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Use of Applied Geotechnology for Analysis of the Permanent Preservation Area - APP of Bico da Pedra Lake, in the Municipality of Janaúba, MG

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Abstract

Urbanization in permanent preservation areas (APP) results in eutrophication of water bodies, water contamination and change in gene flow of the fauna and flora. Given the above, the purpose of this study was to analyze the permanent preservation areas of the Bico da Pedra Lake in the municipality of Janaúba, MG, using geotechnology. The methodology consisted of the use of Linear Spectral Mixture Model (LSMM) and the Bhattacharya unsupervised classification developed from the image of the Landsat-5TM satellite to identify the land use and vegetation in the Lake's APP. Subsequently, we scanned the QuickBird satellite image at a constant scale of 1:5000 with the purpose of measuring the built-up areas located in the APP in the analysis. The results identified the presence of exposed soil and vegetation suppression in certain locations in the APP. The quantitative area of the APP was measured at 1768.89 ha, with the presence of 15% exposed soil, 32% sparse vegetation, 52% dense vegetation, and 1% non-classified area. We performed scanning for the presence of masonry buildings and farms; 79 of which are in the maximum level of flooding and 217 are in the APP. We concluded that the study obtained satisfactory results for the analysis and measurement of the area of permanent preservation area, allowing the identification of targets and vegetation accurately. Thus, it is inferred that this methodology can be applied in permanent preservation areas in separate locations aiming at monitoring and environmental supervision.

Keywords: Remote Sensing, Linear Spectral Mixture Model, Landsat-5TM.

Introduction

Permanent Preservation Areas (APPs) are critically important for the maintenance of vegetation in certain areas, with the aim of maintaining the use of land unchanged, which should remain covered by the original vegetation (BRAZIL, 2002).

To promote the preservation of forests and other forms of vegetation in the Brazilian territory, the Forest Code (Act 4,771 / 65) established the Permanent Preservation Areas (APPs), in which native vegetation should be retained in its entirety (JACOVINE et al., 2008).

According to Skorupa (2003), the APPs have the ability to promote soil stability, stabilize soil erosion, and preserve water resources, landscape, geological stability, and biodiversity.

In Brazil, thousands of people are affected by the urbanization process in the APP, thereby causing geological change in the gene flow of the flora and fauna, landslides, erosion, contamination of water bodies and

erosion, thus affecting the quality of life of people who need water.

Urban sprawl is a causative factor in a number of environmental impacts. Therefore, these factors motivate numerous studies regarding urban sprawl and human intervention in permanent preservation areas (APPs). According to this approach, Brandão and Lima (2002) defend the idea that many of the impacts caused to APPs are related to disorderly urban sprawl.

The use of technologies such as geoprocessing and remote sensing has represented a major contribution to environmental monitoring that, through various techniques, enable soil mapping and identification of environmental impacts.

Eugenio et al. (2010) states that remote sensing, in conjunction with other geotechnologies, has been important in monitoring various ecosystems, with effective contribution in natural resource planning and monitoring activities.

The analysis and monitoring of natural resources have now become essential. To this end, the use of geotechnologies aimed at environmental support is of great importance for the implementation of an environmental analysis that is more accurate and less costly. Thus, these advantages contribute to decision making and knowledge of the local environment, with the aim of contributing to a balanced and harmonious development of the environment.

Given the above, the aim of this study was to analyze the areas of permanent preservation of the Bico da Pedra Lake, in the municipality of Janaúba, MG, using geoprocessing techniques and remote sensing. More specifically, it aims to identify and analyze areas of confrontation between the type of use and covering of lands inserted in the APP.

Material and Methods

According to the Brazilian Institute of Geography and Statistics (IBGE, 2010), the city of Janaúba is located in northern region of the state of Minas Gerais. The municipality has an area of 2,181,315 km^2, with an urban perimeter of 39.54 km^2 and an urbanized area of 20.00 km^2.

