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Mapping of soil degradation by using remote sensing and GIS on Genil-Cordobilla sub basin, Spain

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Abstract

Soil degradation process are site specific and differ in kind, and areal coverage of the affected area. Identification and mapping of areas affected by soil degradation by water in the Genil-Cordobilla sub basin of semi-arid region of Spain was performed. Impact of degradation on physical factors was evaluated. Soil degradation processes were identified by using Landsat TM and GIS integration techniques and ground truth verification. The kind, extend and severity of water degradations were mapped. In this case the water erosion were the major soil degradation process. In an area of over 740.06 Km^2, 54.08% of the area was considered low erosion risk, 24.30% moderate, and 1.34% of the area was very high erosion risk. Nearly 20.28% of the area need urgent attention to arrest the process of soil degradation. Soil degradation process has resulted in the human unsuitable land use management.

1 Introduction

Soil degradation process are site specific and differ in kind. Intensify, and areal coverage of the affect area. Therefore the prime need is to characterise and map these degraded areas so that –specific development plans can be made. Kharin (1986) also felt the need for compilation of land degradation maps prior to planning for desertification control. Recent advances in remote sensing technology have offered repetitive and synoptic views of satellite data is the bare

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real time view of fields conditions. This is very useful in updating the land-degradation maps with current satellite imagery. In semiarid region. Landsat imagery has been used for mapping eroded lands risk (Teotia *et al.* 1980, Moreira, 1991, Dedios, 2001).

FAO (1977, 1983) presented a World Map of Desertification to the U.N. Conference desertification, wherein the lands vulnerable to desertification were classified. Based on this approach, small-scale regional soil degradation maps indicating the kind of degradation were prepared. Such efforts for this part of the semiarid have been limited. Therefore, the study was taken up with slight modification of the FAO (1983). The mapping was done with the help of Landsat TM.

In this paper, remote-sensing and GIS techniques have been applied for the identification of degraded areas.

2 Study Area

The study area covering 740.06 Km^2 is located between 37°20' to 37°30'N and 4°14' to 4°45' S in the Genil-Cordobilla sub basin of Andalucian region (Fig. 1). The climate is to semiarid with mean annual rainfall of 500mm and mean temperatures of 25-28°C in summer and 7-10°C in winter. Shrubs and forest, cutting of tree largely dominate natural vegetation. Olive trees constitute the landscape.

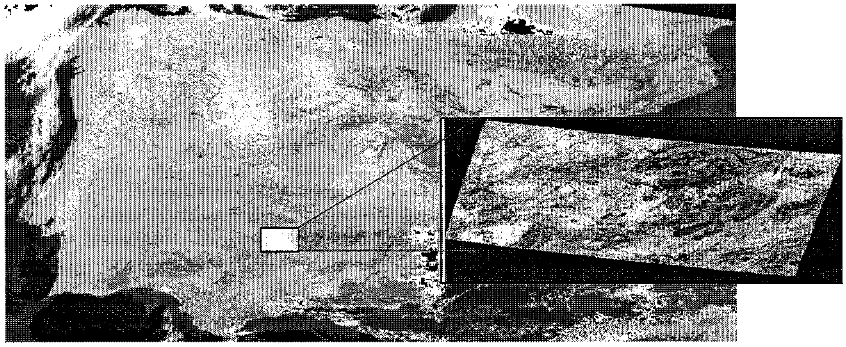

Figure 1: The study area

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3 Methodology

3.1 Data analysis and modelling

The criteria laid out by (CORINE, 1992) were adopted for mapping the area degraded due to different kinds of soil degradation by water. The criteria suggested that vulnerability of land to desertification should be assessed upon consideration of climate, terrain, soil, and vegetation condition. In this region, the most important to degradation process are identified by water (Dedios, 2001).

3.1.1 Remote sensing data

Landsat TM imagery data acquired in the summer, 18 July of 1998 based on tone, texture, shape, etc. Land cover types Water, Irrigated, Dry Farming, Ligneous Crops, Shrub, Forest, Urban, Unproductive were used in the extraction of land use information (Dedios *et al*, 2000). The interpreted results were integrated and analysed using a GIS. A flow chart showing the integration of remote sensing data with other geo-coded data represented by layers or levels of polygon corresponding to a given theme or class adopted in this study is a shown in figure 2. Vegetation cover is considered as a potential factor for identification in the case of water erosion susceptibility from remotely sensed data based on its multi - spectral and textural characteristics.

