Estimation of Soil Erosion using USLE and GIS

M. N. Admankar, G. K. Patil

Abstract**:** ***Soil erosion is one of the most serious environmental problem which must be taken in to consideration to prevent economic imbalances in nature. Soil erosion not only affect the agricultural productivity but also increases level of sedimentation. The study was carried out to determine the soil erosion for the watershed which is located in Godavari middle sub basin, Nanded district, Maharashtra state (India). The universal soil loss equation (USLE) and Geographic information system (GIS) technique was used to determine soil erosion. Present study revealed that, the study area is under moderate erosion with an average soil loss 7.233 tones/ha/yr. Where as minimum and maximum erosion rate observed as 5.39 tones/ha/yr to 10.27 tones/ha/yr respectively. The various maps of USLE factors prepared in QGIS environment. Statistically significant relationship obtained between soil loss and cover management factor (C). It was observed that C factor more influences in soil loss than any other factor.***

Keywords: GIS, USLE, Erosion, Watershed, Maharashtra

I. INTRODUCTION

Erosion is result of action of wind and water, in which soil particles are transported from one place to another. Due to transportation of particles there is loss in nutrients, which results in less agricultural productivity. Erosion also affect life span of reservoir and quality of water. Hence to prevent soil erosion conservation practices carried out and estimation of annual soil loss is most suitable approach to study this conservation measures. In study of Jain and Kothari [1] soil erosion and sediment yield were carried out by USLE and SDR method. The ratio of observed and computed sediment yield for different storm event varies from 0.45 to 1.39 and 0.62 to 11.7 for Nagwa and Karso catchment. Pandey and Chowdary [2] computed soil erosion using MUSLE and GIS. The soil loss was found to be 3.66t/ha/yr. The range of deviation of estimated and observed value was found to be 5.2 to 29.6. In the study of Dhruva et al [3] the total sediment yield was computed based on geographical area, annual rainfall and total runoff estimate.

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Soil loss in cultivated area found to be 64.5 tone/ha/yr where as for eastern region it was 41 tone/ha/yr and for Assam valley it was 28 tone/ha/yr. Suresh Kumar et al [4] carried out study to compute soil loss. GIS technique was used to conclude erosion risk following (MMF) model. In this study the average soil loss for cropland was found to be 10.25 to 21.5 tone/ha/yr. where as for hilly region it was 25.3 to 44.32 tone/ha/yr.

Objective: To assess the annual soil loss for watershed in Nanded region using USLE and QGIS. And to identify critical soil erosion prone areas & suggest conservation measures

II. STUDY AREA

Nanded watershed is selected for present study as, the soil in this area have poor water retention capacity, poor fertility and hence vulnerable to serve soil erosion. The study area is located in Nanded district of Maharashtra (India). The watershed is lies between 190 13'20" N latitude and 77020'34" E longitude.

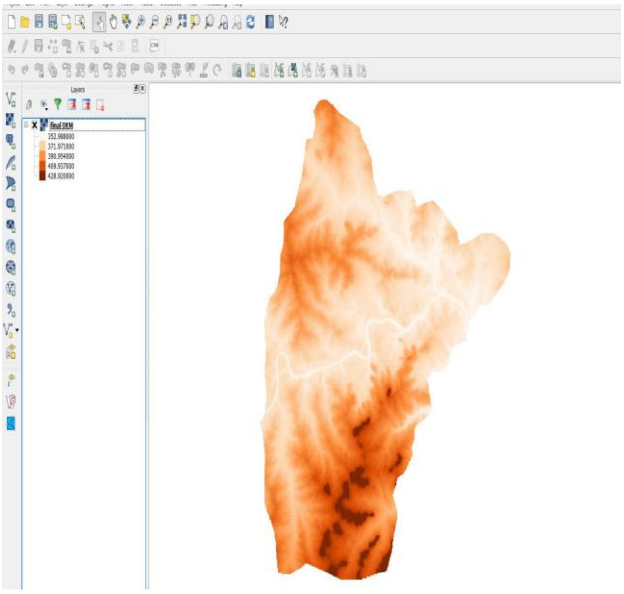

Fig.1 Digital elevation model of the study area

III. DATA COLLECTION

The rainfall data which is required for calculation of rainfall erosivity factor 'R' was collected from IMD Pune. Where as soil map of Maharashtra state was collected from NBSS & LUP Nagpur, to create soil map of study area in QGIS. BHUVAN data used to know land use land cover information about study area. Slope length and percentage of slope was calculated using google earth for computation of topographic factor 'LS'.

