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Research Article

GENERATING ISO-EROSION RATE ZONES FOR THE KUNUR RIVER BASIN USING COMBINE METHODS OF SOIL EROSION ESTIMATE

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ABSTRACT
For integrated watershed management, knowledge about the rate of soil erosion is very much essential. Soil erosion is a natural process over the earth surface. With variation of soil erosion factors, rate of soil erosion is changed. This paper attempts to generate isolines for delineate the variation of soil erosion rate for the entire Kunur River Basin using combine methods of soil erosion estimation, *i.e.*, Catchment Wise Erosion Estimation (CWEE) and Universal Soil Loss Estimation (USLE) integrated with remote sensing and GIS techniques. Estimated maximum erosion rate is 273.79 kg/ha/y and minimum is 3.53 kg/ha/y, with mean rate of 47.61 kg/ha/y. Ten percent of basin area falls under very high erosion rate with more than 150 kg/ha/y and 49 percent area under very low erosion rate with less than 25 kg/ha/y. As major findings, anthropogenic activities like laterite quarrying, deforestation, floodplain encroachment, and unscientific agricultural practices with faulty irrigation are the main causes for huge soil erosion in the upper and middle basin area.

Key Words: *Watershed Management, Isolines, Soil Erosion Rate, CWEE, USLE, RS-GIS Techniques*

INTRODUCTION
One of the most important parameters of fluvial system is sediment load which depends on soil erosion rates form the source points of that watershed (Goudie, 2004). Fluvial degradation and aggradation are the result of changing threshold condition of sediment amount in the river basin; when it is positive then aggradation takes place but if it is negative then degradation takes place. Haphazard erosion and deposition of sediment within the basin may create number of problems for fluvial system. According to Meyer and Wischmeir (1969) the process of soil erosion involves detachment, transport and subsequent deposition of sediments and the information on source of sediment yield within a river basin can be used as a perspective to view the rate of soil erosion occurring within the catchment. Walling (1983) stated that the movement of sediment depends on geomorphologic and environmental surface factors such as topography, slope, drainage pattern, vegetation cover, soil texture, soil condition and rainfall duration. A comprehensive watershed management programme may have multiple objectives like control of damaging power of runoff, management and utilization of these water for useful purposes, erosion control, reduction of the sediment generation, enhancing groundwater storage, and the appropriate use of the land and water resources in the watershed (Suresh *et al.*, 2004). To reduce soil erosion in the river basin, land use planning, conservation and management of that basin, watershed is the vital unit for observation, especially, to estimate the soil erosion rate and identify erosional zones as major source of sediment load. In this context spot specific research work is an upcoming research trend for the fluvio-geomorphologists. It has been estimated that out of the total geographical area of 329 Mha of the India, about 167 Mha is affected by serious water and wind erosion. Out of 167 Mha, 127 Mha affected by soil erosion and 40 Mha degraded through gully and ravines, shifting cultivation, water logging, salinity and alkalinity, shifting of river courses and desertification (Das, 1977).
A number of significant studies have been carried out by different scientists and researchers of the country and also in abroad to measure the rate of soil erosion and to estimate total amount of soil loss using different models with various aspects of rill and gull erosion. Wischmeier and Smith (1972, 1978) had applied the Universal Soil Loss Equation to measure soil erosion in the Alps Mountain belt. Douglas (1976), Kirkby (1976), Morgan (1976), Cooke and Doornkamp (1978), Gerrard (1981), Hudson (1981),

Parsons (2005), Stone and Hilborn (2000), Blanco and Lal (2008) have focused on soil erosion, erosion factors and erosion risk incorporating different types of model. At regional level, Jha and Kapat (2003, 2009, 2011), Ghosh and Bhattacharya (2012), Ghosh and Guchhait (2012) predicted the erosion rate of lateritic soils of the Birbhum District using USLE model. Some of the researchers estimated soil loss from catchment areas for measuring basin wise sediment production rate and related fluvio-geomorphological studies (Jain and Kothyari, 2000; Jain *et al.*, 2001; Suresh *et al.*, 2004). In present research scenario, application of RS-GIS has useful advantages for soil erosion rate assessment with proper management planning, particularly for the remote area also (Sharma *et al.*, 2001). This research work has been carried out with application of combine model of USLE (Musgrave, 1947) and CWEE (Garde *et al.*, 1985) integrated with RS-GIS techniques.

The major objective of the present study is estimate the spatial variation of soil erosion rate for the Kunur River Basin, a GIS based spatial analysis to calculate soil loss amount using SRTM data, soil texture map, geological map, land use / land cover map, topographical maps, and aerial images for total basin. CWEE model has been used after do away with its limitation for micro-level application after combine with USLE model.

