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A CASE STUDY

Identification of critical geo-morpho units using GIS – A study in a micro-watershed of Karamana River Basin

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ABSTRACT : The terrain characteristics of an area have an enormous impact on the natural environment as well as socio-economic activities. GIS based terrain models can provide a spatial element with the analysis of variables such as slope, aspect and watershed or catchment area. The present study aims to understand the terrain aspects of a small micro watershed of Karamana river with the perspective of water shed management in the area. This study was carried out using FOSS GIS to understand the basic principles and utility of this tool in identifying critical geo-morpho units in the area. Thus, compound terrain attributes such as L S factor, total curvature, convergence index and Terrain Ruggedness Index (TRI) were computed for the study area. It is hoped that the information provided in this work will be of use in implementing conservation and management strategies for the river systems of Kerala in general and the Karamana river in particular.

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Key Words :
Terrain modelling, Geo-morpho units, Watershed management

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Streams and rivers represent one of the most valuable ecosystems on earth. Each stream and river has unique characteristics and each one has problems of its own. Since most of the rivers serve as drinking water resources, fisheries, irrigation, tourism, aesthetics etc. their interdependence with human survival and sustenance is of utmost significance. However, rapidly changing land use pattern and conversion of land meant for agriculture to residential or commercial purposes reduce the natural recharging of groundwater during rainy season. Also, the increase in population, fast urbanization of many adjoining regions of the river, the exponential rise in demand for water and sand, together with the direct disposal of solid and liquid wastes into the river, make water resources unsuitable for safe use. For the effective management of our water resources, a scientific approach is utmost necessary and the use of cutting edge technologies like GIS is highly solicited.

The present study aims to undertake a terrain modelling of a small sub-basin of Karamana river with the perspective of water shed management in the area. The study thus attains special significance owing to the choice of the study area as well as the ultimate aim of the study. The results of the study can be made useful in the formulation of watershed management principles for the scientific development and conservation of this delicate ecological unit of nature.

The study area :

The area selected for the study is a small sub-watershed of the Karamana river falling in the Vithura village of Thiruvananthapuram district, Kerala and extends between North latitudes 9°31’ 45.26” to 9° 34’43.96" and east longitudes 74° 0' 3.95" to 74° 34' 39.36" on the eastern slopes of the western ghats in the district of Thiruvananhapuram. The Karamana river originates from Chemmunji Mottai, a peak in the Sahyadri hills, at an altitude of 1717m amsl. The total annual average rainfall in the study area is about 1,500 mm (59 in) per annum. The southwest monsoon, from June to September is the principal rainy season. The study area receives most of its annual rainfall in this season. The second rainy season is the North-East monsoon. It is from October to November. Vegetation and land use pattern is largely dependent on rainfall.

From the geological point of view, the Karamana river basin can be broadly classified into two zones *viz.*, The major parts of the river Basin consist of mainly rocks of Archaean group and the western zone consists of Quilon and Varkala beds. A thin strip of recent sand silt is seen near to the coastal stretches. Major part of the river basin in the mid land and lowland regions consists of laterite soil. In the upper reaches of the river Basin, forest loam is found. In the midland and lowland regions, a thin stretch of river alluvium is found along the river valleys cutting across the extensive laterite soil. The surface soil is mostly reddish brown to reddish yellow in colour. The texture of surface soil ranges from gravelly loam to gravelly clay loam.

Experimental Methodology

Since the study aimed at considering the utility of FOSS GIS (Free and open source software for geographical information system) in the theme of terrain modelling, the materials and the methodology adopted for the study was streamlined accordingly. The base data was obtained from survey of India toposheet (No. 58 H_2) of 1:25000 scale which were scanned and further processed using the software SAGA GIS ver. 2.0.5 (System for automated geoscientific analysis) of the SAGA user group association.