To compute soil erodibility factor 'K', the required data collected from Maharashtra state Gazetteer, Nanded district. Where as, to obtain Cover management factor 'C' and conservation practice factor 'P', the required data collected from NBSS & LUP Nagpur.

IV. METHODOLOGY

Analysis - Calculations of R Factor : 'R' factor was computed for 33 year (1983-2015) by using annual relationship given by Babu (2004) which is as follow R = 81.5 + 0.38P Where, 'R' is rainfall erosivity factor and 'P' is annual rainfall which was collected from IMD Pune. It was observed that annual precipitation values varies between 526.7mm to 1198.1mm. This values then assign to the study area map in QGIS using interpolation. Final 'R' factor map obtained after raster calculation process in QGIS. Calculation of K Factor : Soil Erodibility 'K' (t/yr) is derived by using the equation given by Wischmeir and Smith(1978). K= 1.313 [(2.1 *10-4 M1.14 *(12-a)) + (3.25*(b-2)) +(2.5*(c-3))] /100 Where M= (% silt) *(100-% clay), a=% organic matter, b= soil structure code no., c=permeability class number. Values of 'a', % of silt, % of clay which is required for computation of K factor was collected from Maharashtra state Gazetteer, Nanded district[8].Values of 'b' and 'c' taken from department of agriculture, Govt. of Maharashtra Pune. As loamy and medium black cotton soil present in the study area[7] ,the value for both 'b' & 'c' taken as 3. After that 'K' factor map obtained in QGIS. LS Factor Calculations : Formula given by (after Morgan,1986) used for computation of slope length factor 'L' and slope steepness factor 'S' LS = (0.065 + 0.045s + 0.0065s2)* (λ/22.1)m here 'm' is exponent function which adopted as 0.3 for study area. 'λ' is slope length and 's' is slope steepness in percent. Flow direction of water was used to find out slope length and percentage of slope in google earth pro. The value of LS obtain as 1.573. DEM of study area was used to create 'LS' factor map in QGIS. C Factor and P Factor : cover management factor 'C' is associated with land use and land cover (LU/LC). LU/LC for the Nanded is obtained from BHUVAN-2D. Government agencies such as NBSS-LUP with the state authorities carried out soil and water conservation works under watershed treatment plan. C factor value was obtained by considering geographical conditions, NBSSLUP data and also the data developed by earlier researchers (Morgan,2005). Cotton and soyabean are principal crops in the study area.[7]. It was observed that values of C factor ranges from 0.38 to 0.4 with an average 0.39 Where as P factor value depends upon type of conservation practices.The 'P' value obtain as 0.3 [5]. The C factor map and P factor map created in QGIS.

V. RESULTS AND DISCUSSION

A. *Results of Rainfall Erosivity Factor*

Table 1 Results of R Factor

Year	Rain fall	R factor value	Year	Rain fall	R factor value
1983	1187.6	532.7	2001	732.4	359.8
1984	552.7	291.5	2002	722.1	355.8
1985	575.4	300.1	2003	720.1	355.1
1986	562.9	295.4	2004	678.7	339.4
1987	786.2	380.2	2005	940.5	438.8
1988	1170	526.1	2006	872.9	413.2
1989	1068.3	487.4	2007	714.6	353.04
1990	1198.1	536.7	2008	646.3	327.0
1991	601	309.8	2009	668.9	335.6
1992	726.6	357.6	2010	1011	465.9
1993	806.3	387.8	2011	663.5	333.6
1994	583.8	303.3	2012	526.7	281.6
1995	809.5	389.1	2013	888	418.9
1996	855	406.4	2014	548.9	290.0
1997	790.5	381.8	2015	532.2	283.7
1998	1126.7	509.6			
1999	767.6	373.1			
2000	684.4	341.5			