In 1979, the Gorutuba River was dammed for the construction of the Bico da Pedra dam, as shown in Figure 1. The dam is located 6 km from the city of Janaúba and has a volume of 750,000,000 m³ of water, with the primary objective of supplying the Irrigation Project of Gorutuba and the Lagoa Grande Irrigation Project, both together, with an area of 7,160 hectares. (CITY HALL OF JANAÚBA, 2006).

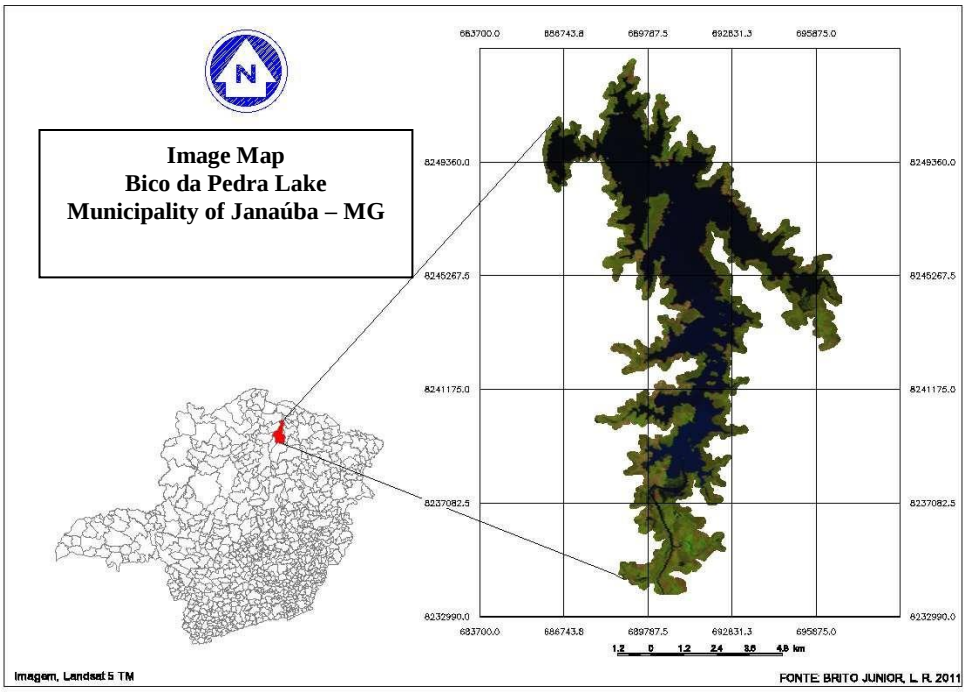

Figure 1. Bico da Pedra Dam.
Source: Own work.

Methodological Approach

First, we created a geographical database defining the study area with its respective geographic coordinates and covering the delineation of the Bico da Pedra Lake in the municipality of Janaúba, MG.

To create the database, we created a project on the computer application SPRING 5.1.2. The data were defined with the Datum SAD69 land model. The database was composed of separate data, with raster and vector file types, represented by layers with image, theme and cadaster categories, as well as other issues of interest, according to the methodology proposed by Mello et al. (2005).

For the remote analysis of the area under analysis, we selected a Landsat-5TM image that is freely available in the catalog of images from the National Institute for Space Research (INPE), on the website http://www.dgi.inpe.br/CDSR. The image used in this study was selected with less than 5% clouds and located at orbit 218 and point 071, dated 3/29/2011.

Image registration is a basic step of Remote Sensing digital image processing. The TM sensor image underwent the digital image processing step in the act of image registration, using georeferencing, through the acquisition of control points. Control points were acquired through the mosaic of images from the National Aeronautics and Space Administration (NASA) and the methodology described by Crósta (1992).

Using the digital archive composed of satellite images, we converted the raster image of the Thematic Mapper Sensor to the "spg" format. The image was then imported into the computer application SRPING 5.1.2.

To distinguish and measure of targets present in the APP of the Bico da Pedra Lake, we used the Linear Spectral Mixing Model (LSMM). Using this technique, we aimed to estimate the proportion of the soil, vegetation and shade components for each pixel in the image, thus generating fraction images for soil, vegetation, and shade. The LSMM is written mathematically according to Equation 1:

$$ri = a*vegei + b*soloi + c*sombrai + ei,$$

Where:
ri = pixel response in band i;
a, b and c = vegetation, soil and shade (or water) proportions;
ei = error in band i; and
i = the band.

