SOIL EROSION HAZARD ZONATION IN BANDU SUB-WATERSHED, INDIA

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ABSTRACT

Soil hazard zonation in watershed is quite significant to take the necessary actions for soil conservation. The present study attempts to identify soil hazard zones for proper soil conservation and prepare a treatment plan for the Bandu sub-watershed of India through morphometric analysis techniques by giving rank based on priority. The result of the prioritization of eighteen micro-watersheds is entirely satisfactory due to the use of fourteen morphometric parameters. The study quantifies the potential soil loss and identifies the soil eroded zone of the sub-watershed using the universal soil loss equation method and the entire region is categorized into three soil hazard zones with varying degrees. Indian Remote Sensing Satellite data have been used to conduct the whole study. The micro-watershed prioritization has been estimated by applying the composite morphometric value. The micro-watershed having 5.625 composite value ranks first for prioritization (most vulnerable with maximum soil erosion) and having 15.875 composite value ranks last for prioritization (least vulnerable with minimum soil erosion). The result also shows that the soil loss ranges from 0-30 tonne/hectare/year with an average soil loss of 0-10 tonne/hectare/year in maximum areas of the sub-watershed. The soil loss map shows that along the Bandu and in some agricultural fields, the central part of the region is susceptible to soil erosion. The scientific approach of this research could be more effective in maintaining sustainable rural planning. The study can be used as a reference work for determining soil hazard zones in any tropical watershed with high soil loss risk.

Keywords: Morphometry; Prioritization; Universal Soil Loss Equation; Watershed.

INTRODUCTION

The concept of watershed or water harvesting should have to necessarily inculcate and imbibe people at large, who could be the ultimate beneficiaries. To delineate the suitable location of different types of water harvesting structures various morphological parameters were evaluated by several researchers (Singh & Dubey, 1994; Nag & Chakraborty, 2003). These are very useful variables of a drainage basin in numerical terms. Morphometric analysis is considered to be the most satisfactory method for water resource development, and management as well as for watershed characterization and prioritization.

For assessing soil erosion and water conservation a method is used which is known as Universal Soil Loss Equation (USLE) given by Weischmeier & Smith (1978). A Digital

Elevation Model (DEM) has been generated to calculate the slope and slope aspect of the project area.

The computation of morphometric parameters of the sub-watershed and generation of the DEM and USLE model can be achieved through the latest technologies like remote sensing and GIS. Morphometric analysis using remote sensing techniques plays a very important role in analyzing the characteristics of the entire Bandu sub-watershed as well as in prioritization of the micro-watershed. Hence, the identification of zones susceptible to soil erosion and the action plan for the utilization and management of resources can be achieved only in remote sensing and GIS environments.

Several soil conservation programmes for sustainable development have been taken up by the Government of India taking the watershed as the management and planning unit. The approach would be more scientific by taking the watershed as a planning unit, as it is a natural unit. Various studies and reports have been prepared for watershed management programmes where soil erosion estimation and watershed prioritization received the top priority. All these analyses have been done by using remote sensing and GIS techniques. Shrimali *et al*. (2001) presented a case study of the 42 km^2 Sukhana Lake catchment in the Shiwalik hills for delineation and prioritization of soil erosion areas.

Orissa Remote Sensing Application Centre (ORSAC) (2005) has prepared the Watershed Atlas and the priority map under the request of the Watershed Mission, the Department of Agriculture, and the Government of Orissa. Both physical and non-physical criteria were used for priority fixation to each micro-watershed. Physical criteria include a high incidence of wasteland and a situation in the upper reaches of the district. Non-physical criteria include a high incidence of drought, contiguity of watershed already treated, and expected community response. Initially, the physical criteria were used for priority fixation, and after that, the district administration considered the other non-physical criteria for the selection of micro-watersheds for their development. The highest priority was given to the micro-watershed, which had more than 40 % of wasteland and had a dominant distribution of 1st and 2nd order streams.

Thakkar & Dhiman (2007) identified the susceptible zone to maximum soil erosion in the Mohr Watershed of Gujarat. Rudariah *et al*. (2008) presented a report on the 1320 sq km area of the Kagna river basin in the Gulbarga district, Karnataka for analysis of morphometric parameters regarding the drainage system. These parameters have been computed using ArcInfo and ArcView software integrated with remote sensing data and they presented an interpretative approach to each parameter and compared with one another.

Moreover, soil loss can be estimated as a function of the factors of watersheds. There are many soil estimation models used for various purposes which Universal Soil Loss Equation (USLE) model (Wischmeier & Smith, 1978) is considered the most effective model for soil loss.

The main objective of this project is watershed prioritization to identify the zone of soil loss at different levels and to maintain sustainable rural livelihood by arresting soil erosion. In this regard, various thematic maps on a 1:50,000 scale have been prepared using multi-seasonal (Kharif, Rabi, Zaid) Indian Remote Sensing Satellite P6 (IRS P6) Linear Imaging Self-Scanning Sensor III (LISS III) imagery supported with Survey of India Topographical Sheet and subsequent ground truth data. The study also aims to determine the soil loss status of the sub-watershed by using the USLE model.

MATERIAL AND METHODS

Study area

The study area, Bandu sub-watershed, lies between the Arsha and Baghmundi blocks of the Puruliya district of West Bengal, India (Fig. 1). The latitudinal and longitudinal extension of the entire area is from 23^{o}11’30” N to 23^{o}19’30” N and from 86^{o}4’0” E to 86^{o}19’0” E, respectively.

