ENVIRONMENTAL CHARACTERIZATION AND LAND USE DEVELOPMET IN THE RIBEIRÃO VERMELHO WATERSHED IN LAVRAS-MG, BRAZIL

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ABSTRACT

This work is part of a project to characterise the physical environment of Lavras county in the state of Minas Gerais in Brazil, and to develop a digital database that could be used not only by researchers but also by the local administration and community for environmental planning. The county territory was divided into 5 main watersheds which were taken as the basic geographical domains. The first study area selected was the watershed of the Ribeirão Vermelho, which is a tributary of the main river of the region, the Rio Grande, and runs along the northern side of Lavras, constituting the drainage channel of this part of the city. The data was obtained by compilation of secondary information, interpretation of aerial photographs and satellite image and complementary field survey. A geographical information system was used to integrate and model the data from different sources. A geomorphopedologic model was used to map the main soil classes. Land cover/land use patterns from 1971 and 1997 were also mapped. The analysis of these maps showed that the principal occupation is agriculture but the main land use types, which include grassland and annual crops did not show significant changes from 1971 to 1997. The most significant changes were observed in the coffee area followed by the area reforested with eucalyptus, natural forest and urban area.

1 INTRODUCTION

Among the factors that limit the development of land evaluation and land use planning studies in Brazil, the lack of detailed environmental information is one of the most difficult to overcome. Brazil is a very large country and the general situation, even for the most developed regions, is that surveys and environmental data are only available at small scales (≤ 1:250.000). There is no financial support for the development of country based surveys at detailed level, but it is possible to carry out studies of smaller areas. This work is part of a project to characterize the physical environment of the *município*[1] of Lavras in the south of the state of Minas Gerais and generate information that could be used not only by researchers but also by the local administration and community for environmental planning. At this first stage, the objective was to create a digital database composed by geo-referenced information, to produce thematic maps of natural resources and evaluate the changes occurred in land use/land cover patterns since 1970.

2 CHARACTERIZATION OF THE STUDY AREA

According to Köppen the município of Lavras is classified as Cwb and Cwa, which characterises a temperate to subtropical temperate climate. The annual mean temperature is 19.4° C. The mean temperature of the coldest month, July, is 15.8°C and of the warmest month, February, is 22.1° C. The average annual precipitation is 1,530 mm (Vilela *et al.*, 1988), which concentrates during the period between November till February (66% of the annual precipitation). The native vegetation types that occur in the region correspond to the Tropical Subperennial Forest and different types of C*errado*.

[1] [illegible]

The entire territory of the município of Lavras was divided into 5 main watersheds, which were taken as the basic geographical domains of the project. The first study area selected was the watershed of the Ribeirão Vermelho river. This watershed occupies an area of 56.972547 km^2 located between 45° 00' and 45° 10' W and 21° 10' and 21° 16' S, with altitudes varying from 800 to 1100 m. The Ribeirão Vermelho is a small river, which is a tributary of the main river basin of the region, the Rio Grande. It runs from SE to NW at the northern part of the município, crossing a large part of the urban area, constituting the main drainage channel of a city of approximately 77,000 inhabitants.

The main geological units mapped in the area by Quéméneur (1995) correspond to Arquean Litho-Stratigraphical units: Calcic Alcaline Potassic Granulites (north of the watershed), Granitic Granodioritic Gnaisses (south of the watershed) and strips units oriented EW of ultramafic rocks of the Greenstone-Belt of Lavras.

3 MATERIAL AND METHODS

The data was obtained by compilation of secondary information, interpretation of aerial photographs and satellite image and complementary field work. The geographical information systems SGI v. 2.5 and SPRING v. 3.3 from INPE (Brazilian Institute for Aerospace Research) were used to integrate and model the data from different sources. The watershed boundaries were defined on topographic maps at 1:50,000 scale (FIBGE – Fundação Instituto Brasileiro de Geografia e Estatística, sheets: Nepomuceno - SF-23-I-II-29, 1969; Carmo da Cachoeira - SF-23-I-II-4, 1969; Lavras - SF-23-X-C-I-1, 1975 and Itumirim - SF-23-X-C-I-3, 1975).

