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Efficacy of Garde's Model for Estimation of Sediment Yield

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Abstract

Garde's Model was used for sediment yield estimation in Sonwal watershed, of Shahadataluka, Nandurbar district, Maharashtra with an area of 9934 ha, located in 74° 53´ to 74°75´ N and 21°54´ to 21°62´ E. The observed sediment yield of the Sonwal watershed in 2002-03 was 5.88 t/ha/yr and 10.22 t/ha/yr in 2008-09, with an increase of 4.34 t/ha/yr. The estimated sediment yield of the watershed for the year 2002-03 using Garde's equation was found to be 12.37 t/ha/year with percent change in observed and estimated sediment yield, 110.37. The estimated sediment yield of the watershed for the year 2008-09 was found to be 14.82 t/ha/year with percent change in observed and estimated sediment yield, 45. The rate of increase of sediment yield can be reduced by increasing agriculture area and reducing the area under wastes land besides, besides the watershed development program need to be implemented effectively to reduce the sediment yield or soil loss.

Keywords: Garde's model; Sediment yield; Sonwal watershed.

Introduction

Soil and water loss from watershed is a common problem due to miss management of thesenatural resourcesand lack of soil and water conservation techniques. Sedimentation due to soil erosion 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. 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 (*Gardeet. al.* 1987).

Garde's equation/method, of which the parameters like rainfall, drainage density, and slope are more or less similar to the parameters, (R, L, S), of Universal Soil Loss Equation (USLE). The USLE does not mention the geological condition of an area however it is so important for the erosion factor calculation. In Garde's equation (eq.1), the vegetal cover factor (Fc) represents the geographical condition of the area, therefore, this method can be used for estimation of sediment yield.

Materials and Methods

Study Area

The research was conducted, during 2013-15, in Sonwal watershed, of Shahada taluka, Nandurbar district, Maharashtra with an area of 9934 ha, located in74° 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 Gomaitriburatory 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 anaverage 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

Garde's Equation

This equation is based on observations of 50 catchments spreading evenly all over the India. This sediment yield equation is dependent not only on catchment area, but also on other parameters like slope, drainage density, annual rainfall and vegetal cover factor. The sediment yield equation developed by (*Gardeet al.* 1987) used by (Upadhyayet al. 2012) is as under

$$V_{SAB} = 1.182 \times 10^{-6} \times A^{1.03} \times P^{1.29} \times S^{0.08} \times D_d^{0.40} \times F_c^{2.42} \quad (1)$$

Where,

V_{SAB} = Sediment yield in (Mm^3 /year),

A = Watershed area (km^2),

P = Annual precipitation (mm),

S = Average watershed slope (m/m),

D_d = Drainage density (km^{-1}) and

F_c = Vegetative cover factor.

Calculation of vegetative cover factor (F_c)

The vegetative cover factor equation developed by (*Gardeet al. 1987*), used by (*Upadhyayet 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

Various parameters estimated, using by Garde's

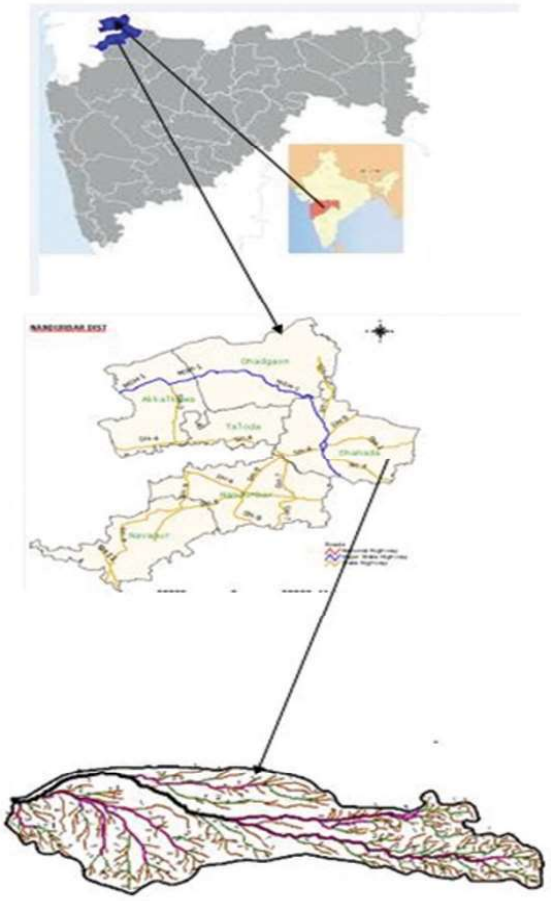

Fig. 1: Location of study area

equation for Sediment yield estimation, are as under:

Table 2: Increase in sediment yield in 2008-09 over 2002-03 of Sonwal watershed using

Year 2002-03	Year 2008-09	Increase in Sediment yield in 2008-09 over 2002-03 (t/ha/year)
Sediment yield (t/ha/year)	Sediment yield (t/ha/year)	
12.37	14.82	2.45

Vegetative cover factor (Fc)

The value of Fc factor was calculated by putting values of area under forest land (km2), agriculture land (km2), grass land (km2) and waste land (km2) 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.

Drainage density (Dd)

The length of watershed was taken from drainage map using attribute table in ArcGIS software. As shown in Fig. 1, the length of watershed basin was found to be 305.356 km. The area of the Sonwal watershed was 99.34 km2. Therefore, the value of Dd 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.

Sediment yield estimation using Garde's equation

After putting all values (Fc, Dd, S, A, P) in equation (1), sediment yield for year 2002- 03 was 12.37 t/ha/yr and for year 2008-09, 14.82 t/ha/yr.

Change detection in sediment yield estimation using Garde's equation

The estimated sediment yield for the watershed for year 2002-03 using Garde's equation was found to be 12.37 t/ha/year. The observed sediment yield for the watershed for year 2002-03 was 5.88 t/ha/yr. Per cent change in observed and estimated sediment yield was 110.37. The sediment yield in the watershed, for year 2008-09, was found to be 14.82 t/ha/yr. The observed sediment yield for year 2008-09 was 10.22 t/ha/yr. As depicted in Table 2, the sediment yield was increased from 2002-03 to 2008-09 by 2.45 t/ha/yr. Percent change

Table 3: Comparison of observed and estimated sediment yield for year 2002-03 and 2008-09 of Sonwal watershed using Garde's equation.

Year	Observed Sediment yield (t/ha/year)	Estimated Sediment yield (t/ha/year)	Percent change in Sediment yield (%)
2002-03	5.88	12.37	110.37
2008-09	10.22W	14.82	45

in observed and estimated sediment yield was 45 Table 3).

Conclusions

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

1. The increasing trend in sediment yield was observed from 2002-03 to 2008-09.
2. The rate of increase was of sediment yield was to the tune of 73.80 % from 2002-03 to 2008-09.
3. The sediment yield using Garde's equation shows the per cent change 110.37 and 45 for 2002-03 and 2008-09 respectively.
4. The area under cultivation need to be increased and insitu soil conservation, besides drainage line treatment should be followed for reduction of sediment yield in watershed.
5. The flow though water drainage path must be restricted with a speed less than nonerosive velocity with respect to soil texture and surface roughness.

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