Fig. 1: Location of the study area

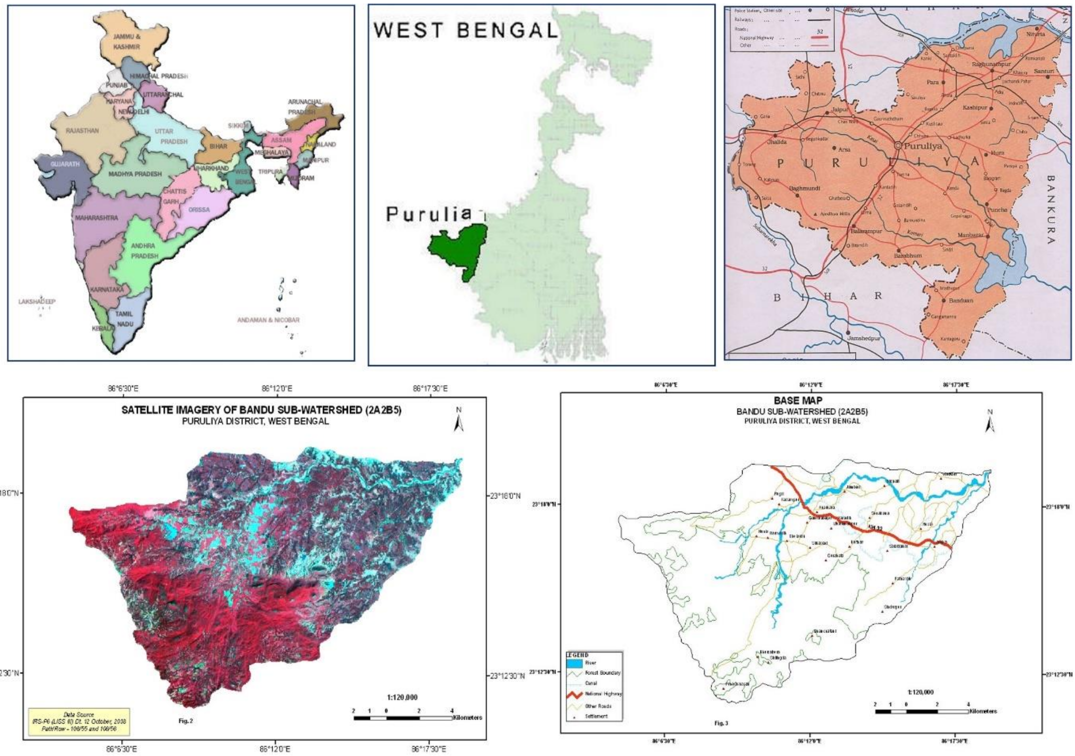
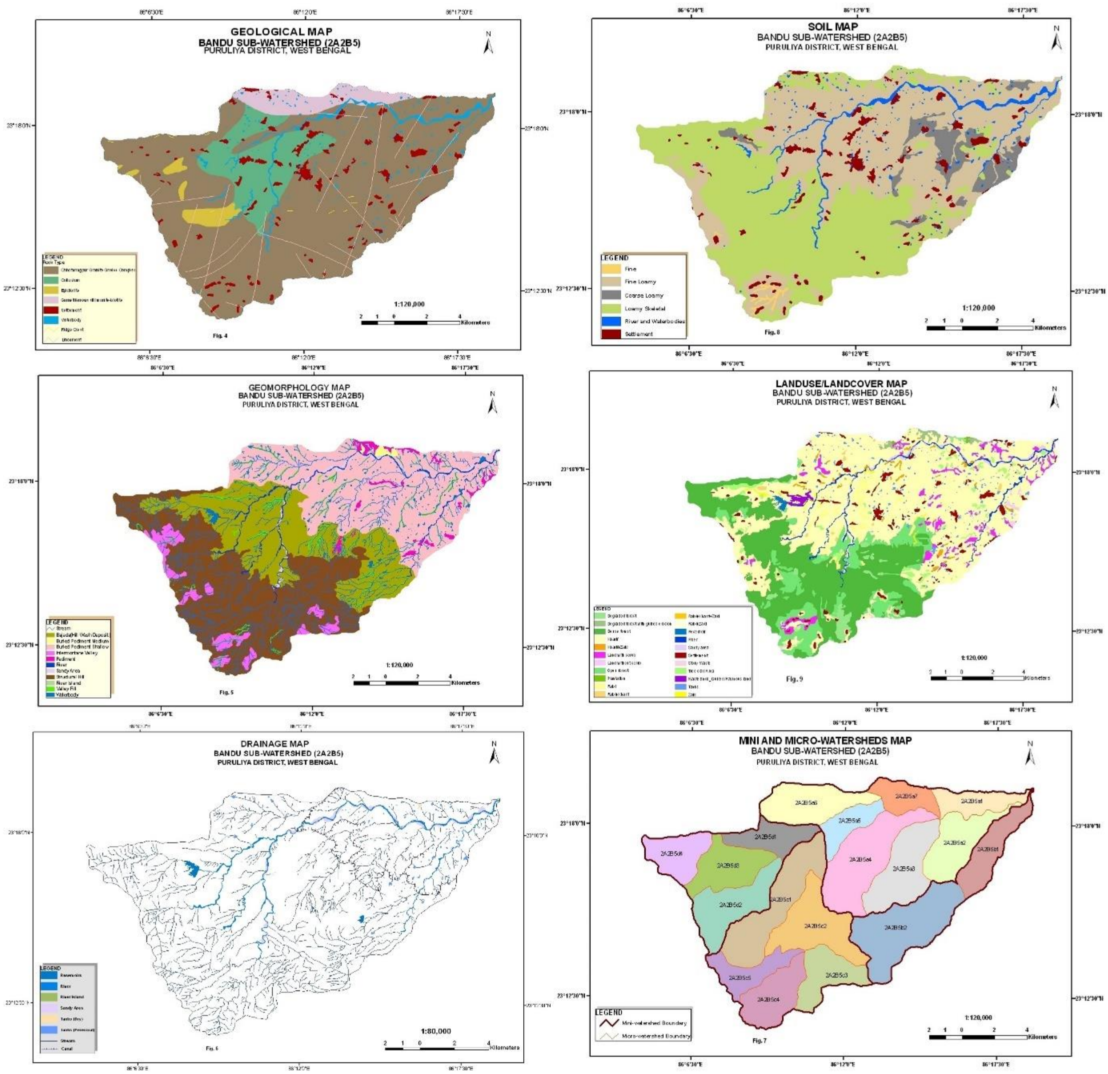


