of colonization, both responsible for the destruction of the primary forest. The third deforestation occurred in 1887, when

started the construction of the telegraphic connection between Bragança and São Luís de Maranhão, through the same route of the Royal Road, impacting again in the regions which probably were in recovery process (VIEIRA et al., 2007).

This study has as objective to analyze the vegetation cover and land use in the Peixe-Boi watershed, through the integrate use of products and techniques of remote sensorial and geoprocessing, seeking to offer subsidies to the planning of its territorial occupation.

Material and Methods

Areas of study

The Peixe-Boi River watershed (Figure 1) possess an area of approximately 109581.01 ha, being located between the geographical coordinates: 47° 24' 28" to 47° 07' 30" of longitude WGr. and 0° 54' 00" S and 1° 26' 05" of latitude S. This has presented great relevance in the hydrous context of the Pará state. Being located in the Pará Northeast Mesoregion, more precisely in the Bragantina Microregion, covering besides of the Peixe-Boi municipality, the municipalities of Capanema, Santarém-Novo, Nova Timboteua, Bonito and Primavera.

This watershed has as Main River the Peixe-Boi, with approximately 71 km of extension. Its spring is located close to the Santo Antônio de Cumaru location and its mouth in the Maracanã River, being identified from some physical characteristics in the study of SILVA and LIMA (2000), such as the watershed shape, drainage system, relief characteristic, weather, rainfall, and hydrometric.

Weather

The basin presents a humid tropical climate of monsoon, having rainy periods which can last five months, with rainfall of up to 400mm in April, being that the annual rainfall is 2,300mm. The average annual temperature varies from 26 °C to 27 °C, being the minimum 21 °C and the maximum 32 °C. The relative annual humidity is 84%, being that in April it comes to 91%, decreasing to 77% in October.

Soil and Vegetation

There is the predomination of soils in

1 Translated from the original.

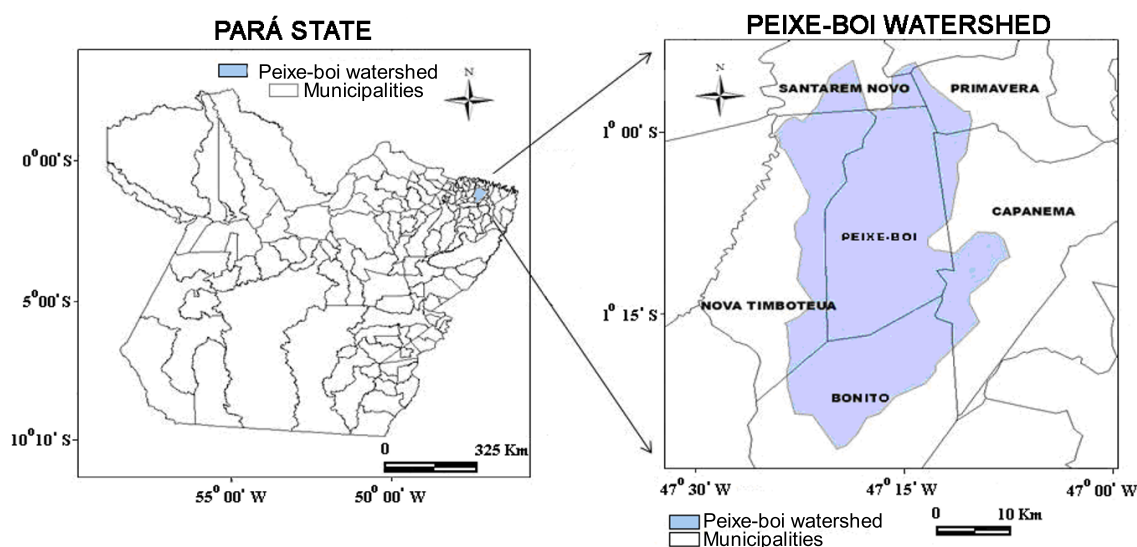


Figure 1. Localization of the Peixe-Boi watershed in the Pará State.

associations, mainly by the Latossolo Amarelo¹, mean texture, and Concrecionários Laterísticos soils⁶; Indiscriminate Hydromorphic Laterite and Alluvial soils. The original vegetation cover is constituted of Upland forests of Amazonia and pasture. Nowadays there is the predominance of secondary vegetation or scrub. At the edges of the water bodies is found the riparian vegetation and wetlands, with strong presence of Cyperaceae.

Systemization of georeferenced data

The treatments and data set analysis along with the georeferenced information of the project areas were done in the programs Envi 4.5 and ArcGis 9.3. Aiming the survey of the vegetation cover and land use, it were selected digital images TM/ Landsat, orbit /point 223/061, TM bands 3, 4 and 5, referent to the year of 2008. It was done the operation of georeferencing in the 2008 year image, from the georeferenced base through high precision process (MrSID).

