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Watershed Characterization and Prioritization Using Remote Sensing and GIS

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Abstract:*The study identifies the extent of soil loss and proposes a method for prioritization of micro-watershed in the Nun Nadi watershed. The study used the Sediment Yield Index (SYI) method, based on weighted overlays of soil, topography, rainfall erosivity and land use parameters in 10 micro watersheds. Accordingly, the values and thematic layers were integrated as per the SYI model, and minimum and maximum sediment yield values were calculated. The priority ranks as per the sediment yield values were assigned to all micro-watersheds. Then the values were classified into four priority zones according to their composite scores. Almost 11.33 percent area of one micro-watersheds (sw1) showed very high priority; approximately 32.11 percent of the study area (sw5, sw8, sw9) fell under the high priority zones. These areas require immediate attention. Conservation methods are suggested, and the locations of check dams are proposed after considering drainage, slope and soil loss.*

Keywords:*Check dam; Prioritization; Nun Nadi watershed; Soil loss; SYI.*

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I. Introduction

Soil is one of the most important natural resources vital for the sustenance of mankind. The growing demand for food, fuel and fiber for huge population of the country without providing adequate protection to soil, has led to the degradation of land by way of soil erosion by wind and water, salinization and/or alkalization, waterlogging etc. Out of 329 million ha geographical area of India about 175 million ha land are subjected to some kind of land degradation.

The process of soil formation takes many centuries, but with rainfall erosion this can be negated in a few major storms, leaving soils residues that are degraded resulting in reduced yields. Soils erosion is common in all areas of the world, but developing countries suffer more because of the inability of their farming populations to replace lostsoils and nutrients (Erenstein, 1999). Therefore, sustainable land management practices are urgently needed to preserve the production potential of land.The efficient and optimum management and conservation of soil, land and water resources is best approached on a watershed basis. Normally, the amelioration processes are developed and applied following prioritization and landscape planning. Prioritization plays a key role in identifying areas that require attention (Kanth& Zahoor-ul, 2010).Watersheds are those areas from which runoff resulting from precipitation flows past a single point into a large stream a river, lake or an ocean. These are natural hydrologic entities that cover a specific aerial extent of land from which rainwater flows to a defined gully, stream or river of a particular point (Kumar & Kumar, 2011).

II. Study Area

Soil is one of the most important natural resources vital for the sustenance of mankind. The growing demand for food, fuel and fiber for huge population of the country without providing adequate protection to soil, has led to the degradation of land by way of soil erosion by wind and water, salinization and/or alkalization, waterlogging etc. Out of 329 million ha geographical area of India about 175 million ha land are subjected to some kind of land degradation.

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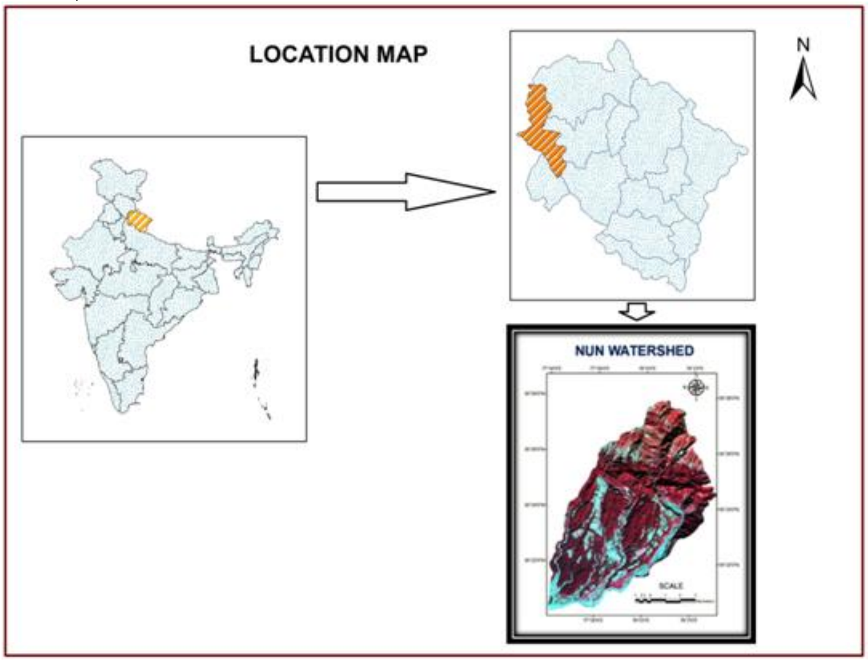


III. Data and methodology

The Survey of India (SOI) toposheet number 53F/15, 53J/2 and Landsat-TM image of October 2009 were the main sources of data for the study. Toposheet were used not only to delineate the watershed and micro-watersheds.