Fig. 2 shows the physical setup of the study area. The study area mainly exposes metamorphic rocks of Proterozoic age comprising the Chhotonagpur granite-gneiss complex which consists of pink granite, porphyritic gneiss containing large crystals of feldspar in a asdmass of fine-grained material, and various granitised gneisses. Hornblende-biotite granite gneiss, garnet- hornblende-biotite granite gneiss, hypersthenes- biotite granite gneiss, composite gneiss with migmatite, composite gneiss with porphyroblasts, injection-gneiss, augen gneiss, biotite and quartz-biotie granite gneiss, garnet-biotite granite gneiss is also found in this study area. All these granite rocks, older schists and gneisses, and basic rocks have been intruded by pegmatites and quartz veins. The Peninsular shield of the Archaean era comprises granites, meta-sedimentaries, calc-granulites, and meta-basics. It lies in the northern part of the study area. Older schistose rocks are also found. The original landmass has been distributed by upliftment and intensively altered since the time of their formation. Rajmahal trap of the Upper Jurassic era comprises mainly basalt rock. It is found in some form of patches in the western part of the study area. Alluvium is found in the west-central part of the study area which was formed in the Recent era. The north-eastern part of the area is composed of buried shallow pediment and intermontane valley, the south-western part is characterized by structural hills and bajada hill wash deposits are found in the middle part. These regions are suitable for agrarian activities. The higher structural highlands (> 300 m) and lower undulating plain (< 300 m) cover the entire study area. The slope of the area is gradually decreasing from southwest to northeast.

Fig. 2: Physical setup of the study area



Most of the rivers originate from south or south-western parts and flow according to the slope. Bandu River is the most significant river in the region. The Panchet and Kangsabati reservoirs lie in the region. The region is characterized by a dry tropical monsoon climate where May and January are considered the hottest and coldest months, respectively. Most of the rain occurs in July and August. The natural vegetation of the study area is mainly deciduous. Now major parts of the area fall under degraded forest. Much of the vegetation has been replaced by shrubs, bushes, meadows, and cultivated fields under intense human intervention. Hence, the region has lost its biodiversity to some extent. Forest degradation is highly responsible for excessive topsoil erosion through sheetwash in the upland region. Hence, the terrain appears barren in the dry season. In the southern part of the region, forest patches are observed. This forest area is classified as a protected forest where sal trees, once the dominant natural species of the area. Some plantations of acacia, eucalyptus, and cashews have been done in recent years but they are suffering from poor management. Outside the forest boundaries tree clad areas are found in a scattered manner. The area is characterized mainly by fine loamy, coarse loamy, and loamy skeletal soil. The existing transport network is perceived as a direct indicator of the level of infrastructural socio-economic and cultural development of the area under study. The existing road network pattern indicates that the connectivity and accessibility between the blocks and villages are quite satisfactory. The NH32 passes through this region from east to west across the Bandu River. Tamna-Arsha Road is another important road passing through the central portion of the study area and creates a link among some villages. Apart from these, other major metalled, unmetalled, and cart-track play an important role in strengthening the communication network of the entire region.

Data

Indian Remote Sensing Satellite P6 (IRS P6) Linear Imaging Self-Scanning Sensor III (LISS III) (106/55) satellite data on 21-01-06, 03-04-06, 12-10-06 and IRS P6 LISS-III (106/56) data on 16-01-06, 29-03-06, 07-10-06 have been collected from Bhuvan website (https://bhuvan.nrsc.gov.in/home/index.php). After georeferencing and mosaicking to the Survey of India toposheet (73I/3, 73I/4, 73I/7, and 73I/8) these merged data were used.

Methods

Watershed Prioritization

The morphometric parameters for the delineated watershed area are calculated based on the formula suggested by various authors viz. Horton, Strahler, Schumn, and Miller, are presented in Table 1.

Universal Soil Loss Estimation

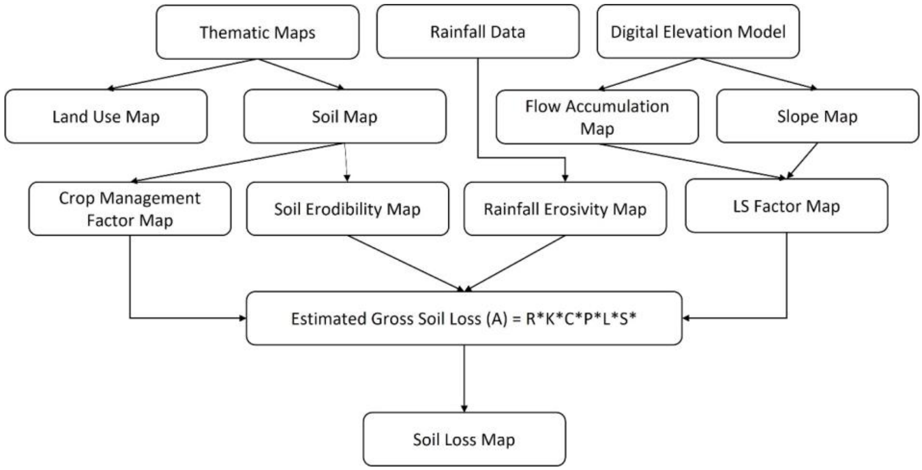
To generate universal soil loss estimation (USLE), SRTM DEM data was downloaded from the Earth Explorer website. A relevant part of the SRTM data with 90 m horizontal resolution has been used. ASCII file is to be converted into a raster file. With the help of a spatial analyst tool, using the Flow Direction function a flow direction raster has been generated. The sinks were identified. After filling all sinks with the Fill Function, using the Flow Accumulation function accumulated flow is calculated. The slope length for every pixel has been calculated by multiplying the flow accumulation value with the resolution. Flow accumulation indicates the slope length. The slope map has also been calculated from the DEM.