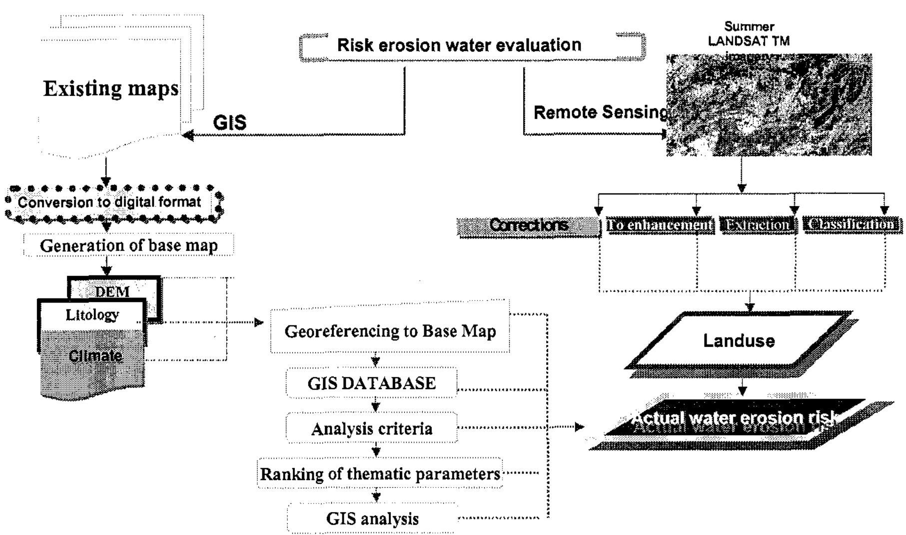

Figure 2: Flow chart showing the integration of remotely sensed data and GIS.

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3.1.2 GIS utilisation

A raster based modular ERDAS 8.2 version, 1996 was used in this study. The central element of this GIS is a spatial modeller database who comprising and integrated collection of data about spatial objects and attributes which describes their spatial reality.

The raster data model used here is a type tasselar spatial data model where spatial objects are described as polygonal units of space in a matrix. It visualises the data as set of layers, each contain data on a single theme. The overlay map encompasses point, neighbourhood and regional operation and Boolean operation can be easily implemented in raster model.

3.1.3 Data integration and classification

Eight categories of land use information derived from the remotely sensed data and other thematic maps were integrated. These were co-registered with the help of ground control points and physical features, and super-imposed using grid cell based overlay-modelling technique. The individual categories were ranked, and weight was assigned to polygons of individual terrain layers towards the triggering of slide. A summation of these layers was carried out and the accumulative score was regrouped into four classes. Finally those cartography are demonstrate to flow chart (Figure 2) indicate the probability of occurrence of a risk water erosion, based on the given terrain condition, erodability of soils, land cover and rainfall of similar intensify.

4 Result and Discussion

Water erosion is the main soil degradation process in the study area in response to torrential rains.

4.1 Erosion risks assessment

Soil erosion is a dynamic hazard, which possess physical attributes, and therefore needs frequent updating of the dynamic factors. The assessment of erosion risk is a specialised form of land resource evaluation which requires the identification of areas where maximum sustained productivity from a given land use is threatened by excessive soil loss. The erosion risk classification aims at dividing the land into regions, which are similar in degree and kind of erosion risk.

The slope, and land use (year 1998) maps were analysed together using ERDAS to produce an erosion risk map of the Genil-Cordobilla sub-basin (Figure 3).

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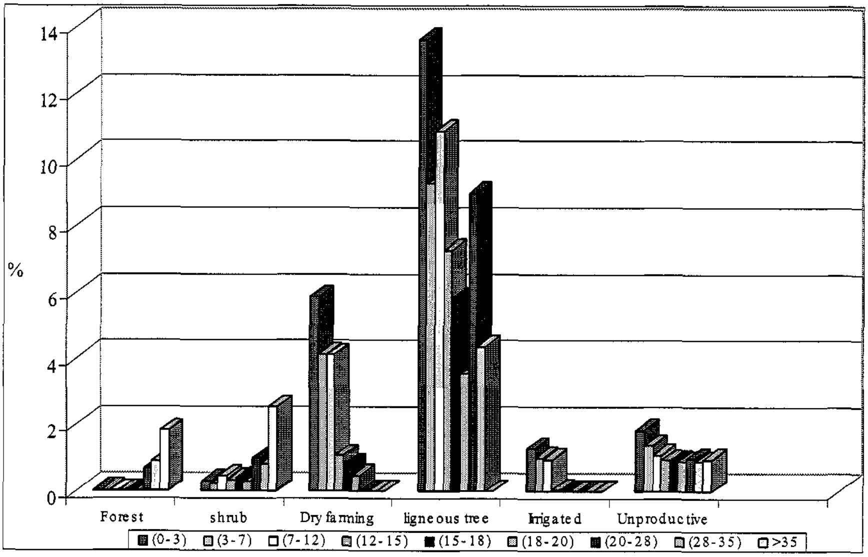

Figure 3: Segmentation of classes according to their susceptibility to erosion

A simple compound scoring approach was used, which required the same level of measurement for each data. Therefore, the land use maps were recategorized into the same number of classes, then ranked from 1 to 4, according to their increasing susceptibility to erosion (Table 1). For example, shrub and forest was considered less susceptible to erosion, because is the most protected of soil and therefore allocated as 4. If two or more classes were considered equally susceptible to erosion, they were merged together (Table 1).

