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ASSESSMENT OF SOIL EROSION BY USLE MODEL USING REMOTE SENSING AND GIS OF HEMAVATHY BASIN

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Abstract

Management of watershed and soil conservationnecessitates assessment of soillerosion areas, for planning and implementation for conservation measures.The study is made using Remotesensing in the determination of soil loss andidentification of critical sub-watersheds of Hemavathyriverbasin. The catchment was delineated into26 sub watersheds depending as per topographical anddrainage pattern. T hematic maps land use/ land cover, slope, soil maps required was prepared using satellite data, Geographic Informationsystem (GIS)and softwarepackage ArcGIS 10. The Universal Soil Loss Equation (USLE) is used to estimate soil erosion in all the subwatersheds of catchment.From soil loss estimation, found that 83% of the area has soil loss between 0.0 and 15.0 t/ ha/ year. The average annual soil loss of the river basin was found to be 8.00 t/ ha/ yr. shows moderate soil loss from the watersheds as per ISRO-NNRMS-TR-103-2002. Based on the results of the model watershed 2,3,6,7 was experiencing high erosion and considered as highly critical and watershed 16-21 least erosion. The most affected watershed is preferred for soil conservation on top priority to reduce soil erosion.

Keywords — GIS, prioritization, remote sensing, USLE,soil conservation, soil erosion

1. Introduction

Soil erosion is a serious problem, the prevention means reducing rate of soil loss to that which would occur under natural conditions, requires selection of suitable strategies for soil conservation needs a thorough understanding of the processes of erosion. The mainfactor, which influence rate of soil erosion is rainfall, runoff and presence of conservation measures. Estimation of soil loss which result in decrease of soil fertility, reduction of crop yields is a necessity for design of conservation structures to reduce the effects of sedimentation during their life time [1]. Remote Sensing and GIS techniques areused in assessment of soil loss and identification of critical erosion prone areas of watershed for prioritization [2]. Assessment of severity of soil erosion is difficult due to the fact that some areas may be more susceptible to soil erosion than others and the rate of erosion is not the same everywhere [3].For this study, Soil Loss value was estimated usingUSLE (Universal Soil Loss Equation), governed by major six parameters i.e. R-factor (rainfall erosivity factor), K-factor (soil erodibility), L-factor (slope length factor), S-factor (slope steepness factor), C-factor (cover and management factor) and P-factor (support practice factor). The estimationof soilloss andidentificationof critical area is required for success of soil conservation, for undertaking soil conservation measures.

2.Study area

The area of present study was Hemavathy catchment situated in Chickamaglur Hassan and Kodagu district lies geographically between 75º30'0" and 76º15'0"E longitude and 12º30'0" and 13º30'0" N latitude. It covers an area of 2910 Sq.km. It is 245 km long and has a drainage area of about 5,698.65 km^2. The principal soil types are red loamy soil and red clayey soil with 13 classes of soil textures found in the catchment.

3.Objectives of the study

Objective of presentstudyare

(1) Analysis of the various parameters of the USLE and single out the factors that most significantly influence soil loss in the region.

(2)To estimate annual average soil loss in the basin.

4.Material and methods

For the present study the soil mapgenerated bymaking use of soil data obtained fromKarnataka Stateremote sensing application center (KSRAC),Bangalore according to NationalBureau of soil survey and land use planning (NBSS and LUP,1998) standards. Using differentyear ofrainfall data, Survey of India (SOI) topomaps and ArcGIS 10.2 software, base map is prepared and is used for the extraction ofstudy area fromsatellite image (Indian Remote Sensing satellite, IRS P-6 LISS III (23.5 m resolution) and Carto DEM (digital elevation model obtained by cartographic satellite), all maps generated converted to Raster of cell size of 50m and amount of sediment transport at the outlet of the watersheds quantified. Estimation of soilloss in the basin is calculated by Universal soil loss equation (USLE) model.

Detailed procedureadopted, to calculate various parameters, is mentioned below.

