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Estimation of Sediment Yield of Randigad Catchment, Pauri District, (Uttarakhand), India, Using Remote Sensing and GIS Techniques

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Abstract

Soil erosion is a worldwide issue due to uncontrolled deforestation, forest fire, grazing, incorrect method of tillage and unscientific agriculture practices, resulting in large increase in sediment and siltation to flow into stream and dramatically influence water quality. Therefore, estimation of sediment yield has become one of the important task for the policy makers before planning for an area sustainability ex-constructing a dam and land use. In this research, sediment yield index integrated with remote sensing and GIS techniques has been used to estimate sediment yield in the Randigad catchment located in Pauri district of Uttarakhand. Remote sensing and GIS technologies were used to prepare required input layer as drainage density D, slope S, vegetation factor F to utilize in SYI model. The estimated drainage density D, slope S and Vegetation factor F range from 0.7832 km/km^2, 20.64^o, and 1.461 km^2 respectively.The result indicate that very low annual sediment yield i.e 0.1477 M.m^3/year*10^3 for the whole catchment. Thus, the result can certainly aid in implementation of soil management and conservation practices to reduce the soil erosion in the Randigad catchment.

Keyword: LULC, SYI, Remote Sensing, GIS

Introduction

Soil erosion due to rainfall and runoff is one of the critical issues contributing to land degradation problems and is vital aspect of land management. The eroded soil in the form of sediment moves downstream due to flow of rain water. The amount of sediment load passing through the outlet of a catchment/watershed is known as sediment yield. The major factors influencing the sediment yield are the land use particularly the vegetation, the soil, the slope and the intensity of rainfall. Watersheds have been identified as planning units for conservation of this precious resource (FAO, 1987; Khan, 2001). The watershed management recognizes the interrelationships between land use, soil, water and the linkages between uplands and downstream areas (Tideman, 1996). Estimates of sediment yield are needed for conservation of soil and water, study of reservoir sedimentation etc. The information on sources of sediment yield within a catchment can be used as perspective on the rate of soil erosion occurring within that catchment (Jain Manoj, 2010). In order to adopt remedial measures to prevent soil erosion, the priority areas are identified within the watershed. For this, usually the whole watershed is subdivided into small sub-areas (called grids or cells) depicting homogeneous characteristics in terms of factors influencing the soil erosion. This type of grid or cell based approach has been used in a number of studies for identifying the erosion prone areas of the catchment (Kothyari, 1997). However there is another approach of sub-dividing the watershed into much smaller segments known as 'micro- watersheds' being the smallest entity in the hierarchy. Instead of grids the micro-watersheds are considered for estimating sediment yield of each one and thereafter prioritizing.

The latest advances in remote sensing technology and geographical information sciences (GIS) provide real-time information on various aspects of the watershed such as land use, physiography, soil, relief, drainage characteristics, etc. It also assists in identification of existing or potential erosion-prone areas and provides data inputs to many of the soil erosion and runoff models. The rate of soil loss is judged by the Sediment Yield Index (SYI), which can be derived through various empirical formulae. In India, SYI model is developed by the All India Soil and Land Use Survey (AISLUS), and is commonly employed in providing criteria for priority delineation in river valley projects and flood-prone rivers. Several attempts have been made to estimate sediment yield in the recent past in various basins of India, using SYI and other conventional methods. The present study makes an attempt to assess the sediment yield of the Randigad Catchment by using standard method with the aid of remote sensing data and drainage parameters.

Study Area

Randigad catchment falls in Pauri district of Uttarakhand which lies between 30º 6' 00"N to 30º 9' 00"N, 78º 42' 00"E to 78º 48' 00" E, covering an area of 24.377 km². The catchment maximum and minimum elevations are 1249 m and 2114 m above the mean sea level respectively. The tributaries Ujyari gad, Kuan gad, Magrau gad, Nalai gad and Tamlak gadhera joins the main stream Randi gad. The soil in the catchment comprise of calcareous loamy, loamy and sandy-skeletal and the catchment mainly predominated by agriculture land and forest cover all around the studied area.