Study Area

The Kunur River Basin is located in the middle portion of the district of Barddhaman in West Bengal, India. It covers a portion of the Ajay and Damodar rivers. It lies in-between latitudes of 23°25'N and 23°40'N and 87°15'E to 87° 55'E longitude. The study area contained the police stations of Faridpur-Durgapur, Kanksa, Ausgram I and II, Mangalkote, and Bhatar (Figure1). The Kunur River is a right-bank tributary of the Ajay River, particularly in the Lower Ajay River Basin. The Kunur River originates in the western upland of the Barddhaman District at more than 100 metres of altitude, flowing from west to east for a length of about 114.1 kms. The outlet of this watershed is close to the village Kogram, about 38-km. from the Burdwan town on Bardwan-Katwa road. The catchment extends over an area of about 922.40 km^2, having an elongated and asymmetrical shape. The Kunur River represents a basin of the 5th order with a drainage density equal to $0.85 km/km^2$, which indicates that the catchment area has good infiltration capacity (Mukhopadhyay, 2010). The drainage pattern of this basin is more or less dendritic. As reported by Mitra (2002), the upstream and central part of the Basin has several patches of forest cover interspersed with paddy fields along watercourses. About 13.8% of the Basin area is under forest while 53.9% is cultivated. 26.2% of the basin area is not available for the cultivation and 6.1% is culturable waste.

Geographically this basin is tropical, Tropic of Cancer (23°30'E) passed over the basin from West to East. The average annual rainfall is 1400 mm of which the maximum occurs within the second week of the month of June to September. During the summer season rainfall exceeds 100 mm and it is even over 1500 mm during the rainy season (Mukhopadhyay, 2010). Geologically it is found that there were ample changes in the present landscape pattern of the Barddhaman since the appearance of human beings. The Barddhaman district is surrounded on the west by hills of Vindhayans formation and Gondowana formation, and on the north by the Rajmahal hills (Chaudhari, 1995). The geological formation of the area consists of lower Gondwana system and Quaternary to Pleistocene sediment with depth of 200 to 300 metres (Pal, 1991). This basin area has been covered with different geological units, like Panskura formation, Sijua formation during the Quaternary Period (Table 1 and Figure 2).

Geohydrologically, following Niyogi (1985), the total basin may be divided into three types of geohydrological characteristics. The upper catchment of the Kunur River Basin, which is covered by hard rock, mainly Archaean formation with high grade metamorphic rocks of which granite gneiss commonly referred as 'Bengal Gneiss', secondly, middle portion consists with semi-consolidated formation of the Gondwana Sedimentaries and hard lateritic patches, lastly, the lower catchment area, which is mainly un-consolidated with new alluvial of the Ajay and Kunur floodplains. Demographically, this area has been occupied by dense population. As per the last census of

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the year of 2011, population density of Barddhaman District is 1100 person/km^2. In the study area there are two important urban centres like Durgapur Municipal Corporation and Guskara Municipality.

Table 1: Geological and Lithological Characteristic of the Study Area

Symbol	**Lithology**	**Geological Unit**	**Age**	**Nature and Characteristic**
Q_2k	Clay alternating with silt and sand	Panskura Formation (QUATERNARY)	Middle to Upper Holocene	Soft Unconsolidated Sediment(oxidised)
Q_2s	Clay with caliche concentration	Sijua Formation (QUATERNARY)	Upper Pleistocene to Middle Holocene	Do
L	Laterite	Laterite	Cainozoic	Hard Crust
P	Red Shale, Sandstone	Panchet Formation	Triassic	Soft to medium
R	Fine grained sandstone, siltstone with coal seams	Raniganj Formation	Permian	Soft to medium

(Source: Geological Survey of India, District Resource Map, Calcutta, 2001)