A flowchart of the methodology of the research work has been given in Fig. 3.

Table 1: Formula of the used morphometric parameters

Sl No.	Morphometric Parameters	Formula	Reference
1	Stream Order	Hierarchical rank	Strahler (1964)
2	Stream Length (Lu)	Length of the Stream	Horton (1945)
3	Mean Stream Length (Lsm)	Lsm=Lu/Nu Where, Lu=Total stream length of order 'u' Nu=Total number of stream segments of order 'u'	Strahler (1964)
4	Stream Length Ratio (RL)	RL=Lu/lu-1 Where, Lu= Total stream length of order 'u' Lu-1= Total stream length of its next lower order	Horton (1945)
5	Bifurcation Ratio (Rb)	Rb=Nu/Nu+1 Where, Nu=Total number of stream segments of order 'u' Nu+1= Total stream length of its next higher order	Schumn (1956)
6	Mean Bifurcation Ratio (Rbm)	Rbm=Average of bifurcation ratios of all orders	Strahler (1957)
7	Drainage Density (D)	D=Lu/A Where, Lu= Total stream length of all orders A=Area of the basin(km^2)	Schumn (1956)
8	Basin Length (Lb)	Lb=1.312*A0.568 Where, Lb=Length of the basin(km) A=Area of the basin(km^2)	Horton (1932)
9	Stream Frequency (Fs)	Fs=Nu/A Where, Nu=Total number of stream segments of all orders A=Area of the basin(km^2)	Horton (1932)
10	Texture Ratio (Rt)	Rt=Nu/P Where, Nu=Total number of stream segments of all orders P=Perimeter of the basin(km)	Horton (1945)
11	Form Factor (Rf)	Rf=A/Lb2) Where, A=Area of the basin(km2) Lb2 =Sq of basin length	Horton (1932)
12	Circularity Ratio (Rc)	$Rc=4*Pi*A/P^2$ Where, Pi='Pi' value i.e.,3.14 A=Area of the basin(km2) P2 = Sq of the perimeter(km)	Miller (1953)
13	Elongation Ratio (Re)	$Re=(2/Lb)*(A/Pi)^{0.5}$ Where, Lb=Basin length(km) A=Area of the basin(km^2)	Schumn (1956)
14	Compactness Ratio (Cc)	$Cc=0.2821*P/A^2$ Where, P=Perimeter of the basin(km) A=Area of the basin(km^2)	Horton (1945)

Fig. 3: Methodology of the research work (for soil loss map)



RESULTS

Morphometric analysis

The highest stream length is noticed in micro-watershed 2A2B5b2. The stream length values vary from 0.17 to 8.09. It is observed that stream length values of 2A2B5b1,2A2B5c1, and 2A2B5c3 micro watersheds are increasing gradually. However, for 2A2B5a1,2A2B5b2, 2A2B5d2 there is a deviation from this general observation. This deviation might be due to changes in topographic elevation and slope of the area.

Fig. 4 and Table 2 represent the morphometric analysis of the Bandu sub-watershed. The stream length ratio shows a change in each micro watershed. The Bifurcation Ratio indicates a uniform decrease for 2A2B5c5 and 2A2B5d3. It ranges from 1 to 8 indicating that all the micro watersheds are falling under the normal watershed category (Strahler, 1957). The drainage density shows a variation from 1.47 to 4.20 per km^2. It suggests a moderately permeable sub-soil and fine drainage texture. The stream frequency values range from 1.20 to 10.37 and exhibit a positive correlation with drainage density. The drainage texture ratio of the study area is from 0.58 to 5.77. The 2A2B5d micro watershed has high values of drainage texture. The form factor values vary from 0.39 to 0.46. The higher values of the form factor suggest an almost circular shape of the micro watershed. The Circularity Ratio values range from 0.30 to 0.63. A higher circularity ratio (> 0.50) represents the circular shape of the micro watershed. The elongation ratio values of the sub-watershed vary from 0.71 to 0.76 which shows that Bandu is an elongated sub-watershed. In the Bandu sub-watershed, the compactness ratio varies from 1.26 to 1.83.

