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Remote Sensing and GIS for Soil Erosion Prone areas Assessment: A case study from Kalrayan hills, Part of Eastern Ghats, Tamil Nadu, India

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ABSTRACT

In this present study, the soil erosion assessment and conservation measures in hill ecosystem is carried out in the Kalrayan hills, Part of Eastern ghats, Tamil Nadu using Remote Sensing and GIS techniques. The geocoded digital data of IRS P6 LISS – III (P101-R65 of 2001) and Survey of India toposheets (1971) were interpreted and various thematic maps such as drainage, lineaments, geomorphology, land use/land cover and slope maps have been prepared. After assigning the weightage factors for each of the parameters they were overlayed and integrated it one another and various soil erosion prone areas were demarcated. GIS integration was carried out using Arc GIS to assess the soil erosion by overlaying the following maps such as lineament density, drainage density, geomorphology, slopes and land use / land cover. The results of interpretation and analysis show that the following areas such as Karnelli, Uppur, Pattivalavu, Arampundi, Vellar, Tekkampattu and Karumanturai are highly prone for soil erosion.

Key words: Soil erosion, Kalrayan hills, Remote Sensing, GIS, prone areas.

INTRODUCTION

Among the various ecosystems existing in our earth, the hill ecosystem occupies its uniqueness by providing shelter to the various floral and faunal species, resources for nation's development, and habitations to its own tribal children and shows its natural beauty to its beloved lovers. Such wide-ranging utilities have made this ecosystem have been induced by a variety of environmental problems such as soil erosion, land slides, floods, depletion of water, diversity in valuable floral and faunal species, changes in climate etc. Among these, the soil erosion is one of the most serious environmental degradation processes in the hilly terrain because, it removes the most productive and nutrient-rich topsoil. Sediment originating from erosion process decreases the storage capacity of reservoirs and water carrying capacity of rivers. For the formulation of various watershed management schemes for sustainable development, inventories on actual and potential rates of sediment yield, the identification of erosion prone areas are essential. The recent development of geo-spatial techniques such as satellite data digital image processing and geographic information systems (GIS) has increased its potential applications and proved its capability in soil erosion assessment and conservation measures in hill ecosystem. These two technologies can enable us to analyze large or small areas, integrates numerous variables on the evaluation process, and easily update the database information. These improvements result in a less time-consuming and less expensive methodology to monitor soil conservation practices and predict erosion rates. Especially, remote sensing techniques offer a good means of monitoring the adoption of these conservation practices (Logan et al., 1982; Trolier and Philipson, 1986; Welch et al., 1984). The black- and-white aerial photographs, satellite remote sensing data and GIS techniques have been applied by several scholars for soil erosion assessment (Karale and Saini (1986); Stephens and Cihlar, 1982; Biswas, 1986; Karale and Das, 1986; Sharma and Kalia, 1987; Manu Omakupt (1989); Saha and Singh (1991) and Petra Fritz, (2004)). Mitchell (1981) and Steglik (1982) have studied the extent and risk of soil erosion in North Africa and Middle East by visual interpretation of Landsat imagery. Louhichi, et. al (2010), Elias Symeonakis and Nick Drake (2010), Sergio Lo Curzio and Paolo Magliulo (2009), Jasmin Ismail and Ravichandran (2008), Pankaj Mani et. al (2003) have also recently used the Geospatial technologies to assess the soil erosion. Hence, here an attempt has been made to develop a soil erosion prone areas model for Kalrayan hills and studied the potentiality of remote sensing and GIS techniques.