Remote Sensing Data: - Satellite: - IRS-P6 Sensor: - LISS-IV

Table no.1: Satellite data Details

LISS-IV Image	Date	Path No.	Row No.
1	17-FEB,2012	096	049
2	7-MAR,2013	096	050

Table no.2: Toposheet Details

Sl. No.	Toposheet No.	Scale
1	53F/15	1:50000
2	53J/3	1:50000

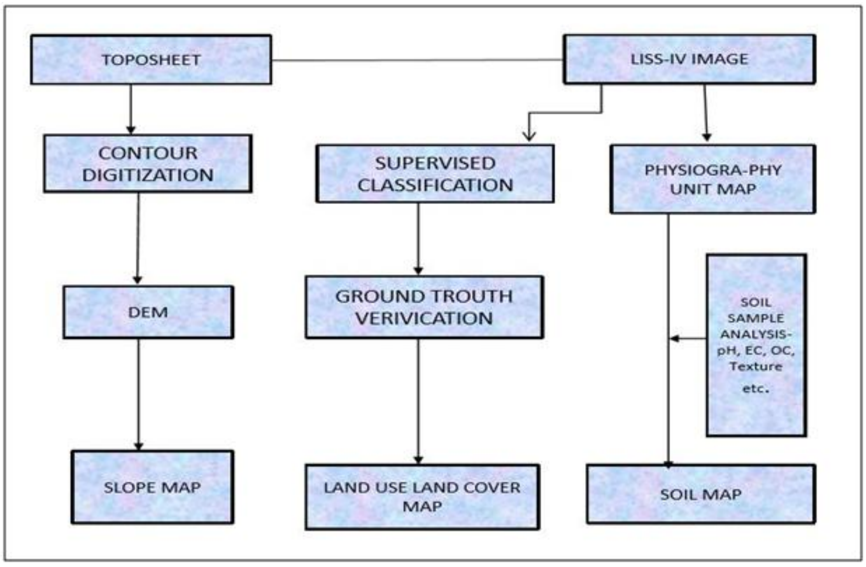


Fig no.1: Flow char for methodology 1

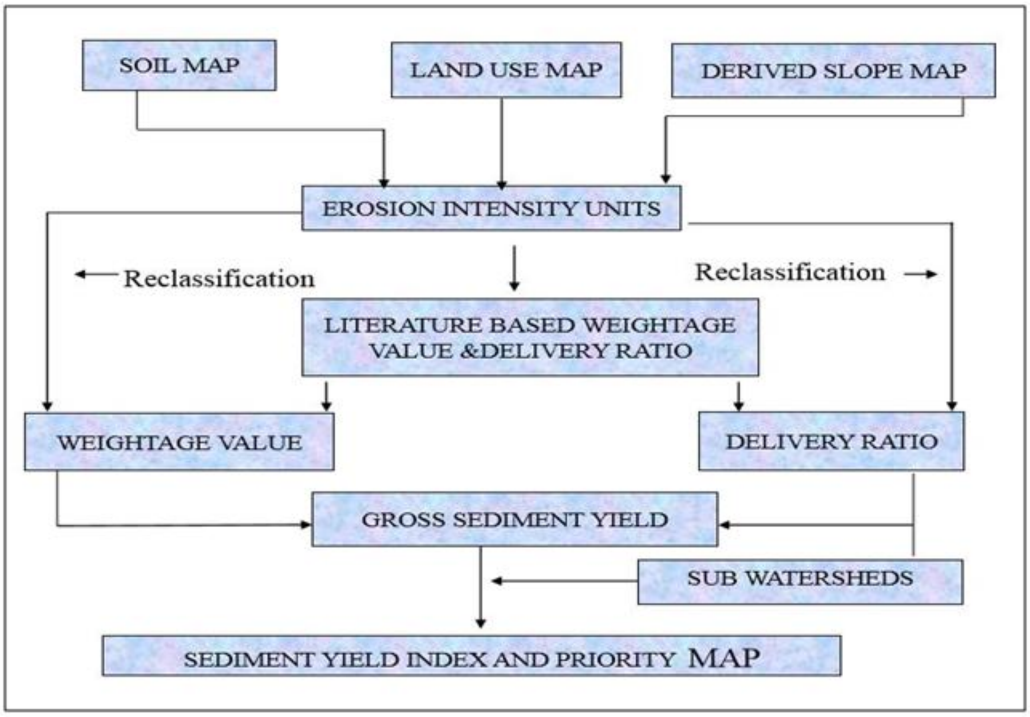


Fig no.2: Flow char for methodology 2

IV. Sediment Yield index

The SYI method is highly useful for prioritization of micro-watersheds according to erosion impact. In this study several important parameters were considered (Table 3), including land use/land cover, soil type, and landscape drainage.Map layers were prepared for each parameter and used for assigning weighted values to calculate the SYI in ton/ km ^{2} /year ^{1} according to the following equation:

$$SYI = \frac{\text{Sum}(Ai*Wi*Di)}{Aw} * 100 \quad \text{.................. (1)}$$

Where,
Ai = Area of ith Unit (EIMU)
Wi = Weightage Value of ith Mapping Unit
Di = Adjusted Delivery Ratio Assigned to ith Mapping Unit
Aw = Total Area Mapping

The rate of soil loss was estimated for each micro-watershed, and then ranked into four priority ranking classes (very high, high, medium and low) according to the SYI values. Several map layers were prepared to determine the W_i in SYI model. Firstly, the weighted values for every factor were assigned on the basis of their risk level, then input into the SYI equation. Priority indicators and the composite score for each micro-watershed were assigned according to Table 2. The weighted values were assigned using the weighted overlay tool in Arc Map.

There are different ways by which the suitability assessment can be done. There have been studies of suitability assessment employing a “maximization” or “worst case” model (Space Applications Centre, 1999), where the “worst”parameter determines the suitability. As a result, a relatively less important parameter could determine thesuitability in the final analysis. This anomaly arises because all parameters are considered to be of equal importance. Table 5shows the criteria for adoption, the weighted values, and the total values that were applied for W_i in the above equation (1) for SYI calculation.

Table no.3: Criteria adopted for weightage values

S. no.	Parameter	Source	Criteria adopted for weightage values
