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PRIORITIZATION OF SUB-BASINS IN JAISAMAND CATCHMENT USING REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM

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ABSTRACT

The drainage characteristics of the Jaisamand catchment have been studied using Survey of India's topographic sheets of 1: 50,000 scales. The drainage pattern for delineated Jaisamand catchment was exported to ARC/GIS-10 software for morphometric analysis. The parameters computed in the present study includes stream order, stream length, stream frequency, bifurcation ratio, drainage density, stream frequency, form factor, circulatory ratio, elongation ratio, relief ratio and ruggedness number by standard methods and formulae. Then prioritization of different sub basins according to the order in which they have to be taken for treatment and soil conservation measures carried out. The total length of stream segments is maximum in first order streams and decreases as the stream order increases. The total stream length in the Jaisamand catchment is 7351.83 km. The values of the stream length ratio vary from 2.31 to 6.29 for the whole Jaisamand catchment. The relief of the catchment is 413 m and it varies from 83 m to 413 m in the sub-basins of the study area. The drainage density in the whole basin and sub-basins of the study area shows variation from 2.33 to11.50 km per km^2 suggesting high drainage density.

KEYWORDS: Jaisamand Catchment, Morphometric Analysis, Prioritization

INTRODUCTION

Morphometry is the measurement and mathematical analysis of the earth's surface, shape and dimension of its landforms and this analysis could be achieved through measurement of linear, aerial and relief aspects of basin and slope contributions (Nag and Chakraborty, 2003; Putty, 2007). Morphometry represents the topographical expression of land by way of area, slope, shape, length, etc. These parameters affect catchment stream flow pattern through their influence on concentration time (Jones, 1999). The morphological parameters directly or indirectly reflect the entire watershed based causative factors affecting runoff and sediment loss. The parameters have been conveniently worked out from the toposheet using GIS tools. Drainage basins are the fundamental units to understand geometric characteristics of fluvial landscape, such as topology of stream networks, and quantitative description of drainage texture, pattern, shape and relief characteristics (Obi, Reddy *et al.,* 2004; Subba, Rao, 2009). Morphometric analysis is an important technique to evaluate and understand the behaviour of hydrological system. It provides quantitative specification of basin geometry to understand initial slope or inconsistencies in rock hardness, structural controls, recent diastrophism, geological and geomorphic history of drainage basin (Strahler 1964; Esper, Angillieri, 2008). Morphometric studies of a river basin comprise discrete morphologic region and have special relevance to drainage pattern and geomorphology (Strahler 1957; Dornkamp and King, 1971). Prioritization is very important to prepare a comprehensive basin management and conservation plan. Several studies have been carried out on prioritization of sub basins based on morphometric analysis, (Krishnamurthy *et al.*, 1996; Biswas *et al.* 1999; Khan *et al.,* 2001; Srinivasa *et al.,* 2008; Nookaratnam *et al*., 2005; Thakkar and Dhiman 2007; Javed *et al*., 2009; Avinash *et al.,* 2011; Vincy *et al.,* 2012). A study by Mesa (2006) reveals that geology, relief and climate are the primary causes of running water ecosystems at the basin scale. Subba, Rao (2009) has attempted to define how the numerical scheme is helpful in watershed development planning programmes. In the present study morphometric parameters have been used to prioritize sub-basin according to soil and water conservation measures.

MATERIALS AND METHODS

Study Area

The Jaisamand lake catchment is located in the Udaipur district which falls semi-arid region of Rajasthan bounded by Longitude $73^0$45' E to $74^0$25'E and Latitude $24^0$10' N to $24^0$35' N Figure 1. The study area falls in Survey of India (SOI) toposheets of 45H-14,15,16, 45L-2,3,4,6,7,8 of 1:50,000 scale. The lake is also a prime source supply of drinking water for the city of Udaipur located at a distance of about 52 km from the lake. The Jaisamand lake with a gross capacity of 414.6 Mm^3 and live storage of 296.14 Mm^3, is Asia's second largest artificial water storage reservoir built across the Gomati_river. Jaisamand is a prominent medium irrigation project with a cultivable command area of 160 km^2 downstream of the lake. The total catchments area of Jaisamand Lake 1,857.87 km^2 with highest elevation is 693 above mean sea level, located in sanctuary area very nears to bund. In Jaisamand catchment Gomati, Thavaria, Siroli, Vagurwa, Jhamri, Sukhali, Godi, Makradi and Bhangar are the major rivers. There is serious threat to environment in the catchment due to admixture of land degradation, severe erosion, declining water table and biodiversity reduction in whole catchments due to lack of sustainable water resources management. The area has humid climate with an average rainfall of 700 mm per year. The area has mild winters and mild summers. The humidity is high and all these factors putting together support good vegetation growth.