The methodology involved data collection, data input, geo-referencing of the data, vectorization of thematic layers for extraction of spatial features and creating the attribute table for various types of attribute data input and finally generation of digital terrain model (DTM) using inverse distance weighted method. Inverse distance weighting (IDW) is a type of deterministic method for multivariate interpolation with a known scattered set of points. The assigned values to unknown points are calculated with a weighted average of the values available at the known points. After building the DTM in SAGA GIS, standard terrain modelling and subsequent terrain analysis module was executed for obtaining important terrain parameters in both numerical value as well as thematic map formats.

Experimental Findings and Discussion

In this study, terrain analysis of a small watershed in Karamana region was carried out using the tool of GIS and the results of the analysis of parameters elevation, slope, L S factor, terrain ruggedness index, total curvature and convergence index are discussed below :

Elevation :

Digital elevation models are data files that contain the elevation of the terrain over a specified area, usually at a fixed grid interval over the bare earth. The closer together the grid points are located, the more detailed the information will be in the file. The details of the peaks and valleys in the terrain will be better modelled with small grid spacing than when the grid intervals are very large.

The result of the digital elevation model pertaining to the study area is given in Fig. 1. The elevation values in the study area ranged between a minimum of 160 m and a maximum value of 1300 m. The north eastern and south eastern portions of the micro-watershed showed the most variation with respect to the elevation parameter, whereas, the western portions showed lesser elevation variations and constituted the hydrological sinks in the study area.

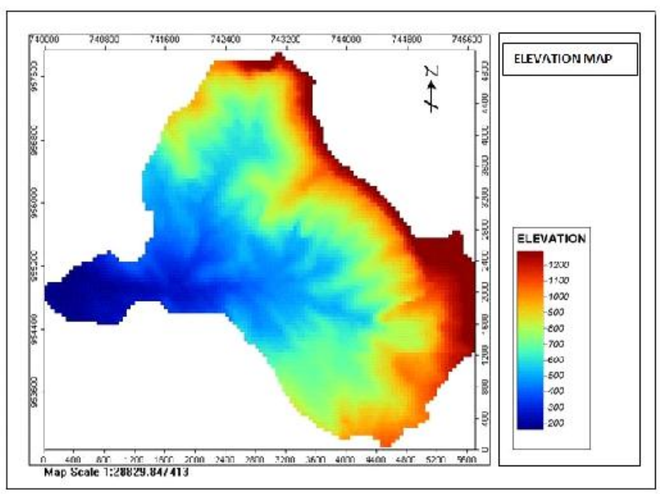

Fig. 1: Elevation map of the study area

Slope analysis :

Slope is calculated with the first order derivative of the elevation at a location, to determine the steepness relative to the 8 surrounding pixel values. The minimum and maximum values for the slope analysis are very different to the original DEM. The units of the slope analysis have been measured in degrees of inclination, with a minimum value of 0.13 degrees and a maximum value of 52.97 degrees (Fig. 2). The histogram shows that there is an abundance of relatively flat areas, but there is also a steady increase in frequency for the higher angles of degree within the data.

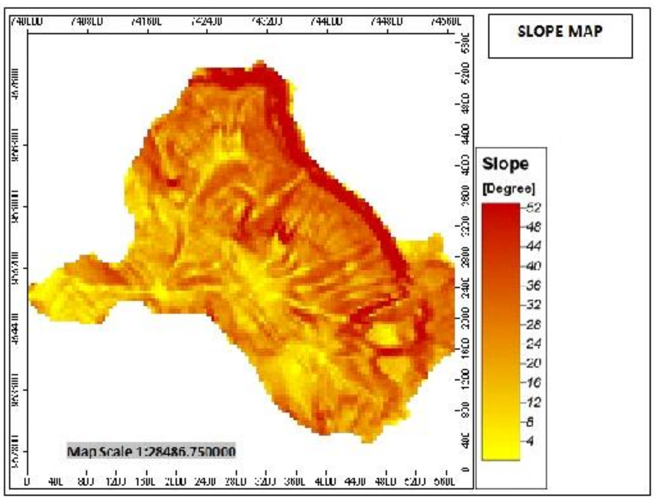

Fig. 2 : Slope map of the study area

Again it was observed that, the greatest slope values were occurring on the eastern boundaries of the micro-watershed and lesser values coincided with low altitude regions in the western sides. Slope values exceeding 40^0 in the eastern margins can be considered as critical category areas where site specific slope reinforcement measures are to be adopted for the proper management of the micro-watershed.