To apply the methodology, we used spectral bands 3, 4 and 5 of the TM sensor of the Landsat-5 satellite, forming a linear equation system that can be solved using the Weighted Least Square method. The three bands generated represent the soil, vegetation and shade proportions at each pixel of the image (CÂMARA et al., 2006).

Subsequent to completion of the LSMM, we used the technique of image segmentation, which consists of data clustering, in which only spectral characteristics and spatially adjacent regions can be grouped (CÂMARA et al., 2006).

To Mello et al., 2005, the execution of the segmentation requires the definition of two thresholds: the area threshold, i.e., the minimum value given in a number of pixels for a region to be individualized; and the similarity threshold, the minimum threshold where two regions are considered similar and grouped in the same region.

Based on the linear spectral mixing model of the Landsat-5TM, we generated a soil fraction image, which was segmented using the region growth method. In this work, we used similarity thresholds of 1 and pixel area of 1.

After segmentation of the orbital picture, we used non-supervised image classification, which required the creation and execution of a context and selection of the segmented soil fraction image. We then conducted training to perform the acquisition of samples of different topics such as: bare soil, dense vegetation, and sparse vegetation. The next step was to run the Bhattacharya classifier with an acceptance threshold of 95%.

We performed a scan via the QuickBird satellite image at a constant scale of 1:5000 with the aim of measuring the built-up areas located in the APP, in order to confront and analyze, with greater mapping accuracy, the use and occupation of the soil in the APP of the Bico da Pedra Lake.

To complete the methodology, we obtained the maximum quota files, which were imported into the computer application SPRING 5.1.2, in DXF format. We then performed a 100-meter buffer based on the water margin to delineate the APP of the lake. We made the thematic maps characterizing

and comparing soil use in the APP of the Bico da Pedra Lake through an extension of the SPRING 5.1.2 application called SCARTA.

The methodological procedures used for analysis of the Preservation Area Permanent - APP Nozzle Stone Lake in the Municipality of Janaúba, MG, are synthesized according to the flowchart of Figure 2.

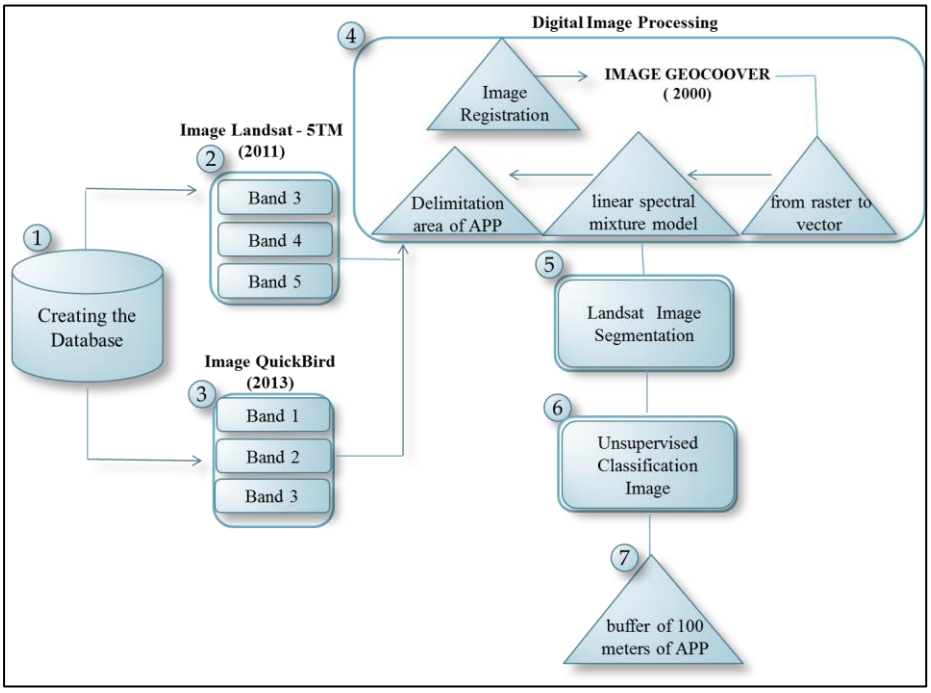

Figure 2. Methodological flow chart for preparation of work.