Geomorphological Analysis

Geomorphological analysis is the systematic description of watershed's geometry and its stream channel system to measure the linear aspects of drainage network, aerial aspects of watershed and relief aspects of channel network. The morphological parameters directly or indirectly reflect the entire watershed based causative factors affecting runoff and sediment loss. The parameters have been conveniently worked out from the toposheet using GIS tools. The geomorphological parameters were determined by using different formulae as shown in Table 1.

Prioritization of Sub–Basins

Basin prioritization is the ranking of different sub basins according to the order in which they have to be taken for treatment and soil conservation measures. Morphometric analysis is a significant tool for prioritization of sub basins. The morphometric parameters i.e., bifurcation ratio (R_b), basin shape factor(S_b), compactness coefficient (C_c), drainage density (D_d), stream frequency (F_s), drainage texture (T), form factor (R_f), circularity ratio (R_c), and elongation ratio (R_e) are also termed as erosion risk assessment parameters and have been used for prioritizing sub-basins for treatment and conservation measures (Biswas *et al*., 1999). The linear parameters such as drainage density, stream frequency, bifurcation ratio, texture ratio have a direct relationship with erodibility, higher the value, more is the erodibility. Hence, for prioritization of sub basins, the highest value of these linear parameters was rated as rank 1, second highest value was rated as rank 2 and so on, and the least value was rated last in rank. Shape parameters such as elongation ratio, compactness coefficient, and circularity ratio and form factor have an inverse relationship with erodibility (Nooka Ratnam *et al*., 2005), lower the value, more is the erodibility. Thus the lowest value of these shape parameters was rated as rank 1, next lower value was rated as rank 2 and so on and the highest value was rated last in rank. The ranking of the sub basins have been determined by assigning the highest priority/rank based on highest value in case of linear parameters and lowest value in case of shape parameters. After completion of rating based on every single parameter, the rating values for every sub basins were averaged to arrive at a compound value. Based on these compound rating values, the sub basin having the least rating value was assigned highest priority number of 1 next higher value was assigned priority number 2 and so on. The sub basin which received the highest compound value was assigned the last priority number.

RESULTS AND DISCUSSIONS

The study was undertaken to determine the morphometric parameters and prioritization of sub-basin in Jaisamand catchment by using Arc-GIS software. For this study different formulae were used for computation of morphometric parameters. The results obtained during research work discussed below.

Linear Aspects

The linear aspects of the basin such as stream order (N_u), stream length (L_u) and bifurcation ratio (R_b) were determined and results have been given in Table 2 (a & b). In the present study ranking of streams has been carried out based on the method proposed by Strahler (1964). Out of these fourteen sub-basins, sub-basin 1, 8, 9 and 10 are sixth order basin Figure 4. Table 3 also shows that the maximum stream frequency was found in case of first order streams and there is a decrease in stream frequency as the stream order increases. The order wise total number of stream segment is known as the stream number. Horton's (1945) laws of stream numbers states that the number of stream segments of each order form an inverse geometric sequence with plotted against order, most drainage networks show a linear relationship, with small deviation from a straight line. The plotting of logarithm of number of streams against stream order is given in Figure 2 according to the law proposed by Horton gives a straight line. It means that the number of streams usually decreases in geometric progression as the stream order increases.

The stream lengths for all sub-basins of various orders were measured on digitized map with the help of GIS. The total length of stream segments is maximum in first order streams and decreases as the stream order increases. The total stream length in the Jaisamand catchment is 7351.83 km and that of the fourteen sub-basins are 857.33 km, 71.39 km, 422.09 km, 418.44 km, 191.53 km, 364.71 km, and 533 km, 336.44 km, 1338.35 km, 341.3 km, 1013.22 km, 840.63 km, 437.53 km and167.87 km respectively Table 2 a. The stream length ratios (R_L) are changing haphazardly at the basin and sub-basins level. The values of the stream length ratio (R_L) vary from 0.08 to 58.93 for sub-basins, while it ranges from 2.31 to 6.29 for the whole Jaisamand catchment Table 2 b. It is noticed that the R_L between successive stream orders of the basin vary due to differences in slope and topographic conditions (Sreedevi *et al.*, 2005). The Stream Length Ratio (R_L) has an important relationship with the surface flow discharge and erosional stage of the basin.