4.1.1 Rainfall erosivity factor(R)

Soil loss is related to rainfall striking the soil surface and contribution of rain to runoff. Rainfall data from 38 rainfall stations in the basin areused to calculate rainfall erosivity factor (R-value).Monthly precipitation for these stations were collected from the year 2005 for11 years factor was determined for all selected rainfall gauge stations using the equation, $R_a = 79 + 0.363 * X_a$ (Chaudhry and Nayak 2003)

Where R_a Annual R factor, Xa = Annual Rainfall in mm

Then, the average R factor for each rainfall gauge station was inserted into Arc GIS and were interpolated spatially using the Arc GIS Spatial Analyst tool.

4.1.2 Soil erodibility factor, (K factor)

The soilerodibility is an expression of its inherent resistance to particle detachment and transport by rainfall. The K factor accounts for the susceptibility of soil particles to detachment and movement by water relates rate at which different soils erode under conditions of equal slope, rainfall.

4.1.3 Topographic factor, (LS factor)

Topographic factor, LS factor was computed in Spatial Analyst module of ArcGIS using SRTM DEM of 90 m resolution. Slope gradient (S) and slope length (L) were determined and combined to form a single factor known as the topographic factor. Digital elevation model (DEM) is used to calculate LS factor. Slopes of DEM in percentage were also generated using surface analysis under the spatial analyst function. The accuracy of estimation depends on the resolution of DEM.

4.1.4 Cover management factor (C factor) and Support practice factor (P factor)

The cover management factor (C) represents the effects of vegetation, management and erosion control on soil erosion is the most important factor represents the most readily managed condition for reducing erosion, reflects the effects of cropping and management practices on soil erosion rates.

Support practice factor (P factor) represents soil loss with a specific supporting practice to cultivation, the values were assigned to the different features based on the soil conservation practicethe P-factor was assumed by using the Conservation practice of the study area.

The USLE estimates the long-term average annual rate of erosion based on rainfall pattern, soil type, topography, crop system and management practices.is calculated by the equation

A=R.K.L.S.C. PWhere, A – Potentialaverage annual soil loss in ton/ha/year,R - Rainfall erosivity factor, K - Soil erodibility factor, LS - Slope length-gradient factor, C - Crop factor