Study Area

The study area, the Kalrayan hills, part of Eastern Ghats, lies between the north latitudes 11^0 36' and 12^0 01' and the east longitudes 78^0 29' and 78^0 54' (Fig.1). It forms part of three districts viz. southern and southwestern portion of Salem, the central and eastern portion of Villupuram and a small part of Thiruvannamalai district occupied by the northern most part of the study area. The Kalrayan hill is divided into '5' nadus (means group of villages, such as Periyakalrayan (western part), Chinnakalrayan (northern part), Jadaya gaundan (southern and eastern part), Kurumba gaundan (central part) and Ariya gaundan (North) and encompasses 79 revenue villages(Fig.1). It acts as catchment for Gomukhi, Kariakovil and Manimuktha nadhis. It supports life to more than one lakh people those who have been living in and around the Kalrayan hills (Sakthivel, 2003 and 2006). The Vegetation types of Kalrayans are scurb jungles existed at an altitude of 500m, and the deciduous forests are situated between 800 to 1300m. The shoals are the sheltered pockets occurred on the plateau (Matthew, 1981). The study area is encircled by Sathanoor dam, in the north, the famous Attur valley in the south, Manimuktha dam in the East and Chitterin hills in the west. The average rainfall in the study area ranges from 782.98 to 1787.20mm. The temperature varies from a minimum of 25^oC to a maximum of 40^oC. The altitude varies from 126 to 1298m. The study area is composed of seven soil types and varies from red-loam to black clay (Kadavul and Parthasarathy, 2001). In the study area numerous lineaments and their points of intersection have been identified and most of them show NE-SW trending direction (Sakthivel *et al*., 2003). A prominent shear zone trending in a N-S direction cut across the entire hills (Sakthivel *et al*., 2010)

Fig.1

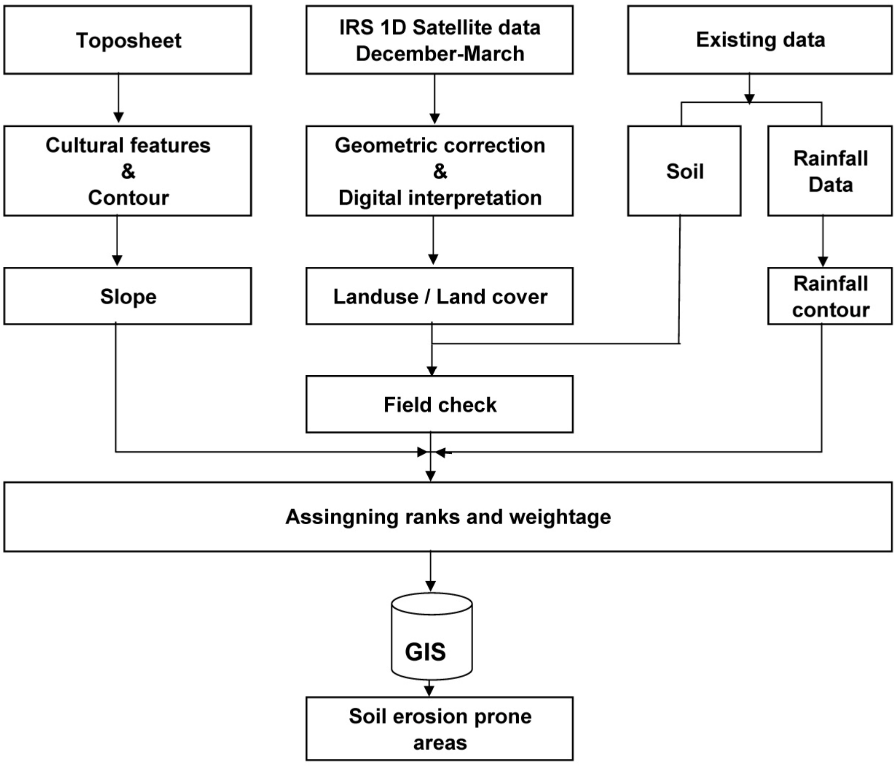
MATERIALS AND METHODS

The parameters of soil erosion is rainfall, slope, soil, land use and land cover. The soil erosion hazard zones have been prepared using the above parameters based on the following methodology.

- *The IRS 1D, satellite data of December,2001 (Path101-Row65) has been geometrically and radiometically 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.*
- *Slope has been generated from the Survey of India topographic map in the scale of 1:50000 (1971) and the contours have been digitized using Arc -GIS software (Fig.3).*
- *Soil map has been generated using the existing data available with the Soil Survey Department, and limited field check has been preformed (Fig.4).*
- *Monthly rainfall data from State government departments have been collected and isohyets map is constructed using Arc GIS – Spatial analyst software (Fig.5)*

- *Suitable ranks and weightage have been given to interpret the erosion prone areas reference with the given thematic layers parameters.*
- *Vector overlay has been performed using the Arc-GIS software*
- *In final, based on the above, the integrated output on high soil erosion prone areas have been identified for implementing soil conservation activities (Fig.6).*

The following schematic diagram shows the methodology of the present work.



