OPEN JOURNAL SYSTEMS
ISSN:2237-2202

Available on line at Directory of Open Access Journals

Journal of Hyperspectral Remote Sensing v.03, n.03 (2013) 071-080

Journal of Hyperspectral Remote Sensing
www.ufpe.br/jhrs

CONFLICT OF LAND USE IN PERMANENT PRESERVATION AREAS OF THE PAJEU RIVER BASIN-PE, BRAZIL

Carlos Tiago A. Rodrigues*, André Quintão de Almeida**, Thieres George Freire da Silva*, Donizete dos Reis Pereira***

* Universidade Federal Rural de Pernambuco-UFRPE, Unidade Acadêmica de Serra Talhada-UAST, Fazenda Saco, s/n, CEP 56900-000, Serra Talhada, Pernambuco. (87) 3929-3001. tiagoamancio@hotmail.com; thigeoprofissional@hotmail.com
** Universidade Federal de Sergipe-UFS, Núcleo de Eng. Agrícola, Avenida Marechal Rondon, s/n, Jardim Rosa Elze, CEP 49100-000, São Cristóvão, Sergipe, Brasil. (79) 2105-6991. andreqa@gmail.com.
*** Universidade Federal de Viçosa-UFV, Rodovia LMG 818, km 06 Florestal, Minas Gerais, CEP 35690-000. (31) 3536-3300. doniagri@yahoo.com.br

Received 05 July 2013; revised 11 August 2013; accepted 21 September 2013

Abstract

According to the Brazilian forest code, Permanent Preservation Areas (PPA) should be protected and covered by native vegetation. However, most river basins found in these areas have been altered. The objective of the present study was to map the PPAs and identify conflicts of use in the Pajeú river basin, PE, Brazil. With the aid of a geographic information system, five classes of PPA s were defined: hill tops (PPA-1), slopes greater than 45° (PPA -2), areas surroundings of springs (PPA -3), areas surrounding watercourses (PPA -4), and areas surrounding lakes (PPA -5). Mapping of land use was performed using images from the Landsat 5 satellite of the year 2010, via supervised classification. The Pajeú basin presents 1,260.92 km² of PPAs, corresponding to 7.46% of the basin area (16,886.22 km²). Of the PPA areas defined, only 33.67% presented misuse, consisting of pasture (27.94%), agriculture (4.84%), exposed soil (0.75%) and urban areas (0.14 %). It can be concluded that in all PPA classes mapped, 66.33% were unchanged, which is consistent with the environmental regulations.

Keywords: PPA, watershed, environment

* E-mail para correspondência:
tiagoamancio@hotmail.com (Rodrigues, C. T. A.).

Introduction

The Brazilian Forest Code , Law 4771 of 1965 (Brazil, 1965) provides for the Permanent Preservation Areas (PPA) located on the tops of hills, hills, mountains, around springs, lakes and waterways, being forbidden the use these areas and the consequent removal of its original vegetation cover. The PPAs are protected in accordance with Articles 2 and 3 of this Law, or not covered by native vegetation, with the environmental function of preserving water resources, landscape, geological stability, biodiversity, gene flow of fauna and flora and protection soil (CONAMA, 2002). The PPAs are of fundamental importance in the maintenance of vegetation as the protection of springs, water courses and their respective areas belonging, as well as the balance of the environment. However, in Brazil, these are areas with a high degree of degradation due to the pressure exerted by agricultural activities and uncontrolled growth of urbanized areas (Nascimento et al., 2005, Oliveira et al., 2008; Soares et al. 2011).

Despite having an extensive and rigorous environmental legislation in Brazil the bodies have not proven agile in meeting their obligations (Nascimento et al., 2005, Soares et al., 2011; Ferrari et al., 2012). In countries with continental dimensions, become essential to the representation and characterization of PPAs in digital maps, assisting territorial planning, supervision of government agencies and field

One tool that has been widely used in the automatic mapping of PPAs (Ribeiro et al., 2005) are the Geographic Information Systems (GIS) . These systems allow you to perform complex analyzes to integrate data from various sources and create geo-referenced databases, enabling the automation of the production of cartographic documents (Cavallari et al., 2007; Silva & Silva, 2010). GIS also allow carry out the distribution and viewing of spatial data, the detection processes of concentration and dispersion flows, with a huge potential and relatively low -cost technology (Calegari et al., 2010).

