REMOTE SENSING AND DATA INTEGRATION TO EVALUATE THE POTENTIAL SOIL EROSION AND LAND CAPABILITY*

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ABSTRACT

Developing countries have an urgent need to improve their agricultural production. This process induces a lot of inadequate land use/cover for the rural environment. The intensification of agricultural activities may result in increasing erosion processes and acelerated soil losses, threatening natural resources integrity, mainly water quality, and the productivity of agricultural systems. In this context the knowledge of potential erosion of specific soil groups is very important to support agricultural and environmental planning. This study was undertaken in an agricultural watershed (Eastern area of São Paulo State-Brazil) and its purpose was to evaluate the Natural Erosion Potential (NEP) to provide information for rural planning. This work presents an approach on the use of remote sensing and GIS- Geographic Information Systems technology applied to survey and data integration of a small watershed . The parameters from the Universal Soil Loss Equation - USLE, such as erosivity, erodibility, slope length and steepness, obtained from ancillary data or calculated, were integrated within a GIS (INPE/SIG).The results allowed the calculation of the natural erosion potential for the watershed. TM-Landsat data (CCT) were digitally analyzed, and a map on land use/cover was obtained (parameter C of USLE). The erosion susceptibility map was obtained from tolerable soil losses and land use data. This map provided further information to elaborate the management plan for this watershed.

1.0 INTRODUCTION

The exploitation of land by agricultural activities has been continuously expanded to supply the food for the great population increase. For a rational territorial ocupation it is necessary that the agricultural policy is worried about the conservation of the environment.

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In this context geoprocessing technics including remote sensing and analytical integration of environmental data by a Geographical Information System (GIS) can be useful in the acquisition and analysis of thematic information (Bocco and Valenzuela , 1988; Ventura et al. 1988; Zou , 1989 ; Pinto, 1991; Castro, 1992).

In relation to data integration technics for the characterization of soil erosion susceptibility, several works have been developed using loss estimate model Universal Soil Loss Equation - USLE (Wischmeier and Smith,1978). In this case there are works examplified by Stephens and Cihlar, 1981; Gesch and Nagle, 1984; Instituto de Pesquisas Tecnológicas do Estado de São Paulo, 1986; Scopel, 1988; Ventura et.al.1988; Valerio Filho et. al. 1990; Pinto, 1991 and Castro, 1992.

The objective of this work is to evaluate the Natural Erosion Potential and Soil Erosion Susceptibility in a small watershed in order to provide additional informations for rural planning.

2.0 METHODOLOGICAL PROCEDURES

This work was carried out in a small watershed located at the eastern portion of São Paulo State -Brazil (São Joaquim River , 22^0 00'- 22^0 05' south latitude and 47^0 20'-47^0 35' west longitude) included in the National Watershed Managenment Program.

The Universal Soil Loss Equation (USLE) was used. Data of this model were sampled from topographic maps (Topographic Factor -LS), available tables (Erosivity (R) Erodibility (K) and thematic classification of Landsat/TM and SPOT/HRV imageries associated with field work (Land Use Management-(C)/Conservationist practices-(P).

The USLE model adjusted to Brazilian conditions (Bertoni and Lombardi Neto, 1985), was applied to the environmental data of the study area.

The Natural Erosion Potential (NEP) was derived from the adjusted USLE using the GIS/INPE (Souza et.al.1990) as follow:

$$NEP = R.K\ (\ 0.00984\ .\ L^{0.63}.\ S^{1.18})$$

The information related to NEP was associated with the tolerable soil loss level T (available tables) to obtain the factor CP tolerable CPt as follow:

$$CPt = T\ /\ NEP$$

Through the evaluation of the actual CP and tolerable CP the susceptibility erosion data (Se) was obtained by the equation:

$$Se = CP\ actual - CP\ tolerable$$

The evaluation of NEP and characterization of the soil loss susceptibility was carried out using raster format data, supported by a GIS developed at INPE. An erosion susceptibility map at the scale of 1:60000 was obtained using a graphic plotter.