The drainage network and past land use/land cover were obtained from aerial photographs of 1971 at 1:25,000 scale. Current land use (1997) was obtained from the interpretation of TM-Landsat-5 image (scene 218-75, 13/08/97, bands 3 – 4 – 5, RGB, scale 1:50,000, resolution 30m).

A correlation between geomorphologic features and soil formation was used to evaluate and map the soils of the region. The geomorphologic features were assessed on the basis of terrain slopes with five selected gradients: *nearly level* - 0-3%; *gently sloping* - 3 – 12%; *strongly sloping* - 12 – 20%; *moderately steep* - 20 – 45%; and *steep* - > 45%. A slope class map was elaborated using the contours of the topographic maps and an abacus according to De Biasi (1970). Six slope classes were defined and related to different types of relief: (1) 0 – 3% - flat top surfaces; (2) 0 – 3% - nearly level lowlands; (3) 3 – 12% - gently sloping relief; (4) 12 – 20% - strongly sloping relief; (5) 20 – 45% - moderately steep relief; and (6) > 45% - mountainous relief. A regular grid of 0.25 x 0.25 cm was used to generate a raster file of this map into the GIS.

Soils were differentiated on the basis of the slope classification and a geomorphopedological model of the regional distribution of soils over the landscape (Andrade *et al.*, 1998; Lacerda, 1999), which relates landforms to soil classes and that was checked during the field work.

4 RESULTS AND DISCUSSION

Figure 1 shows the hypsometric map of the watershed with the landforms and the drainage network taken from the photointerpretation. This information is now being used to develop studies of hydrological characterisation. Due to the importance of this specific watershed, as the main drainage network of the urban area of Lavras, it is essential to implement the use of this database to evaluate and monitor the problems of water quality and pollution, in both, the urban and rural areas that are within its boundaries. The GIS can be an efficient tool in assisting this task.

Table 1 shows the correlation used to map the soils of the watershed on the basis of the geomorphopedologic model. The results showed Latosols occurring on the flat hill tops and gently sloping surfaces with slope gradients of 0 to 12%. Hydromorphic and Alluvial soils were also found in slopes gradients of 0 to 3%, but at different parts of the landscape, related to flooding plains and terraces. Within the slope classes strongly sloping and moderately steep relief (12 to 20% and 20 to 45%) four classes of soils with argillic B horizons were found: Yellow-Red Podzolic (PV), Dark Red Podzolic (PE), Dusky Red Podzolic (TR) and Reddish Brunizem (BV). In the mountainous relief (slope gradient > 45%) occurred Cambic and Litholic soils. These classes of soils were grouped in the map presented in Figure 2, but they are now being separated into lower hierarchical levels using a correlation between soil formation and geology, according to studies carried out by Lacerda (1999).