Fig. 4: Morphometric analysis of Bandu sub-watershed

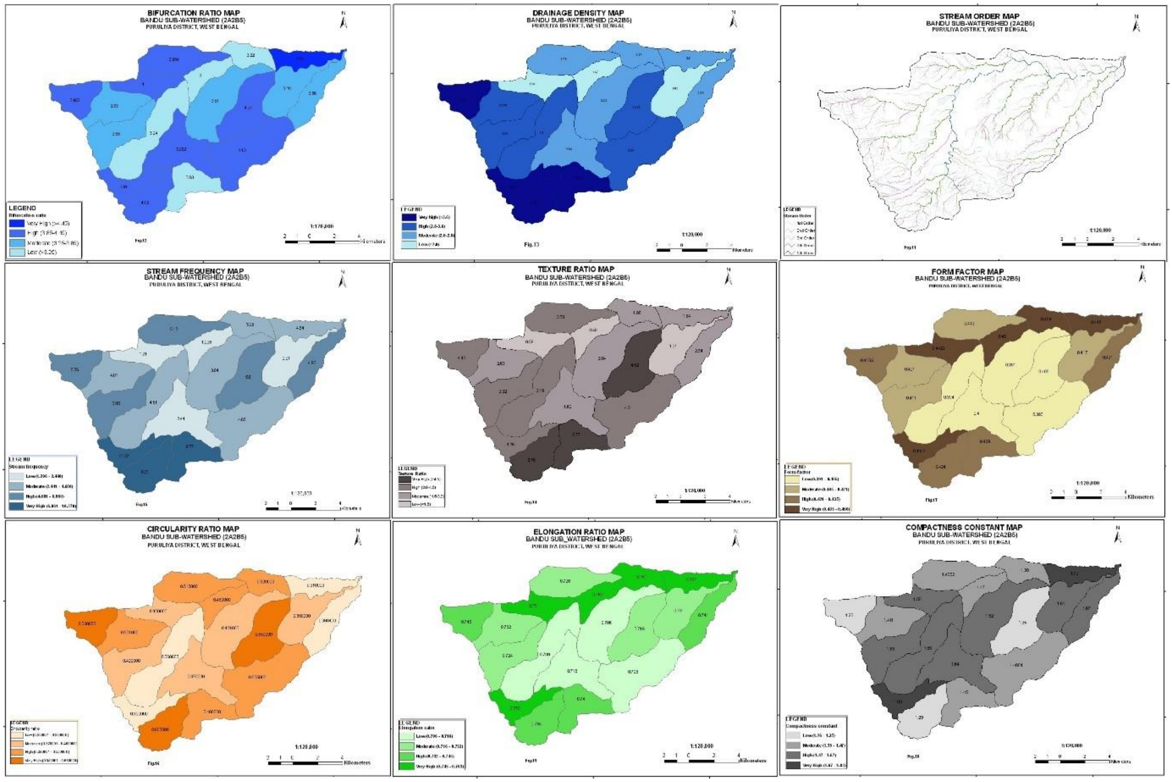


Table 2: Morphometric Parameters of Bandu sub-watershed

Mini-watershed code	Micro watershed code	Mean Bifurcation Ratio	Drainage Density	Texture Ratio	Stream Frequency	Circulatory Ratio	Form Factor	Compact-ness Ratio	Elongation Ratio
2A2B5a	2A2B5a1	4.92	2.60	1.84	4.54	0.31	0.44	1.79	0.75
	2A2B5a2	3.28	1.89	1.31	2.21	0.39	0.41	1.61	0.72
	2A2B5a3	4.07	2.82	4.52	5.80	0.55	0.40	1.35	0.71
	2A2B5a4	3.81	2.23	3.04	3.84	0.431	0.39	1.52	0.70
	2A2B5a5	3.00	1.47	0.58	1.20	0.46	0.46	1.47	0.76
	2A2B5a6	3.95	2.75	3.58	5.12	0.51	0.41	1.40	0.72
	2A2B5a7	3.22	2.37	1.98	3.96	0.52	0.45	1.39	0.76
2A2B5b	2A2B5b1	3.56	2.59	2.54	4.98	0.36	0.43	1.67	0.74
	2A2B5b2	4.13	3.24	4.21	4.68	0.50	0.39	1.40	0.70
2A2B5c	2A2B5c1	3.24	2.81	3.18	4.51	0.36	0.39	1.66	0.70
	2A2B5c2	3.952	2.66	1.62	2.44	0.37	0.40	1.64	0.71
	2A2B5c3	3.03	4.20	5.77	9.77	0.48	0.42	1.45	0.73
	2A2B5c4	4.12	3.98	5.76	8.31	0.60	0.42	1.29	0.73
	2A2B5c5	3.91	4.17	4.26	10.37	0.30	0.44	1.83	0.75
2A2B5d	2A2B5d1	4.00	1.85	0.59	1.21	0.40	0.44	1.58	0.75
	2A2B5d2	3.65	2.92	3.32	5.05	0.42	0.41	1.53	0.72
	2A2B5d3	3.33	2.83	2.63	4.01	0.50	0.42	1.41	0.73
	2A2B5d4	3.952	3.87	4.43	6.86	0.63	0.43	1.26	0.74

Prioritization of micro-watersheds

Table 3 shows the watershed based on the eight above-mentioned morphometric parameters. The highest value of the bifurcation ratio is noticed in the 2A2B5a micro watershed which suggests a high probability of erosion. The highest drainage density (2A2B5d micro-watershed) reflects that soil erosion is quite high in this area. The 2A2B5r has the highest elongation ratio (0.76) indicating a possibility of low erosion.