1.	Barren/bare land	Derived from LANDSAT™	It is a direct result of human interference in environmentally fragile areas. More the coverage of barren land, higher the weightage value.
2.	Dense forest	Derived from LANDSAT™	Since vegetation is a crucial natural resource that can also function as an environmental indicator, the dense forest cover of a region is an important indicator expressing the level of human impact. More the Dense Forest coverage, lower the weightage value has been assigned.

3.	Soil texture	Kumar and Sharma (2005)	Soil texture is a very important parameter in terms of soil loss calculation. High value has been assigned for sandy loam texture.
4.	Topography	SOI Toposheets on 1:50,000 scale	Slope always plays an important role which directly impacts on soil with the amount of been assigned for sandy loam texture. Rainfall. It can vary according to slope steepness and length. Higher the elevation, higher the weightage.
5.	Drainage	SOI Toposheets on 1:50,000 scale	Drainage density/number of streams has a direct bearing on soil erosion leading to highly dissected landscape. Greater the Drainage Density or number of streams, higher the weightage.
6.	Rainfall	Indian Meteorology Department, Dehradun (2009)	Rainfall is the most important factor that determines the soil loss rate. Higher the rainfall, higher the weightage values were assigned.

Table no. 4: Assigned weightage values of all factors for SYI calculation

S. no.	Parameters/factors	Categories/classes	Assigned weightage values
1	Rainfall	473–495	2
		495–518	4
		518–540	6
		540–563	8
2	Slope (in deg.)	0–20	2
		20–40	4
		40–60	6
		60–80	8
3	Soil texture	Gravel sandy loam	2
		Loam	4
		Sandy loam	6
4	Forest land (values in percent)	0–25	8
		25–50	6
		50–75	4
		75–100	2
5	Bare/barren land (values in percent)	0–25	2
		25–50	4
		50–75	6
		75–100	8

Source: H.R. Naqvi et al. / International Soil and Water Conservation Research 3 (2015) 86–96

V. Results and discussion

V.I. Physiographic Soil Map

In physiographic map physiographic units are divided into fifteen parts. These units are divided on the basis of landform, slope steepness and land use land cove. The watershed falls under the hills and river terraces. Each unit has its own characteristics on the basis of soil, vegetation, and slope. The total area of the physiographic unit is 8814 hectare and each unit has different area.