Results and discussion

The Bico da Pedra Lake dam has a perimeter of 170,288.40 m with a flooded area of 3,642.41 ha (Figure 3). The water in this dam is mainly intended for human supply and irrigation of the Gorutuba Project and the Lagoa Grande Project.

The permanent preservation area was measured with an area of 1768.89 ha, and 15% among these areas was characterized as bare soil, 32% as sparse vegetation, and 52% as dense vegetation (Table 1). However, 1% of the area classified in the APP showed confusion between identification of classes through the Bhattacharya technique. It can be inferred that the non-classification of these areas occurred because there are similar spectral responses between targets in the study area, which may be the result of confusion between the classes by the non-supervised classifier due to the small APP area extracted from the Landsat-5TM image, which has low radiometric resolution between its bands.

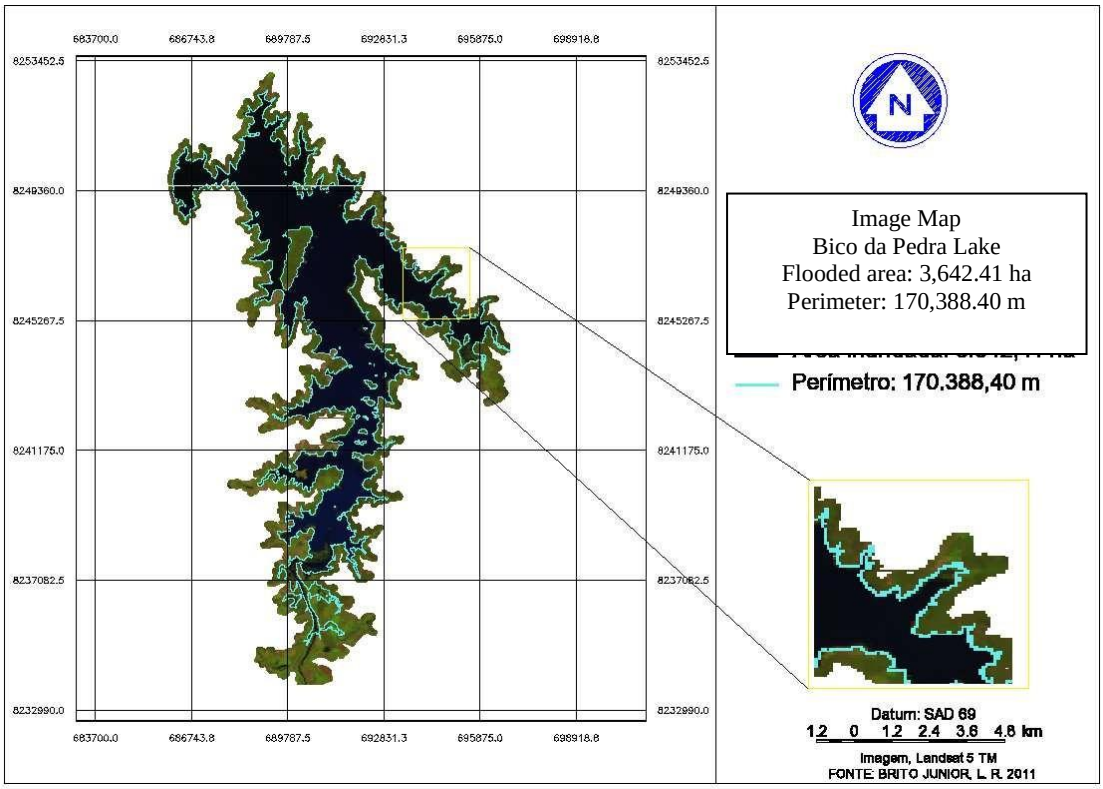

Figure 3. Identification and quantification of the flooded area of the Bico da Pedra Lake. Source: Own author.