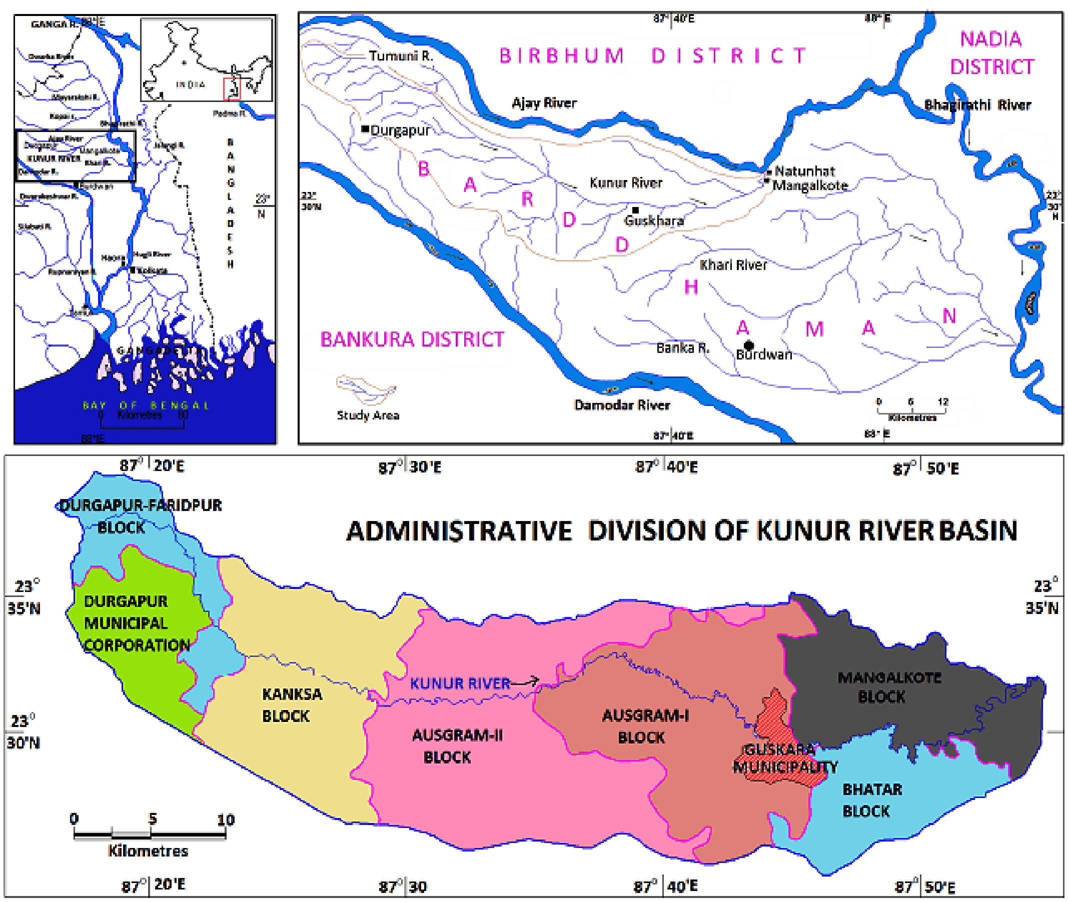

Figure 1: Location of the Study Area

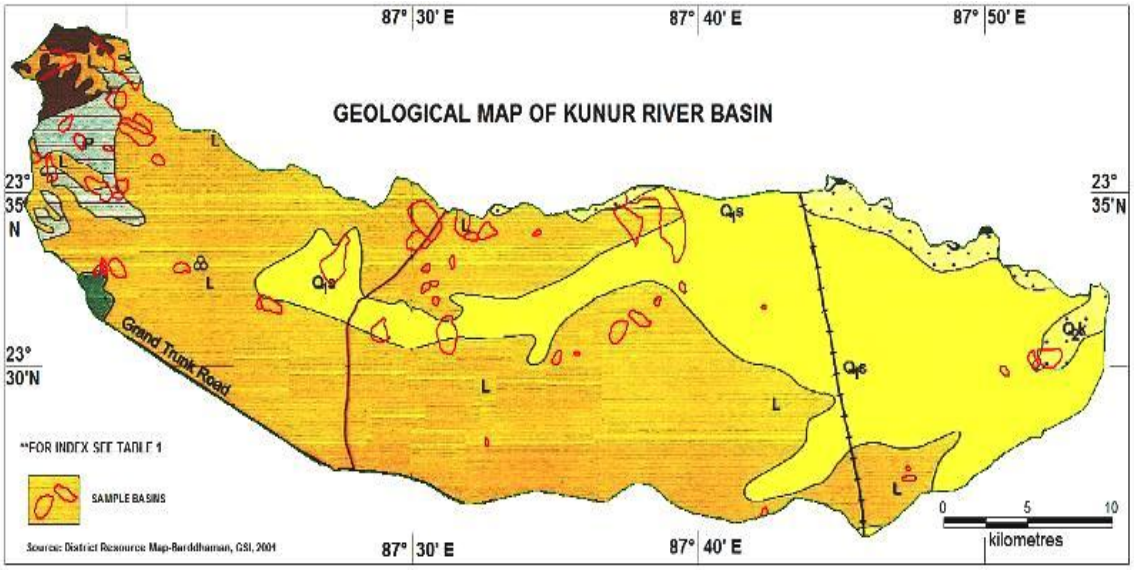

Figure 2: Geological Map of the Kunur River Basin with Superimposed of Sample Basins (Source: Geological Survey of India, 2001)

MATERIALS AND METHODS

GIS and Remote Sensing Work

Remote Sensing (RS) and Geographical Information System (GIS) techniques have been used here to prepare maps and to get information and data for the analysis part. Mainly Global Mapper v.14, Map Info 7.0, ERDAS Imagine 9.1, Arc GIS 9.3 softwares are used here. SRTM data (2005) with 30 metres resolution has been applied for preparing micro level topography with five-metre contour interval for demarcation of basin coverage of first order streams. Land Slope (S) values of that first order streams taken as samples have been calculated from SRTM data using Global Mapper v.14 (Figure 3).

Land Use/ Land Cover (LU/LC) map for the Kunur River Basin has been prepared from Landsat TM imagery data (2006) using ERDAS Imagine (Figure 4). Sample sub-basins have been superimposed over the LU/LC map, soil map (Figure 5) and geological map (Figure 2) of the Kunur River Basin for calculating Crop Management Factor (C) with Soil Conservation Practice Factor (P), and Soil Erodibility Factor (K) after matching with table values giver by Priya and Shibasaki (1998) and Sing *et al.*, (1981) respectively (Table 2) using Map Info and Global Mapper. GIS based other works have been carried out for calculating basin areas (A), stream lengths, drainage density (D_d) and others. Mean annual runoff (Q) data for the study area is available in the annual runoff maps (1901-1951) of Damodar and surrounding river basins prepared by Damodar Valley Corporation (DVC). Mean annual rainfall (P) for the Barddhaman obtained from Agriculture Contingency Plan of Barddhaman District (2010) prepared by NBSS and ICAR.