Table no. 5: Soil characters tics of Physiographic unit

Sl.no.	PH.UNIT	Slope (%)	Drainage	Surface stones (%)	texture	erosion	pH	EC(DS)
1	H11	15-25	Excessive	40-75	Sl	e1/e2	4.95	0.032
2	H12	15-25	Excessive	40-75	Sl	e2/e3	5.24	0.063
3	H13	60-70	Excessive	40-75	Sl	e2	5.31	0.041
4	P11	10-15	well	15-40	Sil	e1	5.66	0.066
5	P12	7-10	Excessive	15-40	Sl	E2/e3	5.49	0.094
6	P13	5-7	Moderate well	<15	L	e1	5.77	0.062
7	P21	5-8	well	<15	Sil	e2	5.63	0.05
8	P22	1-2	well	<15	Sil	e1	5.42	0.04
9	P23	2-3	well	<15	Sil	e1	4.87	0.04
10	P24	5-8	well	<15	L	e1	5.85	0.086
11	P31	5-8	well	<15	Sil	E2/e3	5.61	0.073
12	P32	3-5	well	<15	Sil	e1	5.42	0.061
13	P33	1-2	well	<15	Sil	e1	5.72	0.061
14	RH	7-10	well	<15	Sil	e1	5.49	0.094
15	RT	1-2	Well	<15	sl	e1	5.42	0.061

*Sl=sandy loam *L=Loam *Sil= Silt Loam

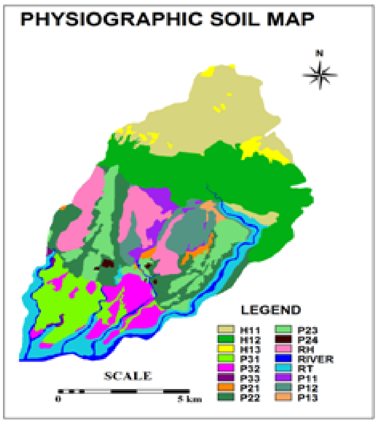


Fig no.3: Physiographic map

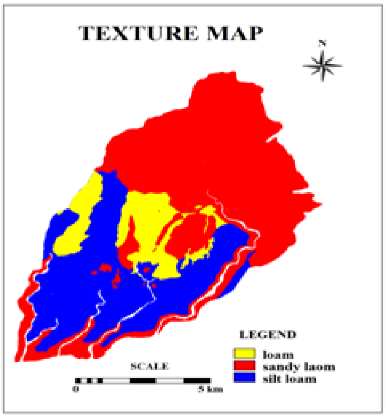


Fig no.4: Texture Map

V.II. Land Use Land Cover

Landuse land cover has been shown below the table: -

Table no. 6: Land Use Land cover

SL.NO.	LULC CLASSES	AREA(H)	AREA (%)
1	orchard	55.99	0.63
2	Dense forest	5503.82	62.41
3	Barren land	8.66	0.10
4	open scrub	616.03	6.98
5	Settlement	130.82	1.48
6	Degraded forest	479.88	5.44
7	Riverbed	515.24	5.84
8	Dense scrub	284.88	3.23
9	agriculture	384.88	4.36
10	current fallow	839.32	9.52
TOTAL		8819.51	100.00

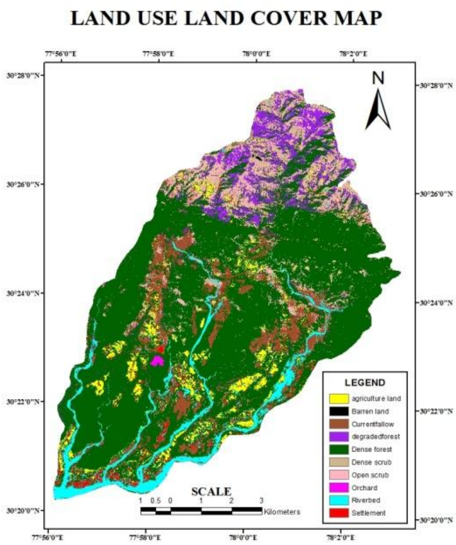


Fig no.5: Land use Land cover

V.III. Slope in degree

Using SOI toposheet, the contour lines having vertical intervals of 20-meters were traced on tracing sheet by visual interpretation method. This manually traced contour map was exported into GIS and digitized to prepare vector layer. The elevation data were processed and graphic simulation was carried out in which an elevation (or Z value) was recorded at each X, Y location to make topographic data usable. Surfacing function in "Image Interpreter" was used to generate a DEM & to represent as a surface or one-band image file where the value of each pixel was a specific elevation value.