L S factor :

L is the slope length factor, representing the effect of slope length on erosion. Slope length is the distance from the origin of overland flow along its flow path to the location of either concentrated flow ordeposition. Computed soil loss values are not especially sensitive to slope length and differences in slope length of + or – 10 per cent are not important on most slopes, especially flat landscapes.

The L S factor map of the study area is given in Fig. 3 and it can be observed that the values range between a minimum of 0.004 and a maximum of 20.35 in the area. The high values coincide with the hill slopes in the eastern margins of the micro watershed and the lower values are found to be occurring in the western sides. The effect of topography on erosion is accounted for by the LS factor, which combines the effects of a hill slope-length factor, L and a hill slope-gradient factor, S. Generally speaking, as hill slope length and/or hill slope gradient increase, soil loss increases.

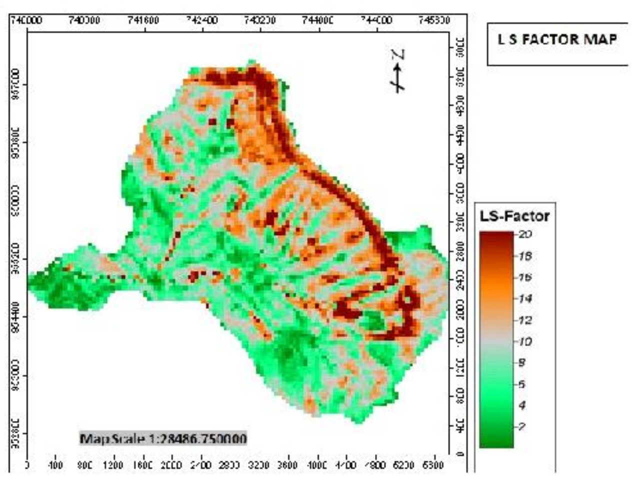

Fig. 3 : L S factor map of the study area

Adediji *et al*., 2010 modelled soil erosion in Katsina state of Nigeria using the RUSLE. It was observed that soil loss increases more rapidly with slope steepness than it does with slope length. The study also ascertained the significance of LS factor in soil erosion as compared to all the other factors. Similar studies were carried out in a number of areas (Igwe *et al*., 1999; Grimm *et al*., 2003; Van *et al*., 1999; Wischmeier and Smith, 1978 and Gitas *et al*., 2009) and the LS values varied widely depending upon the regional topographic characteristics.

Terrain ruggedness index :

The ruggedness index value is calculated for every location, by summarizing the change in elevation within the 3x3 pixel grid and is a dimensionless parameter. The ruggedness index is used as a measurement of terrain. The histogram shows that the majority of the data falls into the level classification, but a fair amount of locations exhibit some of the higher classification ranges. These areas of ruggedness are likely found around the peaks of the highest mountains and in areas with large cliffs, where changes in elevation are more dramatic.

The terrain ruggedness index map of the study area is given in Fig. 4 and the values range between a minimum of 0.001 to a max of 49.80.