Table 3: Prioritization results of morphometric analysis

Micro watershed code	Mean Bifurcation Ratio	Drainage Density	Texture Ratio	Stream Frequency	Circularity Ratio	Form Factor	Compactness Ratio	Elongation Ratio	Compound Parameter	Final Priority
2A2B5a1	1	12	14	10	2	16	17	16	11.000	13
2A2B5b1	12	13	12	8	3	12	16	12	11.250	14
2A2B5b2	2	5	6	9	13	2	6	2	5.6250	1
2A2B5c3	17	1	1	2	11	11	8	11	7.750	4
2A2B5c4	3	3	2	3	17	10	2	10	6.250	2
2A2B5c5	9	2	5	1	1	15	18	15	8.250	8
2A2B5c1	15	9	9	11	4	3	15	3	8.625	9
2A2B5d2	11	6	8	7	8	6	11	6	7.875	6
2A2B5d3	13	7	11	12	12	9	7	9	10.000	12
2A2B5d4	8	4	4	4	18	13	1	13	8.125	7
2A2B5d1	4	17	17	17	7	14	12	14	12.750	16
2A2B5a6	6	10	7	6	14	7	5	7	7.750	5
2A2B5a2	14	16	16	16	6	8	13	8	12.125	15
2A2B5a3	5	8	3	5	16	5	3	5	6.250	3
2A2B5c2	7	11	15	15	5	4	14	4	9.375	11
2A2B5a5	18	18	18	18	10	18	9	18	15.875	18
2A2B5a4	10	15	10	14	9	1	10	1	8.750	10
2A2B5a7	16	14	13	13	15	17	4	17	13.625	17

Fig. 5: Priority map of Bandu sub-watershed

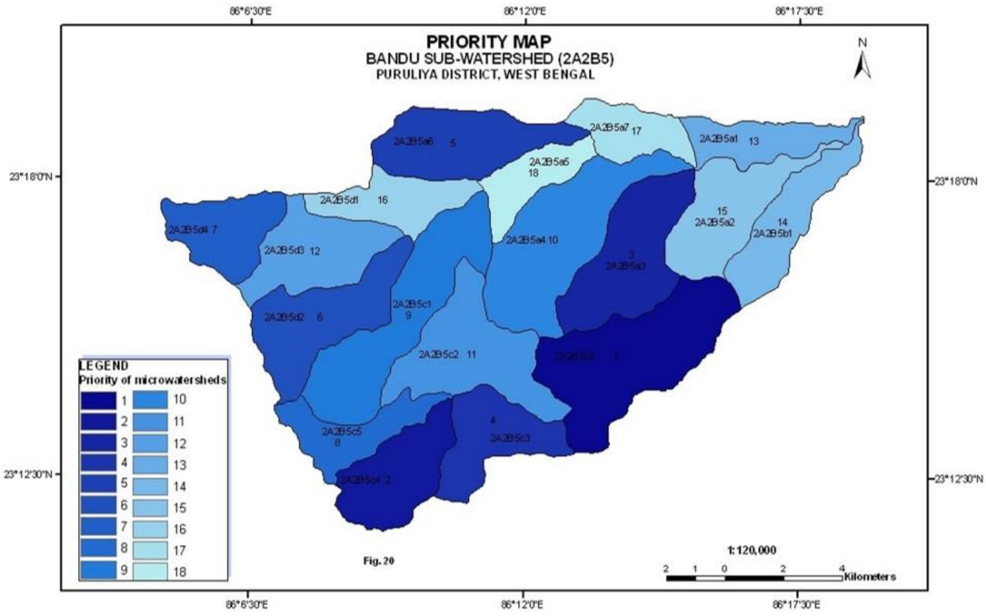
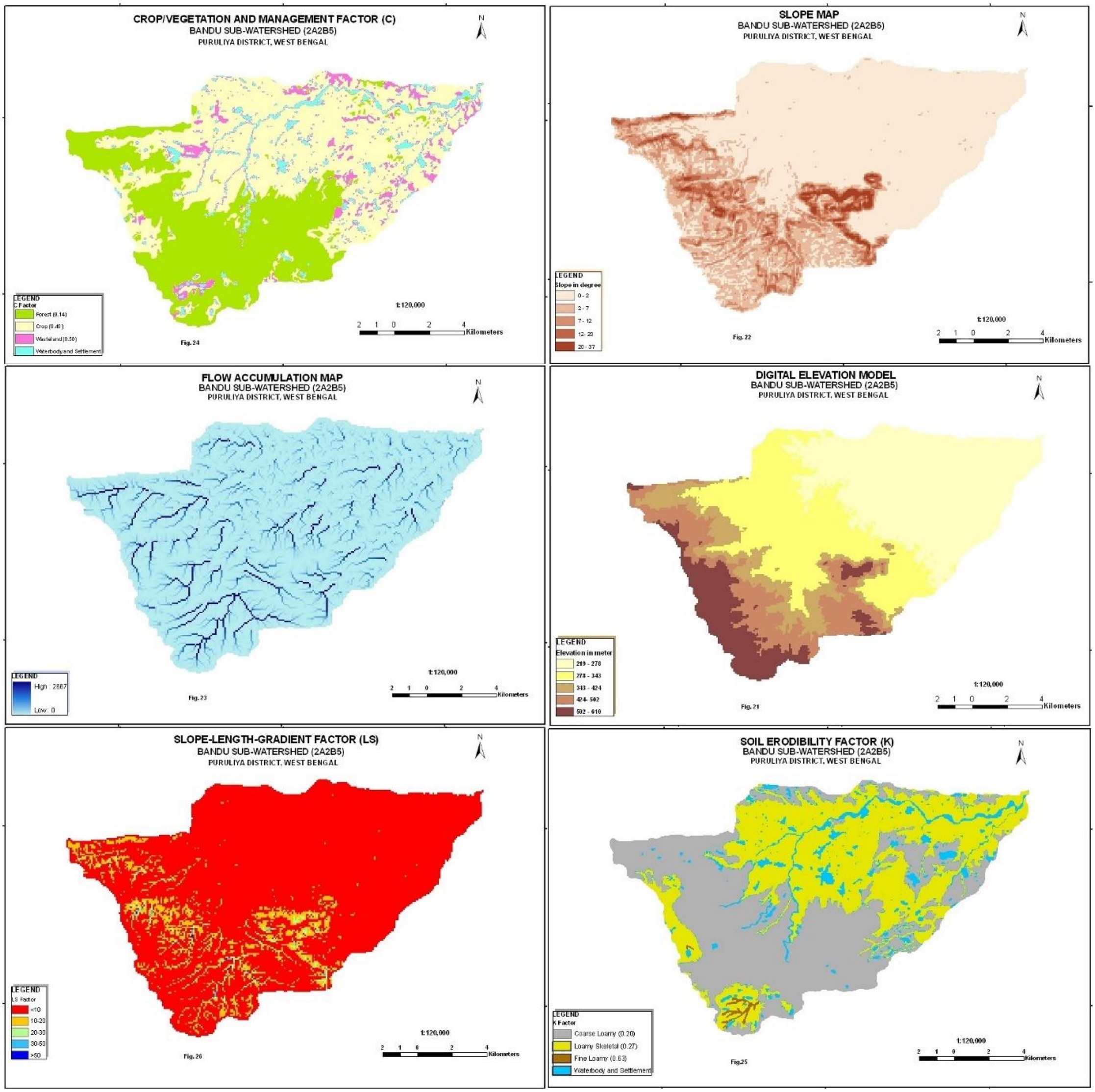