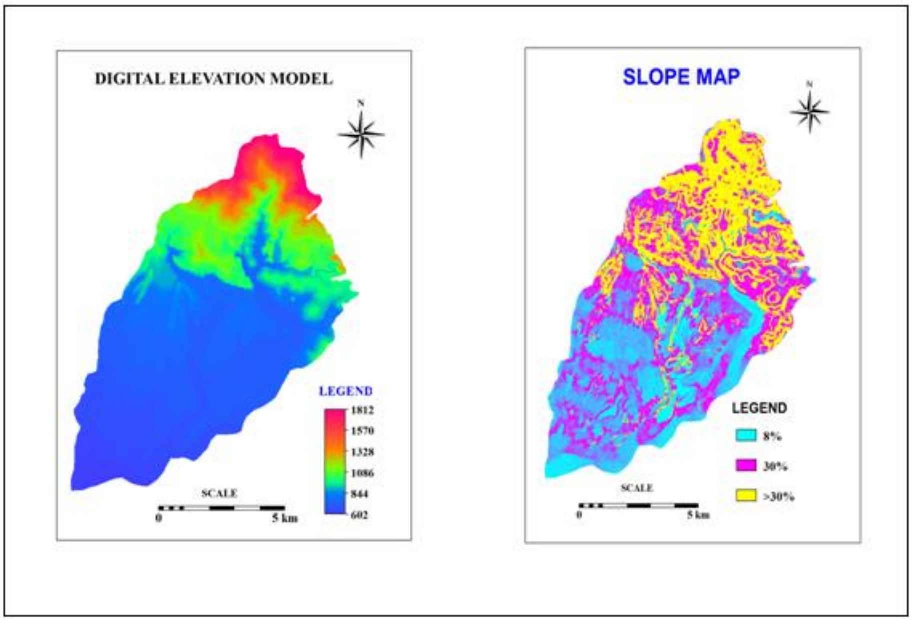
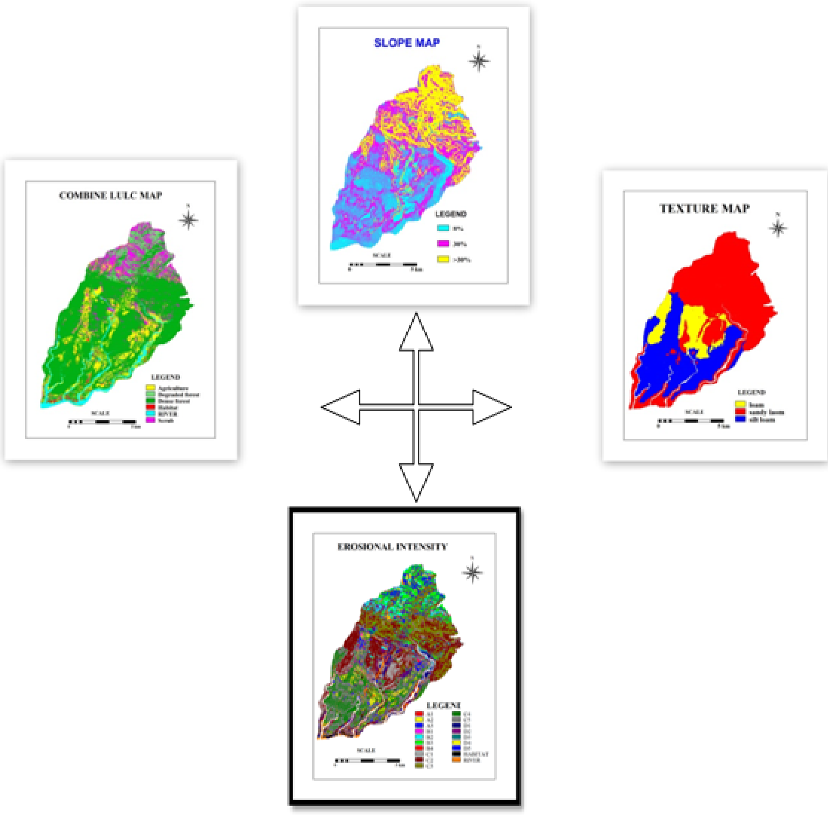


Fig no.6: DEM and Slope Map

V.IV. Erosional Intensity Mapping Unit

EIMU map is created from map overlay operation. The sequence of map in the overlay operation is namely % slope classes less than 8,8-30 and more than 30 and land use land cover map which has agriculture, dense forest, degraded forest, scrub classes.in 2nd overlay operation this map is crossed with texture map. And finally created so many erosional intensity mapping units. And after that reclassification is necessary for prepared effective some erosional intensity mapping unit. Assignment of weightage values and delivery ratio to various Erosion Intensity Mapping Units based on their relative sediment yield.