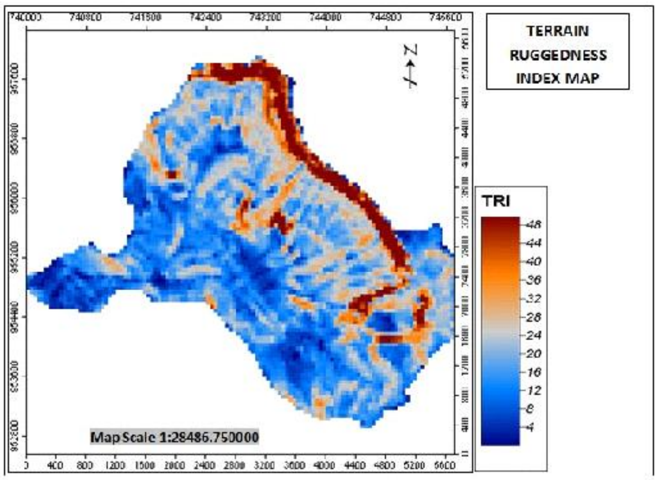

Fig. 4 : Terrain ruggedness index map of the study area

Ruggedness Index (combination of drainage density and relative relief per km^2) of a basin is an indicative of how much the fluvial process dissects the landscape. The high value denotes the high ruggedness of topography having high drainage density and high magnitude of relief (*i.e.* gorge, spur and valley). The statistical analysis reveals that basin wise maximum valley side slope controls the ruggedness of the basin *i.e.* high valley side slope provides high kinetic energy to water erosion and transportation of eroded materials through channels forming dissected profile of the Basin.

Total curvature analysis :

The calculation of total curvature uses the second order derivative for the 3x3 grid of pixels. In theory this is calculating the slope of the slope for every location, where negative values indicate that the surface is upwardly concave at that location and conversely positive values indicate that the surface is upwardly convex. Values of 0 indicate areas where the surface is flat and no curvature exists.

The total curvature map of the study area is shown in Fig. 5 and the values vary between a minimum of -0.02 and a maximum of +0.025. The fact that the minimum value is negative indicates that there are surfaces that are upwardly concave as well as convex surfaces inside the area. The areas with the highest values appear to be located along the boundaries of steep cliff faces.

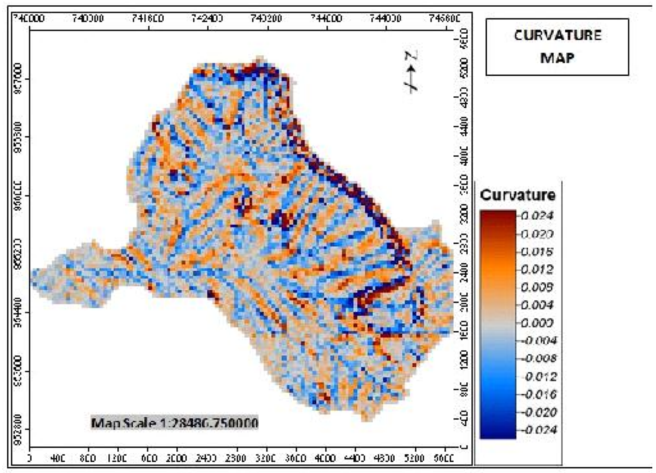

Fig. 5 : Curvature map of the study area

Convergence index :

This module calculates an index of convergence/ divergence regarding to overland flow. By its meaning it is similar to plan or horizontal curvature, but gives much smoother results. The calculation uses the aspects of surrounding cells, *i.e.* it looks to which degree surrounding cells point to the center cell. The result is given as percentages; negative values correspond to convergent,

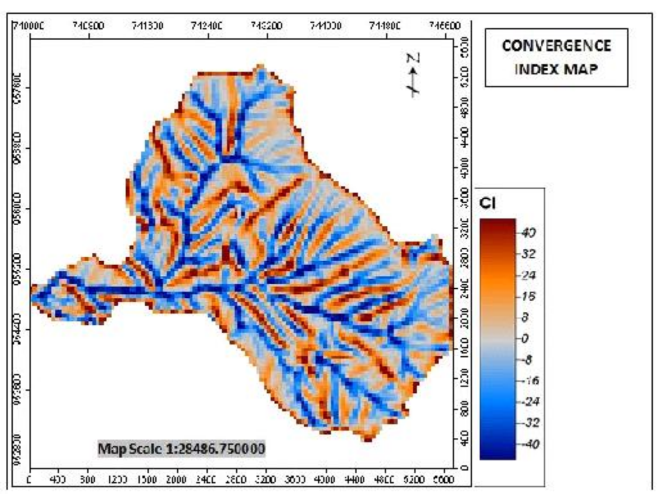

Fig. 6 : Convergence index map of the study area

positive to divergent flow conditions. Minus 100 would be like a peak of a cone, plus 100 a pit and 0 an even slope.