Instead of the traditional qualitative analysis used in land suitability classification, the Natural Erosion Potential values were used with limiting characteristics of land use.

By using the tolerable loss (T) for each soil unit, according to Bertoni and Lombardi Neto (1985) and the NEP values, the Land Use and Management Permitted Class (UMP) related to land use capability, were determined . In that determination the management practice (P) at the agricultural level was considered and described in the following equation :

$$UMP = T / NEP . P$$

The generated map was integrated with soil characteristics and steepness classes, and a land capability map was obtained in the context of rural planning.

3.0 RESULTS AND DISCUSSION

Multispectral TM 7 (Blue), TM 5 (Green) and TM 4 (Red) color composites were selected from the TM band combination analysis for three Landsat image acquisitions. It was possible to generate a land use map of the study area through the interpretation of TM color composites supported by SPOT - PAN images and field data (Figure 1). Furthermore,the derived map allowed to obtain the USLE C factor, that can be considered as actual CP in the context of the model used in this work.

The C factor values were defined for all classes of land use (Bertoni and Lombardi Neto, 1985) as shown in Table 1.

TABLE 1. C Factor Values for all Land Use Classes of the Study Area

Land Use Classes	C Factor
Soybean	0.2086
Corn	0.086
Rice	0.4862
Cotton	0.473
Citrus	0.135
Sugar Cane	0.100
Reforestation	0.0001
Pasture	0.01
Natural Vegetation	0.00004

Considering that it is impossible to recognize conservation practices using only analysis and interpretation of analog data, the conservation practice of contour line row cropping (P=0,5) was chosen.

The physical environment data integration of Erosivity (R), Erodibility (K), Topographic Factor -LS (L = Land slope ,and S = Steepness) and USLE factors was carried out in a GIS. The result is a map with the spatial distribution of NEP classes for the study area which is

shown in Figure 2.

NEP data when integrated to the values of tolerance losses for each soil unit (T) by GIS permitted the acquisition of tolerance CP data, which represent a more appropriate land use to the loss tolerance limits.

Actual CP data and tolerable CP were also integrated, using a GIS which permits the generation of an erosion susceptibility map (Figure 3). It can be observed in this map that there is no erosion in 25% of the area, or the difference between actual CP and tolerable CP is negative. This means that the actual use is not causing losses greater than the tolerable limit. The other classes (75%) present low to high erosion susceptibility.

It may be observed, through the analysis of the NEP (Figure 2), and erosion susceptibility maps (Figure 3) that classes with no or low erosion susceptibility correspond to NEP areas classified as medium and high, explained by the vegetal soil cover (Figure 2) including sugar cane, citrus and natural vegetation.

From the knowledge of susceptible areas to erosion (Table 2) which are represented in the soil erosion susceptibility map, and the combination and fitness of information over other limiting soil characteristics for land use and steepness class, a map of land use capability classes was generated (Figure 4).

TABLE 2. Values of Erosion Risks and Classification of Land Use Capability Classes for the Study Area

Erosion risks	Level	UMP Value	Classification
1	Low	>0.0500	(Ie,IIe,IIIe)
2	Low - Medium	0.050-0.020	IVe
3	Medium - High	0.020-0.001	VIe
4	High	0.001-0.00005	VIIe
5	Very High	<0.00005	VIII

From this map, it is possible to establish conservation planning for small watersheds.

4.0 CONCLUSIONS

The USLE model has been shown to be powerful to detect and characterize the erosion process.

The integration of information through a computer GIS system is an efficient method that permits area classification on a multivariate data base.

Only 25% of the study area does not present losses greater than the tolerable limits, while the loss classes classified as medium and high represent 45% of the total area where the conservation planning must be implemented.

The erosion potential diagnostic using the Universal Soil Loss Equation plus the permissible losses as a conditional land use capacity is an important proposition in this work once it permits the use of quantitative indices in the classification.