Soil map + slope map + Lulc map = Erosional Intensity unit map



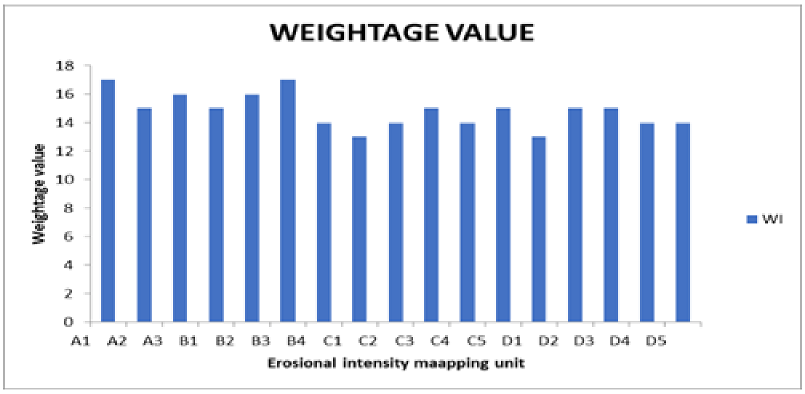


Fig no. 7: Weightage Value

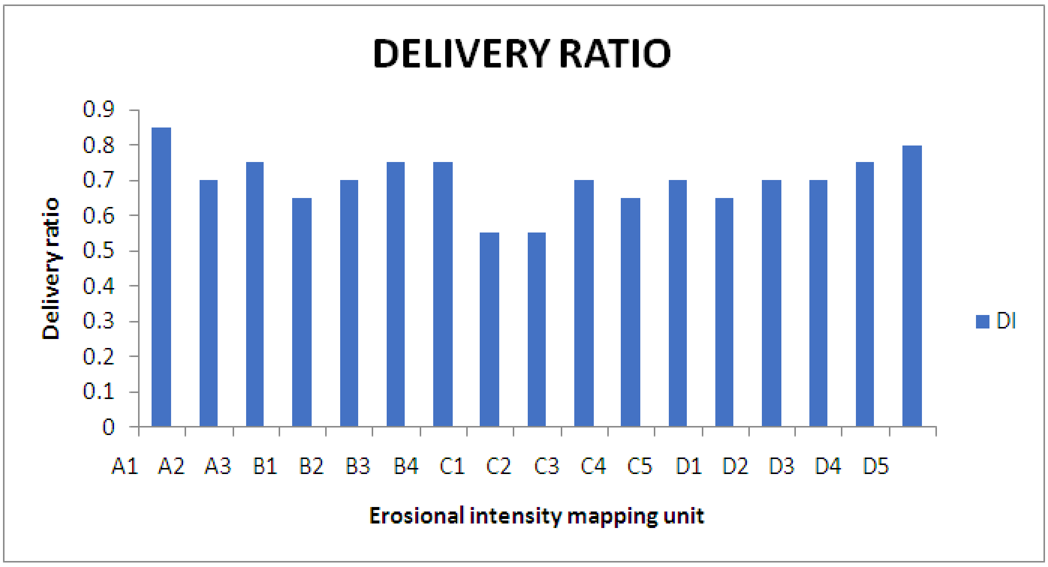


Fig no. 8: Delivery Ratio

V.V. Weightage Value and Delivery ratio

Weighted value for every factor like every component for erosion (table no. 5) should be assigned of their intensity. Delivery ratio has been calculated on the basis of nearest stream (drainage density) distance in kilometers. The values of delivery ratio were assigned according to the length of the stream. In the study area most of the micro-watersheds were assigned 0.9 and 1.0 value from delivery ratio as per the drainage density. In this study, most of the streams are not more than 2 km.