Table 1. Soil Use and Occupation Measurement in the APP of the Bico da Pedra Lake.

Soil Use and Occupation	Area	
	(ha)	(%)
Dense vegetation	926.78	52
Sparse vegetation	571.46	32
Exposed soil	259.94	15
Non-classified area	10.69	1
Total area of the classes (APP)	**1,768.89**	**100**

The APP of Bico da Pedra Lake presents an extensive area with exposed soil, and it can be inferred that devastated 259.94 ha of devastated area and 571.46 ha of sparse vegetation are susceptible to degradation by soil erosion, and the lack of vegetation and allows many environmental liabilities as non-sustainability of the soil, increased surface runoff of precipitated water and water pollution by chemicals (Figure 4).

According to Jucá (2007), among many benefits for the environment, the APPs stand out for the production of water, protection of water sources, soil and water conservation, soil carbon sequestration, and biodiversity conservation. Figure 4 shows the map of current land use in the APP of Bico da Pedra Lake in the municipality of Janaúba, MG.

We found the presence of built-up areas, with small-, medium- and large-size residences in the APP of the Bico da Pedra Lake. Nevertheless, through screen scanning using the QuickBird high-resolution spatial image, we identified a large number of masonry buildings and summerhouse properties, whereas, 79 of them are in the maximum flooding level and 217 in the APP (Figure 5).

We also confirmed the presence of several properties located around the lake, in areas of irregular occupation, according to CONAMA Resolution 303 (2002). After the in situ presence in certain locations in the APP, we also noted that few residences treated effluents generated, thus contributing to the

contamination of the lake, which may cause eutrophication thereof, compromising use in supply for human consumption and making these residences subject to expropriation.

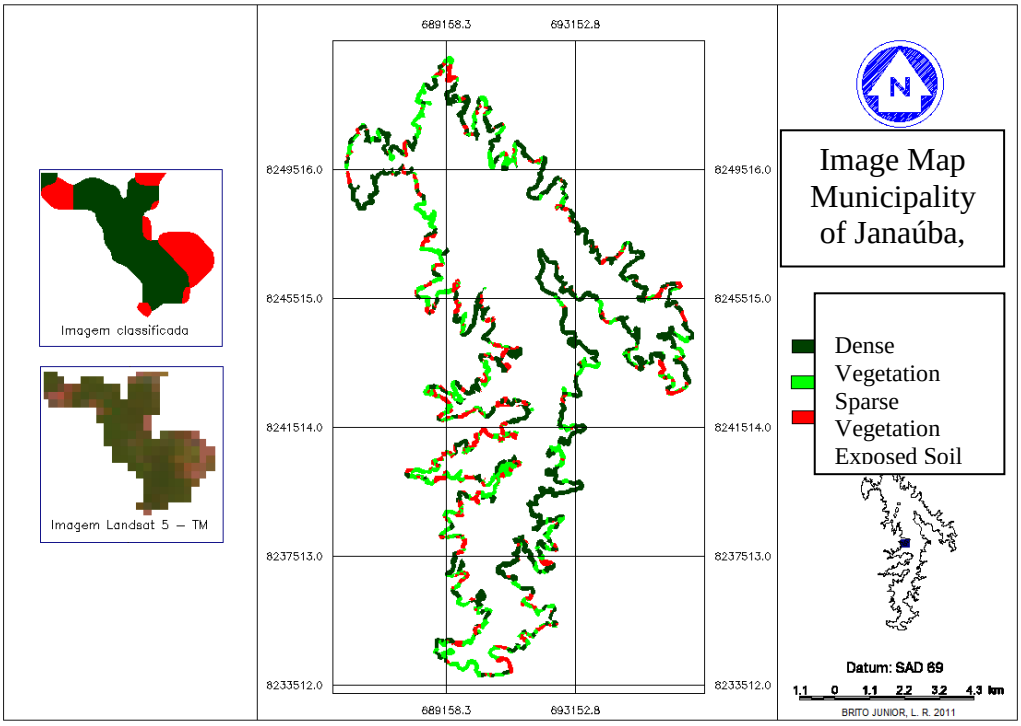

Figure 4. Soil Use and Occupation Map of the APP of Bico da Pedra Lake.
Source: Own work.

