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Control The Soil Erosion & Land Pollution By Flood Reduction in The Tapi River,Surat District, Gujarat, India.

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ABSTRACT

In this study, morphometric analysis and prioritization of the five mini watersheds of ver watershed, located between Bodhan and Ghala of Surat district in Gujarat State, India is carried out using Remote Sensing and GIS techniques. The morphometric parameters considered for analysis are stream length, bifurcation ratio, drainage density, stream frequency, texture ratio, form factor, circularity ratio, elongation ratio, Shape Factor and compactness ratio. The ver watershed has a dendritic drainage pattern. The highest bifurcation ratio among all the mini watersheds is 11.13 which indicates a strong structural control on the drainage. The maximum value of circularity ratio is 0.72 for the mini watershed 5C1A4a. The mini watershed 5C1A4d has the maximum elongation ratio (0.72). The form factor values are in range of 0.37 to 0.40 which indicates that the ver watershed has moderately high peak flow for shorter duration. The compound parameter values are calculated and prioritization rating of five mini watersheds in ver watershed is carried out. The mini watershed with the lowest compound parameter value is given the highest priority. The mini watershed 5C1A4b has a minimum compound parameter value of 2.2 is likely to be subjected to maximum soil erosion hence it should be provided with immediate soil conservation measures. The present study is focused on the identification of suitable sites for location of water harvesting structures like Check Dams, Under sluice way based on Geo-visualization concept with watershed prioritization using Morphometric analysis.

Keywords : SRTM. LTB . GIS . Morphometric Analysis . Prioritization

Introduction

Due to rain and wind action our land is subjected to soil erosion and degradation, which ultimately results in changes in river morphology, reservoir sedimentation and reduction in storage capacity, poor crop yields, floods and more. Integrated use of remote sensing and GIS techniques can be used in soil erosion assessment and watershed prioritization studies. The input parameters required for soil erosion modeling can be generated by remote sensing (for example, land use map of a watershed). Geographical information system helps in creation of a data base for the watershed which is very much useful for carrying out spatial analysis there by helping the decisionmakers in framing appropriate measures for critically affected areas. In the recent past sediment yield and soil erosion studies using GIS and remote sensing technologies have been carried out by many investigators. Desmet and Govers (1996) used a GIS procedure for automatically calculating the USLE LS factor on topographically complex landscape units. Kothyari and Jain (1997) estimated sediment yield using a Geographical Information System. Jasrotia et al. (2002) carried out rainfall-runoff and soil erosion modeling using remote sensing and GIS techniques for the Tons watershed. Morphometric analysis is a significant tool for prioritization of micro-watersheds even without considering the soil map (Biswas et al.. 1999). Morphometric analysis requires measurement of the linear features, gradient of channel network, and contributing ground slopes of the drainage basin. Many works have been reported on morphometric analysis using remote sensing and G1S techniques. Shrimali et all. (2001) presented a case study of the 42 km 2 Sukhana lake catchment in the Shiwalik hills for the delineation and prioritization of soil erosion areas by using remote sensing and GIS techniques. Srinivasa et al. (2004) has used remote sensing and GIS techniques in morphometric analysis of subwatersheds of Pawagada area, Tumkur district, Karnataka. Chopra el al. (2005) carried out morphometric analysis of Bhagra-Phungotri and Hara Maja sub-watersheds of Gurdaspur district, Panjab. Khan et al. (2001) used remote sensing and GIS techniques for watershed prioritization in the Guhiya basin, India. Nookaratnam et al. (2005) carried out study on check dam positioning by prioritization of micro-watersheds using the sediment yield index (SY1) model and morphometric analysis using remote sensing and GIS. In the present study, morphometric analysis and prioritization of miniwatersheds are carried out for five miniwatersheds of Ver watershed lying between Bodhan and Ghala of Surat district in Gujarat State, India by using Remote Sensing and GIS techniques.

Description of Study Area

The Ver watershed, a part of the LTB of Surat district in Gujarat, covering an area of 92.51 km2 and is bounded by North latitudes 21° 00″ to 21° 43″ and East longitudes 73° 15″ to 78° 16”. The study area is located immediately downstream of the Ukai reservoir, the main reservoir on the LTB, and extends up to 65 km. The left bank canal of Ukai reservoir passes through Ver watershed. At 25 km downstream of Ukai reservoir, Kakrapar weir is situated on river Tapi, which leads left bank and right bank canal and also passes through some watersheds. The topography in LTB comprises narrow valley and gently sloping ground (Central Water Commission 2000–2001). The mean daily maximum temperature in study area rises up to 44.4°C in summer, while mean daily minimum temperature can be as low as 10°C in winter. In LTB, humidity varies from 40% to 80% and an average annual rainfall is 1376 mm. The main crops are sugarcane and cotton, mainly irrigated by Kakrapar left bank and right bank canal.