In the present study, it was observed that the plot of logarithm of the cumulative stream length as ordinate vs. stream order as abscissa is almost a straight line fit. The straight-line fit indicates that the ratio between cumulative length and order is constant throughout the successive orders of a basin Figure 3.

The mean bifurcation ratio values range between 3.71 to 5.73 for the basins of the study area indicating that all the basins are falling under normal basin category (Strahler, 1957). The bifurcation ratio is also an indicative tool of the shape of the basin. Elongated basins have low R_b value, while circular basins have high R_b value (Morisawa, 1985). In this study area, the higher value of R_b indicates a strong structural control in the drainage pattern whereas the lower value indicates that the sub-basins are less affected by structural disturbances (Strahler, 1964, Vittala *et al.*, 2004 and Chopra *et al.*, 2005).

Aerial Aspects

The aerial aspects of the basin like drainage density (D_d), stream frequency (F_s) elongation ratio (R_e), circularity ratio (R_c), form factor (R_f), were calculated and results have been presented in Table 3. The drainage density in the whole basin and sub-basins of the study area shows variation from 2.33 to11.50 km per km^2 suggesting high drainage density. It indicates that the region is composed of weak or impermeable subsurface materials; sparse vegetation, mountainous relief and fine drainage texture (Reddy *et al.*, 2004). The stream frequency (F_s) mainly depends on the lithology of the basin and reflects the texture of the drainage network. The stream frequency (F_s) values of the basin and sub-basins of the study area are varying from 4.04 to 11.83. It is also seen that the drainage density values of the sub-basins exhibits positive correlation with the stream frequency, suggesting that there is an increase in stream population with respect to increasing drainage density. Generally, High value of stream frequency (F_s) is related to impermeable sub-surface material, sparse vegetation, high relief conditions and low infiltration capacity (Reddy *et al.*, 2004).

Form Factor (R_f) proposed by Horton (1945) to predict the flow intensity of basin of a defined area. The index of R_f shows the inverse relationship with the square of the axial length and a direct relationship with peak discharge. The value of form factor would always be greater than 0.78 for a perfectly circular basin. Smaller the value of form factor, more elongated will be the basin. Form Factor (R_f) values of whole basin and sub-basins of the study area vary from 0.12 to 0.35, which indicate that they are sub-circular and elongated in shape. The elongated basin with low form factor indicates that the basin will have a flatter peak of flow for longer duration. Flood flows of such elongated basins are easier to manage than of the circular basin (Nautiyal, 1994).

The circularity ratio (R_c) is affected by the lithological character of the basin. Its values approaching one indicates that the basin shapes are like circular and as a result, it gets scope for uniform infiltration and takes long time to reach excess water at basin outlet, which further depends on the prevalent geology, slope and land cover. The ratio is more influenced by length, frequency (F_s) and gradient of various orders rather than slope conditions and drainage pattern of the basin. The R_c of the whole basin and sub-basins of the study area vary from 0.27 to 0.54, which indicates the dentritic stage of a basin.

The elongation ratio (R_e) is a very significant index in the analysis of basin shape, which helps to give an idea about the hydrological character of a drainage basin. Elongation ratio (R_e) for the study area varied from 0.39 to 0.67 as shown in Table 4. The value near 1 is typical of regions of very low relief, whereas values in the range of 0.6 to 0.8 are generally associated with strong relief and steep ground slopes (Strahler, 1968).

Schumm (1956) used the inverse of drainage density as a property known as the constant of channel maintenance (C). It is the area of basin surface needed to sustain a unit length of stream channel and is depends on the rock type, permeability, climatic regime, vegetation cover as well as duration of erosion. In areas of close dissection, its value will be very low. The value of constant channel maintenance (C) of the study area varied from 0.09 to 0.43, which indicates that these basin and sub-basins are under the influence of high structural disturbance, low permeability, steeps to very steep slopes and high surface runoff.

The length of overland flow (L_g) is the length of water over the ground before it gets concentrated into definite stream channels. It is approximately equals to half of the reciprocal of drainage density (Horton, 1945). This factor relates inversely to the average slope of the channel and is synonymous with the length of the sheet flow to the large degree. The length of overland flow (L_g) is one of the most important independent variables, affecting both the hydrological and physiographical development of the drainage basins (Horton, 1945). The computed value of L_g for all sub-basins and basin varies from 0.04 to 0. 21 km^2/km. The low L_g values of basin and sub-basins indicate to short flow paths, with steep ground slopes, reflecting the areas associated with more run-off and less infiltration.