Sample Basin Selection

In a research work, a small subset of individuals is selected for detailed study from a statistical universe or population. The interest of total population may be infinite and therefore sampling is the only alternative (Burt *et. al.*, 1996). In a micro level investigation to obtain soil erosion rate of the entire Kunur River Basin, major focus has been given on first order stream as sample area. Therefore, in this work, systematic random sampling is used, placing the first order streams length wise, with sampling at n+1 interval, where, n=3 for selection of sample basins of the first order streams. Out of 209 first order streams of the study area, there are 53 samples of the first order streams (with basin area) selected (Figure6) with 1% significance level (Table 3).

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Table 2: Table Values of K, C and P factors

	Soil Types	Values (t/ha/y)
K Value	Loamy sand, alluvial	0.07
	Silt loam	0.15
	Red Chalka sandy loam	0.08
	Soil from lateritic rock	0.04
	Kota clay loam	0.11
	Loam, alluvial	0.17
	Sandy loam, alluvial	0.06
C value	Fairly Open Mixed Forest	0.006
	Open Scrub	0.014
	Agricultural Land	0.38
	River Bed	1
	Earthen Work	1
P value	Agricultural Land	0.39
	Other Land Use Type	1

(Source: For K values Sing et al., (1981) and Priya and Shibasaki (1998) for C and P values)

