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MAPPING FOR ENVIRONMENTAL PLANNING THE BASIN OF CÓRREGO RICO, SÃO PAULO

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Abstract

The landuse is usually an human phenomenon that occurs over the years, due to population increase. The territorial knowledge is needed, and is the first step for environmental planning to implement conservation practices on agricultural production system. This study aimed to develop thematic maps as: hydrography, soil, slope, land use, and subbasins to obtain the main geomorphic morphometric data (physical) of the Córrego Rico Watershed. The techniques of remote sensing and geographic information system were used to elaborate the maps and for calculating the geomorphological data, as area, altitude and length of the drainage net, which were submitted to multivariate statistics. The Córrego Rico Watershed has an area of 563 km^2. The predominant slopes were 3-8%, with 55.3% of the total area; and the main use was sugar cane. The soils that predominate in the area are Oxisols towards the Mogi-Guaçú river mouth and Ultisols at the upstream of the basin.

Keywords: soil, slope, land use.

1. Introduction

The diagnosis of natural resources is an excellent tool in problem determination, which may assist in the rational planning at appropriate scales, all the space in question. An efficient way of representing this spatial information is the description of a graphical (maps), to assist in planning and environmental monitoring. The use of GIS (Geographic Information System) allows the generation of new databases by operation maps and integrates different types of information (ULLRICH AND VOLK, 2009; PISSARRA, et al., 2013; SOMMERLOT et al., 2013).

The analysis of the use of the main soil units and the slope in an area subsidizes the development of an environmental planning, aimed at the implementation of conservation practices in the middle. The knowledge of the soil occurring in an area is important for the development of physical planning in the conservation assessment of agricultural potential (Rodrigues et al., 2011).

Thus, this work has as main objectives to develop thematic maps as hydrography, soil, slope, soil use and occupation of Rico Creek Basin, targeting the environmental planning.

2. Material and Methods

The watershed of Córrego Rico is localized in region of northeast of São Paulo state and is consists of the municipalities Jaboticabal, Taquaritinga, Monte Alto, Guariba and Santa Ernestina (Figure 1), occupying an area of approximately 563 km2, with geographical position defined by coordinates UTM, 762.000 and 766.000m E, 7.664.000 and 7.945.000m N, MC 51^{o}W Gr.

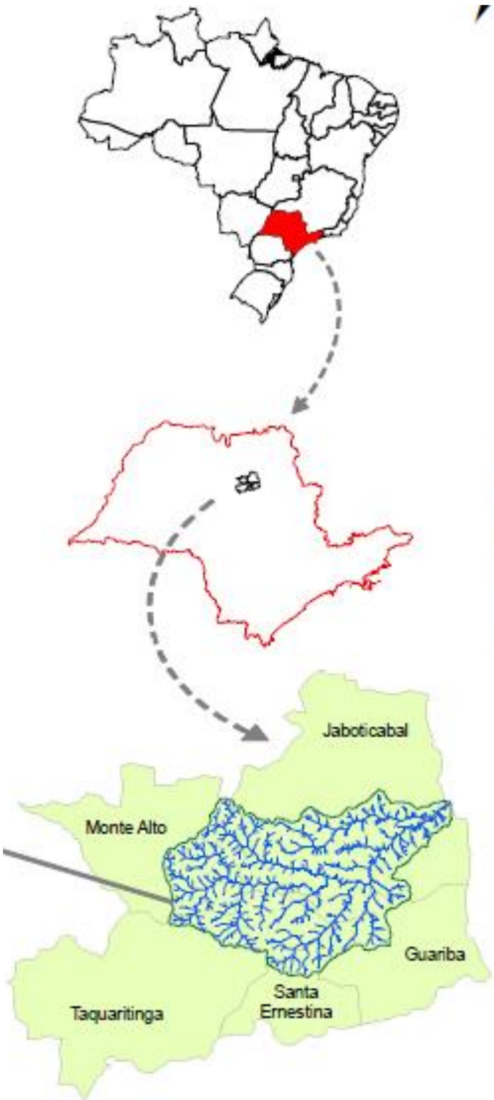

Figure 1: Localization of watershed of Córrego Rico, Jaboticabal – SP.