Relief Aspects

Relief aspect of the watershed plays an important role in drainage development, surface and sub-surface water flow, permeability, landform development and associated features of the terrain. Relief is the maximum vertical distance between the lowest and the highest points of a basin. The maximum height of the Jaisamand catchment is 693 m and the lowest is 280 m. Therefore, the relief of the basin is 413 m Figure 5. The relief of sub-basins of the study area is varying from 83 m to 413 m. The high relief value indicates the gravity of water flow, low infiltration and high runoff conditions of the study area. Relief ratio has direct relationship between the relief and channel gradient. The relief ratio normally increases with decreasing drainage area and size of the watersheds of a given drainage basin. The relief ratio of the Jaisamand catchment is 0.00123, while that of the fourteen sub-basins vary from 0 to 0.02 as given in Table 4. The relief ratio of the basin as well as the sub-basins of the study area are low which are characteristic features of less resistant rocks of the area (Sreedevi, 1999).

Ruggedness number, R_N is the product of relief and drainage density in order to define the slope steepness and length. It is a dimensionless term and indicates the structural complexity of the terrain. The Jaisamand catchment displays the ruggedness number as 1.74 and indicate that the area is extremely rugged with high relief and high stream density. The ruggedness number of sub–basins varies from 0.19 to 4.75 as given in Table 4.

Prioritization of Sub–Basins

All of these morphometric parameters are compounded and a final rating scale was generated for the study area as shown in Table 5. Sub-basins were prioritized according to these rating. Based on the average value of compound parameters, the sub-basins having the lowest rating value is assigned the highest priority number of 1, next higher value was assigned second priority number of 2 and so on. The sub-basin, which got the highest compound parameters value, was assigned last priority. It was found that the lowest compound parameters value is 4.63 occurred in the sub-basin number 9 that is given high priority for conservation measures. The next priority is given to sub-basin 7, sub-basin 12, sub-basin 3, sub-basin 4, sub-basin 5, sub-basin 13, sub-basin 2, sub-basin 1, sub-basin 6, sub-basin 11, sub-basin 8 and sub-basin 14 respectively Table 5. Thus, soil and water conservation measures can first be applied to sub-basin number 9 and then to other depending on their priority.

Table 1: The Formulae Used for the Computation of Different Morphometric Parameters

Morphometric Parameters	Formula	Reference
Linear Parameters		
Length (L)	$L= 1.31*2A^{0.568}$ where L=Basin length (km) A=Area of the basin (km^2)	Nookaratnamet al. (2005)
Stream Order (u)	Hierarchical rank	Strahler (1964)
Stream Length (L_u)	Length of the stream	Horton (1945)
Mean Stream Length (L_{sm})	$L_{sm} =L_u/N_u$ where L_{sm}=Mean stream length L_u=Total stream length of order ‘u’ N_u=Total no. of stream segments of order ‘u’	Strahler (1964)
Stream Length Ratio (R_L)	$R=L_u/L_{u-1}$ where R_L=Stream length ratio L_u=Total stream length of order ‘u’ L_{u-1}=The total stream length of its next lower order	Horton (1945)
Bifurcation Ratio (R_b)	$R_b=N_u/N_{u+1}$ where R_b=Bifurcation ratio N_u=Total no. of stream segments of order ‘u’ N_{u+1}=Number of segments of the next higher order	Schumm (1956)
Mean Bifurcation Ratio (R_{bm})	R_{bm}=Average of bifurcation ratios of all orders	Strahler (1957)
Areal Parameters		
Form Factor (F_f)	$F_f =A/L^2$ where F_f=Form factor A=Area of the basin (km^2) L=Basin length (km)	Horton (1932, 1945)
Elongation Ratio (R_e)	$R_e =1.128\sqrt{A/L}$ where Re=Elongation ratio A=Area of the basin (km^2) L=Basin length (km)	Schumm (1956)
Circularity Ratio (R_c)	$R_c =4\pi A/P^2$ where R_c =Circularity ratio π=3.14 A=Area of the basin (km^2) P=Perimeter (km)	Miller (1953), Strahler (1964)
Shape Factor (S_b)	$S_b =L^2/A$ where S_b =Shape factor L=Basin length (km) A=Area of the basin (km^2)	Horton (1932)
Compactness Co-Efficient (C_c)	$C_c =0.2821* P/A^{0.5}$ where Cc =Compactness coefficient P=Perimeter (km) A=Area of the basin (km^2)	Gravelius (1914)
Drainage Density (D_d)	$D_d =L_u/A$ where D_d =Drainage density L_u =Total stream length of all orders A= Area of the basin (km^2)	Horton (1932, 1945)
Stream Frequency (F_s)	$Fs =\sum N_u/A$ where F_s =Stream frequency $\sum N_u$ =Total no. of streams of all orders A=Area of the Basin (km^2)	Horton (1932, 1945)