B. *Result Analysis of USLE*

Table 2 Result Analysis of USLE

Year	R	K	LS	C	P	Soil loss Tone/ ha/yr
1983	532.7	0.104	1.573	0.39	0.3	10.19
1984	291.5	0.104	1.573	0.39	0.3	5.570
1985	300.1	0.104	1.573	0.39	0.3	5.744
1986	295.4	0.104	1.573	0.39	0.3	5.653
1987	380.2	0.104	1.573	0.39	0.3	7.277
1988	526.1	0104	1.573	0.39	0.3	10.06
1989	484.4	0.104	1.573	0.39	0.3	9.329
1990	536.7	0.104	1.573	0.39	0.3	10.27
1991	309.8	0.104	1.573	0.39	0.3	5.931
1992	357.6	0.104	1.573	0.39	0.3	6.844
1993	387.8	0.104	1.573	0.39	0.3	7.424
1994	303.4	0.104	1.573	0.39	0.3	5.805
1995	389.1	0.104	1.573	0.39	0.3	7.447
1996	406.4	0.104	1.573	0.39	0.3	7.778

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1997	381.8	0.104	1.573	0.39	0.3	7.309
1998	509.6	0.104	1.573	0.39	0.3	9.754
1999	373.1	0.104	1.573	0.39	0.3	7.142
2000	341.5	0.104	1.573	0.39	0.3	6.537
2001	359.8	0.104	1.573	0.39	0.3	6.886
2002	355.8	0.104	1.573	0.39	0.3	6.811
2003	355.1	0.104	1.573	0.39	0.3	6.797
2004	339.4	0.104	1.573	0.39	0.3	6.496
2005	438.9	0.104	1.573	0.39	0.3	8.400
2006	413.2	0.104	1.573	0.39	0.3	7.908
2007	353.0	0.104	1.573	0.39	0.3	6.757
2008	327.0	0.104	1.573	0.39	0.3	6.260
2009	335.6	0.104	1.573	0.39	0.3	6.424
2010	465.9	0.104	1.573	0.39	0.3	8.917
2011	333.6	0.104	1.573	0.39	0.3	6.385
2012	291.6	0.104	1.573	0.39	0.3	5.381
2013	418.9	0.104	1.573	0.39	0.3	8.018
2014	290.0	0.104	1.573	0.39	0.3	5.558
2015	293.7	0.104	1.573	0.39	0.3	5.621

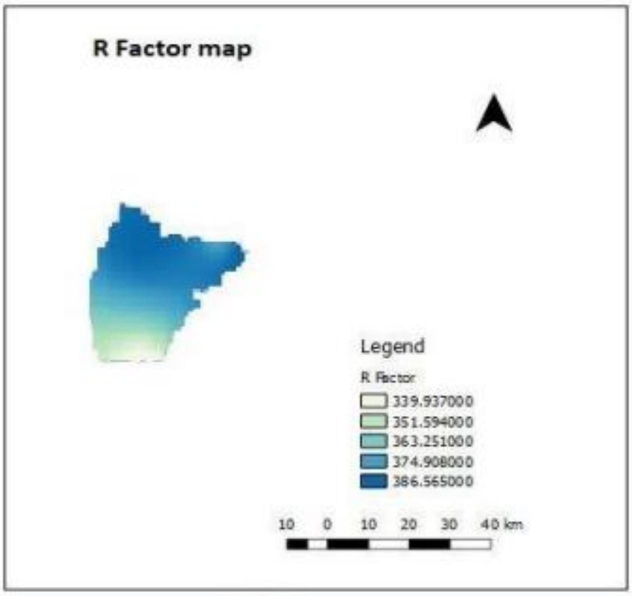

Fig 2. R Factor Map

From results it is observed that, the R factor values varies between 281.64 to 536.77 with an average value 376.91 Where as R factor map shows that values of R varies from 339.93 to 386.56 with average value 363.25 conforming to the USLE 'R'factor modeling value.