The climate is classified as Aw (Köppen System), with average rainfall between 1,100 mm to 1,700 mm and annual average temperatures of the warmest month 22°C and the coldest month is 18°C (CEPAGRI, 2013).

The area lies in the province geomorphic V - Western Plateau of São Paulo state. In the higher elevations of the basin, the soils are predominantly Ultisols Red-Yellow whose geologic material consists of sandstones with calcareous cement, classified as Bauru Formation and in the lower levels, dominated by Red Oxisols originating from rocks effusive basic Serra Geral (SÃO PAULO, 1974).

Soil units according to the classification of Embrapa (1999), Oxisols (distroférricos/distróficos, a moderate and prominent, clayey, undulated relief) and Ultisols (undulated relief, sandy texture/ medium and medium to moderately eutrophic and relief undulated and wavy abrupt sandy texture medium, a moderate and normal) that appear, respectively, in lower levels, intermediaries upper basin (POLITANO, 1992).

In this work were used letters planialtimetrics (Taiúva, Jaboticabal, Pirangi Taquaritinga, Pitangueiras and Guariba) scanned the IBGE (1971), horizontal datum Corrego Alegre, MG, and vertical datum tide gauge Imbituba, SC. Projection Universal Transverse Mercator - UTM, originated in Ecuador and mileage Meridian 51 W Gr plus the constant 10.000km and 500km respectively. It is equidistance of 20 meters.

The satellite images of 2010 were obtained from the Indian Remote Sensing Programmer (IRS) Resourcesat - 1 , Linear System Self - Scanning System III - LISS III, the enhanced version of the sensor aboard IRS 1 - D with four spectral bands (Red, Green, Near Infrared and Short Wave Infrared), all with 23.5 meter resolution, swath of 141 km. The sensors on board the satellite to provide data related to the wide application and the characterization of vegetation and crop plant species.

The digital terrain model (Digital Elevation Model, DEM) was obtained for the watershed in program of the EMBRAPA, produced by NASA, NIMA (National Imagery and Mapping Agency), DOD (United States ' Department of Defense) and the Spatial Agencies Germany and Italy, and then refined by excellent Embrapa Relief Project (Miranda et al . , 2011).

We used as the basis for processing and storing data and a microcomputer aimed to choose the most appropriate software for each step of the work. Were used: ArcGIS 10, ArcMap version 10 (ESRI ArcGIS ® 10) and ArcSWAT 2009 (Soil and Water Assessment Tool).

The methodology used in this study consisted in the application of GIS resources, the organization of georeferenced databases of Corrego Rico Watershed in digital image processing for environmental analysis and preparation of thematic maps that depict the results. At the base of the digital model (DEM) obtained by Embrapa Relief Project (Miranda et al., 2011) was generated automatically in geographic information system ArcGIS 10, the drainage network of Corrego Rico Watershed.

The slope map was generated from the digital terrain model (Digital Elevation Model, DEM) obtained for the watershed in geographic information system ArcGIS 10. The definitions of each class of slope followed the precepts of the work performed at EMBRAPA (1999).

Visual analysis of the images was based on the existing relations between the elements of the images and the physiognomic characteristics of plant communities and targets, identifying the faces in the field and in the satellite image. The database was georeferenced mapping in the IBGE (1971), horizontal datum Corrego Alegre. The main occurrences of soils were prepared in accordance with the Pedological Map of the State of São Paulo (Oliveira et al., 1999). The procedure vectorization limit of each soil was carried out in the program is a geographic information system ArcView, ArcGIS 10. The digital classification of satellite images for the making of Use Map and Land Use involved the use of methods by which pixels are associated with use classes and soil cover, was performed by supervised Maximum Likelihood Gaussian. This classifier uses the spectral information of each pixel to define homogeneous regions and is based on statistical methods (PONZONI and CHIMABUKURU, 2007). The thematic maps were updated to SIRGAS Datum 2000, UTM projection, zone 22S.

3. Results and discussion

The study of hydrography is essential for the identification of components involved in natural and anthropogenic hydraulic flow. It appears a total area of 563.13 km², with elevations of 754 meters along the Serra do Jabuticabal with drainage network more branched and altitude of 498 meters in the pipeline exit of Rio Mogi (Figure 2).