Fig. 6 shows the convergence index map of the study area and the values ranged between a minimum of -45.89 to a maximum of +45.19, the negative values corresponding to convergent flows and the positive values corresponding to divergent flows in the area.

Conclusion :

A DEM based terrain analysis was carried out using FOSS GIS in a small micro watershed in the Karamana river basin to understand the basic principles and utility of this tool in identifying areas of critical geo-morpho-units. Compound terrain attributes such as elevation, slope, L S factor, total curvature, convergence index and Terrain ruggedness index (TRI) were computed for the study area.

A comprehensive analysis of the said parameters was done to conceptualize the range and significance of these parameters and their effect on the regional environmental setting. The slope parameter was found to be varying between 0 and 52 degrees and the areas falling in the slope category of >40° were isolated as critical geo-morpho-unit as far as the slope parameter was considered. Since the L S factor of slope significantly influences soil erosion by surface water movement, the areas with higher values need to be treated as critical geo-morpho units.

The high terrain ruggedness index values denote the high ruggedness of topography having high drainage density and high magnitude of relief especially in the eastern margins of the micro watershed. These areas fall in the critical geo-morpho-unit category and hence, needs to be specifically managed. The total curvatures as well as convergence index maps prepared all are in conformity with the said observation and the findings underscore the need for specific scientific management practices to be adopted in such areas.

A clear and scientific perspective of the environmental setting of a region is the basic pre-requisite for the formulation of conservation and management of our basic landscape units *viz.*, watersheds. The study has thus, proved efficient in generating the thematic results essential for the above purpose. Moreover, the employment of an advanced technology like GIS especially in the FOSS GIS category emphasizes its utility for the academic community without effecting any financial constraints; yet fulfilling the objective of environmental conservation.

REFERENCES

Adediji, A., Tukur, A.M. and Adepoju, K.A. (2010). Assessment of revised universal soil loss equation (RUSLE) in Katsina area, Katsina State of Nigeria using remote sensing (RS) and geographic information system (GIS). *Iranica J. Energy & Environ.,* **1** (3): 255-264.

Gitas, Ioannis Z., Kostas, Douros, Chara, Minakou, George, N. Silleos and Christos, G. Karydas (2009). Multi-temporal soil erosion risk assessment In : N. Chalkidiki Using A Modified Usle Raster Model. EARSeL eProceedings 8, 1/2009.pp.40-52.

Grimm, Mirco, Robert, J.A. Jones, Ezio Rusco and Luca Montanarella (2003). Soil erosion risk in Italy: a revised USLE approach. European Soil Bureau Research Report No.11, EUR 20677 EN, (2002), 28pp. Office for Official Publications of the European Communities, Luxembourg.

Igwe C.A., Akanigbo F.O.R. and Mbagwu J.S.C. (1999). Application of SLEMSA and USLE Erosion models for potential erosion hazard mapping in Southeastern Nigeria. *Internat. Agrophysics,* **13**: 41-48.

Van, der Knijff J.M., Jones, R.J.A. and Montanarella, L. (1999). Soil erosion risk assessment in Italy. European Soil Bureau. EUR 19044 EN, 52pp.

Wischmeier, W.H. and Smith, D.D. (1978). *Predicting rainfall erosion losses – a guide for conservation planning.* U.S. Department of Agriculture, Agriculture Handbook 537.