Table 1: Contd.,

Drainage Texture (T)	$T = D_d * F_s$ where T=Drainage texture D_d =Drainage density F_s =Stream frequency	Horton (1945)
Texture Ratio (T_r)	$T_r = N_1/P$ N_1= Total number of first order streams P =Perimeter of watershed	Horton (1945)
Constant of channel maintenance (C)	$C=1/D_d$ where C=Constant of channel maintenance D_d=Drainage density	Schumm (1956)
Length of overland flow (L_g)	$L_g = 1/2D_d$ where L_g =Length of overland flow D_d=Drainage density	Horton (1945)
Relief Parameters		
Basin relief (R)	R =H-h where R=Basin relief H=Maximum elevation in meter H=Minimum elevation in meter	Hadley and Schumm (1961)
Relief ratio (R_r)	R_r=R/L where R_r =Relief ratio R=Basin relief L=Longest axis in kilometre	Schumm (1956)
Ruggedness number (R_n)	$R_n = H*D_d$ where R_n =Ruggedness number H=Basin relief D_d =Drainage density	Schumm (1956)

Table 2(a): Linear Aspects of Jaisamand Catchment Sub-Basins

Basin/ Sub-Basin	Area (km^2)	Perimeter (km)	Stream Number of Different Orders							Order Wise Total Stream Length (km)						
			1	2	3	4	5	6	Total	1	2	3	4	5	6	Total
1	179.32	64.80	1683	344	73	14	5	2	**2121**	527.54	159.71	94.08	36.11	22.32	35.57	**875.33**
2	15.031	18.79	126	24	7	1	1		**159**	42.028	16.852	7.37	0.0859	5.06		**71.39**
3	92.04	47.21	695	132	33	5	1		**866**	270.56	74.96	43.97	21.79	10.81		**422.09**
4	11 8.87	57.01	734	138	27	8	2		**909**	256.41	78.28	40.58	26.28	16.89		**418.44**
5	38.79	38.32	337	71	16	2			**426**	117.72	43.98	15.52	14.31			**191.53**
6	89.42	53.23	611	124	23	4	1		**763**	222.16	70.91	27.36	28.51	15.77		**364.71**
7	143.75	59.51	921	166	33	7	3		**1130**	332.96	90.08	62.21	28.38	19.37		**533**
8	119.43	58.32	486	99	19	2	2	1	**609**	198.73	65.40	34.03	11.12	23.45	3.71	**336.44**
9	116.41	56.69	987	188	45	10	4	1	**1235**	339.50	899.97	50.04	34.29	9.41	5.14	**1338.35**
10	109.16	61.18	443	89	17	6	4	1	**560**	196.06	62.96	45.91	11.89	13.73	10.75	**341.3**
11	350.56	101.75	1556	262	60	17	5		**1900**	630.38	189.29	104.19	66.42	22.94		**1013.22**
12	240.65	80.35	1383	240	54	14	2		**1693**	494.30	163.61	98.99	59.26	24.48		**840.63**
13	172.43	89.79	639	106	25	8	1		**779**	280.58	76.89	42.87	27.45	9.74		**437.53**
14	71.95	48.28	237	39	11	3	1		**291**	129.81	20.44	10.32	5.77	1.53		**167.87**
Catchment	**1857.87**	**835.23**	**10838**	**2022**	**443**	**101**	**32**	**5**	**13441**	**4038.73**	**2013.33**	**677.44**	**371.66**	**195.50**	**55.17**	**7351.83**

