GIS AND REMOTE SENSING TECHNIQUES APPLIED FOR LAND-USE SUITABILITY STUDY

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ABSTRACT

The purpose of this work is the evaluation of discrepancies in the current land-use/land-cover (LU/LC) and the land-use capability (LUC) for agriculture in São Paulo State, Brazil. The LU/LC map was produced by processing and interpreting a Landsat TM image. Soil map, topographic maps and ground truth data were used as ancillary data for image analysis. After image interpretation, the thematic map resulted in the following LU/LC classes: urban/developed, water, agriculture, pasture and forest. A triangular irregular network (TIN) was interpolated from contour lines and elevation points (VIPs) considering drainage as breaklines. The slope map was created from DEM with 30 meters cell resolution and it was recoded in 5 classes. The soil map was converted into a grid. Both slope map and soil map were combined and the LUC map was created. The criteria for evaluating LUC classes were based on USDA approach. The combination of both LU/LC and LUC maps allowed the production of land-use suitability (LUS) map in which discrepancies could be detected as a result. The class "suitable land-use" is the predominant class in the study area. In decreasing order follow: "underused" and "overused" land classes. This information can be used for decision-making, management and monitoring agricultural areas in order to avoid soil sustainability losses. The methodology used here may be improved by changing the image processing techniques for the LU/LC map production as well as by using multitemporal images in order to detect perennial and temporary cultures in the study area.

1 INTRODUCTION

Land-use planning is an essential process to mitigate problems resulted from the uncontrolled land-use (Oliveira and Berg, 1985). Suitability land-use studies are an important part of this process and the verification of the discrepancy between the actual use and the potential use is the base of territorial organization for the agricultural activity management. In Brazil, several researches have contributed for land-use planning and control. Assunção et al. (1989) and Formaggio et al. (1992) produced soil suitability maps for agriculture from Landsat TM land-use/land-cover maps (LU/LC) integrated with both soils and slope maps in a Geographic Information System (GIS).

Valério Filho et al. (1992) generated a land-use capability map in order to propose conservation activities in a watershed. They used GIS and emphasized the efficiency of data classification based on multivariate data. Pereira et al. (1994) combined both Landsat TM and SPOT data for Land-use mapping in order to detect the critical areas.

Davidson (1992) declares that GIS applications are relevant to land resources studies in many scales, such as global, regional or local. In these levels, the ability of prediction raises according to the detail considered in the study. GIS and its prediction capabilities provide strong tools for land-use planing and monitoring. This is really important when we deal with small parcels and with a strong dynamic in the environmental processes as well.

The purpose of this work is the evaluation of discrepancies in the current land-use/land-cover and the land-use capability (LUC) for agriculture. The study was supported by GIS spatial analysis over an agricultural region. A comparison between LU/LC map (derived from Landsat TM image analysis) and the LUC map (derived from both soil and terrain classes) was made so.

The study area is located in the São Paulo State (Brazil), between the coordinates 22°30’S to 23°00’S and 47°00’WGr to 47°30’WGr (Fig. 1). It comprises two counties (Sumaré and Hortolândia) with an area of 20,800 ha. In terms of agricultural Land-use, the region is representative of the center-east of São Paulo State.

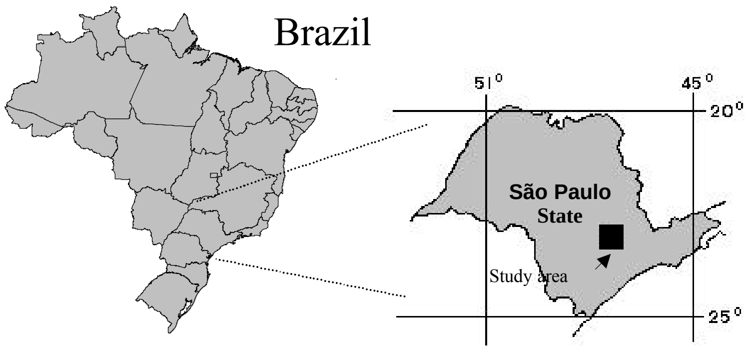

Figure 1. Study area in São Paulo State, Brazil

In the study area, the relief is gently rolling with altitude varying from 540 m to 660 m, showing favorable conditions for monitoring agricultural areas through the optical remote sensing techniques, due to the predominance of an uniform illumination over the terrain. The activity is mainly agricultural based on sugarcane, tomato, potato and corn. It usually occurs on the slopes and hilltops. In the bottomlands there are grasslands and pasture.