P - Conservation practice factor

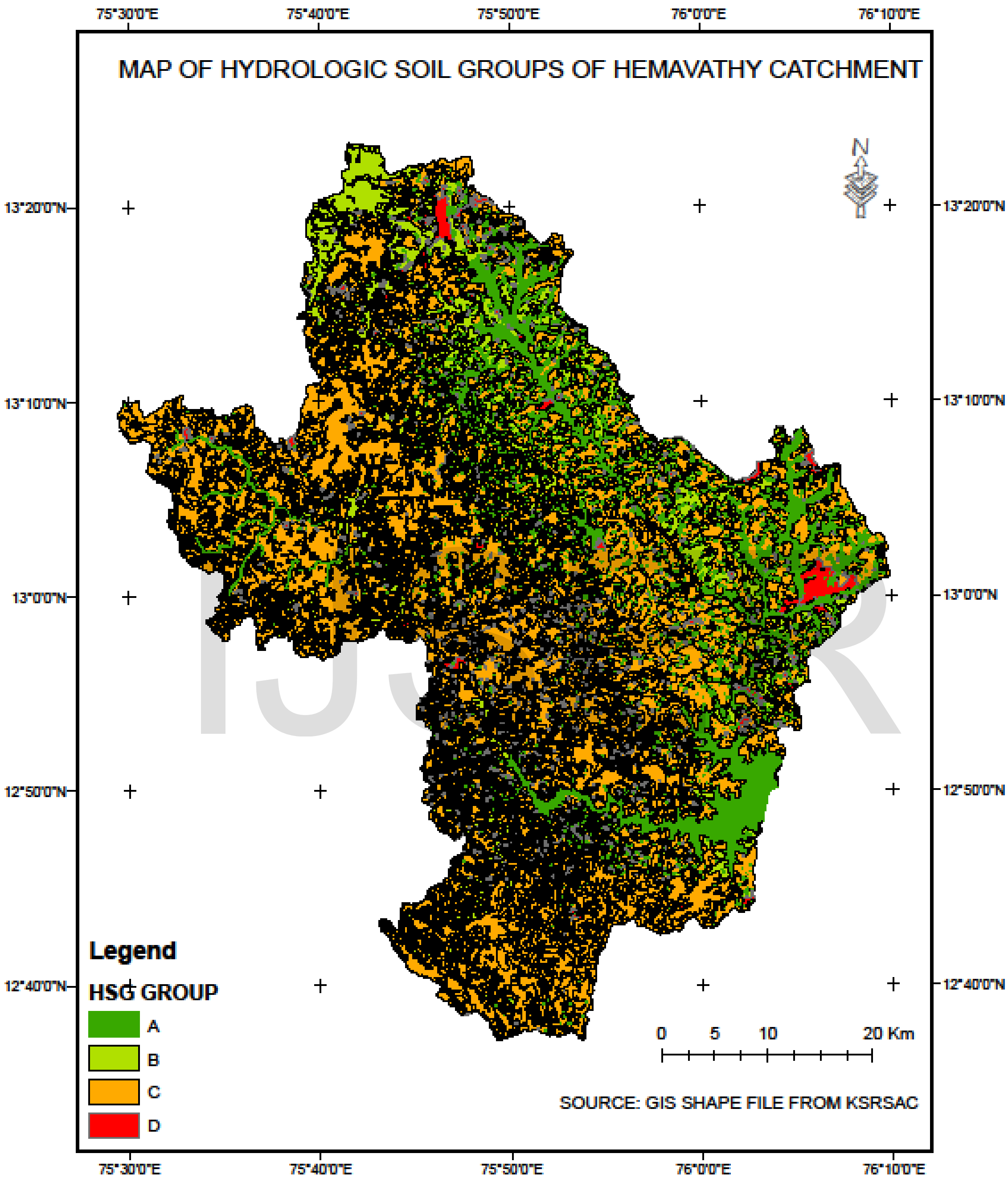
4.2. Soil Classification

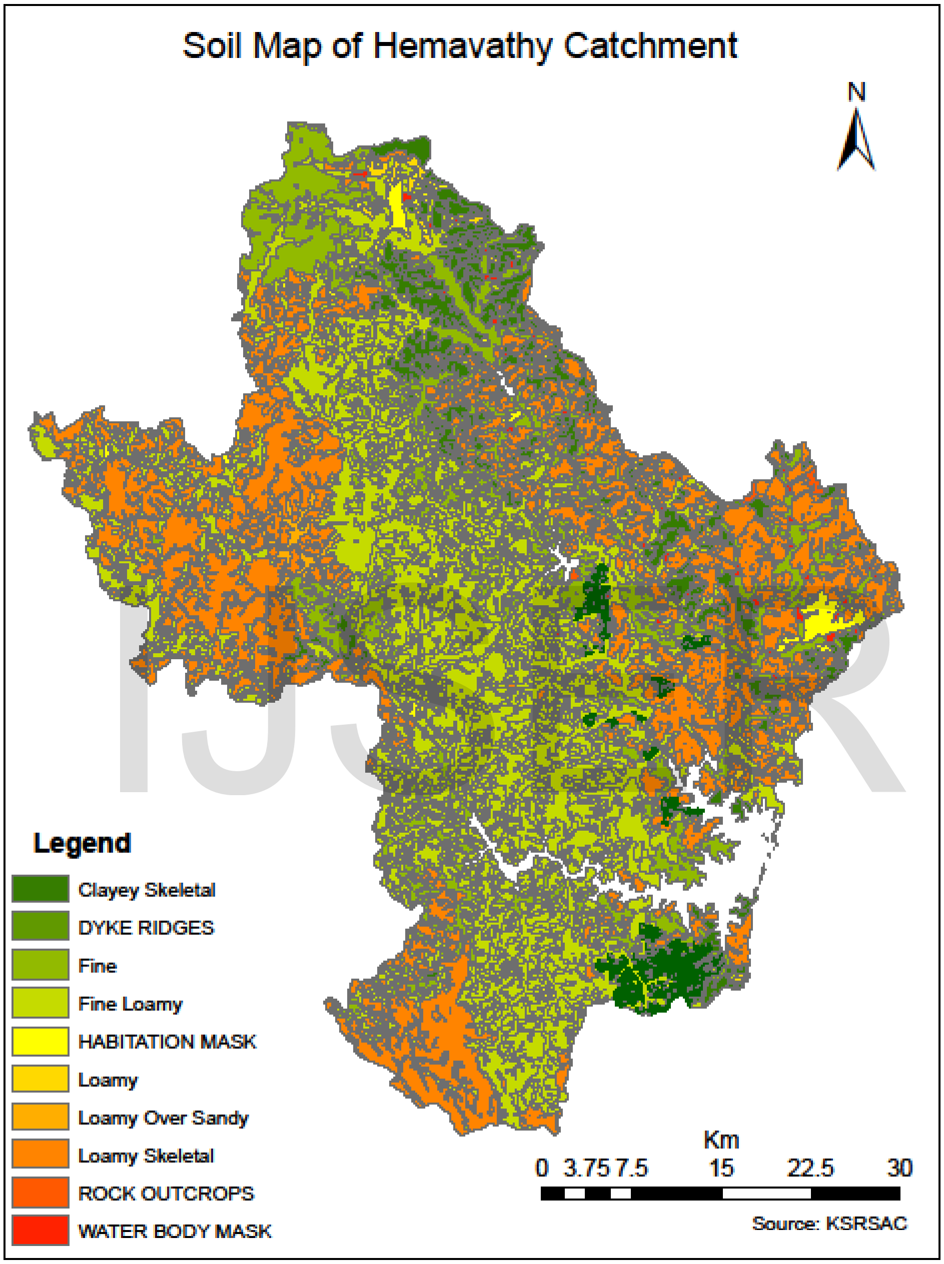
The major type of soils in the basin are red soils, gravely, sandy, loamy in texture, red loam soil covers more than the red sandy soil. The loamy structure of red soils makes them suitable for the cultivation of a large variety of crops. They have low water holding capacity.Mixedsoils also occur are reddish brown to yellowish in color.**Table 1** shows spatial soil group in the catchment,**Figure 1** shows the soil map and **Figure 2**showsHydrological soil group map.Soils of the watershed were classified into hydrologic soil groups B, C and D based on infiltration and runoff generating potentials.