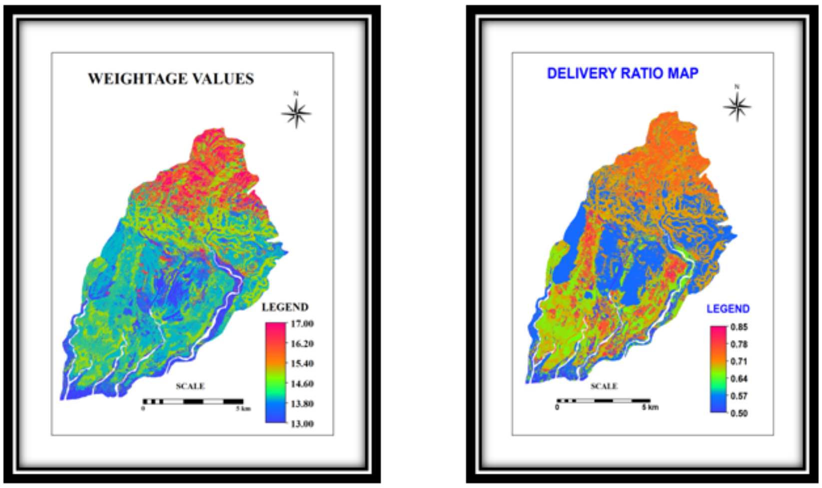


Fig no. 9: Weightage value and Delivery Ratio map

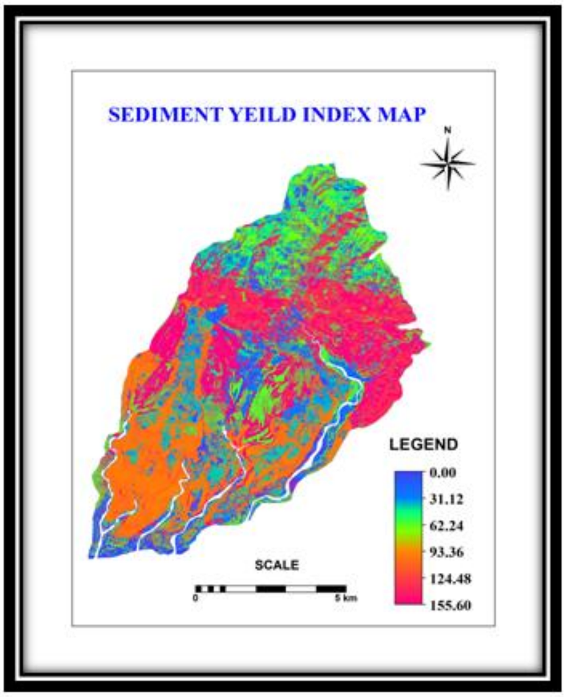


Fig no. 10: Sediment yield index map

The major land use land cover of the study area is forest (62%), and agriculture, current fallow and scrub the forest compromising dense forest, moderate forest, degraded forest. The scrub compromising with open and dense scrub.in the agriculture field terrace agriculture is important. And also, somewhere orchard is found but lees amount.