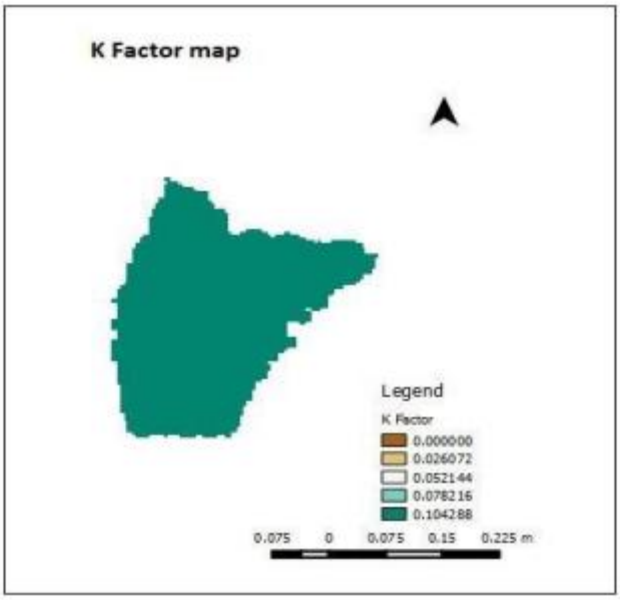

Fig. 3 K Factor Map

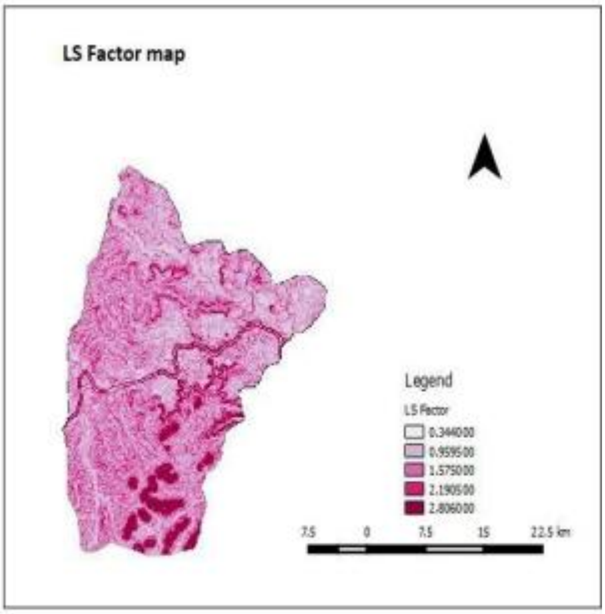

Fig. 4 LS Factor Map

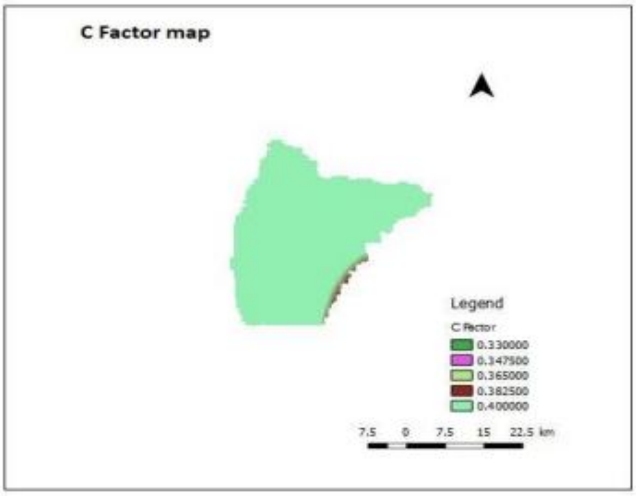

Fig. 5 C Factor Map

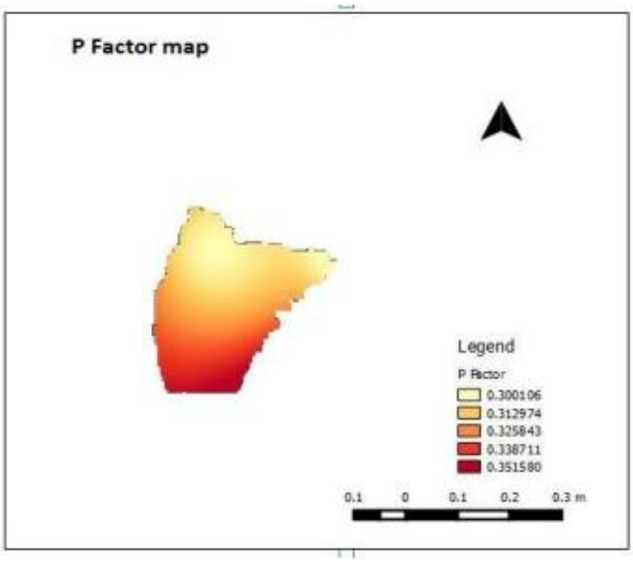

Fig. 6 P Factor Map

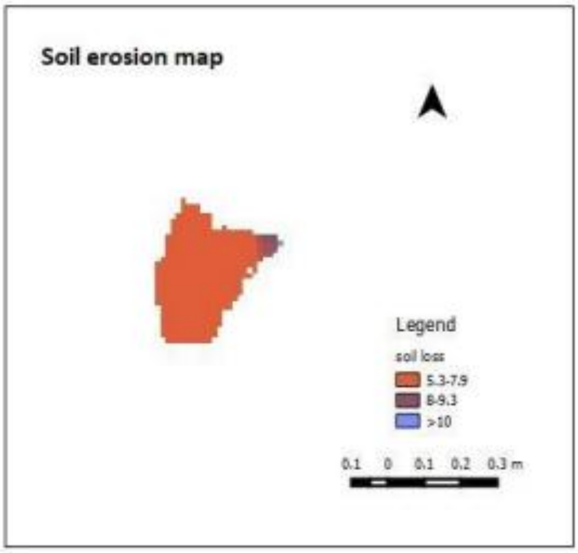

Fig. 7 Soil Erosion Map

From the soil erosion map it can be observed that, erosion rate varies 5.3 t/yr to 7.9 t/yr for maximum study area. Where as less than 10 % area having erosion rate 8 t/ha/yr to 10 t/ha/yr.

C. Regression analysis:

From the results given in table 3 it was observed that the soil loss is strongly affected by rainfall erosivity factor.

Table 3 Results of regression analysis

	Year	R square value
Calibration for R factor and soil loss	1983-2000	0.99
Validation for R factor and soil loss	2001-2015	0.99

D. Bivariate relationship:

This is statistical technique which was apllied to find out which factor more influences in soil loss. The following empirical equations shows the relationship between soil loss and other factors.

Table 4 Results Of Bivariate Analysis

Attribute	Equation	R^2	P Value
Soil loss and K factor	A = 4.265 K + 6.62	0.77	0.3
Soil loss and LS factor	A = 4.05 LS + 1.07	0.99	0.04
Soil loss and C factor	A = 18.5 C - 0.018	0.99	0.009

Where, A - Soil loss
K - Soil erodibility factor
LS - Slope length gradient factor and C - Crop factor

VI. CONCLUSION

It was observed that, the soil loss rate varies between 5.39 tone/ha/yr to 10.27 tone/ha/yr. The average soil loss rate is 7.23 tone/ha/yr.

The statistical results indicate that the crop factor is more influencing factor in soil loss than any other factor. Its high exponent value (18.5 from bivariate correlation) shows that the contribution of C factor is more in soil loss than any other factor. There is good correlation between C factor and soil loss (R^2 =0.99). The relation is significant ($P<0.05$). The relationship between K factor and soil loss is statistically insignificant ($P>0.05$). On other hand relationship between LS factor and soil loss is significant ($P< 0.05$). Exponent value of LS is 4.05 which is less as compare to exponent value of C factor. This exponent value indicate that the contribution of LS factor is less in soil loss as compare to C factor.

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