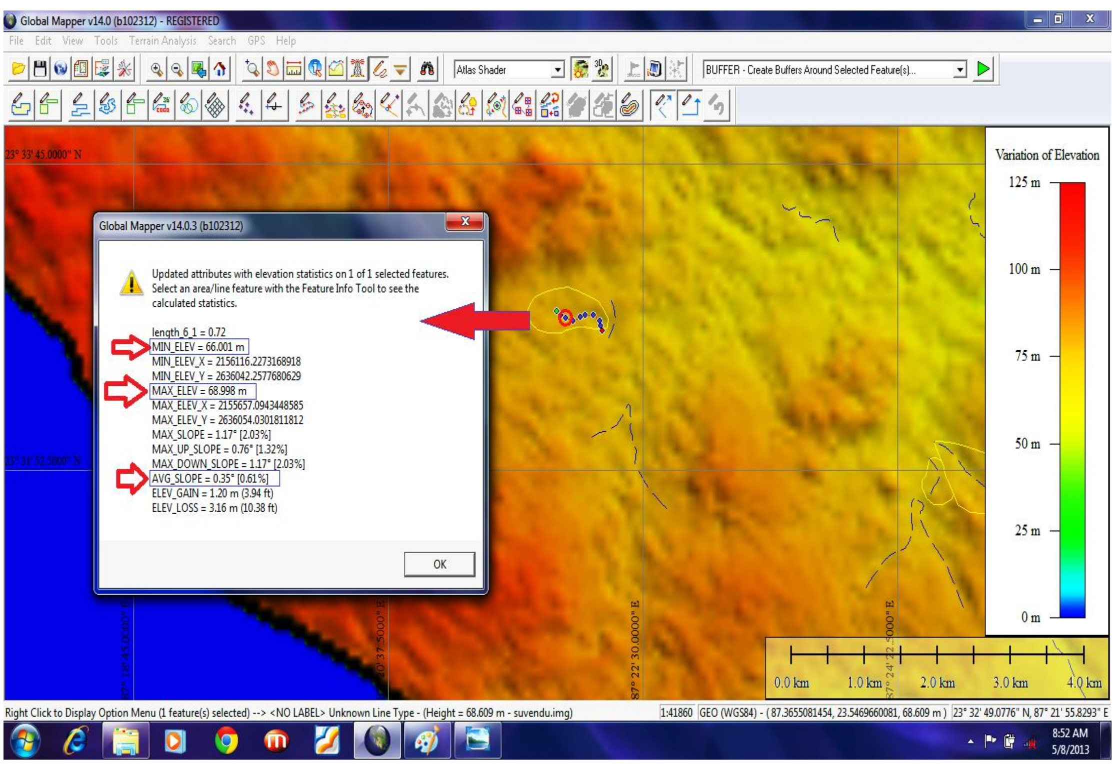

Figure 3: Application of Global Mapper v.14 Software for Slope Calculating

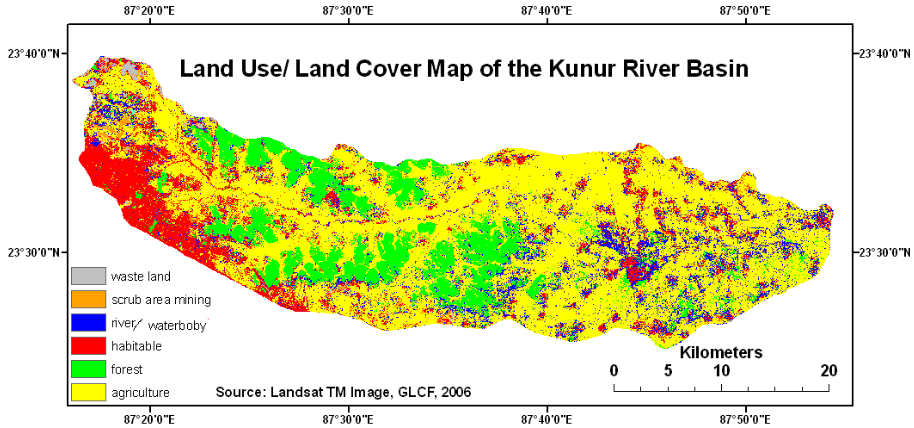

Figure 4: Land Use/ Land Cover Map of the Kunur River Basin with Sample Basins

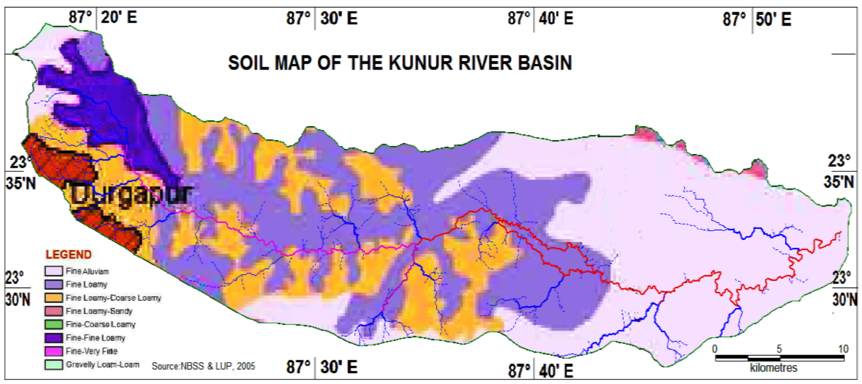

Figure 5: Soil Texture Map of the Kunur River Basin (Source: NBSS and ICAR, 2010)

Table 3: Significance Testing of Systematic Sampling for Sample Basins Selection

Stream Order	**Total Stream No. (p)**	**Standard Deviation of Length (km)**	**Sample Stream No. (n)**	**Mean of Sample Stream Length (km)**	**Using Formula for Significance Testing**	**Standard Error of Mean (S.E.)**	**Significance Level (%)**	**Table Values of S.E. of Mean**
First	209	0.87	53	0.99	S.E. of Mean= **σp/√n** (σp=Standard Deviation of Population, n= no. of samples	0.35 (3 S.E.)	1%	2.58 S.E.(1%Level), 1.96 S.E.(5%Leve)

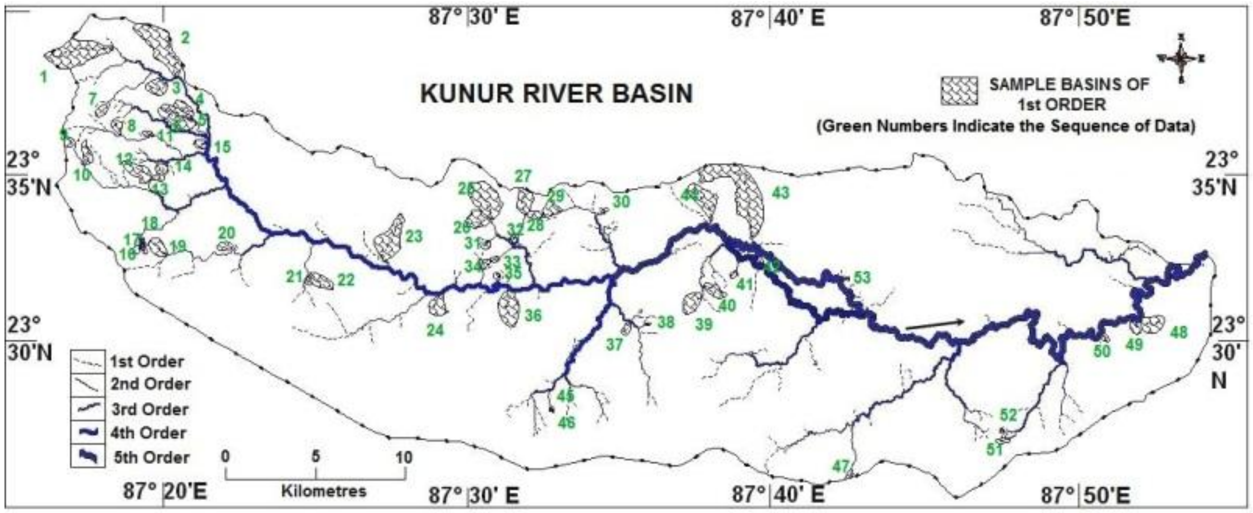

Figure 6: Sample First Order Streams for Calculating Erosion Rate of the Kunur River Basin

Model Used

Throughout the world, several soil loss estimation models are prepared and used to calculate the amount of soil loss in different fields of study. Here the Catchment Wise Erosion Estimation (CWEE) model (Garde *et al.,* 1983) was used as its efficiency in calculation soil losses from any river basin throughout the Indian subcontinent is positively significant. This model is based on observations of 135 catchments spreading evenly all over the India. The form of this model is as follows;

$$V_{SAB}= 1.182*10^{-6}A^{1.026}\,Q^{0.287}\,P^{1.289}\,S^{0.075}\,D_d^{0.398}\,Fc^{2.422}$$

Where, A =is the catchment area in hectare;
Q= is annual mean runoffs in million cubic metres;
P= is annual mean rainfall in cm;
S= is land slope;
D_d =is the drainage density in km/km^2;
F_c =is the erosion factor.

