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Geoinformatics based Natural Disaster Management- A Case Study from Yercaud Hills, Tamilnadu, India

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Abstract

Soil erosion is the serious environmental problems in hilly terrains. An attempt has been made to delineate the soil erosion prone areas in Yercaud hills using Geoinformatics tools (Remote sensing and GIS). The study area, Yercaud is the hill station in the Servarayan range of hills in Eastern Ghats of Taminadu. The parameters considered for identifying the soil erosion prone zone are Soil, Geology, landuse/land cover, drainage, rainfall and Geomorphology. There are 4 drainage patterns observed, the hill region is majorly covered by Charnockite rock type. Comparing all these parameters the soil prone areas have been observed in the south eastern part of the region.

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Keywords: Erosion; Geomorphology; Hills; Landuse/Lancover; Geoinformatics.

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1. Introduction

Soil is the natural resource which supports life on the earth. Soil erosion is one of the significant environmental problems of hill ecosystems [1]. In order words can be explained as detachment and transportation of soil particles caused by various erosive agents such as wind and water [2]. It is assessed that one-sixth of the world's soils have already been degraded by water and wind erosion. It is considered to be most serious degradation processes in hills because in sometimes it leads to the

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landslides. It decreases the holding capacity of soil water, soil fertility, removing of top soil and vegetation growth [3, 4, 5]. Erosion destructs the most productive and nutrient rich top soil in step parts [6]. Soil deprivation results by converting the forest land into agricultural areas in the Chitwan district of Nepal is reported by Burton et al [7]. In general removal of topsoil occurs through sheet erosion. It depends on surface soil condition, steepness and vegetation cover [8]. Hills are most vulnerable to soil erosion due to its undulating topography, slopes and high rainfall.

The intensity of erosion depends on erosivity (energy of water causing erosion) and erodibility (friction of the soil against erosion). In addition to that, it also depends on anthropogenic processes like human impact changes in landscape budget, vegetation cover and in physical soil properties. The land use/land cover modifications have also enhanced the soil erosion problems. Deforestation is the major problems in hilly terrain that creates soil erosion besides heavy rainfall that leads to rain splash and surface runoff erosion creates and leads to the major events of soil erosion [9, 10, 11]. Rainfall and runoff in hilly areas activate the mass movement and soil erosion [12, 13]. Soil moisture is considered as the other main factor that also accelerates soil erosion and landslide [14] especially in hilly areas [15]. Conservation of natural resources such as soils, gains its importance as a significant factor [16] to control soil erosion. Erosion by rain and river in hilly terrain causes the landslides and floods whereas grazing by a livestock, construction of roads, quarrying, agricultural practices, cutting trees leads to the heavy soil erosion.

Soil erosion can be appraised by a number of ways. In using direct measurement, formula-driven estimates based upon the Universal Soil Loss Equation using natural rainfall or its derivatives [17] and in using instruments such as the soil erosion bridge [18] were not possible to measure the large areas. Erosion plots have a demerit because they simplify topography and ignore storage of runoff and sediment [19]. Evaluation of soil erosion in hills is important to frame the effective soil conservation plans for defensible development. Identification of erosional prone areas by physical surveys is very extensive time consuming and costly in hills, hence remote sensing techniques with GIS or Geoinformatics can be effectively used to solve this problem. The information from these techniques can assist decision makers for the preparation of resource map accurately in consuming less time.

Soil erosion and their degradation has been developed and studied around the world [20, 21, 22]. Estimation of Soil erosion and its spatial distribution can be calculated using combination of many techniques such as remote sensing, GIS [23 – 30]. Using of GIS in linking all maps with other information related to geographic location helps in modeling, analyzing and solving complex problems. Therefore, Geoinformatics applications (Remote sensing and GIS) have been used in the present study to demarcate the soil erosion prone zones in Yercaud hills.

2. Study area

The study area, Yercaud is the hill station in the Servarayan range of hills. It lies between (11˚48' N & 78˚11' E) of Eastern Ghats situated in Salem district of Tamil Nadu at an altitude of 1515 m (above Mean Sea Level) (Fig.1). Temperature ranges between 25˚C and 30˚C. The average rainfall of the area is 1500 - 2000 mm and the highest rainfall (1594.3) mm is noted in the northern part of the study area [31]. Owing to its mild climate, yercaud has started alternating tourists from all over the country and has emerged as a popular "tourist destination". It is surrounded by wooded slopes, coffee plantations, thickly forested slopes and it is a good place for trekking and boating. In this hill citrus fruits most notably oranges, are grown in abundance apart from Bananas, Pears and Jackfruits. Bauxite and Magnesite are the chief mineral resources. The bauxite is considered to be of grade II and grade III of Indian Standard Specifications and alumina content of the bauxite of Yercaud ranges between 42% to 51%. Hence, extensive bauxite mining is adopted here. Medicinal plant survey suggested that about 48 plant species belonging to 45 genera and 29 families of medicinal plants related to folk medicine used by the local people [32].