Table. 1. Hydrological soil group in the catchment and their Spatial distribution (Sq.km)

HSG	Description	Area (Sq.km)	% of area
A	Soils with low runoff potential excessively drained, sands or gravels with	311.23	10.69

	high rate of water transmission.		
B	Moderately, well drained, moderately fine to coarse textures with moderate rate of water transmission	424.63	14.59
C	Soils with moderately fine to fine texture with slow rate of water transmission.	2098.72	72.12
D	Clay soils with high swelling potential with very slow rate of water transmission	75.14	2.58


MAP OF HYDROLOGIC SOIL GROUPS OF HEMAVATHY CATCHMENT
75°30'0"E
75°40'0"E
75°50'0"E
76°0'0"E
76°10'0"E
13°20'0"N
13°10'0"N
13°0'0"N
12°50'0"N
12°40'0"N
N
Legend
HSG GROUP
A
B
C
D
0 5 10 20 Km
SOURCE: GIS SHAPE FILE FROM KSRSAC


Soil Map of Hemavathy Catchment
N
Legend
Clayey Skeletal
DYKE RIDGES
Fine
Fine Loamy
HABITATION MASK
Loamy
Loamy Over Sandy
Loamy Skeletal
ROCK OUTCROPS
WATER BODY MASK
Km
0 3.75 7.5 15 22.5 30
Source: KSRSAC