The use of GIS associated with remote sensing techniques have been proven effective in the diagnosis and identification of areas of conflict and land use in the permanent preservation areas (Oliveira et al., 2008; Victoria et al., 2008; Florencio & Assumption 2010; Soares et al., 2011). These tools meet the need for information at various scales making planning much more dynamic and efficient, allowing monitoring, evaluation, and especially decision-making to better manage natural resources available, as well as geological, agricultural, forestry, among others (Destro, 2010; Silva & Silva, 2010; Amaral et al., 2009).

The present study aimed to map the PPAs and identify conflicts of use and land cover in the river basin Pajeú-PE from the combination of GIS techniques and remote sensing.

Materials and Methods

Location of the study area

The study was conducted at river basin Pajeú (BRP), located in the state of Pernambuco, among the coordinates 7 ° 16 ' and 8 º 56' south latitude and 36 º 59 ' and 38 º 57' west longitude (Figure 1). The basin is inserted in the middle region of the Hinterland and the San Francisco Pernambuco, the largest in the state, with a total area of 6,886.22km².

According to the Agency Pernambuco Water and Climate (APAC), the main source of the BRP is located in the hills of balance, Brejinho municipality, at an altitude of approximately 800 m, between the states of Pernambuco and Paraíba, covering 353 km before flowing in Itaparica dam, in São Francisco river. BRP is characterized by a relief ranging from flat to rolling, with elevation and slope of 518 and 20%, respectively. The climate is semiarid (Bswh '), according to Koppen's classification, with the warmer months (October to March) those with higher levels of rain and the cold months (April-September) those drier.

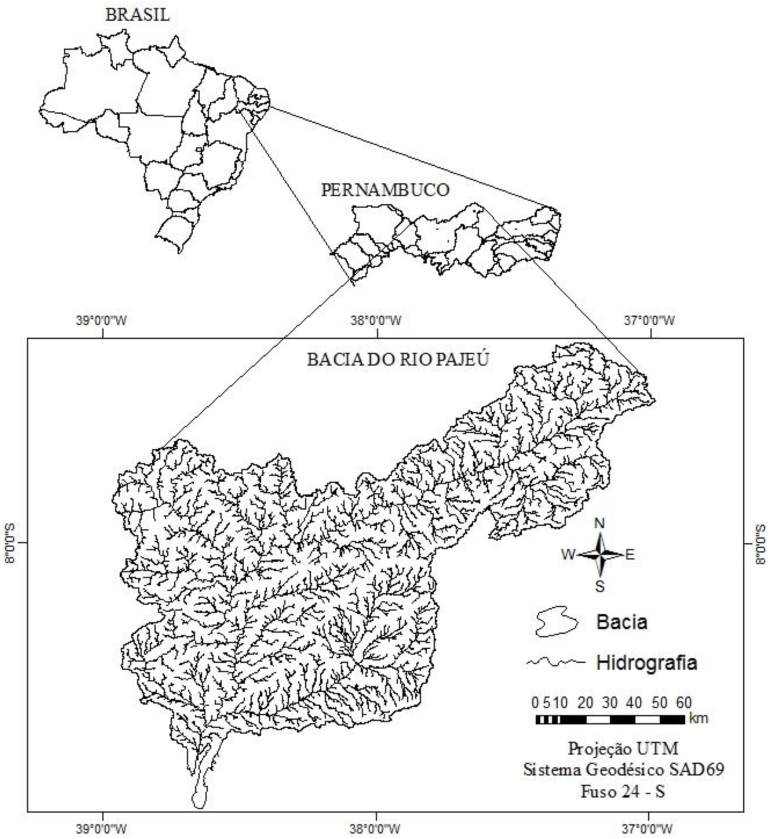

Figure 1. Spatial localization of watershed of Pajeú river, PE.

Data Analysis

Data analysis was performed using computational GIS application, which led to the production of maps for use and occupation of land and PPAs. The use mapping and land cover belonging to the basin was made from images sensor Thematic Mapper (TM) aboard Landsat 5, with spatial resolution of 30 m. We used four different scenes of the satellite in 2010, points 215/216 orbits and 65/66. Initially, the images were preprocessed and georeferenced obtaining a mean squared error (RMS) of 8.5 meters. In use mapping and land cover was used a supervised classification Verosssimilhança Maximum (maximum likelihood). Were considered in the supervised classification spectral bands blue, green, red and near infrared. For each spectral band was performed atmospheric correction, where the digital levels were converted into spectral radiance according to the methodology of the dark object subtraction and subsequently converted to reflectance (ρ). The gain values, elevation and azimuth of the sun needed to convert the radiance in reflectance were obtained directly from the images used.