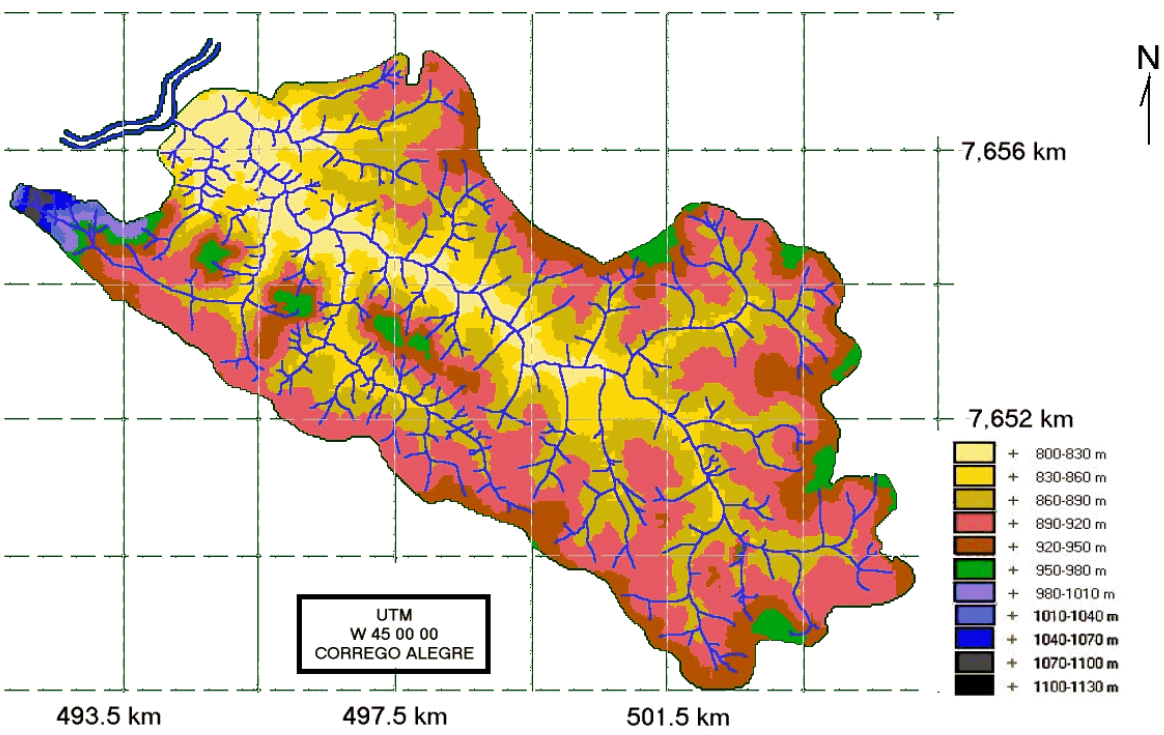

Figure 1: Hypsometric and drainage network of the Ribeirão Vermelho watershed

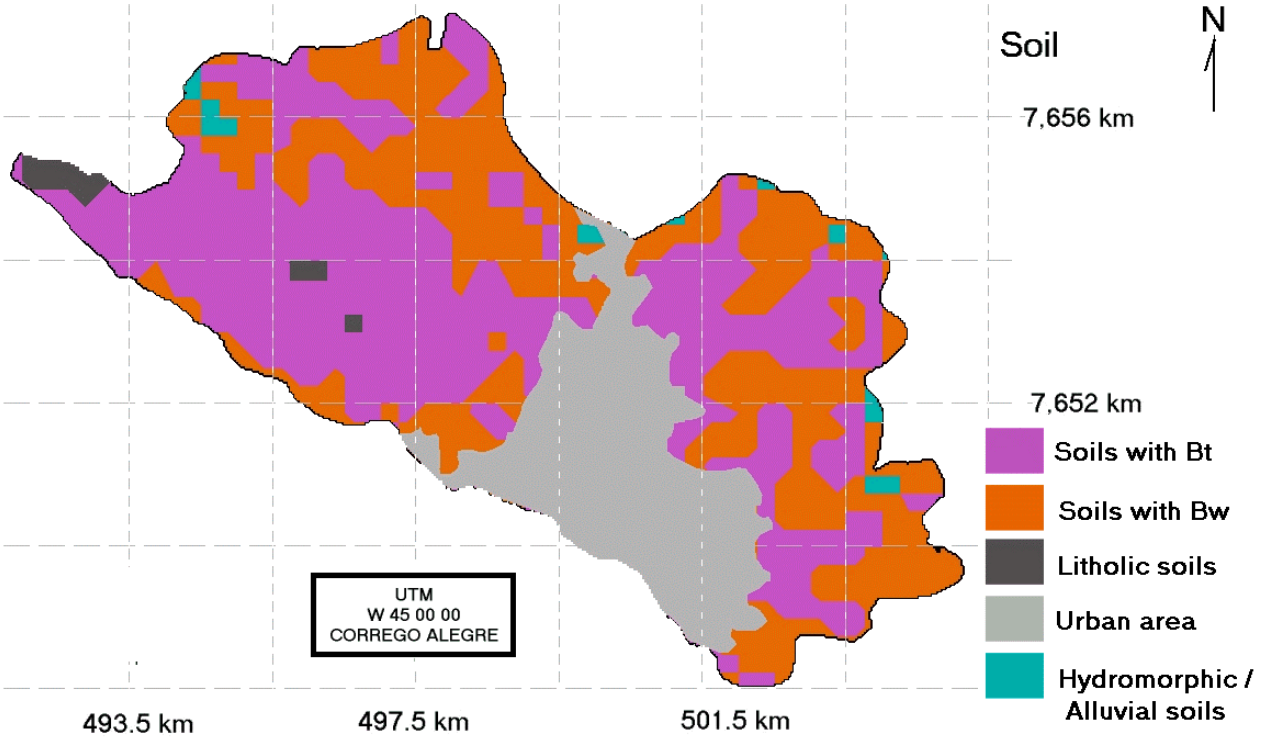

Figure 2: Map of the main soil classes of the Ribeirão Vermelho watershed

Slope gradients (%)	Slope classes	Soil classes	Area (km^2)
0 – 3	Nearly level lowlands	Hydromorphic and Alluvial soils	0.681832
0 – 3 3 - 12	Flat top surfaces & Gently sloping relief	Latosols (***Bw***)	19.085974
12 - 20 20 - 45	Strongly sloping relief Moderately steep relief	Soils with argillic B(***Bt***) horizons (TR, BV, PE, PV)	25.265937
> 45	Mountainous relief	Cambisols and Litholic soils	0.666628

Table 1: Correlation between slope gradient, relief and soil class.

Table 2 shows the results of the evaluation of land cover/ land use patterns in this watershed between 1971 and 1997, which were derived from the maps showed in Figures 3 and 4. The principal land use in the two periods of time analysed is agriculture and the largest area is grassland (natural and cultivated pastures), followed by land farmed with annual crops. The area occupied with grassland and annual crops however did not show significant changes from 1971 to 1997 (decreases of approximately 2% in relation to the areas in 1971). The most significant change in agricultural land use was observed with the area cultivated with coffee, which increased approximately 25% in relation to the area occupied by the crop in 1971.