Table 1: Segmentation of classes according to their susceptibility to erosion

Ranking Soil Land Protection Index	Land use classes	%	Surface (Km^2)
1	Forest	3,45	25,53
0,8- 0,6-0,4-0,2	Shrub	6,26	46,33
0,4-0,3-0,2-0,1	Dry farming	16,45	121,74
0,6-0,4-0,2-0	Ligneous tree	63,64	470,97
0,9-0	Irrigated	3,30	24,42
0	Unproductive	9,88	73,12
Total		100	740,06

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These maps with values 1 to 5 were simply added together (e.g. output = map1+map2+map3) using function of ERDAS, to define the combined effect of these parameters on erosion risks. The compound score, was segmented into five erosion risk classes where a score of less as having a very low erosion risk very severe risk of erosion. This segmentation procedure assumed equal probability of each class and assigned equal weighting. Area extent of these erosion risk classes was computed, and data show in table 2.

Table 2: Details of risk classes on the Genil-Cordobilla sub-basin.

Erosion risk class	Km^2	Area extent %	% (Accumulate)
Low	400,2	54,08	54,08
Moderate	179,83	24,30	78,38
High	9,91	1,34	79,72
Very High	150,08	20,28	100
Total	740,06	100	

Without extensive field data collection and monitoring of the area, it is very difficult to describe the detailed characteristics of these erosion risk areas. However, an attempt has been made to analyse the erosion risk map by referring to the slope and vegetation maps, and available field data. It is observed that very severe erosion risk areas are characterised by large concentrations of gullies/streams, and are eroded mainly due to gulling and overland flow. Much of this land is steeply sloping (up to 15%), with up to 10% vegetation cover. The severe erosion risk areas include the land in the vicinity of rivers, and the small channels (rills). Such areas lie mainly on marls, the supporting up to 20% vegetation cover. The areas with moderate erosion risk lie on cultivated land where sheet, rill and gully erosion are common. These areas have medium slope supporting up to 40% vegetation cover. Most of the slopes in such areas are stable except where is heavy gully/rill erosion due to overland flow. Low erosion risks areas are those regions where development of absents or where concentrated soil-water movement.

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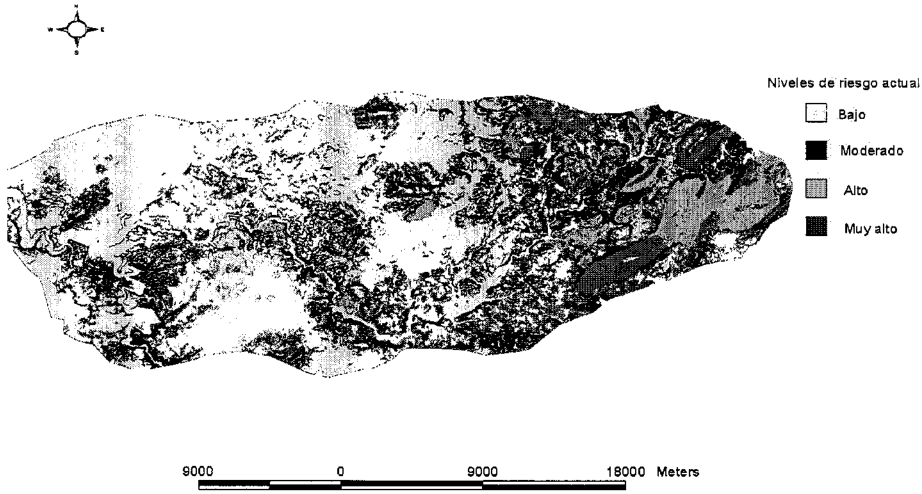

Figure 4: Map showing the actual risk erosion of the Genil Cordobilla Sub basin. The integration of remotely sensed data and GIS

Such areas are, in general, far away from the drainage channels, and lie on nearly flat ground. The slopes in such areas are reasonably stable at present, but any imbalance due to human activity may cause unstable slopes. Only 54.08% of the area has very low susceptibility to erosion. The soils in these areas are well protected by dense vegetation and grassy cover (up to 60%).

Analysis of erosion risk map reveals that nearly 24.30% of the total area is susceptibility to mode rate to very severe erosion risks; 17% of which is severely eroded by gullies. Further, the erosion risk map us studied together with the slope data, and it is observed that most areas susceptible to very severe erosion risk lie on >12 slopes are critical features since both the land use change and erosion risks are greatest between these slopes. Joint analyses of the erosion risk map and land use map of 1998 indicated that about 50% of the cultivated land is threatened by erosion risks, ranging from moderate to very severe. The severity of erosion in such lands is likely to increase in future un-lees some suitable protective measures are adopted.

5 Conclusion

This study has demonstrated that the selection of integrated data to GIS and Remote Sensing would help in the demarcation and identification of areas prone to risk water erosion under a given rainfall. This spatial information would aid in the assessment of risk to habitat and resources located at the downstream side. This approach is best suited on the *"La tiñosa"* mountain.

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The results of the present study revealed that satellite remote sensing data is a valuable tool for mapping degraded lands. In a area of 740.06 Km^2, nearly 20.28% (150.08 Km^2) of this area needs immediate attention to arrest the processes of soil degradation

The methodology can be applied to other published maps. However, the analysis shows that it is difficult to use archives that were not intended for computerisation.

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