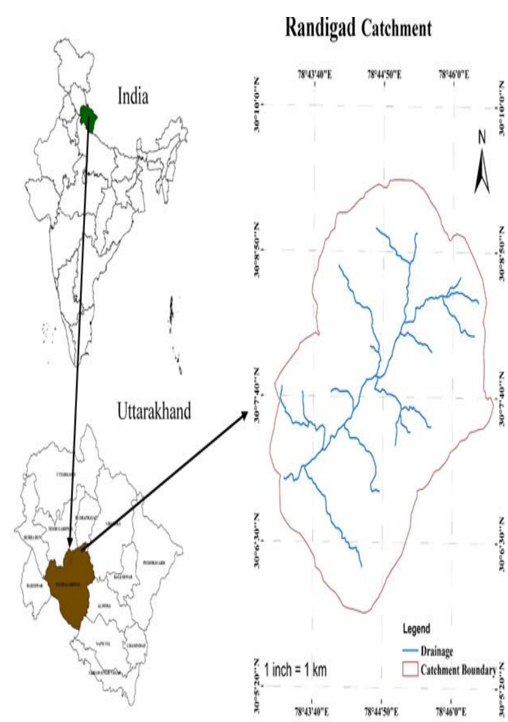

Fig. 1 Location Map of study area

Materials and Methods

The input materials required for preparation of different thematic maps using spatial and non-spatial data. Spatial information was used in the form of Digital Elevation model (DEM), Satellite images and non-spatial data in the form of rainfall data.

LISS IV satellite data having a spatial resolution of 5.8 meter was used to prepare LULC map. The Cartosat-1 Digital elevation model (DEM) with 30m resolution, was used to generate stream, stream order and slope. Rainfall data downloaded from SWAT (Soil and Water Assessment Tool). In order to prepare Annual rainfall, data from five weather stations had been collected for the past five years and annual rainfall was calculated. The

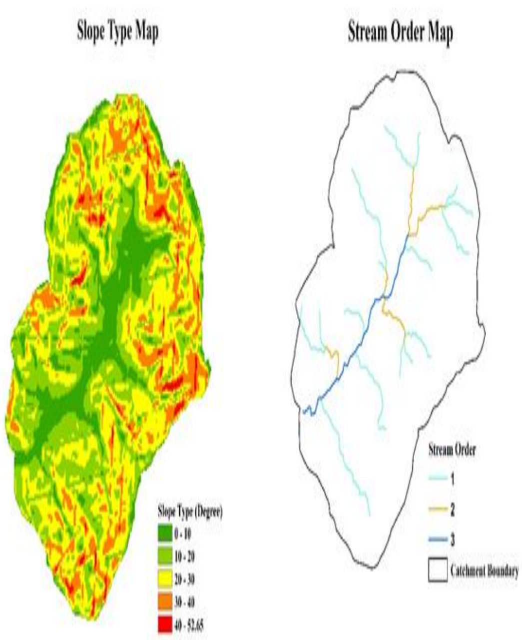

Fig2: Input Parameters of SYI model

result of each station was entered in Kriging (Spatial Analyst) interpolation tool to interpolate the whole catchment.

Sediment Yield Index (SYI) was computed taking inputs from drainage parameters, land use/cover, annual rainfall and slope of area to assess sediment yield rate, in Randigad catchment. The Cartosat-1 DEM was used to generate the drainage network and ordering of the basin using ArcSWAT tool.

In order to prepare LULC map, standard visual interpretation method was used which is based on tone, texture, size, shape, pattern, association and field knowledge and classified into different classes i.e. agriculture land, dense forest, open forest, open shrub, wasteland, settlement and water body.

Result and Discussion

Land use land cover analysis

Agriculture crop land, Agriculture fellow land, Barren land, dense forest, Open forest, Shrub, Settlement and Water body are the main LULC class type in the Randigad catchment (Table 1). Settlement and Water body has covered the minimum area of the catchment. The total catchment area is 24.48 km² and the area statistics indicate that 3.167 km² of an area under Agriculture fellow land, which is 12.74 % of the total watershed area. The agriculture crop land area is about 3.83 km² (15.47%). The area under barren land is about 2.759 km². The maximum area of the catchment covered by dense forest which is 35.33 % of the total watershed area. The other Lulc types of i.e. dense forest, open forest, shrub, settlement and water body occupy areas of 8.77 km², 4.49 km², 1.007 km², 0.77 km² and 0.04 km² respectively.

Table 1. Land use land cover statistics

LULC	Area (km²)
Agriculture Fellow Land	3.162671745
Agriculture Crop land	3.838777107
Barren Land	2.758205563
Dense Forest	8.769175362
Open Forest	4.488129718
Shrub	1.006539048
Settlement	0.764833906
Water Body	0.037248159