According to Brazilian classification approach, the following soil classes prevail in the study area (Oliveira et al., 1979): *Latossolo Vermelho-Amarelo*, *Latossolo Vermelho-Escuro*, *Latossolo Roxo* (Oxisols); *Podzólico Vermelho-Amarelo* (Ultisol); *Hidromórficos* (Entisols) and *Cambissolos* (Inceptisols).

2 MATERIAL AND METHODS

Image processing techniques such as geometric rectification, spatial/spectral enhancement and interpretation were conducted in ERDAS IMAGINE 8.2 software (ERDAS, 1997). The Landsat-5 TM image (220/076E - 08.Jun.97) was geometrically rectified and afterwards it was cut according to the municipalities boundary. The visual interpretation of LU/LC classes was conducted over a 543/RGB band combination. The interpretation was supported by ground truth data as well.

Spatial data were processed in ARC/INFO 7.0.2 environment (ESRI, 1994). A triangular irregular network (TIN) was interpolated from contour lines and elevation points (VIPs) considering drainage as breaklines. A slope map (percentage) was created from DEM with a 30 meters cell resolution and recoded in 5 classes. A soil map was digitized and converted into a grid. Both slope map and soil map were combined in GRID module resulting in a new map with new classes and subclasses. Land parcels were classified for land-use capability based on both soil and terrain classes and according to SCS-USDA (Soil Conservation Service - United States Department of Agriculture) criteria (Klingebiel and Montgomery, 1961). Then, the LUC map was created.

The combination of both LU/LC and LUC maps allowed the production of land-use suitability (LUS) map in which discrepancies could be detected as a result.

The spatial analyses for Land suitability were conducted with Map Algebra (Tomlin, 1990) tools in GRID module. Figure 2 shows the scheme of the spatial analyses.

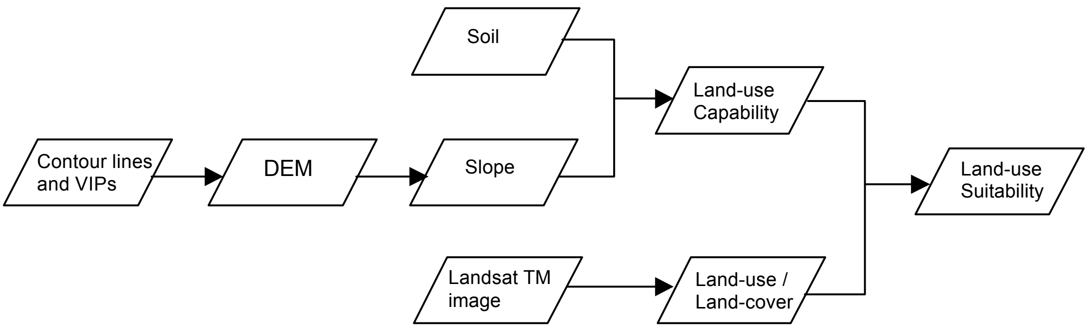

Figure 2. Scheme of the spatial analyses

3 RESULTS AND DISCUSSION

3.1 Land-use/cover interpretation

The LU/LC map resulted in 5 classes: urban/developed, water, agriculture, pasture and forest (Fig. 3).