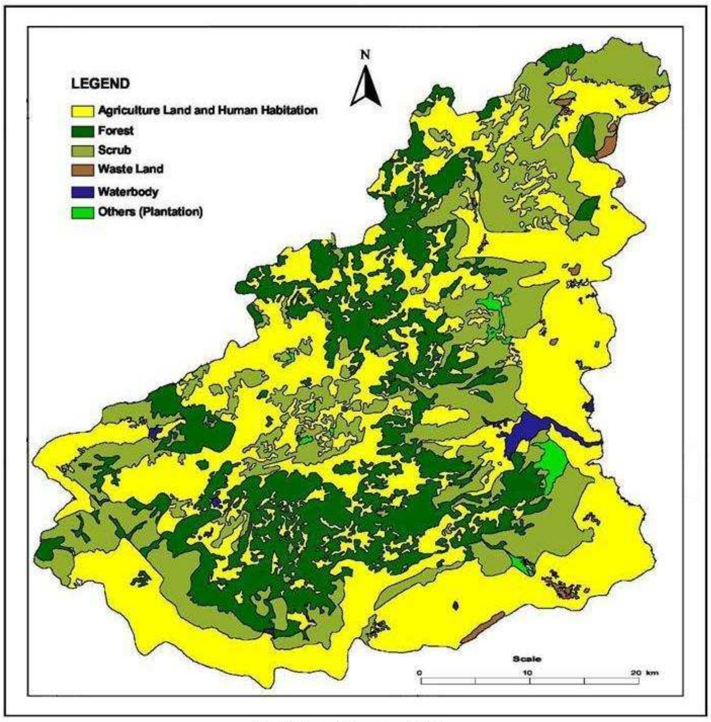


Fig.2 Forest Cover - 2001

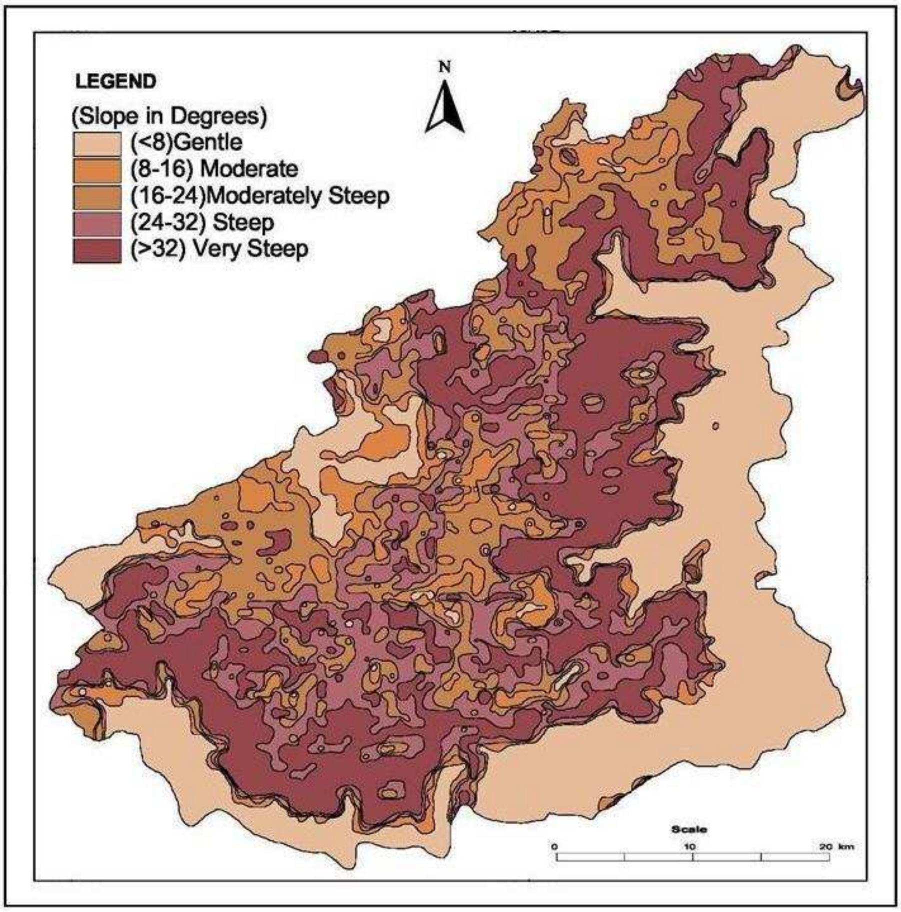


Fig.3 Slope

Parameters	Weightage
Forest Cover	
Agriculture	5
Scrub	4
Wasteland	3
Forest & Plantation	2
Waterbody	1
Slope in Degrees	
> 32	5
24 – 32	4
16 – 24	3
8 – 16	2
< 8	1