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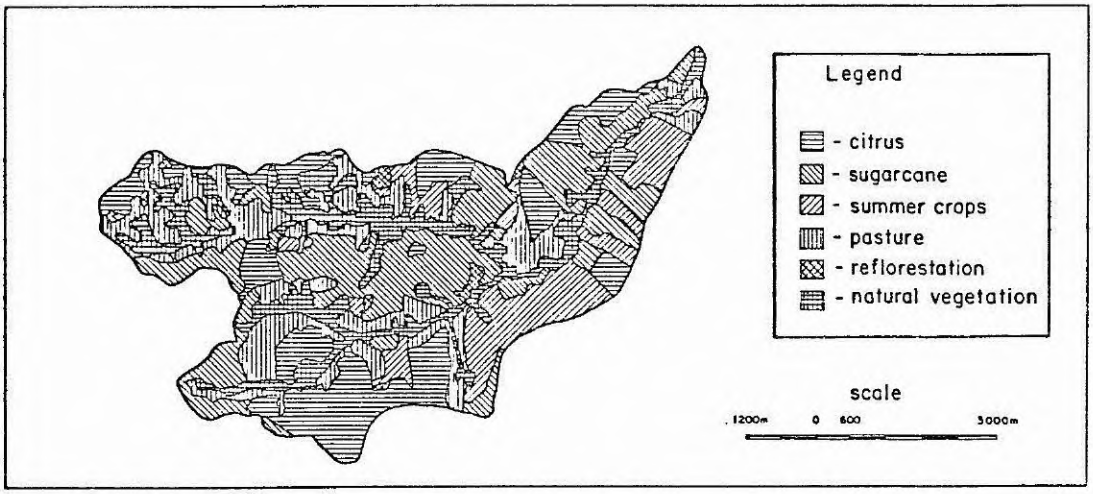

Figure 1 - Land Use/Cover Map of the Study Area.

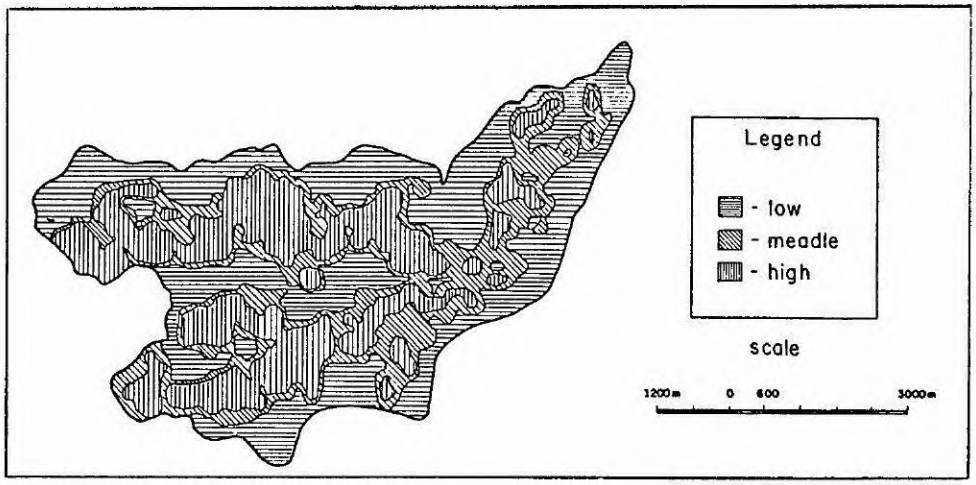

Figure 2 - Natural Erosion Potential Map of the Study Area.