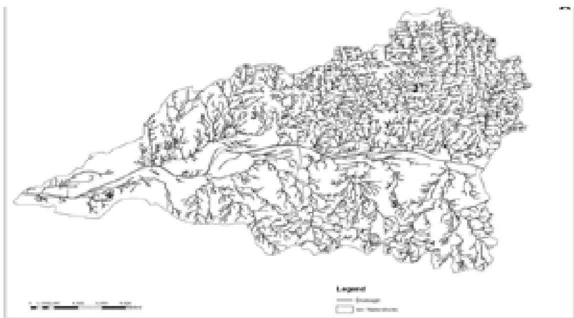

Fig. 1. Drainage map of the Ver watershed

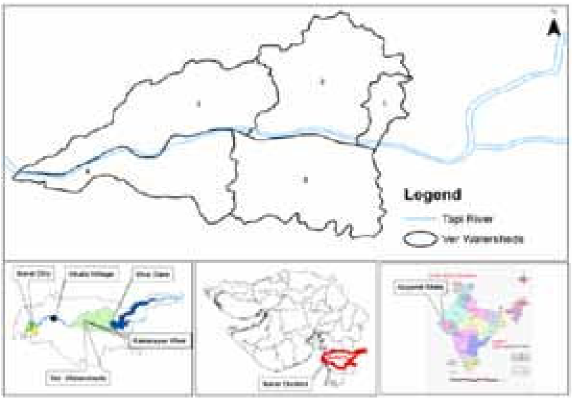

Fig. 2: Location Map of the Study Area

Methodology

In the present study, morphometric analysis and prioritization of miniwatersheds in Ver watershed is based on the integrated use of remote sensing and GIS techniques. The satellite images taken by The satellite image of IRS-P6 PAN + LISS-III merged geocoded products on 1:50,000 scale are used for classification of various themes. The satellite data dated 20.4.2005 were used for preparing the drainage layer. The remotely sensed data was geometrically rectified with respect to Survey of India (SOI) topographical maps at 1:50,000. Image enhancement techniques were applied for better interpretation of drainage from images. The digitization of dendritic drainage pattern was carried out in GIS environment. The stream ordering was carried out using the Horton's law. The fundamental parameters namely; stream length, area, perimeter, number of streams and basin length were derived from the drainage layer. The morphometric parameters for the delineated watershed area were calculated based on the formula suggested by Horton (1945), Strahler (1964), Schumn (1956), Nookaratnam et al. (2005) and Miller (1953) given in Table 1. The morphometric parameters values namely; stream length, bifurcation ratio, drainage density, stream frequency, form factor, Shape Factor, texture ratio, elongation ratio, circularity ratio, and compactness constant were calculated. Prioritization ratting of all the five miniwatersheds of Ver watershed was carried out by calculating the compound parameter values. The miniwatershed with the lowest compound parameter value was given the highest priority. To find suitable locations, site was visualized through fly tool of ArcScene 9.1 as per the priority assigned. It means higher ranked watersheds were visualized first and so on. Thus, we can visualize each mini watershed using morphometric analysis, and thus can find the best feasibility of positioning a water harvesting structure by overlaying of DEM (fig-3), soil map(fig-4) and slope map(fig-5).The proposed water harvesting structures has been validated with the data of previous water harvesting structures in the area.

Table 1 : Formula for Computation of Morphometric Parameters

Morphometric Parameters	Formula	Reference
Stream Order (u)	Hierarchical rank	Strahler (1964)
Basin Length (Lb)	Lb = 1.312×A0.568 Where,Lb = Length of Basin (km) A = Area of Basin (km2)	Nookaratnam et al. (2005)
Stream Length (L)	Length of the stream	Horton (1945)
Bifurcation Ratio (Rb)	Rb = Nu/Nu+1 Where,Rb = Bifurcation Ratio Nu = Total number of stream segment of order'u' Nu+1 = Number of segment of next higher order	Schumn (1956)
Drainage Density (Dd)	Dd = Lu/A Where, Dd = Drainage density Lu = Total stream length of all order A = Area of the basin	Horton (1945)
Stream Frequency (Fu)	Fu = Nu/A Where, Fu = Total number of streams of all order A = Area of the Basin (km2)	Horton (1945)
Texture Ratio (T)	T = Nu/P Where, Nu = Total number of streams of all orders P = Perimeter (km)	Horton (1945)
Length of Overland Flow (Lo)	Lo = ½ Dd Where, Lo = Length of the Overland Flow D = Drainage density	Horton (1945)
Form Factor (Rf)	Rf = A/Lb2 Where, Rf = Form Factor A = Area of the basin (km2) Lb2 = Square of the basin length	Horton (1945)
Shape Factor (Bs)	Rf = Lb2/ A Where, Bs = Shape Factor A = Area of the basin (km2) Lb2 = Square of the basin length	Nookaratnam et al. (2005)
Elongation Ratio (Re)	Re= (2/Lb) × (A/π) ½ Where, Re = Elongation Ratio Lb = Length of basin (km) A = Area of the basin (km2)	Schumn (1956)
Compactness Constant (Cc)	Cc = 0.2821P/A0.5 Where, Cc=Compactness Constant A = Area of the basin (km2) P = Perimeter of the basin (km)	Horton (1945)
Circularity Ratio (Rc)	Rc = 4πA/P2 Where, Rc = Circularity Ratio A = Area of the basin (km2) P = Perimeter (km)	Miller (1953)