Agriculture represents a very important part in the município's economy and the main activities are dairy and coffee production. During the seventies the implementation of a government programme to expand and revitalise the coffee production sector caused the expansion of the areas occupied with the crop. During the last three decades there were ups and downs for the coffee farmers, but the sector is still very important within the whole region's economy. The extinction of the Brazilian Institute of Coffee (IBC) in 1990 however, left the sector without the necessary information for a sound management of the production system. These new geoprocessing techniques that make use of remote sensed data and geographical information systems can become a solution in providing the data needed in the decision making process of land use planners at reasonable costs.

**\ 1971 1997 **	**Grassland**	**Annual Crops**	**Urban Area**	**Coffee**	**Reforested**	**Natural Forest**	**Total**
Grassland	34.0079	0.4170	0.0138	0.0129	0.5206	0.5428	**35.515**
Annual Crops	0.2685	5.5327	0.0000	0.0141	0.0000	0.0585	**5.8738**
Urban Area	1.4623	0.0003	9.8306	0.0115	0.0011	0.0001	**11.3059**
Coffee	0.4593	0.0432	0.0066	1.7786	0.0000	0.0002	**2.2879**
Reforested	0.0002	0.0000	0.0001	0.0000	0.3673	0.0000	**0.3676**
Natural Forest	0.0926	0.0175	0.0000	0.0000	0.0000	1.5112	**1.6213**
Total	**36.2908**	**6.0107**	**9.8511**	**1.8171**	**0.8890**	**2.1128**	**56.9715**