The main stream is called Corrego Rico and follows the eastward flowing into the western basin of the Middle Mogi. Comprises the downstream, its right bank, the catchments of the source of Corrego Rico (12.21 km²) watershed of the stream of Fazenda Gloria (20 km²), Córrego do Rumo (39 km ²), Corrego do Vivã (12, 5 km2), Córrego do Carretão (22.4 km2), Córrego do Coco (72.5 km2), Córrego do Fundo (32.6 km2) and Córrego do Gordura (13.2 km2). On the right bank, one observes that the Córrego do Gambá (27.7 km2), Córrego do Tijuco (39 km2), Córrego das Éguas (10 km^2) and Córrego do Jabuticabal (74 km^2) (PISSARRA et al . 2009).

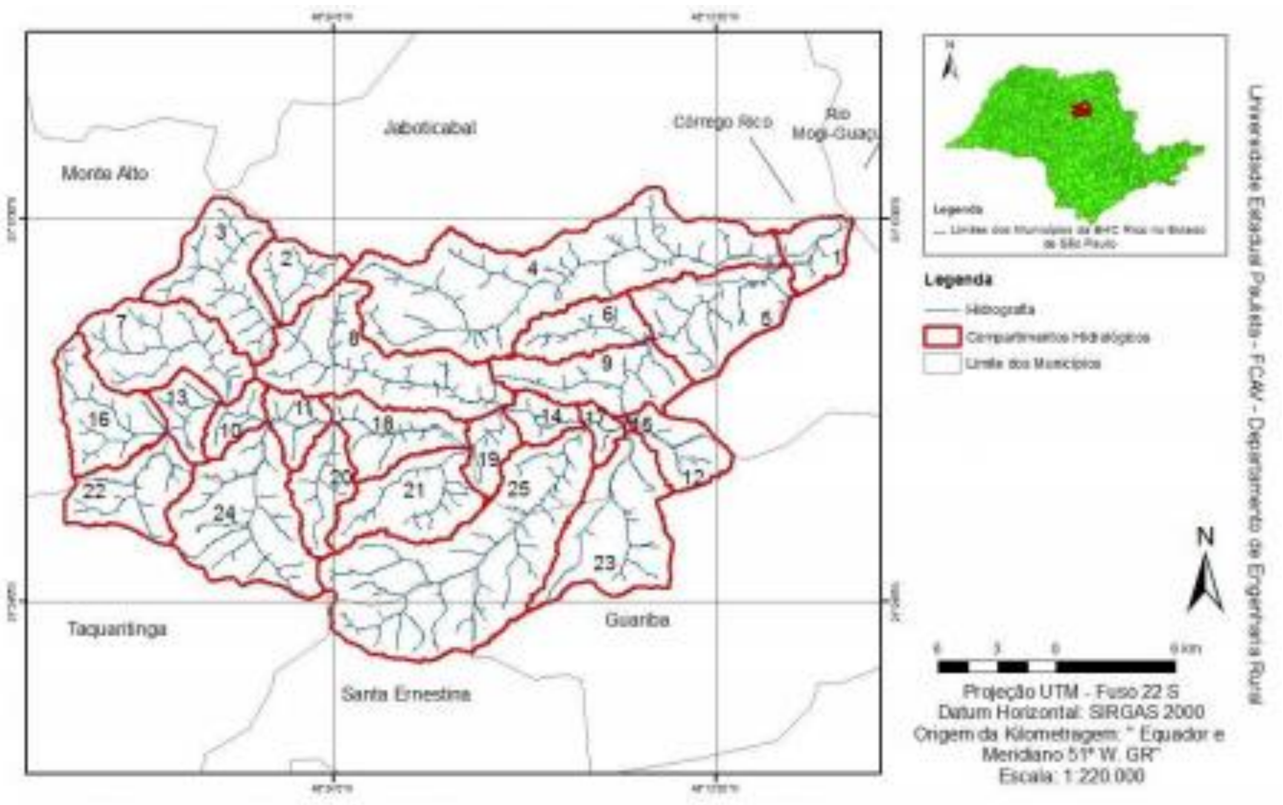

Figure 2: Hydrology of watershed of Córrego Rico, São Paulo.