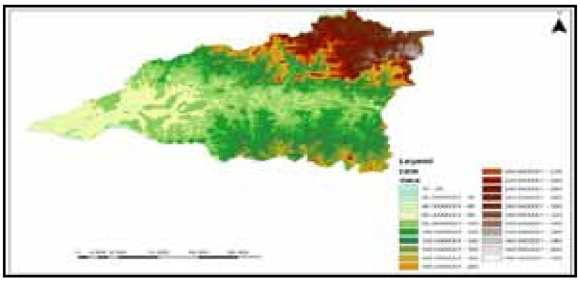

Fig:3 DEM Map

Results and Interpretation

The drainage map and Location Map of the Ver watershed (Fig. 1& 2) is prepared using the spatial tools . The stream order analysis is carried out using the neworder software developed by Bhaskaracharya Institute for Space Applications and Geo-informatics (BISAG). The number of streams of a given stream orders for all the five rniniwatersheds of Ver watershed are shown in Table 2. The fundamental parameters namely stream length, area, perimeter, basin length,bifurcation ratio, drainage density, stream frequency, form factor,Texture Ratio. elongation ratio, Shape Factor, circularity ratio, and compactness constant of streams for each of the miniwatersheds are calculated and shown in Table 3.Ver watershed shows a dendritic drainage pattern. The highest bifurcation ratio is 11.13 for 5C1A4a miniwatershed. The highest circularity ratio is 0.72 for miniwatershed 5C1A4a. The miniwatershed 5C1A4d has the highest elongation ratio (0.72) indicating possibility of less erosion. The form factor values are in range of 0.37 to 0.40. The compound parameter values of Five miniwatersheds of Ver watershed are calculated and prioritization ranking is shown in Table 4.

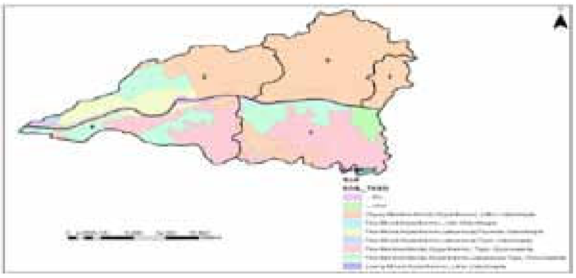

Fig:4 Soil order map of the Ver watershed

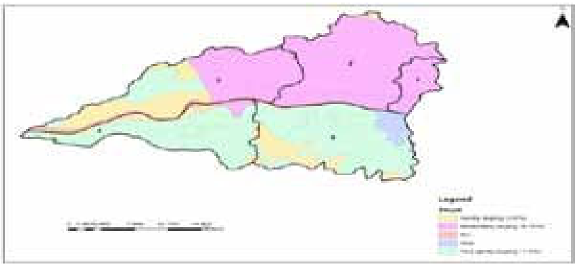

Fig:5 Slope map of the Ver watershed

Miniwatershed no. 5C1A4b with a compound parameter value of 2.2 receives the highest priority (one) with the next in the priority list is miniwatershed number 5C1A4e having the compound parameter value of 2.7. Highest priority indicates tile greater degree of erosion in the particular miniwatershed and it becomes potential candidate for applying soil conservative measure. The final prioritized map of the study area is shown in Figure 6. Thus soil conservation measures can first be applied to miniwatershed area 5C1A4b and then to the other miniwatersheds depending upon their priority. The others points where there is a need of these water harvesting structures are suggested in mini-watershed 5C1A4b and 5C1A4e (Fig. 7). These analyses show that the priority based characterization is a promising approach for water harvesting structures allotment in the watersheds. Timely placement of these structures may reduce a number of losses and flood in the downstream area.

