Original Article

Indian Journal of Waste Management
Volume 1 Number 2, July - December 2017

Use of RS and GIS for Estimation of Sediment Yield

R.D. Bansod[1], Sudhir Lad[2]

Abstract

Detached and transported soil particles, due to action of water or wind deposite at downstream side of river, watershed and any other watershed structure leads into degradation of the land and ecology. The observed sediment yield of the Sonwal watershed in 2002-03 was 5.88 t/ha/yr. However, it was found 10.22 t/ha/yr with an increase of 4.34 t/ha/yr in 2008-09. The estimated sediment yield of the watershed for the year 2008-09 was found to be 14.82 t/ha/year with per cent change in observed and estimated sediment yield, 45. The area under waste land is increased by 15.55 per cent, agriculture area increased to a very less extent 0.18 per cent and forest land is reduced by 2.69 per cent, therefore the increased sediment yield was observed to the extent of 4.34 t/ha/yr (73.80%) in six years i.e. from 2002-03 to 2008-09. To reduce the rate of increase of sediment yield, the agriculture area needs to be increased by decreasing the wastes land besides, the watershed development program need to be implemented effectively to reduce the sediment yield or soil loss.

Keywords: Sediment Yield; Soil and Water Conservation.

Introduction

Detached and transported soil particles, due to action of water or wind deposite at downstream side of river, watershed and any other watershed structure leads into degradation of the land and ecology. Soil and water conservation structures are designed based on the principle of either obstructing the runoff and its subsequent recharge in to soil profile or to store it for the purpose of recycling. Sedimentation depletes the capacity and life of soil and water conservation structures and reservoirs which leads into uneconomic and over estimation of the structures. Since part of the sediment eroded from an area can deposit in the lower reaches, the rate of erosion is usually greater than the rate at which sediment is carried downstream at any section; the latter is known as the sediment yield. It may be mentioned that since landscape formation and changes in it are due to differential erosion and deposition of sediment, erosion, sediment yield and landscape formation are closely interrelated; therefore study of soil erosion and sediment yield assumes great importance in river morphology (Garde *et. al.* 1987). Conventional methods of data collection are uneconomical and require more time to provide information. Remote Sensing (RS) and Geographical Information System (GIS) technique have capability of providing information about the environment parameters more accurately, which is helpful for decision makers with the kinds of information that can't be effectively provided by conventional methods.

Land use land cover change represents the changes in area under various land use land cover categories, which helps to decide importance of watershed development planning, therefore, land use land cover change study was necessary for watershed development.

[1]Professor & Head, Dept. of Soil and Water Conservation Engg., Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, Maharashtra 413722, India. [2]Assistant Professor, Dept of of Agril. Engg., Shiv Shankar College of Agricultural Engineering, Mirajgaon, Ahmadnagar, Maharashtra 414401, India.

Correspondence and Reprint Requests: Ravindra Bansod, Professor & Head, Dept. of Soil & Water Cons. Engg., Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri,Maharashtra 413722, India.
E-mail: rtuljapur1808@gmail.com
Received: January 03, 2018 | **Accepted:** January 19, 2018

Materials and Methods

Study Area

The research conducted, during 2013-15, was in Sonwal watershed, of Shahada taluka, Nandurbar district, Maharashtra with an area of 9934 ha, located in 74°53´ to 74°75´ N and 21°54´ to 21°62´ E with average elevation of 455 m above sea level. Satpura Mountain Range just 30 km from north of Shahada, the basaltic bedrock is on an average 5 metres below the ground level. The watershed is situated on Gomai triburatory of Tapi River, empties in it at Changdev in Prakasha in Nandurbar district. It originates in Satpura Mountain North Maharashtra and merge into the Tapi River.

Climate

The maximum temperature of the region reaches to 48°C and minimum to 9°C. The climate of Shahada is dry except during the south-west monsoon season and winter months December to February with an average rainfall of 552 mm.

Data used

The data required for study was as follows

- Digital imagery data : Landsat 7 for year 2002-03 and 2008-09.
- Mean annual rainfall (mm) for year 2002-03 and 2008-09.
- Monthly rainfall data (mm) for year 2002-03 and 2008-09.
- Survey of India toposheet (1: 50,000) (Toposheet No. 46 K/10).
- Observed sediment yield for year 2002-03 and 2008-09.

Fig. 1: Location of study area

Preparation of Land Use/Land Cover Map

In the present day world, land use and land cover mapping is of great significance in scientific, scholarly research, planning and management. Regional land use pattern reflects the character of interaction between man and environment and the influence of distance and resources based on mankind's basic economic activities. Remotely sensed satellite images provide a synoptic overview of the whole area in a very short time span. This leads to quick and truthful representation of the real world in the best possible manner. It provides an insight to coordinate relationship among transportation, residential, industrial and recreational land uses, besides providing broad-scale inventories of natural resources and monitoring environmental issues, including land reclamation, mangrove restoration, disaster relief, water quality. Land use/land cover data obtains after classifying raw satellite data into "land use and land cover" (LULC) categories based on the return value of the satellite image.