The drainage network of the source of Corrego Rico, Córrego do Gambá and Córrego do Tijuco born in the municipality of Monte Alto, in the hills of Jabuticabal, at altitudes of 740 meters. The streams in Jabuticabal have altitude of 670 meters.

The Corrego Rico is a tributary of 6th order (Pissarra, 2002) of basin of the Upper Paraná River located in the northern state of São Paulo. It crosses five counties and covers approximately 60 km to find the Rio Mogi Guaçu. Still in its upper course the Corrego Rico receives the discharge of treated sewage from the town of Monte Alto (45000 inhabitants). In its medium-haul supplies part of the city of Jaboticabal (70 000 inhabitants) and receives treated sewage effluent, justifying the importance of studies in this area.

The hydrographic network in Jaboticabal is a plateau that distributes water that drains Mogi Guacu River. In Soil Map (Figure 3) we note that the area of the Corrego Rico presents: Two associations Argissolos Red-Yellow.

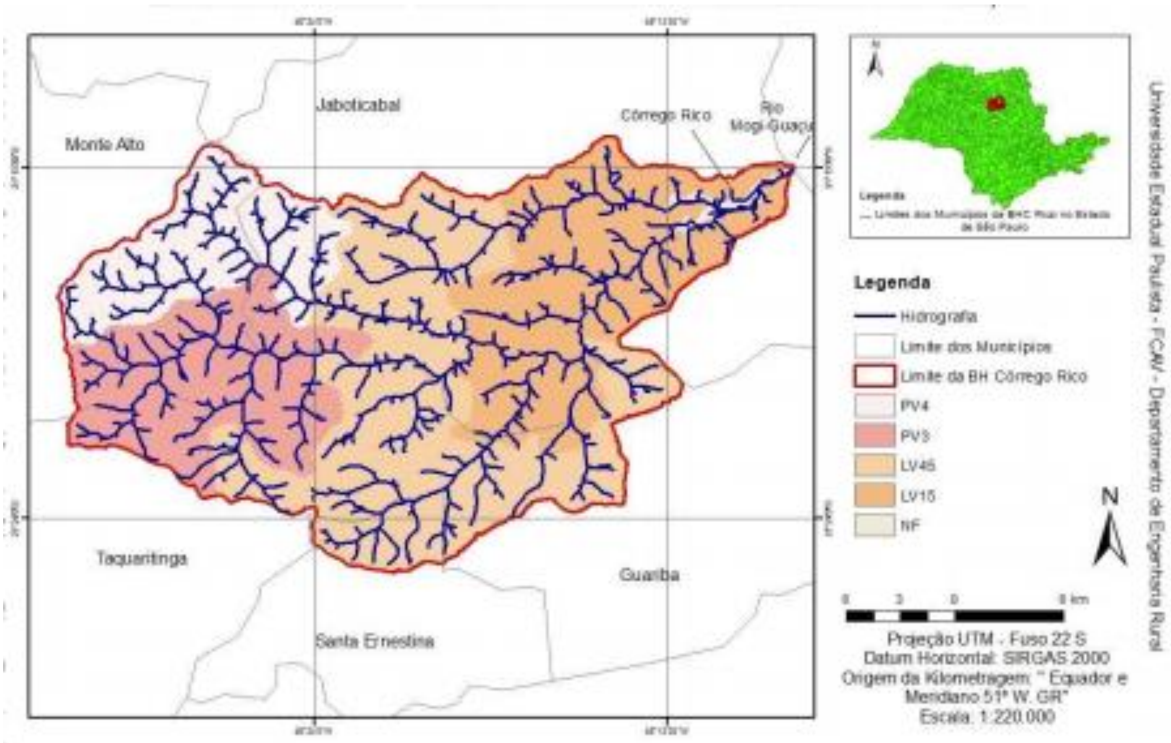

Figure 3: Soils unit of Córrego Rico basin, São Paulo state.

Knowledge of soil-landscape relationships is essential for monitoring and conservation planning environment. Noting jointly hydrography and soils, it is clear that drainage density, the frequency of rivers varied depending on the soil units. As relief undergoes evolution of strong corrugated cardboard for the average values of these morphometric characteristics increased, reflecting greater difficulty in this environment morphological infiltration and better condition for intense surface runoff, causing higher water sculpturing of the land, as observations of Campos et al. (1993); Pissarra (1998) and Silva (1999). The higher the average density frequency and rivers were draining, the stronger the erosion process, which indicates the expected morphological change under conditions of low surface resistance and is a parameter which aids in identifying the correct use of land in basins basin (Rocha, 1991).