F_c is related to land use. The value of F_c is obtained following the formula given below.

$$F_c= [(0.2A_1 + 0.4\,A_2 + 0.6A_3 + 0.8A_4 + 1.0A_5)/\Sigma A_i\,(_{i=1,2,3,4,5})]$$

Here, A_1=area of classed and protected forest;
A_2=area covered by unclassed forest;
A_3=arable area;
A_4=scrub and grass area, and
A_5= waste area

Using this method Garde *et al.,* (1985) already prepared an iso erosion factor curves map for the whole India and based on this map, the Kunur River basin falls under 0.5 iso-erosion factor curve. But, as per Garde *et al.,* (1985) these values have less than $\pm$30 percent error for 90 percent of data. As the importance of erosion factor (F_c) for estimation of soil erosion rate is noteworthy therefore it is very much essential to take accurate erosion factor value. To eradicate this error, Universal Soil Loss Estimation (USLE) model has been superimposed on the CWEE. The model of USLE has worldwide acceptance for the estimation of soil loss. Major parameters of soil erosion are directly or indirectly connected with soil characteristics. That is applied in this model.

A= R*K*LS*C*P

Where, A= average annual soil loss (tonnes/ha./y)
R= rainfall erosivity factors;

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K= soil erodibility factor;
L= slope length factor;
S= slope steepness factor;
C= crop management factor, and
P= soil conservation practice factor

In the Grade's model, the parameters like runoff, rainfall, drainage density, and slope are used, which are more or less similar to the USLE's R, L, S parameters. CWEE model did not mention the geological condition of an area but that is so important for the erosion factor calculation. Therefore, K factor of USLE model has been joined with F_c value of CWEE model. Grade *et al.*, (1985) used land use land cover data for the large catchment areas and prepared iso-erosion factor curve for all over the India. In a micro level study, it is not suitable. In this respect, C and P factors of USLE model are used and also joined with F_c value of CWEE model. After sum of these four values (Iso-erosion-curve based erosion factor, K factor, C, and P factor), average erosion factor is calculated for the all 53 samples of first order basins. It is used in CWEE model (Table 4).

RESULTS AND DISCUSSION

In this study we have recorded all the necessary parameters for 53 first-order streams to measure soil erosion rate with the help of CWEE and USLE models in Table 4. An iso-erosion rate zone map has been prepared (Figure 7). There we have considered five classes to depict iso-erosion rate zones like Very High (>150 kg/ha/y), High (100-150 kg/ha/y), Medium (50-100 kg/ha/y), Low (25-50 kg/ha/y) and Very Low (<25 kg/ha/y). Table 5 shows, among the sample basins, about 9.43% falls under very high erosion rate zone. There highest erosion rate is over 273 kg/ha/y at '1' and '43' number sample basins. It indicates that the high risk of soil erosion found in the Kunur River Basin. Maximum portion (49.06%) of the Kunur Basin falls under the very low rate of soil erosion zone (Table 5), which indicates better opportunity for a proper land use planning and agricultural practices.

Table 4: Soil Erosion Rate of Sample First Order Streams/ Basins

Sample Basin ID	A (ha.)	P (cm)	S	Q (Mm^{3})	D_d (km/ km^2)	F_c (Garde , 1985)	K value (t/ha/y)	C	P	Mean F_c	Erosion Rate (tonnes/ ha./y)	Erosion Rate (kg/ha/y)
1	370	144.09	0.55	2000	1.06	0.5	0.15	0.2	0.70	0.39	0.27379	273.796
2	336	144.09	0.57	2000	0.77	0.5	0.15	0.2	0.70	0.39	0.21960	219.604
3	84	144.09	0.92	2000	1.56	0.5	0.11	0.2	0.70	0.38	0.06783	67.8390
4	51	144.09	0.53	2000	1.71	0.5	0.04	0.38	0.39	0.33	0.02872	28.7268
5	52	144.09	0.43	2000	2.56	0.5	0.04	0.38	0.39	0.33	0.03375	33.752
6	121	144.09	0.57	2000	1.62	0.5	0.04	0.38	0.39	0.33	0.06862	68.6268
7	38	144.09	1.04	2000	2.18	0.5	0.15	0.014	1.0	0.42	0.04403	44.0381
8	34	144.09	0.87	2000	2.21	0.5	0.15	1.0	1.0	0.66	0.11646	116.463
9	28	144.09	1.87	2000	1.36	0.5	0.04	0.2	0.70	0.36	0.01927	19.2755
10	54	144.09	0.92	2000	2.35	0.5	0.11	0.014	1.0	0.41	0.06077	60.7787
11	12	144.09	0.82	2000	3.42	0.5	0.11	0.38	0.39	0.35	0.01015	10.1570
12	112	144.09	0.74	2000	0.99	0.5	0.15	0.014	1.0	0.42	0.09572	95.7250
13	20	144.09	2.01	2000	2.25	0.5	0.11	0.014	1.0	0.41	0.02287	22.8708
14	40	144.09	1.93	2000	1.53	0.5	0.11	0.014	1.0	0.41	0.03996	39.9633