LULC provides a very valuable method for determining the extents of various land uses and cover types, such as urban, forested, shrub land, agriculture, etc. Land use/land cover data are most

commonly used in a raster or grid data structure, with each cell having a value that corresponds to a certain classification. This structure allows for creating summary tables and performing suitability analyses. A total number of five distinct land use/ land cover types, namely reserve forest cover, agriculture land, water bodies, waste land and resident land was used for identification and modelisaton.

Calculation of Vegetative Cover Factor (Fc)

The vegetative cover factor equation developed by (Garde *et al.* 1987) used by (Upadhyay *et al.* 2012) is as under

$$F_c = \frac{0.8\,F_A + 0.6\,F_G + 0.3\,F_F + 0.1\,F_W}{A} \quad \text{..... (2)}$$

Where,

F_A = Area under Agriculture land (km^2),

F_G = Area under Grass land (km^2),

F_F = Area under Forest area (km^2),

F_w = Area under Waste land (km^2) and

A = Total watershed area.

Drainage Density (D_d)

The drainage density is the ratio of total channel length to the area of the watershed. A drainage map of the study area (the Survey of India toposheet at a scale of 1:50,000) was used for drainage map preparation and calculating the drainage density. The ArcGIS Software was used to draw the different order streams and calculate the length which directly gives the drainage density.

Slope Map and Stream Slope (S)

The slope map was prepared using the ASTER DEM and using the SOI toposheet. Stream slope was calculated by dividing the total fall between the end points of the main stream by its length.

Results and Discussion

Land Use and Land Cover

Land use/ land use map for Sonwal watershed was used to represent the classification of land in various categories viz. forest, wasteland, water bodies and resident land, which is depicted in Table 1.

Change Detection of Land Use/ Land Cover

Land use/ Land cover change indicates the impact of the developmental activities in the watershed. Comparison of change in statistics of two different years 2002-03 and 2008-09, changes are given in the Table 1. The area under agriculture land for year 2002-03 was 70.71km^2 and the area under agriculture land for year 2008-09 was 70.84 km^2 with per cent change (increase) of 0.18 in 2008-09 over 2002-03.

The area under forest land for year 2002-03 was 21.93 km^2 and for the year 2008-09, 21.34 km^2 with per cent decrease of 2.69 in 2008-09 over 2002-03. The area under waste land for year 2002-03 was 2.70 km^2 and the area under waste land was 3.12 km^2 with per cent increase of 15.55 in 2008-09 over 2002-03.

Vegetative Cover Factor (FC)

The value of Fc factor was calculated by putting values of area under forest land (km^2), agriculture land (km^2), grass land (km^2) and waste land (km^2) in equation (2). These areas were calculated using LULC map. The value of Fc for year 2002-03 was 0.638 and for year 2008-09, 0.638.

Table 1: Land use/land cover statistic in 2002-03 and 2008-09 of Sonwal watershed

Sr. No.	Land use categories	Year 2002-03 Area (km^2)	Year 2008-09 Area (km^2)	Per cent Change in LULC
1	Agriculture land	70.71	70.84	0.18
2	Forest land	21.93	21.34	-2.69
3	Resident land	1.15	1.24	7.82
4	Waste land	2.70	3.12	15.55
5.	Waterbody	2.85	2.80	-1.75
6.	Grass land	0	0	*
	Total	99.34	99.34	

* There was no area under grass land in the year 2002-03 and 2008-09
(-) Sign indicates reduction in area.