Visits were made to the field and collected samples of training with a global positioning system (GPS) model of GARMIN 12XL. These samples were used at the time of supervised classification and subsequent validation of the result. The validation of the generated classification was performed by the kappa index according to Equation 1.

$$\hat{K} = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r} x_{i+}x_{+i}}{N^2 - \sum_{i=1}^{r} x_{i+}x_{+i}} \qquad (1)$$

where: $\hat{K}$ - Is the Kappa index;

r - the number of rows in the matrix;

x_{ii} - the number of observations in row [i] and column [i] ;

x_{i+} e x_{+i} - total marginal row [i] and column [i], respectively;

N - the total number of observations.

The identification and delineation of PPAs entered into the BRP were used, relief information of the hydrographic network and use and land cover. Altitude values were extracted from the digital elevation model (DEM) obtained by the Shuttle Radar Topography Mission (SRTM). With spatial resolution of 90 me 1:250,000 scale equivalent to (Sreedevi et al., 2009), these data are available on the website of the American Space Agency (NASA) site "http://srtm.usgs.gov/data/obtainingdata.html" . From the SRTM DEM was generated the hydrologically consistent (MDEHC).

The hydrography was generated automatically from the accumulation of the direction of flow of runoff from the drainage network. The manipulation of the drainage was performed in a GIS based on SRTM data. The springs were determined considering the beginning of each section of the river system generated.

Mapping of PPAs was adopted methodology Pelúzio et al. (2010) and the by strict specifications of arts. two and three of Resolution 303/2002 of CONAMA. The categories were demarcated PPAs that were located in the upper third of hills (PPA - 1) , on the slopes with slopes greater than 45 ° (PPA - 2) , around springs (PPA - 3), Course of water (PPA - 4) and lakes (PPA - 5).

To demarcate the PPA - 1, we calculated the ratio between the heights of the top of the hill to the base for each cell MDEHC. This procedure made it possible to identify all cells that had ratio equal to or greater than 2 /3.

The delimitation of PPA - 2, the MDEHC was reclassified, identifying the areas with slopes greater than 45 °. PPA in category - 3 gave a (buffer), to delimit circles with a radius of 50 m around the springs, having originated at the point associated with each source.

The PPA -4 was considered that all streams had widths less than 10 m, this category was delimited by establishing ranges of 30 meters for both sides.

In defining the class of PPA - 5, it was considered a track with footage of at least 30 m to the lakes located in urban areas and 100 m for those who were located in rural area. The identification of the urban area was performed directly from the land use map generated.

The conflict of land use in the areas of preservation was obtained with the overlay of maps classes PPAs delineated and land use map generated. The entire process was also performed within the GIS.

Results and Discussion

The classes of land use and their percentages can be seen in Figure 2 and Table

2, respectively. The Landsat 5 satellite images of 2010 and field surveys have identified six classes of land use, beyond class cloud (Figure 2). The value of the Kappa index was 0.8, which is considered excellent (Congalton & Green, 1998).

Classes mapped in the Caatinga vegetation and pasture, had the biggest events, with 46.55 and 46.52 % of the total area, respectively, corresponding to more than 90 % of the basin. It should be noted, that were considered in this work, the different successional stages of the Caatinga, as the shrub, tree and shrubs and trees . In a study of morphometric analysis and identification of areas susceptible to erosion of the river basin Pajeú (Feitosa et al., 2011), the authors demonstrated that much of the basin is covered by various configurations of the Caatinga.