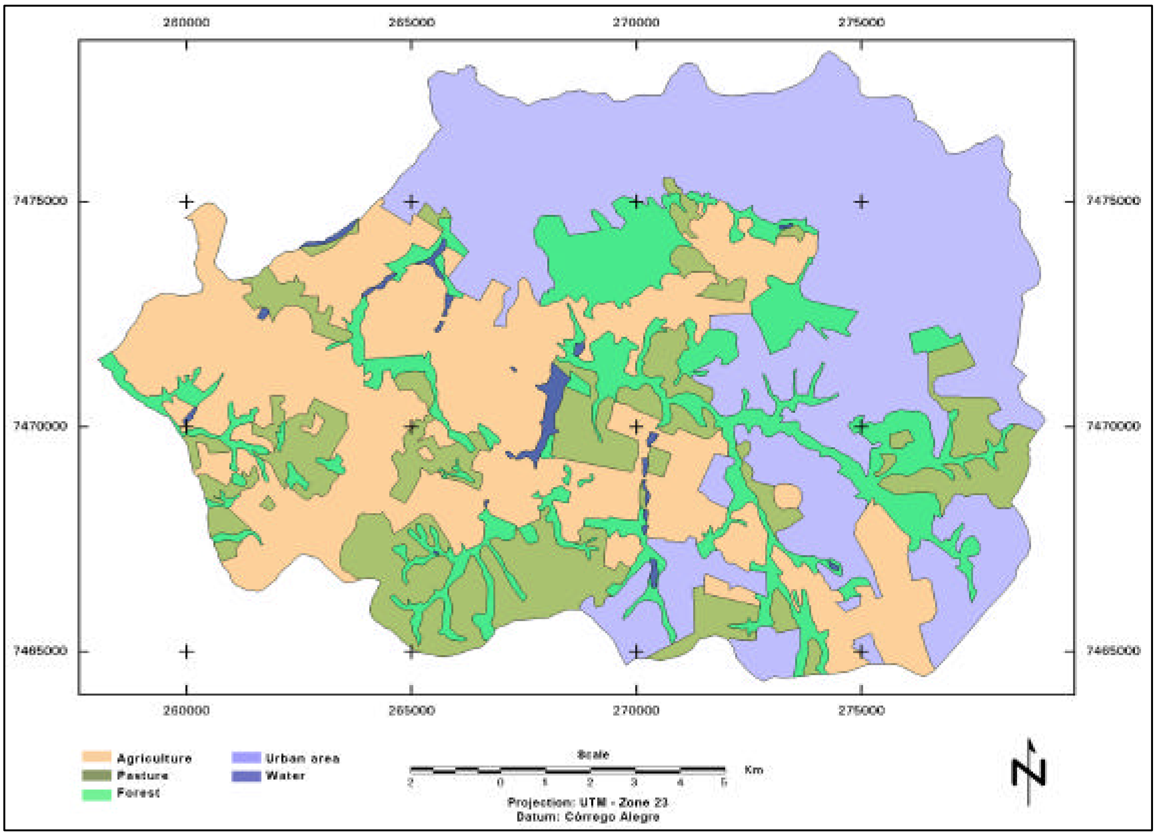

Figure 3. LU/LC map resultant from Landsat TM image interpretation.

Table 1 presents the criteria for LUC classes detection on the study area. These criteria consider both soil and slope attributes.

	Slope (%)				
Soil Class	**0 - 3**	**3 - 6**	**6 -12**	**12-20**	**>20**
Cambissolo	IV_{es}*	IV_{es}	IV_{es}	VII_{es}	VII_{es}
Hidromórficos	V	V	V	-	-
Latossolo Vermelho-Escuro	III_{s}	III_{s}	III_{es}	III_{es}	IV_{es}
Latossolo Roxo	II_{s}	II_{s}	III_{es}	III_{es}	-
Latossolo. Vermelho-Amarelo	III_{s}	III_{s}	III_{es}	IV_{es}	IV_{es}
Podzólico Vermelho-Amarelo	III_{s}	IV_{es}	VI_{es}	VII_{es}	-

* Classes of land-use capability ➡ I, II, III e IV: lands that support annual culture, perennial culture, pastures, reforest and wildlife; V, VI e VII: unsuitable lands for intensive culture, but suitable for reforest, pasture and wildlife; VIII: suitable lands exclusively for wildlife protection. Subclasses ➡ e: limitations due to erosion; s: limitations due to soil; a: limitations due to excess of water; c: climatic limitations.

Table 1. Land-use capability classification applied in this study according to USDA approach.

Table 2 presents the area covered by each class and subclass of the Land-use Capability map

LUC class	Area (ha)
IIs	1361
IIIs	9521
IIIes	2561
IVs	307
IVes	3383
V	90
VIes	2549
VIIes	977

Table 2. Area (ha) covered by each class and subclass of the LUC map

3.2 Land-use suitability

Table 3 presents the criteria for determining the LUS map based on the combination of LUC and LU/LC maps. Figure 4 shows the resulting LUS map.

	LUC class							
LU/LC class	**IIs**	**IIIs**	**IIIes**	**Ivs**	**IVes**	**V**	**VIes**	**VIIes**
Agriculture	A*	A	A	S*	S	S	S	S
Pasture	s*	s	S	S	A	A	A	S
Forest	s	s	S	S	s	A	A	A

* A-suitable use; S- overused; s- underused

Table 3. Land-use suitability classes for the study area

Table 4 presents the area covered by each suitability class on the study area. These results shows that the class "suitable land-use" is the most predominant class in the study area (33%) if the “not-considered class” (water/urban) is negligenced. In decreasing order follow: "underused" land (20%) and "overused" land (9%) classes.