Fig. 5 shows the final priority map of the sub-watershed based on the composite parameter. The composite parameter is calculated by adding the ranks. The composite parameter values and prioritization rating of 18 micro-watersheds are presented in Table 3. 2A2B5c micro-watershed (5.625 composite value) ranks first for prioritization followed by 2A2B5e (6.25). The lowest composite value (15.875) in prioritization is estimated for 2A2B5p. The highest priority indicates the most vulnerable zone with maximum soil erosion.

Soil loss map

Fig. 6 describes the factors responsible for soil loss. Crop/vegetation management factor, slope, flow accumulation, digital elevation, slope-length gradient factor, and soil erodibility factors are essential for soil loss estimation.

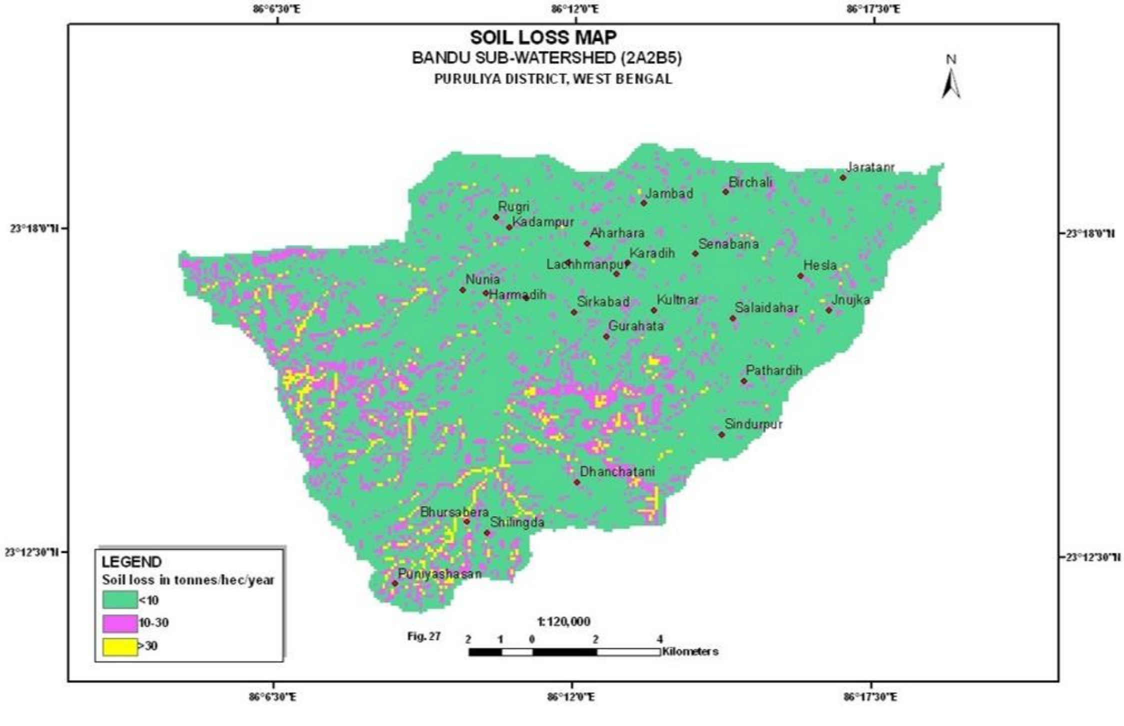
Fig. 6: Factors responsible for soil loss



DISCUSSION

The derived soil loss map (Fig. 7) depicts the overall soil erosion scenario of the region under study. The map shows the positive relationship between the slope and soil loss. Due to the presence of structural hills in the western part of the region, the slope gradient is quite high. The map shows that in this region soil loss is maximum and it occurs in linear form. In the northern, central, and eastern parts of the area, a marginal amount of soil erosion has occurred due to the presence of a gentle slope. There is an intimate relationship between drainage and soil erosion in any particular area. In the western and southern parts of the study area, maximum soil erosion is observed along the first-order river channel and most of the rivers in this region are structurally controlled. From the soil loss map, it is clear that the extreme southern part of the region is susceptible to soil loss. Due to the presence of numerous first-order streams, the western and southern parts of the area are subjected to massive soil erosion. The occurrence of soil erosion in the study area is highly related to different geomorphic units of the region. In the western part of the region, the hill slopes are highly dissected and steep, and erosion has played a dominant role in soil loss.