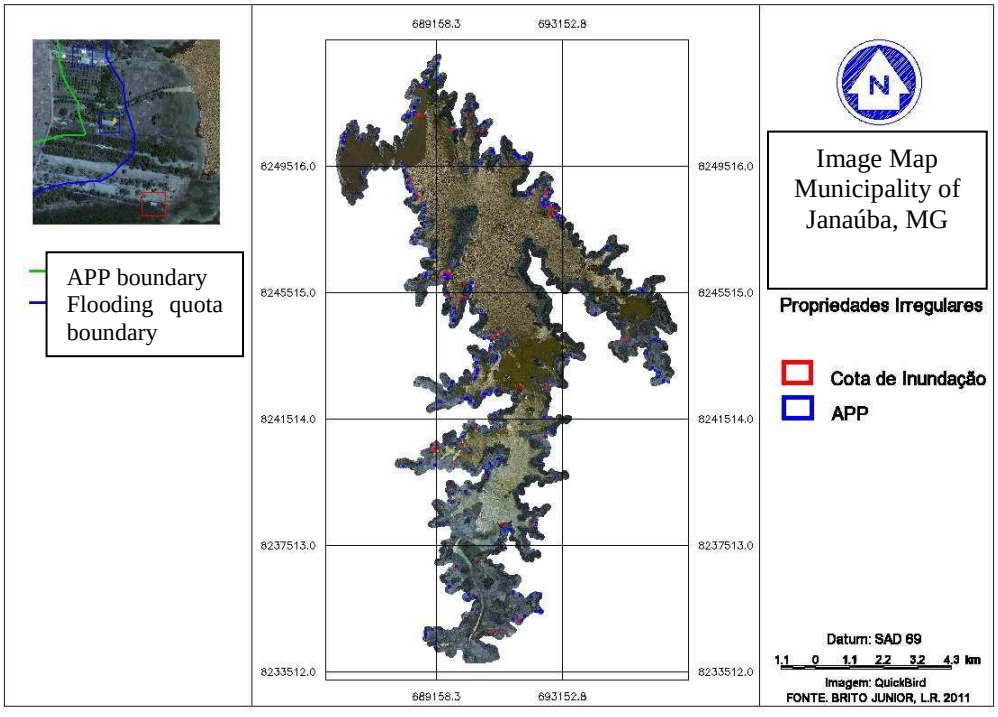

Figure 5. Identification of irregular properties built in the APP.
Source: Own work.

Scardua et al. (2012) corroborate this study by analyzing the permanent preservation areas in the Forno Grande State Park, in the municipality of Domingos Martins, state of Espírito Santo, using Geographic Information Systems (GIS) at the time of the study. The authors also demonstrated the presence of built-in areas in the APPs, measuring an area of 124.79 ha of built-up areas within the APPs. They also demonstrated the noncompliance with CONAMA Resolution 303, of 2002.

Eugênio et al. (2010) characterized built-in areas in APPs in the basin of the Alegre River, in the municipality of Alegre, state of Espírito Santo. Nevertheless, in this study, the authors measured only 2.52 km^2 of built-in areas in the permanent preservation area in a drainage basin with an area of 280.20 km^2.

Conclusion

Municipal measures addressing environmental issues such as natural resource protection and forest restoration should be carried out in locations with the presence of bare soil and sparse vegetation, located in Permanent Preservation Area of the Bico da Pedra Lake.

The remote sensing and geoprocessing techniques adopted for automatic delineation of the APP proved efficient, producing accurate information in an effective and quick way and allowing the spatial distribution of the use and occupation of the Lake soil.

We recommend the testing of different image classifiers, both supervised and non-supervised, with the aim of proving whether the measurement of soil use classes in the APP differ statistically.

Human actions in the APP of the Bico da Pedra Lake are located in noncompliance with the environmental law, thus violating the CONAMA Resolution 303, of 2012.

This methodology can be carried out in different locations with permanent preservation areas aiming at monitoring and environmental supervision.

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