15	31	144.09	0.87	2000	1.61	0.5	0.07	0.2	0.70	0.38	0.02459	24.5932
16	17	144.09	1.78	2000	1.71	0.5	0.15	0.02	1.0	0.42	0.01827	18.2764
17	11	144.09	1.85	2000	5.0	0.5	0.15	0.02	1.0	0.42	0.01780	17.8008
18	7	144.09	1.42	2000	6.14	0.5	0.15	0.02	1.0	0.42	0.01188	11.8884
19	73	144.09	1.18	2000	1.42	0.5	0.15	0.02	1.0	0.42	0.0735	73.5248
20	38	144.09	0.35	2000	1.89	0.5	0.07	0.38	0.39	0.34	0.02301	23.0129
21	14	144.09	0.34	2000	3.36	0.5	0.07	0.38	0.39	0.34	0.01031	10.3109
22	76	144.09	0.61	2000	1.61	0.5	0.07	0.006	1.0	0.4	0.06804	68.0429
23	226	144.09	0.54	2000	1.38	0.5	0.17	0.38	0.39	0.36	0.15050	150.503
24	86	144.09	0.58	2000	1.04	0.5	0.17	0.38	0.39	0.36	0.0503	50.2998
25	254	144.09	0.54	2000	0.82	0.5	0.07	0.38	0.39	0.34	0.12065	120.650
26	96	144.09	0.5	2000	0.95	0.5	0.07	0.38	0.39	0.34	0.04680	46.8094
27	98	144.09	2.11	2000	1.59	0.5	0.07	0.2	0.70	0.37	0.07986	79.8676
28	29	144.09	0.82	2000	2.45	0.5	0.07	0.2	0.70	0.37	0.02523	25.2377
29	62	144.09	0.72	2000	1.60	0.5	0.07	0.2	0.70	0.37	0.04617	46.1747
30	9	144.09	0.8	2000	3.33	0.5	0.07	0.2	0.70	0.37	0.00854	8.54523
31	16	144.09	0.42	2000	2.50	0.5	0.07	0.2	0.70	0.37	0.01314	13.1425
32	15	144.09	0.64	2000	3.27	0.5	0.07	0.38	0.39	0.34	0.01148	11.4830
33	12	144.09	0.33	2000	3.25	0.5	0.07	0.006	1.0	0.4	0.01285	12.8518
34	18	144.09	0.6	2000	3.56	0.5	0.11	0.2	0.70	0.38	0.01864	18.6442
35	14	144.09	1.1	2000	1.86	0.5	0.15	0.006	1.0	0.41	0.01407	14.0785
36	179	144.09	0.56	2000	0.93	0.5	0.17	0.7	0.39	0.44	0.16567	165.671
37	27	144.09	0.8	2000	1.41	0.5	0.07	0.2	0.70	0.37	0.01888	18.8827
38	4.5	144.09	0.95	2000	3.11	0.5	0.07	0.006	1.0	0.4	0.00499	4.99945
39	90	144.09	0.81	2000	0.53	0.5	0.07	0.2	0.70	0.37	0.04442	44.4263
40	63	144.09	0.83	2000	2.22	0.5	0.07	0.2	0.70	0.37	0.05388	53.8882
41	11	144.09	1.22	2000	3.0	0.5	0.07	0.38	0.39	0.34	0.00847	8.47835
42	16	144.09	0.43	2000	3.25	0.5	0.17	0.38	0.39	0.36	0.01364	13.6442
43	558	144.09	0.61	2000	0.82	0.5	0.07	0.38	0.39	0.34	0.27301	273.014
44	172	144.09	0.61	2000	1.24	0.5	0.07	0.38	0.39	0.34	0.09586	95.8647
45	4	144.09	0.36	2000	5.75	0.5	0.17	0.38	0.39	0.36	0.00405	4.05355
46	6	144.09	0.78	2000	5.16	0.5	0.07	0.38	0.39	0.34	0.00543	5.43596
47	14	144.09	68	2000	2.57	0.5	0.07	0.38	0.39	0.34	0.01382	13.8227
48	104	144.09	0.34	2000	1.38	0.5	0.11	0.2	0.70	0.38	0.07473	74.7325
49	34	144.09	0.95	2000	2.0	0.5	0.11	0.2	0.70	0.38	0.02961	29.6133
50	19	144.09	0.43	2000	3.21	0.5	0.07	0.38	0.39	0.34	0.01410	14.1028
51	19	144.09	0.84	2000	3.05	0.5	0.17	0.006	1.0	0.42	0.02425	24.2520
52	4	144.09	1.57	2000	5.0	0.5	0.17	0.006	1.0	0.42	0.00622	6.22786
53	4	144.09	0.36	2000	5.75	0.5	0.07	0.38	0.39	0.34	0.00352	3.52949

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Table 5: Soil Erosion Rate of the Kunur River Basin

Erosion rate (kg/ha/y)	No. of Sample Basins	Percentage of Sample
<25	26	49.06
25-50	9	16.98
50-100	11	20.75
100-150	2	3.78
>150	5	9.43
Total	53	100

Highest Erosion rate is 273.79 kg/ha/y (Sample Basin 1)
Lowest Erosion Rate is 3.53 kg/ha/y (Sample Basin 53)
Mean Erosion rate is 47.61 kg/ha/y