Delimitation of the Watershed in study

The limit of the Apeú River watershed is based in georeferenced data of the area relief, derived from the Shuttle Radar Topography Mission – SRTM, through the Hidrology command of the Geographic

Information System ArcGis 9.3. The limit of the basin, therefore, was defined by the topographic divisors which circumscribe the area of drainage of the same.

Image Processing

After achieving the rectified image, the same was subjected to the classification process through the Maximum-likelihood algorithm (Maxrver). This method needs a prior knowledge of the features occurring in the study area, thus this research needed a field work, to correlate the spectral features present in the images, determining the vegetation cover and use of the observed land patters on the field.

After the sample harvest of the classes of interest was made an analysis of performance of the same under threshold of 99.9%, being then generated the classification with the same threshold. It was used the confusion matrix with kappa index to assess the image classification, having to establish a value above 80% to be considered representative classification.

In the Post-classification were identified misclassified targets, the same were classified again, being associated to the correct class. Aiming to reduce the amount of observed isolated points in the classified images and, consequently, promote a better uniformity of the defined classes, it was applied a median filter, through a mask of convolution with a dimension of 3x3.

¹ Brazilian soil classification

Temporal-Space Analysis

The quantification of the areas of vegetation classes and land use, for each of the years involved in the study, was made considering the function 'Statistic Classes'.

Results and Discussion

According with the field analysis and the characteristics of the region in study (Figure 2 and Table 1), was possible to differentiate eleven classes of use and occupation of the land, along the coverage area of the Peixe-Boi River watershed for assessment in the vegetation cover.

The conceptual definitions of each class were based in the classification of the vegetation proposed by the IBGE (1992) and used by SOUZA et al. (2001).

a) Exposed soil (area with low level of buildings, under preparation of some productive activity or devoid of any protection);

b) Urban area (is characterized by continuous buildings and the existence of social equipments intended for the basic urban functions);

c) Agriculture (productive areas derived from monocultures with the objective of obtaining food, fibers and energy, being these both the perennial and annual plantings);

d) Pasture (great areas with the dominance of forages used for the alimentation of animals, in this case it includes both degraded and preserved pasture);

e) Low scrub (secondary vegetation composed by grasses and bushes, possessing low diversity of forest species);

f) High scrub (very closed secondary vegetation, being confused with a dense forest by many people);

g) Riparian vegetation (vegetation that appears on the shores of rivers and springs, forest which keeps green during the whole year);

h) Natural fields (area of formation of natural

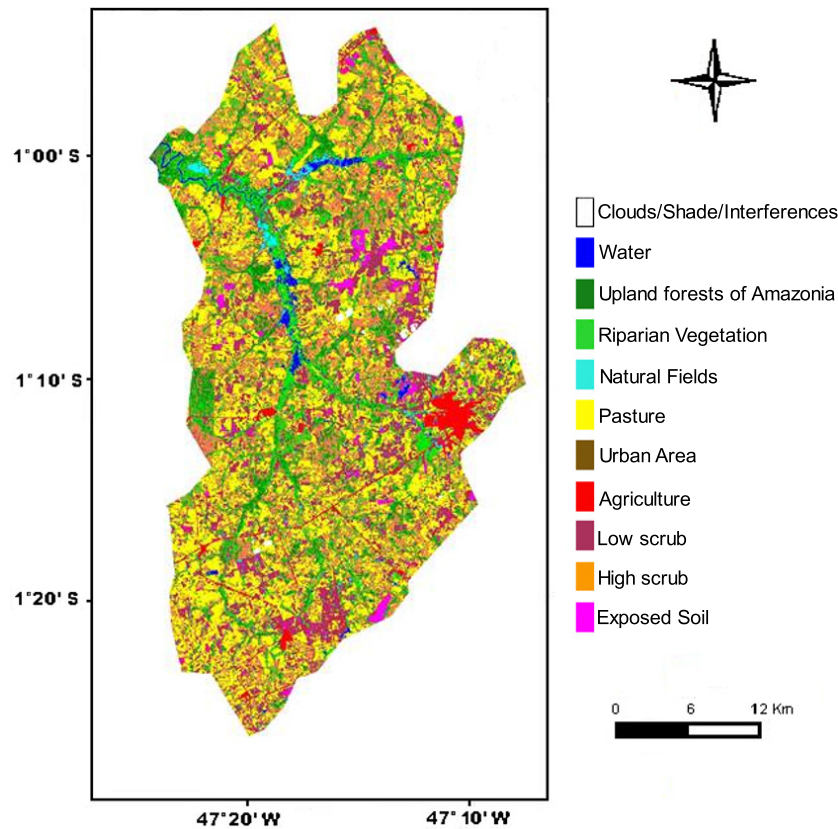


Figure 2. Representation of the vegetation cover and land use in the Peixe-Boi watershed - 2008.