5. Results and discussion

To evaluate and prepare map of soil loss of catchment, various generated factors map overlaid within the raster tool in ArcGIS. From the calculations and using remote sensing data is seen the average value of rainfall erosivity factorR is 250 mm/ ha/ hour. ***Soil erodibility f actor, (K)*** varies from 0.003 to 0.04. DEM of the studyarea has altitude from 733 m to 1692m. Slope gradient (S) and slope length (L) were determined and combined to form a single factor known as the topographic factorderived using the DEM of the area vary from 0 to 45.94 and the cover management factor (C)value varies from 0 to 0.6. Support practice factor P value is observed between 0.12 to 1. **Table2**shows value of C factors and **Table 3** shows the values of K factors of the study. By using USLE equation after multiplying allfactors, the soil loss was generated.Finally,with all the maps of the cited factors, the soil loss map was generated. The result for the estimated gross soil erosion in t/(ha/year) is shown in**Figure 3**.In the study area two major types of soils are found namely red loam, and sandy loam. The R factor does not have a big influence in soil loss, The C factor has a visible influence in the A factor. Smaller C factors, 0.2 (built up) and 0.02 (forest), causes visible smaller soil erosion values. However, the value of 0.50 (cultivated area) can cause bothhigherandsmaller soil erosion values. Therefore, the C value of 0.50 is more influenced by the LS factor. The P factor value of 1 causessmaller values for the A factor.The LS factor has the biggest influence on the soil erosion, when a high soil loss rate occurs, the LS factor is also high. The soil loss reflects very well the K Factor of 0.02 (red gravelly and red sandy soil) and 0.3 (red loamy). These soil types seem to have an influence on the soil loss, because they cause visible marks in the map. The soil loss for catchment was estimated using Universal Soil Loss equation (USLE) the rainfall erodibility factor (K) of 0.04, the slope length and slope steepness of 1.28 was found. The crop management factor (C) taken as average values for various crops grown was 0.50, As per study it was observed that slope (LS) and land cover (C) factors are the most significant ones to estimate the soil loss in the catchment. From soil loss estimation, found that in 10% of the area soil loss is above the tolerance limit, 83% of the area has soil loss between 0.0 and 15.0 t/ ha/ year. The average annual soil loss of the river basin was found to be 8.00 t/ ha/ yr. shows moderate soil loss from the watersheds as per ISRO-NNRMS-TR-103-2002. Based on the results of the model watershed 2,3,6,7 was experiencing high erosion and considered as highly critical and watershed 16-21 least erosion. The most affected watershed is preferred for soil conservation on top priority to reduce soil erosion and enhance the cultivable area of catchment.

Table 2 Values of K factor

Sl.No.	Type of Soil (Texture)	K factor
1	Fine	0.003
2	Loamy over sandy	0.017
3	Clayey Skeletal	0.029
4	Fine Loamy /Loamy Skeletal	0.04

Table 3 Values of C factor

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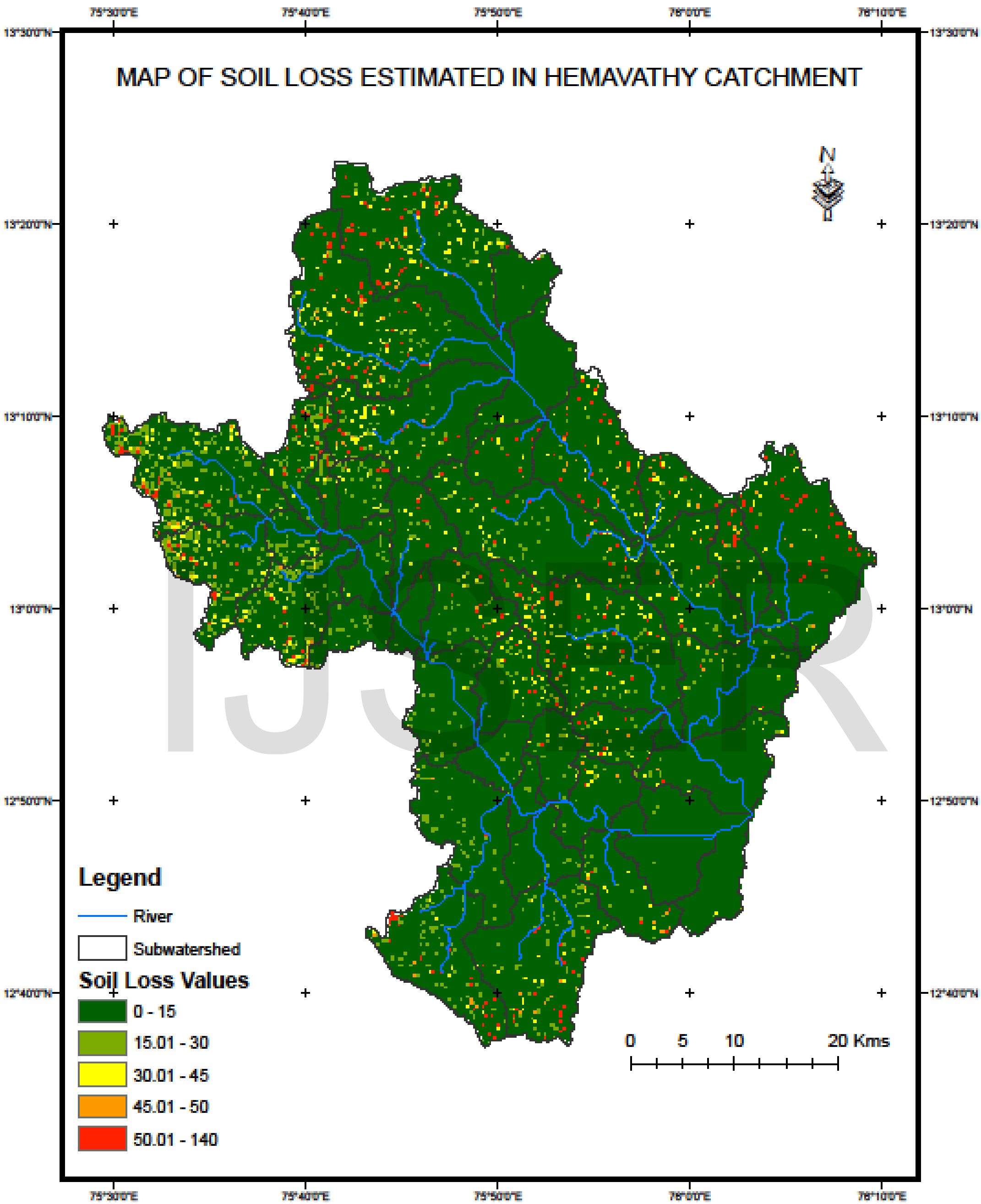
Land Use	Sub Land use	C-factor
Agriculture	Current Fallow	0.6
	Kharif + Rabi (Double cropped)	0.6
	Kharif crop	0.5
	Plantation	0.5
Built-up	Commercial	0.2
	Industrial	0.2
	Town/cities (Urban)	0.2
	Villages (Rural)	0.2
Forest	Scrub Forest	0.02
Others	Quarry	0.15
Wasteland	Land with Scrub	0.95
	Land without scrub	0.8
Water bodies	Canal, River, Rivers, ponds, lakes	0