In limit of the municipality of Monte Alto, there is more intense erosion, deep ruts and gullies. In field work, was detected and defined as the most critical area of the Basin Corrego Rico since there is lots of growth due to the expansion of the city and to be inserted in the drive Ultisol. In the municipality of Taquaritinga are predominant Argissolos and Guariba Oxisols.

The average altitude of Corrego Rico watershed is approximately 650 meters. The slope is a feature that infers the movement of soil particles, and therefore the intensity of the erosion process.

In the area of basin of Corrego Rico predominant class of gentle relief wavy surface topography busy little set consists of hills or hills (elevations relative height up to

50 meters and 50-100 meters), with gentle slopes, ranging 3 to 8 % (Figure 4). By analyzing the Soil Map it turns undulated relief predominantly in the areas of Oxisols and Ultisols in rougher.

According Caldas (2007) the digital elevation model generated contributed to the delineation of the watershed, setting drainage, preparing the slope map and delineation of soil mapping units.

Importantly areas upstream watershed erosion is more intense, mainly due to the physical characteristics of the soil, with frank and accelerated process of dissecting therefore contributes to high load of debris to siltation of rivers. Thus, it is necessary the restoration of areas along the headwaters and drainage channels with natural plant species in the region.

Studies Feltran Son and Lima (2007) on the slope of the river basin Uberabinha in Minas Gerais, Table (2006) in Argentina showed similar results, confirming that, as the morphology of the land is becoming busier and more embedded channels, the number of channels increases proportionally and the erosion is most intensive.

Cardoso et al. (2006); Feltran Filho and Lima (2007) and Dinesh (2008) reported that the slope influences the relationship between rainfall and runoff in the basin due mainly to the higher speed of runoff rainwater. Thus, the values denote channel density rich with water generators springs upstream point of maximum slope and thus the area of application required better conservation practices.

Practices to contain the erosion process are necessary, especially in areas of high soil sealing, due to the development of urbanization of the municipality of Monte Alto, underscoring RODRIGUES et al. (2011), in the area of Taquaritinga is predominant agricultural use.

Visual analysis of satellite images was based on the existing relations between the elements of images and physiognomic characteristics of plant communities and targets, identifying the faces in the field and in the satellite image.

According to Italian et al. (2003), the main factors impacting on Watershed Corrego Rico to the environment are the monoculture of sugar cane, clearing of permanent preservation areas, discharge of sewage and industrial animal to open and untreated, erosion, burial of springs and siltation of rivers and water bodies . Some studies with different approaches were conducted in Watershed Corego Rico (PISSARRA et al. 2004).

According Donadio et al. (2005) in the Municipality of Taquaritinga, east with remaining natural vegetation is inserted in a forest fragment with an approximate area of 8 hectares, being the permanent preservation area greater than 50 meters provided to the Forest and the surrounding natural vegetation remaining there is an area of 200 meters of grassland formed then cane sugar. In the municipality of Guariba the forest fragment where it is located to the east with remaining natural vegetation has approximately 5 acres, also with the natural vegetation strip within the required legislation and forest, around, the dominant culture is the cane sugar. In springs with a predominance of agriculture, sugar cane is the main crop, and Taquaritinga, the cane is approximately 10 meters from the source, and Guariba 20 meters. In both areas, the sugar cane is the predominant vegetation cover for over 10 years.

Using as a tool the geographic information system, was held in Hydrologic Modeling SWAT - Soil and Water Assessment Tool several scenarios with different types of management and conservation practices. We identified five scenarios with management systems for the culture of cane sugar, cane area: bare soil after burning and harvesting of cane sugar; Cana in early stages of emergence and tillering; Cana mature growth culms; Cana to reap; mechanized harvest (straw), and were also identified 4 more scenarios with other uses: Forest, Grassland, water bodies; urban and other uses (Figure 5).

To date mapping of the satellite image was observed that occurs in approximately 67% of the area using the culture of sugar cane.