Fig. 7: Soil loss map



The soil loss map reveals that soil erosion is comparatively less in the Buried Pediment Shallow and Buried Pediment Medium zones than in a structural hill. From this point of view, it can be said that human interference is not the only responsible factor for soil loss in this particular area rather than physiographic. In the upper pediment and stony wasteland, the erosion processes are almost completed. But in the zone of intermontane valley soil erosion takes place due to human intervention. The soil loss map also depicts the intimate relationship between land use/land cover pattern and soil erosion. In the extreme southern part of the region, where the forest becomes degraded is subjected to excessive soil loss due to the absence of sufficient forest coverage. In comparison to this, topsoil erosion is comparatively less in dense forest areas. The map shows that the gulley eroded area; the developed extreme western part of the study area is subjected to a considerable amount of soil erosion. In the extreme southern and western parts of the forest fringe area, a considerable amount of soil loss is observed due to human intervention. Particularly in these areas, habitation has been developed by cutting hill slopes and it induces rill/sheet erosion by rainfall run-off. Based on the soil loss map, it can be said that the remaining area is subjected to less soil loss due to the practice of mono and double crop.

From the discussion, it can be concluded that soil loss is highly related to physical and anthropogenic factors. Here, the authors used only Indian Remote Sensing Satellite data which is freely available. The data has a moderate spatial resolution compared to the other freely available satellite data. The other data can also be used to conduct this kind of study. The fourteen morphometric parameters used by the authors are common to the researchers and these are frequently used in prioritization analysis. Other morphometric parameters may also be used to perform similar type of research works.

Let us consider some available recent literatures using the USLE method for the assessment of average annual soil loss in any tropical or sub-tropical basin or watershed. Haile & Fetene (2011) assessed the rate of soil erosion by applying USLE model in Kilie catchment, East Shoa Zone, Ethiopia and found that about 97 % of the study catchment falls within a range of 0–10 tonne/hectare/year soil erosion rate. This rate is almost same to the soil erosion rate in Bandu sub-watershed. Zhu (2014) estimated the average annual soil erosion (31.18 t hm−2 yr−1) in the Danjiangkou Reservoir Region, China by using USLE method which is also very similar to the present research work. Mati *et al*. (2000) used USLE method in Upper Ewaso Ng'iro North basin of Kenya to predict the soil erosion hazard and showed that 36 % of the basin has a soil erosion rate of 0-9 tonne/hectare/year. This result is also near to the the outcome of the present study. Selmy *et al*. (2021) used USLE model to compute 0-3.5 tonne/hectare/year annual soil erosion in Dakhla oasis, Egypt which is very close to the present study result. Jazouli *et al*. (2019) calculated 0.68 tonne/hectare/year average annual soil loss in Ikkour watershed in the Middle Atlas (Morocco) by using USLE and it is close to the result of our study. Another study found in the Gumara watershed of Ethiopia showed that the annual soil eroded estimated area is > 18 tonne/hectare/year which is also similar to the current result (Belanyeh *et al.*, 2019). All these studies have a similarity in output with the present performance.

Some close results on average annual soil loss are also found in Indian context. Sridhar & Ganapuram (2021) prioritized the watersheds using the fuzzy analytical hierarchy process method in the Peddavagu watershed of the Krishna River basin and got almost similar results. Another study performed in lower Sutlej sub-basin of Punjab, India showed that about 94.4 % and 4.7 % of the total area suffered from very slight erosion (0–5 tonne/hectare/year) and slight erosion (5–10 tonne/hectare/year), respectively, whereas 0.11 % area experienced very severe soil loss (> 25 tonne/hectare/year) that is very similar to the present study (Sharma *et al.*, 2022). A new study performed using a revised universal soil loss equation method in Nainital district, Uttarakhand, India revealed the annual average soil loss ranged between 20 to 80 tonne/hectare/year in the study area which has a similarity with the present result (Kumar *et al*., 2021). A study conducted in the Banas basin of Rajasthan of India reflects that 90 % area has under 0–10 tonne/hectare/year soil loss category (Singh *et al.*, 2023). Hence, Bandu sub-watershed prioritization and its soil loss estimation can be a reference work for the researcher in similar physical environment.

CONCLUSION

The study examines some morphometric parameters to find out the most critical zone through the watershed prioritization method. Remote sensing data along with the USLE model would be utilized for finalizing the soil loss map for assessment of the amount of soil loss in the area under study. This technique helps to assess the soil hazard zone as well as the causes of watershed deterioration in the study area. It is observed that there is a direct relationship between soil erosion zone and area of watershed deterioration. Southern and southeastern parts of the structural hill are recommended as the zone with a very high rate of soil erosion. 2A2B5c micro-watershed (5.625 composite value) ranks first for prioritization followed by 2A2B5e (6.25). The lowest composite value (15.875) in prioritization is estimated for 2A2B5p. Thus, 2A2B5c and 2A2B5e micro-watersheds should be given the most priority for soil conservation as they are the most vulnerable micro-watersheds examined from the composite ranking of morphometric parameters. The least priority should be given to the 2A2B5p micro-watershed. The result also shows that the annual soil loss of the study area is ranging from 0-30 t ha−1 yr−1. In the agricultural plain high rate of soil erosion is observed in a scattered manner. Specifically, a few settlements like Sitarampur, Rugri, Sirkabad, Lachmanpur, Senabana, and Harmadih suffer from high rates of soil erosion and these areas are also under higher rank of watershed prioritization. Hence, these particular areas need to be paid more attention in comparison to the remaining zone. This work may be beneficial as a case study in any tropical river basin or watershed with the possibility of high soil loss risk.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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