5.Conclusions

For sustainable land use and soil conservation management, the USLE, GIS and remote sensing techniques were very effective in assessing soil loss, erosion risk and importance of land cover for the watershed management, slope (LS) and land cover (C) factors are significative in estimation of the soil lossin the area. The areacould be considered as high-priority areas for management in order to reduce soil losses, which are mostly found in the upstream part of the watershed.

It is also observed that the quantity of erosion varies
mainly on topography and land use-land cover. It is necessary to implement suitable soil
conservation practices in such areas

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7. References.

1. Jain, S.K., Kumar, S. and Varghese, J. (2001) ‘Estimation of soil erosion of Himalayan watershed using GIS technique’, water resource management vol-15.

2.Pandey. A, Chowdary.V.M, and Mal.B, “Identification of critical erosion prone areas in the small agricultural watershed using USLE,GIS and remote sensing”, *WaterResourceManagement* vol 21,no,pp 729-746

3.Morgan, R. P. C. 1986. Soil Erosion and Conservation, Longman Group Limited. 63 -74

4.Alka Sahu, TriambakBaghel, Manish Kumar Sinha, Ishtiyaq Ahmad, Mukesh Kumar Verma Soil Erosion Modeling using Rusle and GIS on Dudhawa Catchment, International Journal of Applied Environmental Sciences ISSN 0973-6077 Volume 12, Number 6 (2017), pp. 1147-1158

5. Jain.K,Das.D, 'Estimation of Sediment Yield and Areas of Soil Erosion and Deposition for Watershed Prioritization using GISand Remote Sensing', *Water Resources Management*, vol. 24, no. 10, pp. 2091-2112, 2009.

6. Bhaskar J. Das, Singal S. K, Ranvir Singh, (2008), Estimation of erosion in an ungauged Wetland Catchment, *Hydrology journal, 31(1-2), pp. 65-76.*

*7.*Jasrotia A. S, Dhiman S. D, Aggarwal S. P, Rainfall – Runoff and Soil Erosion modeling using Remote Sensing and GIS Technique – A case study of Tons watershed, *Journal of Indian Society of Remote Sensing, Vol. 30, No. 3, pp. 168-180.*

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