Table 2: Stream analysis

Watershed	Stream orders					
	I	II	III	IV	V	TOTAL
5C1A4a	161	55	33	23	0	**272**
5C1A4e	819	358	209	118	0	**1504**
5C1A4d	526	257	129	58	0	**970**
5C1A4a	225	113	59	24	2	**423**
5C1A4b	389	196	75	68	11	**739**
TOTAL	**2120**	**979**	**505**	**291**	**13**	**3908**

Table 3 : (Table A,B,C)Stream Morphometric Parameters

Table A

Water shed	Basic para.					
	A	P	L	N	N1	Lb
5C1A4a	17.95	20.36	142.72	272	161	6.76
5C1A4e	15.33	22.29	721.86	1504	819	6.18
5C1A4d	15.05	19.05	546.24	970	526	6.12
5C1A4a	27.62	21.97	295.32	423	225	8.64
5C1A4b	16.56	22.33	490.59	739	389	6.46

Table B

Water shed	Linear para.				
	Rb	Dd	Fu	T	Lo
5C1A4a	2.01	7.9	15.15	7.9	3.97
5C1A4e	1.92	47.08	98.1	36.7	23.54
5C1A4d	2.08	36.29	64.45	27.6	18.14
5C1A4a	11.13	10.69	15.31	10.24	5.34

Table C

Watershed	Shape para.				
	Rf	Bs	Re	Cc	Rc
5C1A4a	0.39	2.54	0.7	1.35	0.544
5C1A4e	0.40	2.49	0.71	1.6	0.387
5C1A4d	0.41	2.48	0.71	1.38	0.521
5C1A4a	0.37	2.7	0.68	1.17	0.719
5C1A4b	0.39	2.52	0.71	1.54	0.417

Table 4: Prioritization Results of Morphometric Ranking

Water sheds	Rb	Dd	Fu	T	Lo	Rf	Bs	Re	Cc	Rc	Cf	Rank
5C1A4a	4	2	2	2	2	4	3	4	4	2	2.9	4
5C1A4e	5	3	3	3	3	1	2	1	1	5	2.7	2
5C1A4d	3	5	5	5	5	5	5	5	3	3	4.4	5
5C1A4a	1	4	4	4	4	2	1	2	5	1	2.8	3
5C1A4b	2	1	1	1	1	3	4	3	2	4	2.2	1

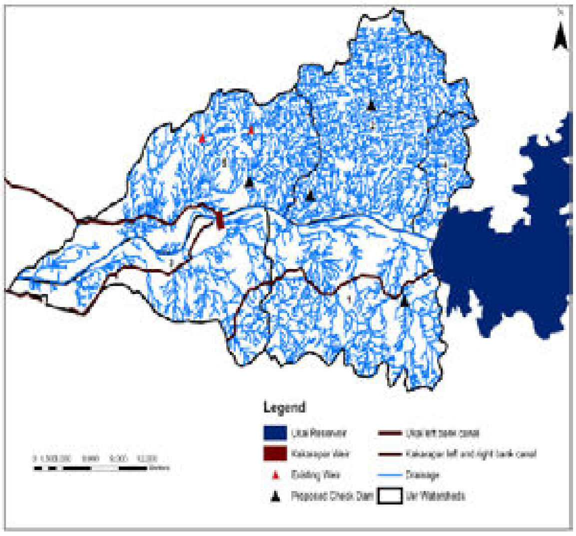

Fig:6 Water storage structures and Ranking map at Ver mini watersheds

Fig:7 A Positioned water harvesting structure by Geovisualization concept

Conclusions

The present study demonstrates the usefulness of GIS for morphometric analysis and prioritization of the miniwatersheds of Ver watershed of Gujarat. Further, the remote sensing techniques have been found to be suitable for the preparation of updated drainage map in a timely and cost-effective manner and should be preferred in soil erosion studies for deriving input data. Results of morphometric analysis show that miniwatersheds 5C1A4b and 5C1A4e are possibly having high erosion. Hence, suitable soil erosion control measures are required in these miniwatersheds to preserve the land from further erosion. Geo-visualization is helpful for positioning a water harvesting structure in Ver mini watersheds. These structures directly check the excessive water coming from the Ver mini watersheds. It leads the soil as well as water conservation and reduces the high run off and flood potential. Thus, for sustainable development of watersheds, soil and water conservation can be done by positioning suitable water harvesting structure in Ver watersheds. A site without field visit can be visualized and decisions of locating an appropriate water harvesting structure be taken. These structures directly check the excessive water coming from the watersheds. If this flow of excess water flowing from watershed is reasonably controlled, it will lead to a reduction in flood occurrences in the Tapi river

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