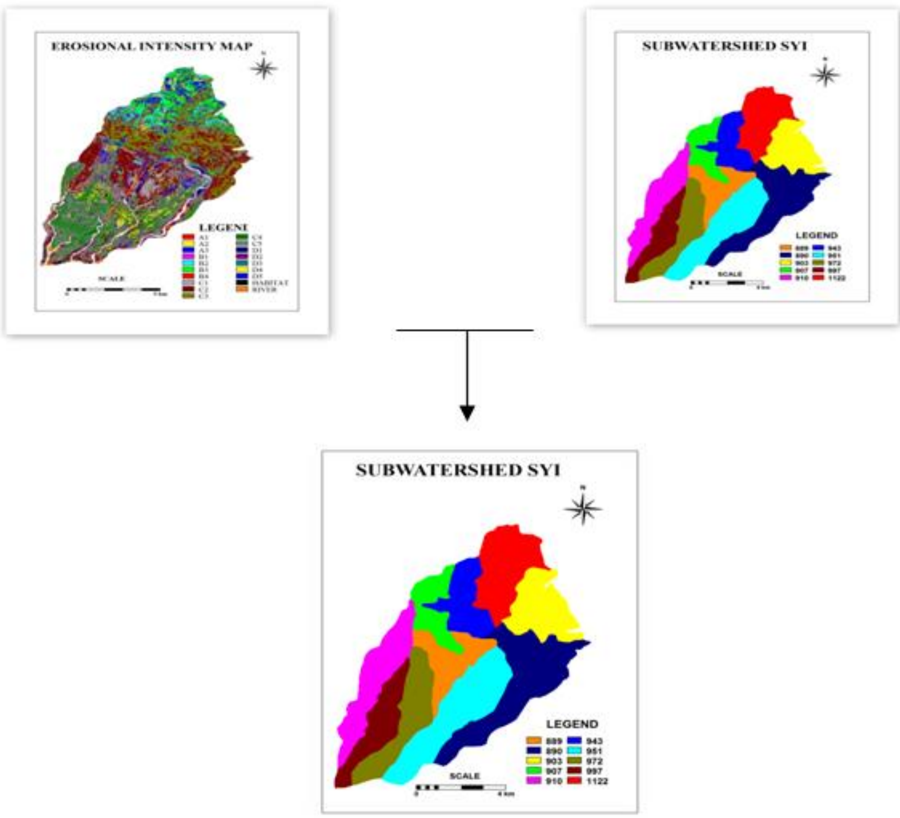


Fig no. 11: Sub watershed wise SYI map

VI. Conclusion

The study area under taken in a part of Dehradun district of Uttarakhand with aim to assess the soil sediment yield of NUN watershed using remote sensing and GIS technique. The physiography of the study area divided in to three parts such land forms, topography and land use land cover. Further landform of the region differentiated on the basis of slope in to three parts hills, piedmont, river terrace. Topography of the region is divided on the basis of very steep slope, moderate to steep slope, and gentle to moderate slope. And the major land use land cover is forest, scrub, agriculture. The physiographic soil map showed mainly the physiochemical characteristics of soil mainly texture (loam, sandy loam, silt loam), pH. varied from 4 to 6, EC varied from 0.03 to0.95 ds, slope class (0-8, 8-30,>30) etc.

Average Sediment yield of the whole area varied from 3 to 155.high SYI value is obtained in the steep to very steep slope combined with degraded and dense forest also combine with sandy loamy texture. And the low value is obtained of the gentle sloping with river terrace and agriculture combined with silt loamy texture.

Estimation of priority sub-watershed by following SYI model, the sub watershed viz. SW1 of NUN watershed falls under very high and SW5, SW8, SW9 falls under high priority and SW 7, SW10 falls under low categories demanding immediate attention for soil conservation works. very high priority class occur in the sandy loam texture combined with degraded forest region. Eastern part and western part of the catchment occur medium priority due to the occurrence of loamy and moderate slopping area. Here the river bank erosion is more predominant. And the southern part of the catchment occurs low priority due to the occurrence of silt loamy texture and very gentle slopping are combined with dense forest and agriculture.

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References

[1]. Bhuyan SJ, Marjen LJ, Koelliker JK, Harrington JA and Barnes PL (2002) Assessment of runoff and sediment yield using remote sensing, GIS and AGNPS. *J. Soil. Wat. Conser*. *Soil. Wat. Conser*. Soc. USA, vol. 57, No. 6, pp 351-363.

[2]. Food and Agricultural Organisation (FAO) (1987) Soil and water Conservation in semi-arid areas.

[3]. Jain Manoj K Mishra Surendra K and Shah RB (2010) Estimation of sediment yield and areas vulnerable to soil erosion and deposition in Himalayan watershed using GIS. *Cur. Sci*. 98(2), 25.

[4]. Khan MA Gupta VP and Moharana PC (2001) Watershed prioritization using Remote Sensing and Geographical Information System: a case study from Guhiya, *Ind. J. Ari. Environ*. 49, 465-475.

[5]. Kothyari Umesh C and Jain Sanjay K (1997) Sediment yield estimation using GIS. *Hydro. Sci.–J.Sci. Hydrologique*. 42(6), 833-844.

[6]. Ministry of Agriculture, Government of India (1972) Hand book of hydrology.

[7]. National Remote Sensing Agency, Government of India, Hyderabad (1995) Integrated mission for sustainable development' guidelines for field survey and mapping.

[8]. Pandey Asish, Cowdary V and Mal B (2007) Identification of critical erosion prone areas in the small agricultural watershed using USLE, GIS and Remote Sensing. *Water Resour. Manage*. 21(4), pp 729-746.

[9]. Pal DK (1998) Remote Sensing and GIS in study of and use and soil in some watersheds. Ph.D. Thesis, Dep. Agri. Food. Engg, IIT, Kharagpur (India).

[10]. Scott J Goetz, Robb K Wright, Andrew J Smith, Elizabeth Zinecker and Erika Schaub (2003) IKONOS Imagery for resource management: Tree cover, impervious surfaces, and riparian buffer analysis in the mid-Atlantic region. Remo. Sens. Environ. 88,195–208.

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