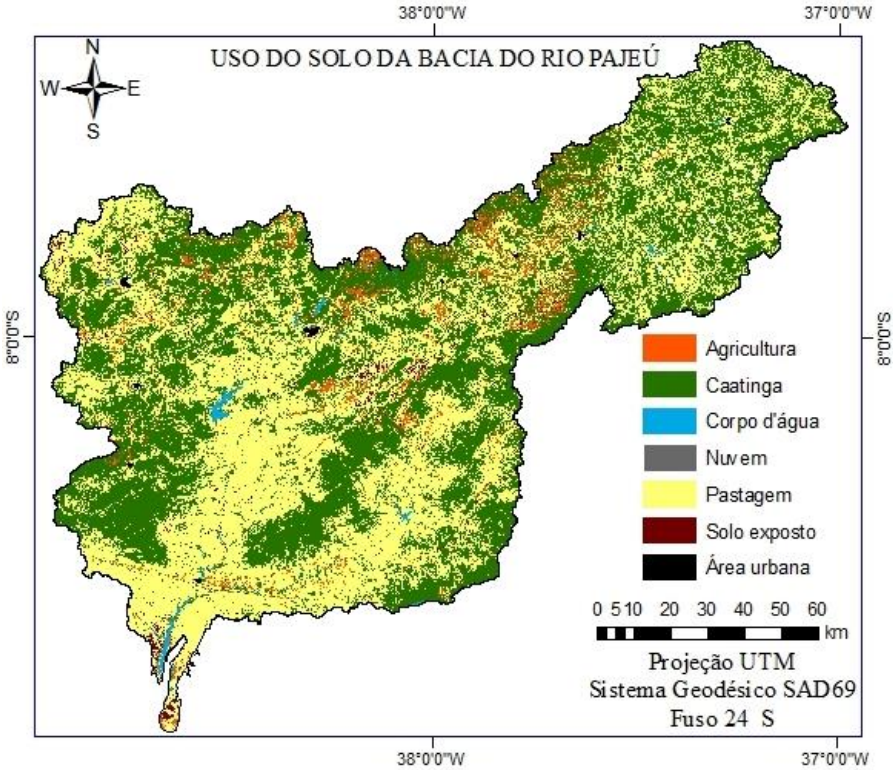

Figure 2. Use and ocupation of soil of watershed of Pajeú-PE river.

The urban area was the class that had the lowest (0.18 %) contribution to the landscape composition. The class of land use water body, comprising lakes, reservoirs and dams, has a contribution (0.92 %) significant within the BRP. What can be explained by the fact that the basin be present in a region of semi-arid type climate. In these areas, the construction of hydraulic structures such as weirs and dams, it is necessary to ensure the supply of water for human consumption and practice activities related to fisheries and agriculture.

In agriculture class, we considered all types of agricultural practices in the region. However, these practices differentiation was not possible due to the small spatial resolution of Landsat 5, which is only 30 meters, that is to be identified and differentiated in the image; the respective agricultural practice should have a minimum 900 m² or a linear distance greater than the value of the image resolution.

Figure and Table 3 presents the results of the delimitation of conservation areas in the basin Pajeú. It is worth mentioning, the occurrence of overlap between different classes of PPAs as classes around watercourses and springs, however, in the final calculation of the conservation areas, overlays are counted only once.

Table 2. Quantification of áreas of ocupation and use of land in watershed of Pajeu-PE.

Intervalo f ocupation	Area	
	(km²)	(%)
Urban area	30.16	0.18
Agriculture	739.55	4.38
Caatinga	7,860.62	46.55
Water	155.71	0.92
Cloud	65.32	0.39
Pasture	7,855.09	46.52
Soil	179.77	1.06
Total	16,886.22	100

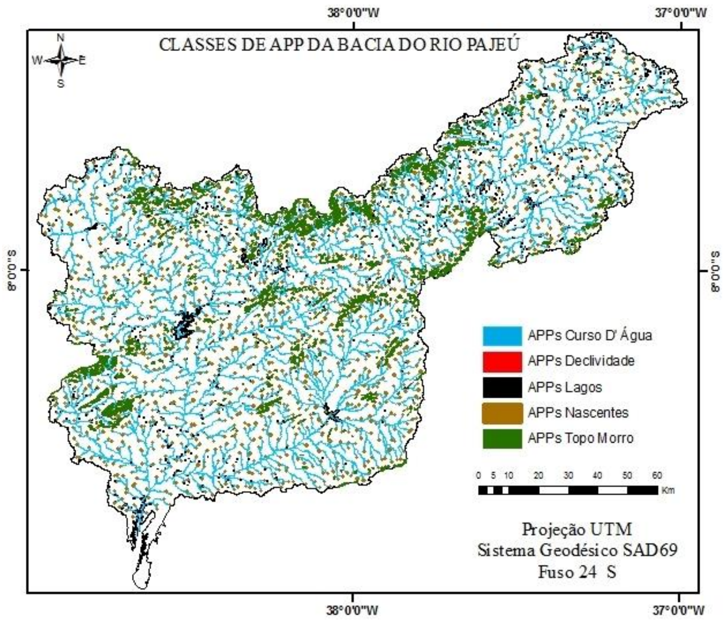

Figure 3. Map corresponding to the PPAs on hill tops (PPA-1), slopes greater than 45° (PPA-2), areas surroundings springs (PPA-3), watercourses (PPA-4), and lakes (PPA-5) of the Pajeú river basin, PE

The total catchment area (16886.22 km ²), only 7.46 % are legally protected. Classes with higher PPAs and fewer were the PPA - 1 (648.75 km ²) and PPA - 2 (0.03 km ²), located on top of hills and slopes greater than 45 º, respectively. Several studies on automatic delimitation of PPAs show results similar to those found in this work (Nascimento et al., 2005, Oliveira et al., 2008; Soares et al., 2011). The low value found in the class of PPA - 2, in areas with slopes greater than 45 °, can be explained, in part, by the low spatial resolution (90 m) and low equivalent scale (1:250,000) SRTM. In a study of delimitation of PPAs, considering two different topographic scales, 1:10,000 and 1:50,000, Almeida et al., (2007) found a 40% difference in the total area of mapped PPAs.