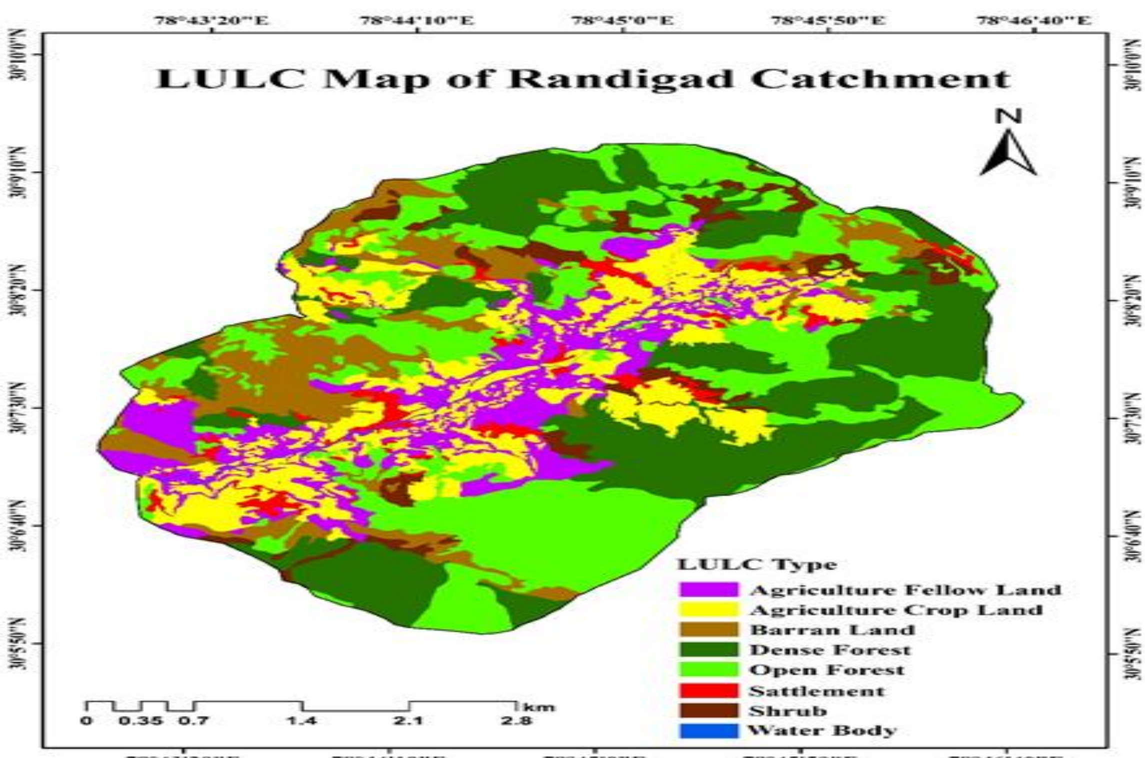

Fig.3 LULC map of Randigad Catchment

Sediment yield index analysis

The quantitative estimation of Sediment Yield Index (SYI) were carried out by Bali and Karale and updated by National Remote Sensing Agency. A common empirical model for SYI employed under Indian conditions, was carried out following Kumar besides Rao and Mahabaleswara, and is as follows:

$$\boldsymbol{Vs = 1.067 * 10^{-6}\, P^{1.384}\, A^{1.292}\, D^{0.392}\, S^{0.129}\, F^{2.51}} \quad \textbf{(1)}$$

Where

Vs = Sediment Yield, (Mm^3/year × 10^3)

P = Annual precipitation, (cm)

A = Catchment area, (km^2)

D = Drainage density, (km/ km^2)

S = Average slope of watershed, (degrees)

F = Vegetative cover factor, (km^2)

Where, F can be determined as:

F = 0.21F1+ 0.2F2 + 0.6F3+ 0.8F4 + F5 + F6 + F7 /7 (2)

F1 = Agricultural land

F2 = Dense forest

F3 = Open forest

F4 = Open scrub

F5 = Barren Land

F6 = Settlement

F7 = Water body

The Land use land cover map, drainage map and slope map are the essential key for derived A, D, S and F parameters. In the order to calculate sediment yield index of the Randigad catchment using equation 1 and 2. The value of every parameter in Equations (1) and (2) have been put and the resultant value of Vs has come out to be 2.74 M·m3/year × 103 (Table 3). The sediment yield rate in Randigad reservoir is found to be 0.07 ha·m/year.

Table 2. SYI parameter and sediment yield

Parameter	Value
Area (A) (km^2)	24.33
Drainage Density (D) (km/ km^2)	0.7832
Slope, S (Degree)	20.64
Precipitation, P (cm)	106.8
Vegetation Factor, F (km^2)	1.461
Sediment Yield Index, Vs ($M.m^3$/year*10^3	0.1477

Conclusion

In this study, the SYI method used to calculate sediment yield in the Randigad catchment. The input thematic layer for this study are drainage density map, slope map are used. The results provide a scope of satellite data with SYI data without compromising the interpretability of prioritization in a time and cost effective manner.

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