LUS class	Area (ha)	%
A – suitable use	6787	33
S - overused	1995	9
s - underused	4003	20
Not-considered*	7964	38

* “Not-considered” refers to both water and urban classes in the LU/LC map.

Table 4. Land-use suitability classes for the study area

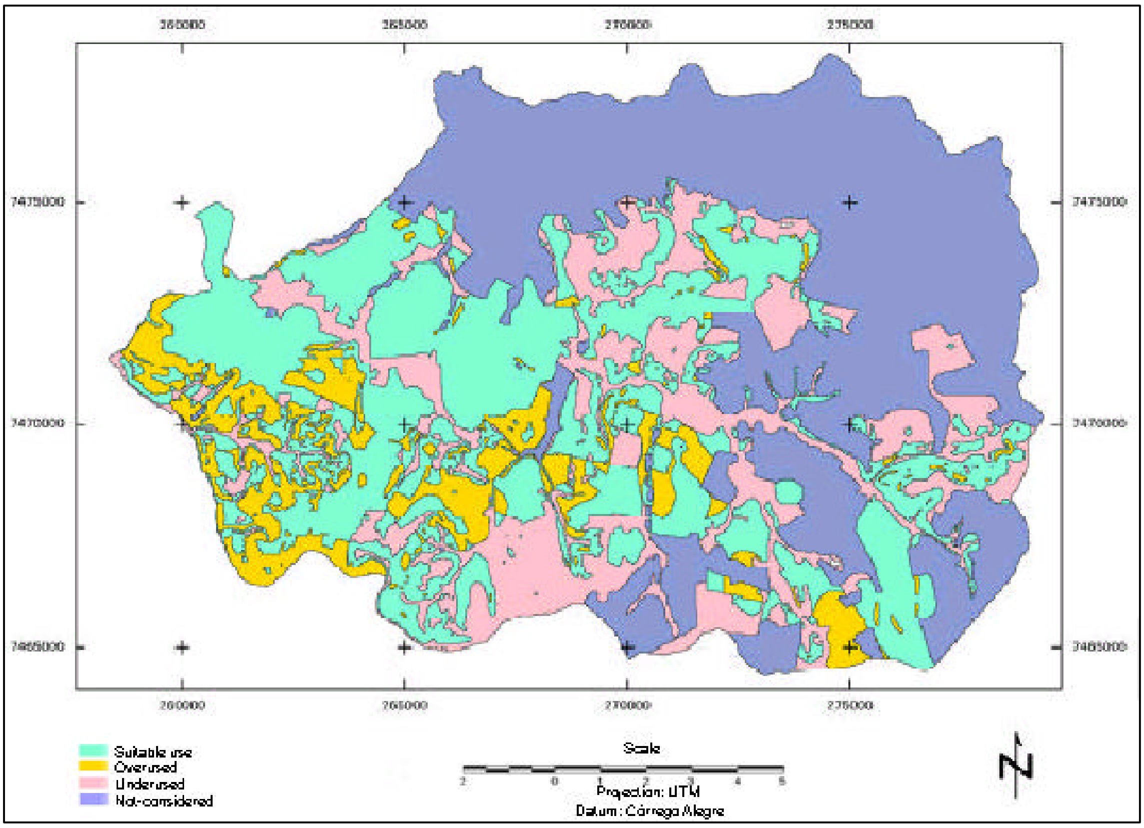

Figure 4. Land-use suitability map

4 CONLUSIONS

This work was supported by image processing and spatial analysis and had the purpose of detecting discrepancies in the comparison of land use capability against the actual LU/LC in agricultural areas of São Paulo State, Brazil.

In the results, the "suitable" land-use class had the major covered area and the "overused" class had the minor covered area. However, it is important to take actions regarding to both the "overused" and "underused" areas and keep monitoring those areas in order to get the most suitable land-use.

The information obtained in this study can be used for decision-making, management and monitoring agricultural areas in order to avoid soil sustainability losses. The methodology used in this work may be improved by changing the image processing techniques for the LU/LC map production as well as using multitemporal images in order to detect perennial and temporary cultures in the study area.

The experience acquired in this work has showed that there were no restrictions in terms of time and costs for its development. In addition, it showed that remote sensing and GIS are really essential tools for monitoring and management of territorial issues.

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