Table 1. Quantification of areas defined by the classes of vegetation cover and land use in the Peixe-boi watershed, in 2008

Classes	Area	
	ha	%
Urban area	3080.38	2.81
Exposed soil	2769.69	2.53
Agriculture	21506.18	19.63
Low scrub	9631.74	8.79
High scrub	11281.67	10.30
Pasture	34806.70	31.76
Riparian vegetation	15805.33	14.42
Upland forests of Amazonia	7837.40	7.15
Natural fields	1034.73	0.94
Water	1474.64	1.35
Cloud/Shade/Interferences	352.55	0.32
TOTAL	109581.00	100

pastures, without anthropogenic interference);

i) Upland forests of Amazonia (Forests located in a higher region, its vegetation can reach about 40 meters high);

j) Rivers (Natural water course, usually fresh water, which flows in the direction of an ocean, a lake, a sea, or other river);

l) Cloud/ Shade/ Interferences (Involves the clouds and its shades and all the non classified regions).

The Pará northeast, as well as the rest of the Amazonia, has as characteristic the shifting cultivation system or slash-and-burn agriculture, which employs the land exploitation during 2 to 3 years, exhausting all resources originated on the soil and then abandoning the land, passing to occupy a new area while the previous one recovers. This process demands a long time for the formation of a scrub, which will bring ideal conditions for the recovery of the soil natural fertility. According to SANTANA et al. (2008), when the land is used for longer and the period of fallow decreases, it is observed a soil fertility loss and an increase of weed infestation.⁵

The agriculture and scrubs categories are linked to the economic process of the region, being that the main agricultural activities are the cassava cultivation for the production of flour and cultivations of maize and rice for the subsistence. The agricultural class present in 19.63% (Table 1) of the basin, characterized by small farmers who do not possess adequate technology and use the

shifting agriculture in the region, have been showing the relation of dependence of the scrub with the agricultural activity. SOUZA et al. (2011), states that in the Pará northeast region exists the predominance of small producers and most of them uses the system of subsistence, being its main products the cassava, beans, maize and pepper.

The scrubs represented by the high and low scrub are 10.30% and 8.79% (Table 1), respectively, of the area. This is due to the model of agricultural activity employed in the region and by the public politics of occupation in the Pará northeast. According to VIEIRA et al. (2007), "though the political, historical and economical events which occurred in the Amazonia, is possible to evidence that the deforestation and the high demographic pressure which occurred had a great impact, at the replacement of the forest by areas of cultivation and scrubs.⁵"

The pastures were the more significant vegetal cover in the basin, because they are present in 31.76% of the landscape (Table 1), being evident as the category which occupied most of the land, showing the regional vocation to produce livestock. These results coincide with the observed in many areas of the Pará state (MCCRACKEN et al., 1999; MERTENS et al., 2002; WATRIN et al., 2009; SOUZA, 2011), where the most evident feature, in terms of area, corresponds to the pastures in its different stages. FEARNSSIDE (2001) estimates that in the Legal Amazon, 80% of the deforestations are now occupied by pastures, mainly degraded or abandoned, being

that these belong to the great land owners. According to VEIGA et al. (2001), "the pasture is the main use of the land in these regions, in virtue of being a more common strategy among all other social agents, because is the cheaper way and is efficient to obtain the effective control of the area when compared with all other systems of land use."⁵

Among the classes, it can be considered those of most importance for the ecosystem, the riparian vegetation, the upland forests of Amazonia and the natural fields, which represented 15805.33ha, 7837.4ha and 1034.73ha of the basin, respectively, these classes represent around 22.51% of the total area, making clear that the region has a high degree of anthropization, having its natural characteristics replaced by areas of greater economic interest. These classes are of fundamental importance for the ecological balance of the region and for the population life quality, because it serves as protection against the siltation of rivers and lakes, and has a great importance for the fauna and flora.

The other categories are presented in a smaller proportion, however they are of extreme importance in the regional context (urban area, natural fields, exposed soil and water), covering 2.81%, 2.53% and 1.35% (Table 1), respectively, of the basin.

The clouds and shades (0.32%) were obstacles in the classification obtainment, because they cause light refraction and as consequence, obstruction of the

image, so, were ignored in the post-classification, to avoid problems with the results.

Conclusion

The vegetal cover and the use and occupation of the area Peixe-Boi River basin evidenced a great exploitation of the natural resources.

The scrubs were the classes of dominant use in the landscape of the Peixe-Boi River basin. The significant occupation of this class is attributed to sustainability of the local agricultural production system, it is used as a fallow component for the reestablishment of nutrients and organic matter stocks used and/or lost during the agricultural period.

The most significant class of soil use and occupation in the basin was the pasture, denoting that the area is strongly marked by livestock activity, reflex of the Oriental Amazon occupation, specially, of the Pará northeast.

The landscape in the Peixe-Boi River basin area, reflects in a general manner, the Oriental Amazon occupation in the Pará northeast, where the taking of territorial space is done in an unorganized and accelerated form. In this manner are, opened precedents for the environmental impacts which appear soon after the intervention in the use of natural resources.

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