The Other Uses can be defined as areas with permanent crops, forestry, field dirty and associations. Checking the results, in conjunction with field work can be concluded that stand out the facts impacting the environment : most of the area used with the monoculture of sugar cane, strong felling of permanent preservation areas and in some areas there is the release of industrial sewage and animals in the outdoors and untreated, intense erosion, especially in areas of stream Possum, (municipality of Monte Alto) aggravated by human action , burial of springs and siltation of rivers and bodies water, causing contamination of water sources, and observation of gullies, expanding laterally. In this case, the material from the sidewalls is adduced with sewage released, silting and polluting surface waters.

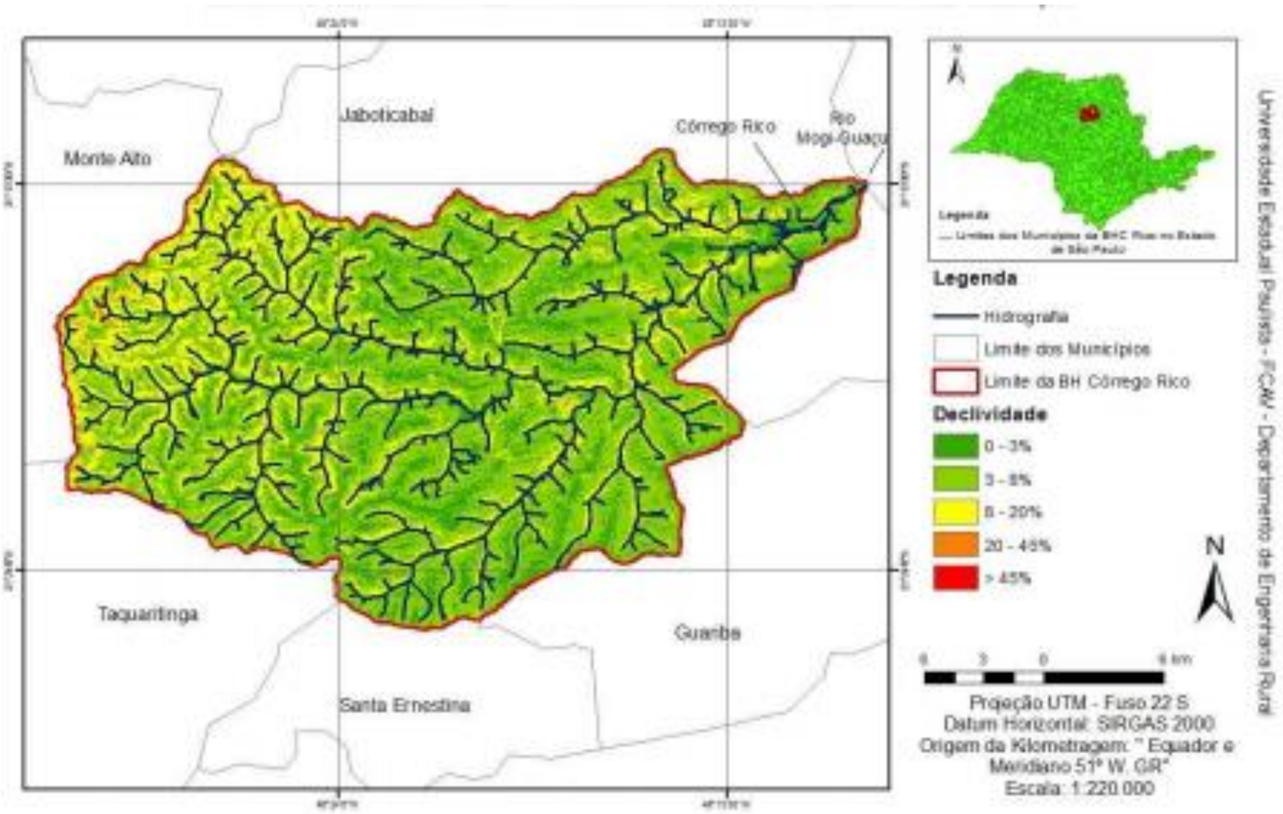

Figure 4: Slope of the Basin of Córrego Rico, São Paulo state.