Parameters	Weightage
Rainfall	
> 1600	5
1400 – 1600	4
1200 – 1400	3
1000 – 1200	2
< 1000	1
Soil Type	
Gravelly loamy	5
Loamy	4
Gravelly clay	3
Clay	2
Calcareous clay	1

RESULTS AND DISCUSSION

For the rainfall parameters, higher weightage values were assigned to the areas of very high rainfall and the values were progressively reduced for the lower rainfall categories. As far as slope is concerned, the highest weightage value was assigned to the very steep slopes followed steep categories and the weightage values were progressively reduced. For the lower steep slope categories for the soil parameters the gradually loamy soil, which have greater potential for erosion are given higher weightage factors. For the other soil categories lower values were assigned to clay soil followed by loamy soil. The gravel clay soil was assigned the least values.

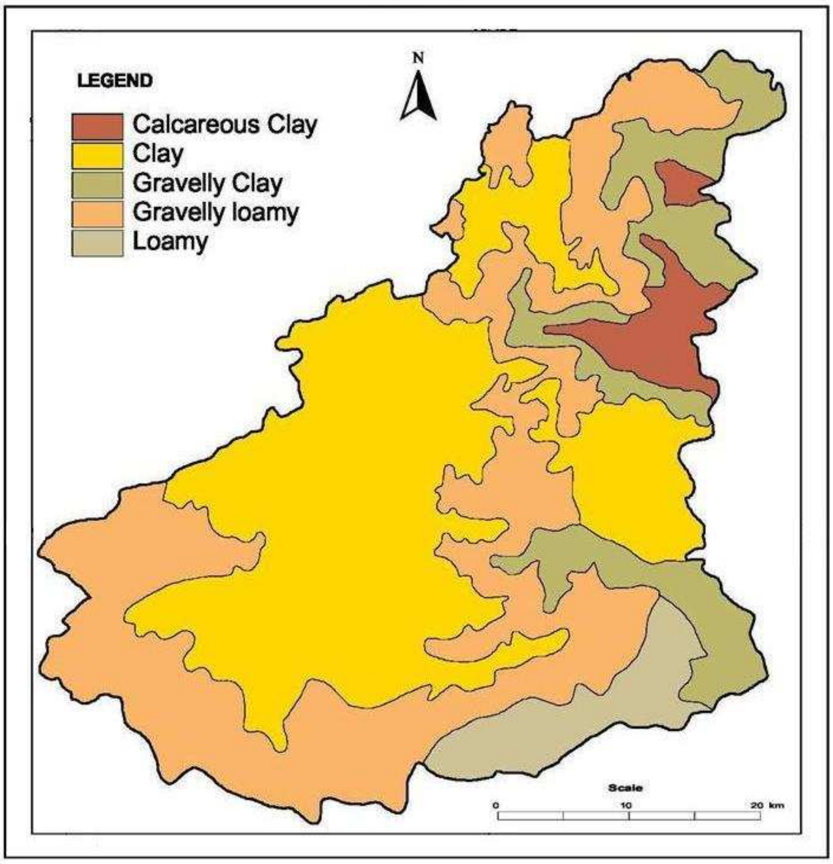


Fig.4 Soils

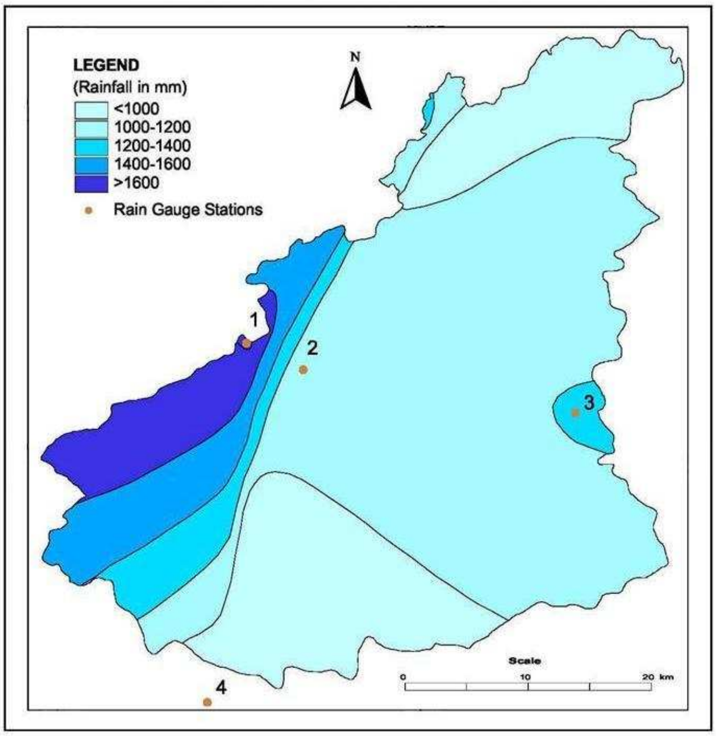


Fig.5 Average Annual Rainfall

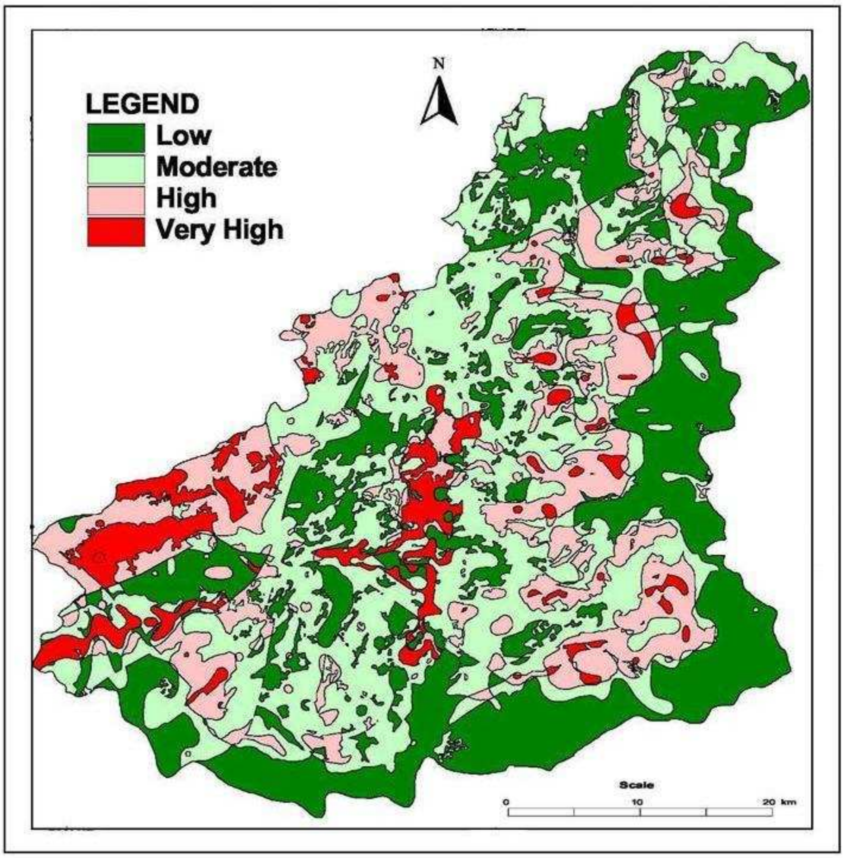


Fig.6 Soil Erosion Prone Areas Model

As far as the land use / land cover is concerned, the higher values were assigned to agriculture and human habitation category. Lower values were assigned for scrubs and for forest least values was assigned.

After assigning the weightage factors for each of the parameters they were overlaid and integrated it one another and various soil erosion prone areas were demarcated as shown in fig.6

CONCLUSION

From the present study, it is evident that very high soil erosion hazard zones are found at the inner slopes of the plateau portion and these areas represent the steep slopes in the human habitation where agricultural activities are practiced. Also, such very high soil erosion prone areas are found at the higher outer slopes of Tumbal extension reserved forest area of western side of the study area which is due to agricultural practices. The area which is highly prone for soil erosion are Pattimedu, Jadayagaundan (Southern portion), Kanai and Puttai reserved forests (Eastern portion) are due to deforestation and human interferences. The area with moderate soil erosion hazard zones area confined to the lower outer slopes occurred in the reserved forest and more confined to, the plateau portions of the study area, Vellimalai, Kariyalur and Innadu . Areas with low soil erosion hazards are found to the foothills and plain regions of the study area.

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