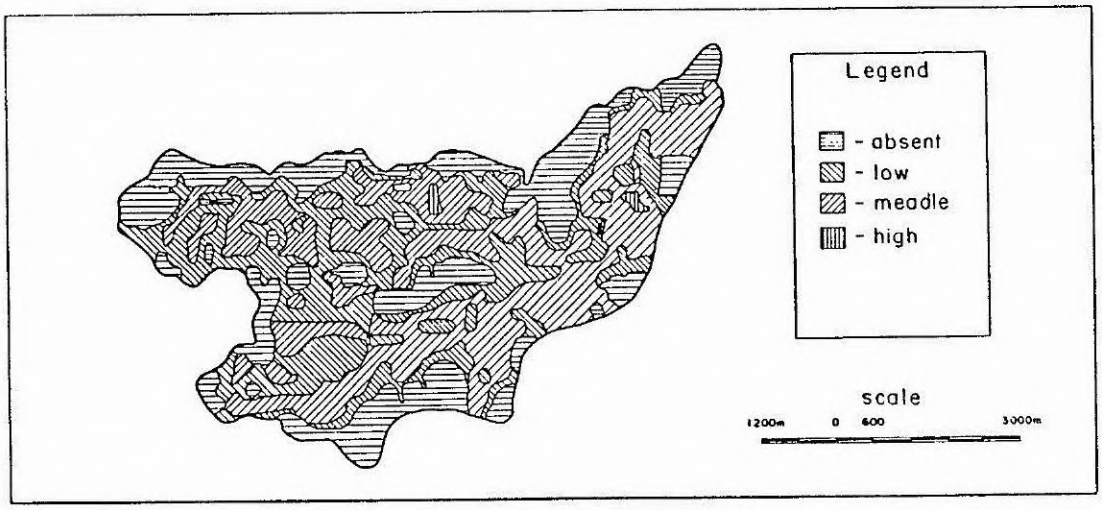

Figure 3 - Erosion Susceptibility Map of the Study Area.

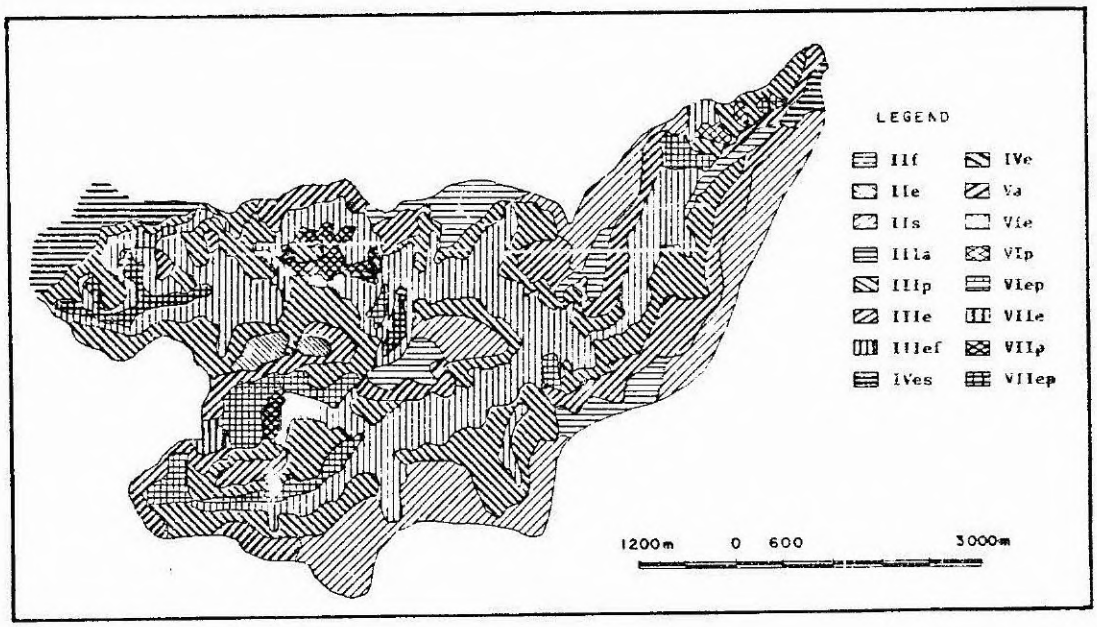

Figure 4. Land Use Capability Map of the Study Area.