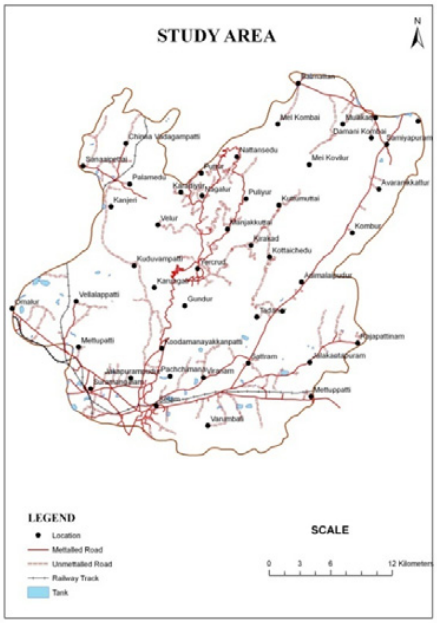

Fig.1 Location map of the study area

3. Materials and methods

Various thematic layers like Geology map, Lineaments map, Soil map, Rainfall, Drainage map, Landuse/Landcover map have been generated and integrated using weighted index overlay (WIO) methods to demarcate the zones of soil erosion.

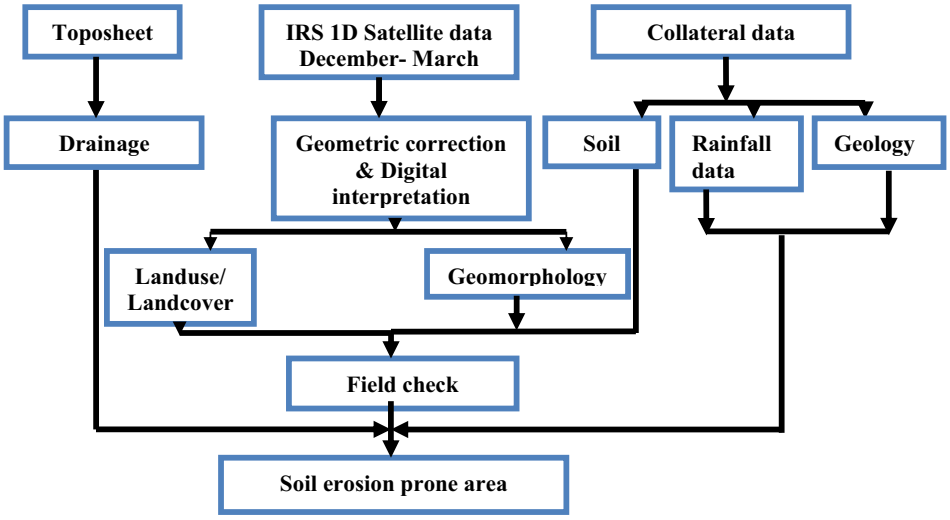

Fig.2 Schematic diagram of methodology adopted for the study (after Sakthivel et al., 2011)

- The IRS 1D, satellite data of December, 2001 (Path101-Row65) has been geometrically and radiometrically corrected and the land use and land cover have been digitally interpreted and classified using ERDAS software (Fig.2). Limited field check has been undertaken for the correctness of the interpreted data.
- Soil map has been generated using the existing data available with the Soil Survey Department and limited field check has been performed (Fig.2).

- Monthly rainfall data from State government departments have been collected

4. Results and discussion

4.1. Geology

The study area is majorly covered by Charnockite rocks. The southern part of the region comprises of migmatite quartzite, some patches of ultramafics (Chalk hills) rocks are also present in southern part with the extent to the Migmatites. Massive charnockites is the petrogenetic evidence for post-metamorphic deformat. Some of the economic minerals such as Bauxite, Magnesite, Chromite, Gypsum and Gemstones are present in the study area (Fig.3). The northern part of Yercaud is more dissected than southern part hence no bauxite deposits present in northern part.