Table 2: Cross tabulation of the areas (km^2) of different land use/land cover types from 1971 (columns) and 1997 (lines)

The other significant changes observed occurred in the areas occupied by the natural forest, which decreased 23.26% in relation to 1971 and the area reforested with eucalyptus, which suffered the highest decrease, 58.65% in relation to 1971. Part of the areas with natural forest were probably taken by coffee but this big difference in the area reforested with eucalyptus may be a consequence of environmental policies that transferred the deforestation to the commercial forests.

The urban area increased almost 15%, showing the pressure of urban expansion, which is expected to become more important in the near future in this particular region of the state of Minas Gerais. In relation to the total area of the watershed, this was the land use class that showed the biggest difference, 2.55% increase from 1971 to 1997.

The comparison between this watershed and the other 4 main watersheds of the município will show a more truthful scenario. An assessment of the land cover/land use patterns of a period between the two years analysed in this work would also be important to understand land use development in the region.

All these maps were entered in the GIS and are now available to other users. They will be integrated with the other 4 watersheds digital data sets to complement the database of Lavras.

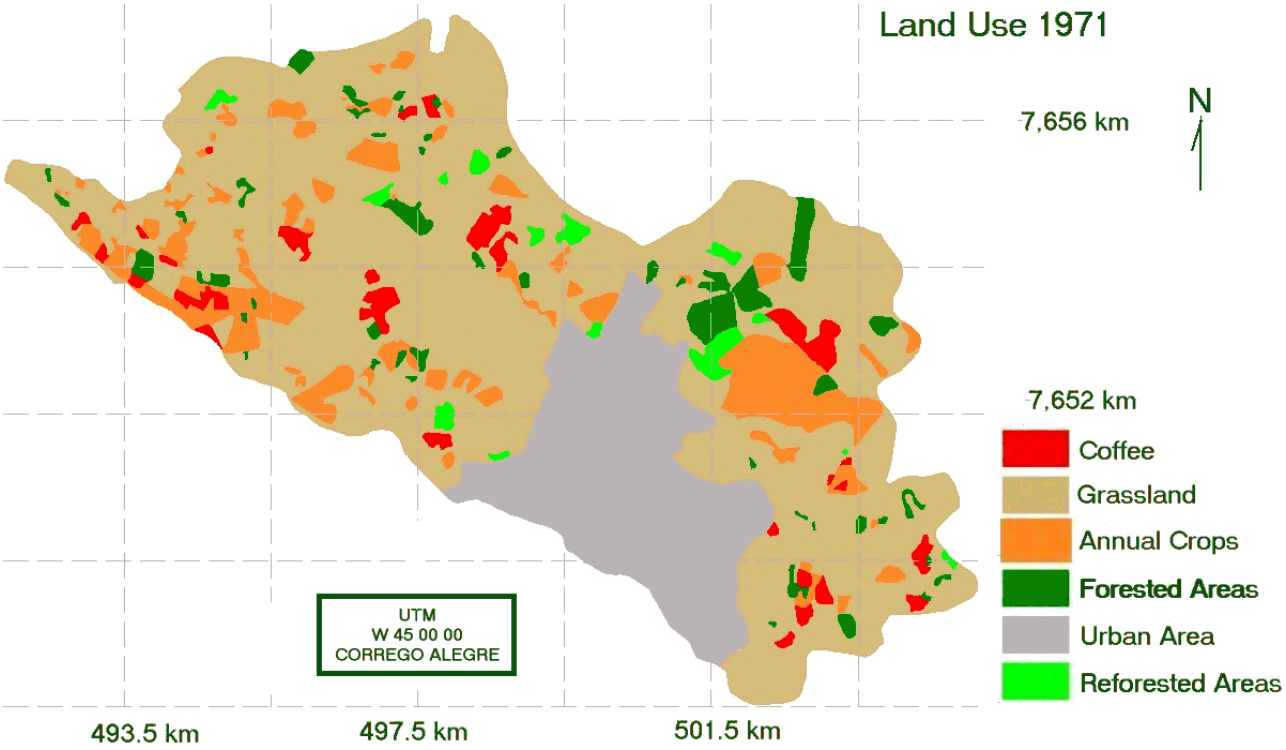

Figure 3: Map of land use/land cover of the Ribeirão Vermelho watershed from 1971

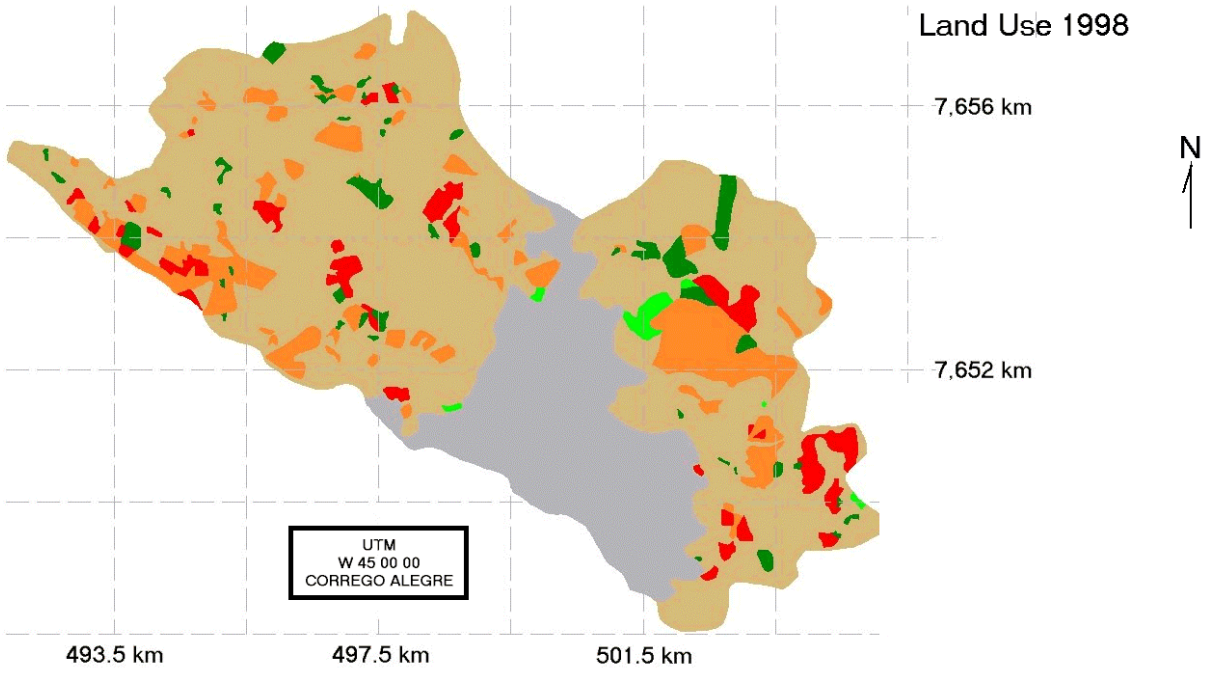

Figure 4: Map of land use/land cover of the Ribeirão Vermelho watershed from 1997

5 CONCLUSION

The work showed the importance of temporal and spatial analyses in the understanding of land use development and as a way of providing valuable information to land use planners and decision makers. The expansion of the urban area combined with the depletion in forested land will certainly cause degradation in the watershed environment. A digital database at a reasonable scale combined with a GIS can be used to model scenarios and explore possible solutions for the conservation of this environment

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