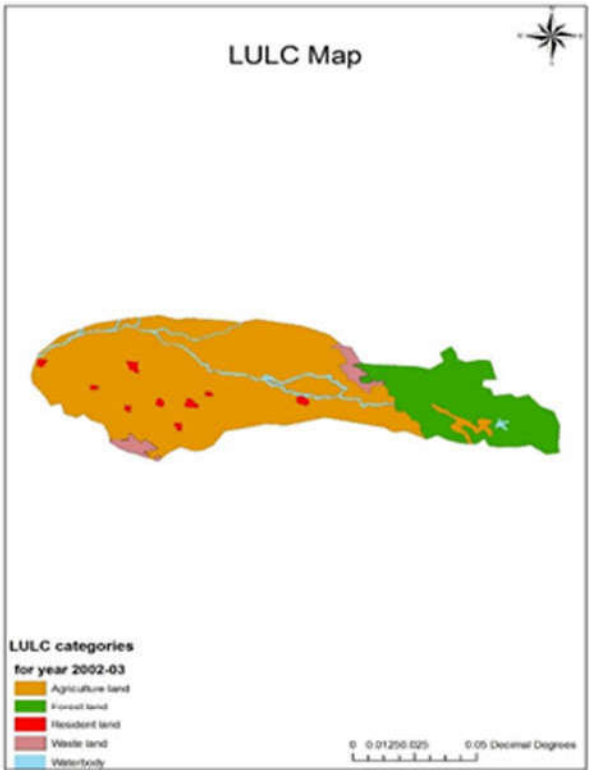

Fig. 1: Land use land cover map of Sonwal watershed For year 2002-03

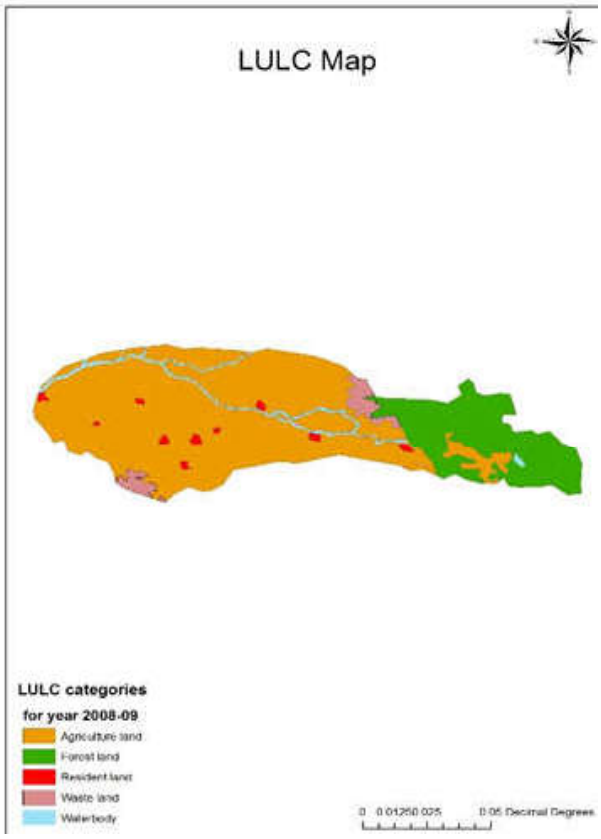

Fig. 2: Land use land cover map of Sonwal watershed for year 2008-09

Drainage Density (D_D)

The length of watershed was taken from drainage map using attribute table in ArcGIS software. The length of watershed basin was found to be 305.356 Km. The area of the Sonwal watershed was 99.34 Km^2. Therefore, the value of D_d was 3.073 Km^{-1}.

Slope Map and Stream Slope (S)

The length of main stream was 22.24 Km and the total fall between the ends points of the main stream, 177 m. Therefore, the stream slope of the watershed was 0.00796 m/m.

Conclusions

Based on the results of the study, conclusions obtained are as follow

1. Waste land of Sonwal watershed is increased by 15.55 per cent, agriculture land increased to a very less extent 0.18 per cent and forest land is reduced by 2.69 per cent, therefore the increased sediment yield was observed to the extent of 4.34 t/ha/yr (73.80 %) in six years i.e. from 2002-03 to 2008-09. To reduce the rate of increase of sediment yield, the agriculture land need to be increased by decreasing the waste land.
2. The area under resident was increased by 7.82 per cent in 2008-09 over 2002-03. The area under water body was decreased by of 1.75 per cent in 2008-09 over 2002-03.

References

1. Garde, R. J. and U. C.Kothyari. *Sediment yield estimation*. J. Irrig. & Power India, 1987;44(3):97-123.
2. Jain, M. K. and U. C. Kothyari. *Estimation of soil erosion and sediment yield using GIS*. Hydro. Sci. J., 2000;45(5):771–786.
3. Jain, S. K., P. Singh, A. K. Saraf and S. M. Seth. 2003.*Estimation of Sediment Yield for a Rain, Snow and Glacier Fed River in the Western Himalayan Region.* Water Resources Management, 2003;17:377–393.
4. Kothyari, U. C. and S. K. Jain. *Sediment yield estimation using GIS*. J. Irrg. & Drain. Engg. Div. ASCE Hydrological Sciences-Journal-des Sciences Hydrologiques, 1997;42(6):833-843.
5. Suvendu Roy. *Generating iso-erosion rate zones for the kunur river basin using combine methods of soil erosion*

estimate. International Journal of Geology, Earth & Environmental Sciences, 2013;3(2):77-89.

6. Upadhyay, R., K. A. Pandey, S. K. Upadhyay and A. Bajpai. *Annual Sedimentation Yield and Sediment Characteristics of Upper Lake, Bhopal, India*. Research Journal of Chemical Sciences, 2012;2(2):65-74.