A prominent class of PPA in BRP was the PPA - 5, around the lakes, with approximately 1 % of the total catchment area. As discussed earlier, the basins located in the regions of semi-arid climate, with reduced water availability, it is common the construction of hydraulic structures such as dams and weirs, increasing significantly in relation to the basin, the percentage of conservation areas around these works.

Table 3. *Quantification of permanent preservation areas which comprise the Pajeú river basin, PE*

Interval of PPAs	Area		Total (%)
	(km²)	(%)	
(PPA-1) - Hilltop	648.75	3.84	51.45
(PPA-2) - Slope > 45º	0.03	-	-
(PPA-3) - Source	11.60	0.07	0.92
(PPA-4) - Water	439.54	2.60	34.86
(PPA-5) - Lakes	161.00	0.95	12.77
Total	1,260.92	7.46	100

Of the total identified PPAs. More than half (51.45 %) are located in the watershed (PPA -1) mainly in the northern portion of the basin the boundary between the states of Pernambuco and Paraiba (Figure 3). In the study of delimitation of PPAs in the basin of the river São Bartolomeu - MG (Soares et al.. 2011). The authors found the same result. The PPA - 5 with a contribution of 12.77 % of the total area of preservation of BRP. Much of this contribution is related to the buffer areas of direct Serrinha dams. in the municipality of Floresta and Itaparica dam (Figure 3).

Table 4 shows the values of conflict of land use for the classes of PPAs mapped in BRP. Mostly classes PPAs are covered by Caatinga vegetation, approximately 834 km ² area preserved, equivalent to 66.33 % of the protected areas of BRP. Different result from that found in most studies of delimitation of PPAs in Brazil (Nascimento et al .. 2005; Oliveira et al .. 2008; Soares et al .. 2011). This shows that much of PPAs are mapped according to environmental regulations and not contrary to the forest code. In the study of analysis of the use and occupation of land in areas of permanent preservation in Lavras - MG (Reis et al.. 2012). The authors found 60 and 92 % of PPAs watercourses and slope exceeding 45 ° covered with natural vegetation of the Atlantic.

Table 4. Quantification of use conflit and soil cover in watershef of Pajeú-PE

Use	PPA-1		PPA -2		PPA -3		PPA -4		PPA -5		Total area	
	(km²)	(%)	(km²)	(%)	(km²)	(%)	(km²)	(%)	(km²)	(%)	(km²)	(%)
Urban area	0.08	0.01	-	-	0.01	0.08	1.14	0.25	0.53	0.37	1.76	0.14
Agriculture	28.77	4.43	-	-	0.62	5.07	25.64	5.64	6.10	4.20	61.13	4.84
Caatinga	576.32	88.74	0.03	99.81	5.93	48.34	187.15	41.16	67.47	46.44	836.90	66.33
Pasture	43.33	6.67	0.00	0.19	5.58	45.50	234.73	51.62	68.86	47.40	352.49	27.94
Exposed soil	0.93	0.14	-	-	0.12	1.01	6.04	1.33	2.33	1.60	9.42	0.75
Total	649.43	100	0.03	100	12.26	100	454.70	100	145.28	100	1261.7	100

Whereas only the classes of land use resulting from human activities can be considered misuse grazing (352.49 km ²) and agriculture (61.10 km ²) were greater occurrences of use. occupying respectively. 27.94 and 4.84 % of legally protected areas legislation. The river basin Pajeú most dams are located in urban areas serving to supply the population. Even so urban area (1.76 km²) had the lowest occurrence of misuse with 0.14 %.

Areas of spring protection (PPA - 3) riparian (PPA - 4) and lakes (PPA - 5) showed the greatest conflicts of misuse. In these three categories the main conflict of land use was found to pasture with 45.5 % occurring in PPA – 3, 51.62 % in PPA -4 47.4 % in PPA - 5.

Conclusions

We identified six classes of land use in the river basin Pajeú, beyond class cloud. The categories of PPA s bounded basin occupied a total area of 1.260.92 km², representing a percentage of 7:46 % of the total area. Classes PPAs at greater prominence was hilltop and slope greater than 45 º, respectively. In general, classes PPAs bounded River Basin Pajeú comply with environmental regulations.

Acknowledgement

The Federal Rural University of Pernambuco (UFRPE) and CNPq for grant of scholarship scientific initiation of the first author of the paper.

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