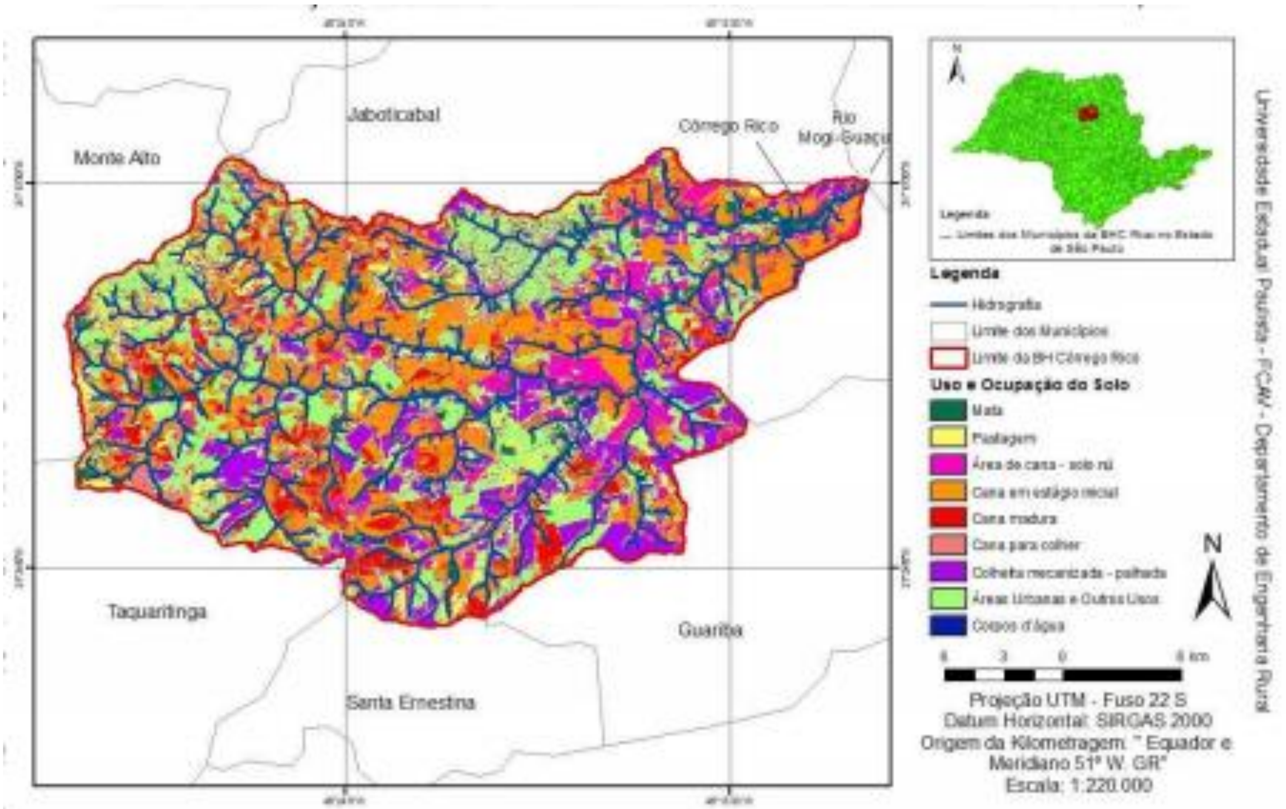

Figure 5: Use and ocupation of soil in watershed of Córrego Rico, São Paulo State.

According to Costa et al. (2012) mapping of the use and occupation of the areas of the municipality, together with studies of slope and soil bearing capacity can assist in the study and planning of areas of erosion risk. From the use of satellite imagery and geo-referencing is possible to prevent the establishment of large erosive processes that generate risk of death or economic loss to the local population.

Recommended to continue the monitoring process and continue the corrective actions in priority areas, such as the implementation of reforestation projects mainly in headwater areas and environmental education, being involved at this stage farmers, mills cane sugar and the population in Jaboticabal, in order to minimize their negative contribution to the local community, the waters of the stream Rico and in turn, the Rio Mogi Guacu.

4. Conclusion

The watershed of Córrego Rico presents an area of 563 km^2. We identified three soil units. The predominant slopes are between 3 and 8%, undulated relief. The land use is mainly agricultural highlighting the culture of cane sugar and cane these areas with early-stage emergency is approximately 26%.

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