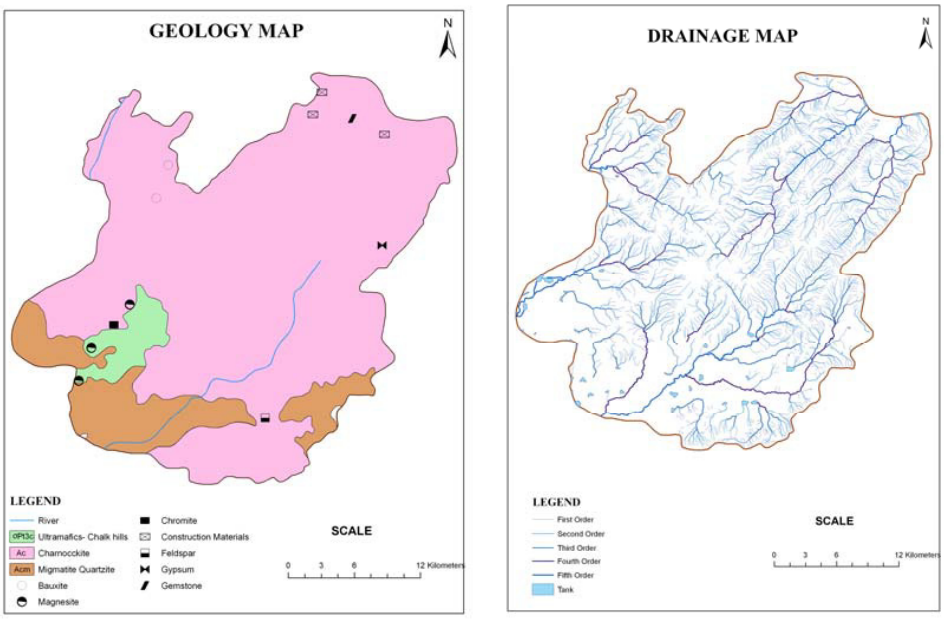

Fig.3 (a) Geology and (b) Drainage map of the study area

4.2. Drainage

Drainage is the important parameters for estimating the soil erosion zone in an area. Hill's slope evolution is controlled by the sediment transport processes which change in response to the evolving topography and by their interaction with stream processes at the slope base. In the study area, drainage pattern are unique. There are 4 drainage patterns such as parallel (N and NE parts), subparallel, Trellis (NE and E parts), rectangular and dentritic (mostly in southern part) (Fig.3b). The river Tirumanimuthar is originated in the study area. The drainage architecture of the terrain indicates that the area is highly controlled by prominent structures.

4.3. Rainfall

Yercaud receives a rainfall of 22.40mm in winter, 268.10mm in summer, 870.20mm in south west monsoon, 540.90mm in northeast monsoon analysed for the year 1980 to 2010 [33]. Rainfall analysed from six stations over the period 1901-2003 of the salem district shows that maximum rainfall is observed around yercaud hills (1594.3mm) in the northern part (CGWB, 2008). The higher rainfall is observed in the south western part, the lowest rainfall is observed in the central and northern part whereas the moderate rainfall is observed in the south eastern part.

4.4. Soil types

Soil is an outer skin of the land masses of the earth which acts as an interface between lithosphere, hydrosphere, atmosphere and biosphere. Brown Soil occupies major portion of hills, they occur in deep and non-calcareous. The top most hilly region is characterized by clay loamy soil whereas the bottom of the valley is distinguished by alluvial and clay loam soil. The soil types range from clayey soil (Rhodic palestalfs) typic ustropepts, udic chromusterts, cracking clay soil and Gravelly clay soil are identified in the southeastern, eastern, and some selected pockets of Northern and western part of the study area respectively (Fig.4a). In the southwestern part Gravelly loamy soil present. Central part of the study area mainly occupied by loamy soil variants.