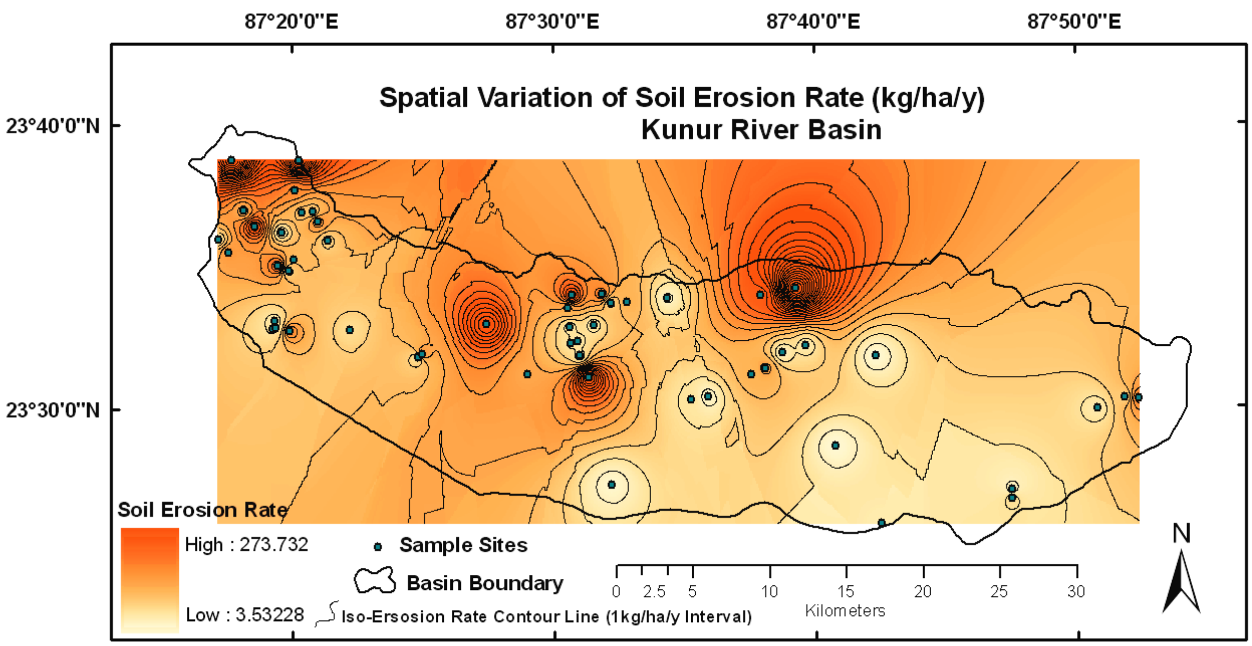

Figure 7: Iso-Erosional Rate Zones of the Kunur River Basin

From this study it can be said that major causes behind the high erosion rate (>150kg/ha/y) in the upper catchment area are anthropogenic activities, mainly '*murram'* (laterite) quarrying (Figure8a) which removed the top soil layer (Ghosh and Ghosh, 2003). Causes behind high erosion rate in the middle basin are extensive agricultural practices with faulty irrigation and over grazing (Figure8b). After correlation of major parameters, considering soil erosion rate as dependent variable (Y) and other are independent variables (X). It is found that human influenced parameter (CP) plays positively significant role for accelerate the erosion rate and make basin wise spatial variation. This result is also indicated that surface land cover and land use practices control the overland flow and associated soil erosion rate. Role of forest cover to control soil erosion rate is proved in middle portion of the right bank catchment area of this basin because of existing dense *Sal* (*Shorea robusta*) forest and very low to low rate of soil erosion.

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Table 6: Basin Wise Correlation Values between Soil Erosion Rate and Other Parameters

Independent Variables (X)	**Dependent Variable (Y)**	**'r' value**	**Calculated 't' Value**	**Tabulated 't' Value at 51 degree of freedom and 1% significance level**
Slope (S)		-0.10	0.72	2.66
Drainage Density (D_d)	Erosion Rate (kg/ha/y)	-0.55	4.68	2.66
CP factors		+0.23	1.64	2.66

Figure 8: a) Extensive *murram* quarrying accelerate the soil erosion in the upper catchment area, b) Agricultural practices over active floodplain and grazing helps to increase soil erosion rate, c) Lateritic profile in the basin area, d) Huge soil remove from surface, and e) River bank erosion of the Kunur River in Domra village surrounding

Conclusion

Finally, it can be concluded that application of combine model (CWEE and USLE) for catchment wise soil loss estimation integrated with RS-GIS techniques is a valuable approach for integrated watershed management. It is important to note that accurate results may not be guaranteed by CWEE and USLE calculations due to their limitations, but this approach provides useful tools to estimate erosion hazard over watersheds for rehabilitation planning with least error. According to Morgan (2005), USLE was developed as a tool to guide soil conservation planning and not for use as a research technique. However, due to data limitations and shortage of time, these two models have been used integrated with RS-GIS technique that helps to demarcate soil erosion prone areas in the Kunur River Basin for integrated watershed planning and sustainable land management. Very high erosion rate zones were mostly observed in the mining and cultivated area, which indicates the role of man on changing geomorphic features and fluvial landscape. It would be possible to see how the upland areas of the Kunur Basin have a higher soil degradation potential within a range of more than 250 kg/ha/y than lower basin areas. Therefore, in the upland areas of this basin, sustainable land management practices are urgently required to reduce the soil erosion rate. Agricultural activities and irrigational practices should continue with improvements through terracing, practicing crop rotation, improved agro- forestry practices, other appropriate biological and physical soil and water conservation methods. Moreover, as settlement rapidly increases in that area, afforestation should be adopted in the degraded land with reduces forest loss due to human encroachment for agricultural land and settlements purposes.

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