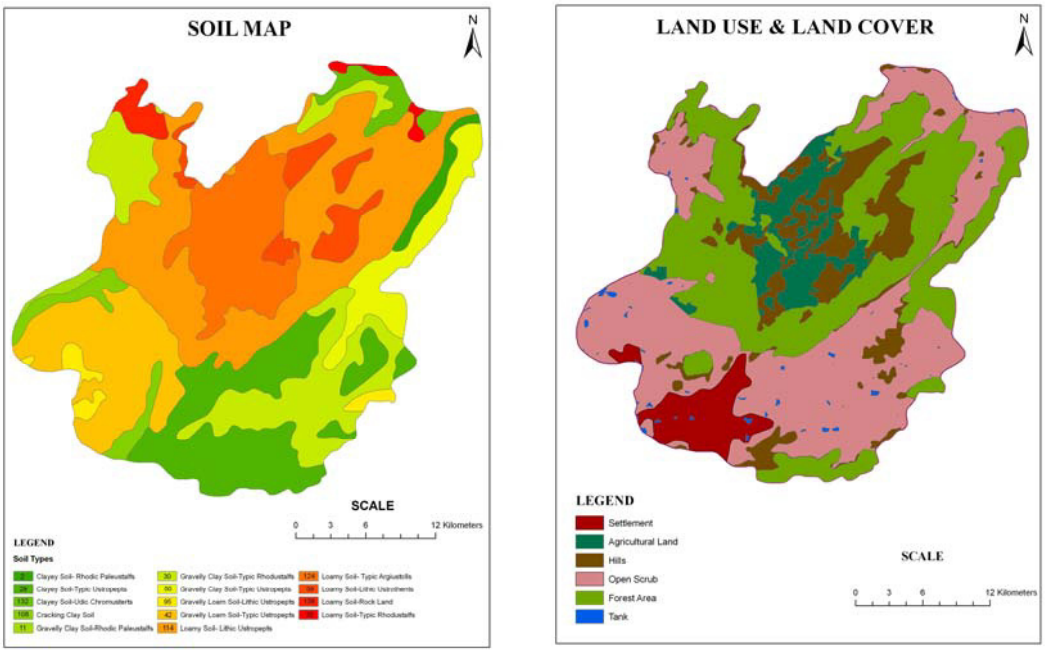

Fig.4 (a) Soil and (b) Land use/ Land cover map of the study area

4.5. Land use and land cover map

Evaluation of some of the land use systems practices in the region indicates that most of them are hazardous to resources and are not conducive to the aims of permanent agricultural systems with sustainable production [34]. Land cover is an indirect indication of the stability of hill slopes. The thickly vegetated forest areas are less prone to erosion and are generally more stable. However, the barren and sparsely vegetated lands are more prone to erosion and instability. The various land use/land cover classes are classified as Settlements, Agriculture, Hills, Open scrub, Forest area and tanks. Evergreen to moist deciduous forest occurs in these hills [35]. Hills cover a most part of the study area with an 457.59 Km^2. Next to that, Open scrub covers a next part with a 350.42km^2(Fig.4b). Agriculture covers an area of 322.60 km^2 and forest regions covers an area of 310 km^2. But the settlements and tanks covers a minor part in the hills with an area of 53.03 and 4.55 km^2 respectively.

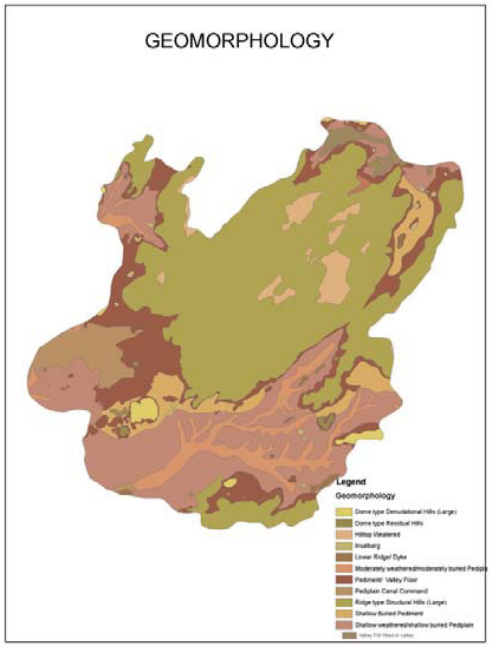

Fig.5 Geomorphology map of the study area

Geomorphology features / Landforms are one of the significant parameters for soil erosion [36] , to identify the geomorphological features influencing the soil erosion in study area are layer are Dome type denudational hills, residual hills, Inselberg, Linear ridge cycle, Pediment, pediplain canal, ridge type structural hills, shallow buried pediment, shallow weathered buried pediplain (Fig.5). Most of the part of study area is covered by Ridge type structural hills. The southern part of the study area is underlained by the shallow weathered/ shallow buried pediments.

5. Conclusions

Soil erosion is considered to be most serious degradation processes in hills because sometimes it leads to the landslides. It decreases the holding capacity of soil water, soil fertility, removing of top soil and vegetation growth. The higher rainfall region is noted in the southern eastern part whereas the soil type (Rhodic palestalfs) typic ustropepts, udic chromusterts, cracking clay soil and Gravelly clay soil also been observed in these regions and the charnockite is the major rock types of the hills. When Charnockite rocks tend to weathering, it results in the formation of laterite and lithomorphic clays. During heavy precipitation the overlying laterite may be eroded and they will lead to the soil erosion. More rainfall on the rock hill areas resulted to more soil loss as reflected also in increasing rate of soil detachment. From the study it is inferred that south-eastern part is highly prone for soil erosion and moderate zones (South eastern part) and low (Central and Northern part). The importance of the monitoring schemes should be emphasized and the need to continue with surveillance in times of changing land use and climate is clear.

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