Table 2(b): Linear Aspects of Jaisamand Catchment Sub-Basins

Basin/ Sub-Basin	Average Stream Length (km)							Stream Length Ratio(R_L)						Bifurcation Ratio(R_b)					
	1	2	3	4	5	6	Total	2/1	3/2	4/3	5/4	6/5	Mean R_L	R_b1	R_b2	R_b3	R_b4	R_b5	Mean R_b
1	0.31	0.46	1.29	2.58	4.46	17.79	**26.89**	1.48	2.78	2.00	1.73	3.98	**2.39**	4.89	4.71	5.21	2.80	2.50	**4.02**
2	0.33	0.70	1.05	0.09	5.06		**7.23**	2.11	1.50	0.08	58.93		**15.65**	5.25	3.43	7.00	1.00		**4.17**
3	0.39	0.57	1.33	4.36	10.82		**17.47**	1.46	2.35	3.27	2.48		**2.39**	5.27	4.00	6.60	5.00		**5.22**
4	0.35	0.57	1.50	3.29	8.45		**14.16**	1.62	2.65	2.19	2.57		**2.26**	5.32	5.11	3.38	4.00		**4.45**
5	0.35	0.62	0.97	7.16			**9.1**	1.77	1.57	7.38			**3.57**	4.75	4.44	8.00			**5.73**
6	0.36	0.57	1.19	7.13	15.77		**25.02**	1.57	2.08	5.99	2.21		**2.96**	4.93	5.39	5.75	4.00		**5.02**
7	0.36	0.54	1.89	4.06	6.46		**13.31**	1.50	3.47	2.15	1.59		**2.18**	5.55	5.03	4.71	2.33		**4.41**
8	0.41	0.66	1.79	5.56	11.73	3.71	**23.86**	1.62	2.71	3.11	2.11	0.32	**1.97**	4.91	5.21	9.50	1.00	2.00	**4.52**
9	0.34	4.79	1.11	3.43	2.35	5.14	**17.16**	13.92	0.23	3.08	0.69	2.18	**4.02**	5.25	4.18	4.50	2.50	4.00	**4.09**
10	0.44	0.71	2.70	1.98	3.43	10.75	**20.01**	1.60	3.82	0.73	1.73	3.13	**2.20**	4.98	5.24	2.83	1.50	4.00	**3.71**
11	0.41	0.72	1.74	3.91	4.59		**11.37**	1.78	2.40	2.25	1.17		**1.90**	5.94	4.37	3.53	3.40		**4.31**
12	0.36	0.68	1.83	4.23	12.24		**19.34**	1.91	2.69	2.31	2.89		**2.45**	5.76	4.44	3.86	7.00		**5.27**

Table 2b: Contd.,

13	0.44	0.73	1.71	3.43	9.75		**16.06**	1.65	2.36	2.00	2.84		**2.21**	6.03	4.24	3.13	8.00		**5.35**
14	0.55	0.52	0.94	1.93	1.53		**5.47**	0.96	1.79	2.05	0.79		**1.40**	6.08	3.55	3.67	3.00		**4.07**
Catchment	**5.4**	**12.84**	**21.04**	**53.14**	**96.64**	**37.39**	**226.45**	**2.50**	**2.31**	**2.76**	**6.29**	**2.40**	**3.25**	**5.35**	**4.52**	**5.12**	**3.50**	**3.13**	**4.32**

Table 3: Aerial Aspects of Jaisamand Sub-Basins

Basin/Sub-Basin	Form Factor	Shape Factor	Circulatory Ratio	Elongation Ratio	Texture Ratio	Compactness Constant	Drainage Density (km/km^2)	Stream Frequency	Constant of Channel Maintenance	Length of Overland Flow (km^2/km)
1	0.12	8.58	0.54	0.39	25.97	1.37	4.88	11.83	0.20	0.10
2	0.24	4.17	0.53	0.55	6.71	1.38	4.75	10.58	0.21	0.11
3	0.17	5.72	0.52	0.47	14.72	1.40	4.59	9.41	0.22	0.11
4	0.29	3.47	0.46	0.61	12.87	1.49	3.52	7.65	0.28	0.14
5	0.13	7.42	0.33	0.41	8.79	1.75	4.94	10.98	0.20	0.10
6	0.15	6.77	0.40	0.43	11.48	1.60	4.08	8.53	0.25	0.12
7	0.31	3.19	0.51	0.63	15.48	1.41	3.71	7.86	0.27	0.13
8	0.22	4.60	0.44	0.53	8.33	1.52	2.82	5.10	0.35	0.18
9	0.31	3.23	0.46	0.63	17.41	1.49	11.50	10.61	0.09	0.04
10	0.14	7.14	0.37	0.42	7.24	1.66	3.13	5.13	0.32	0.16
11	0.20	5.03	0.43	0.50	15.29	1.54	2.89	5.42	0.35	0.17
12	0.25	4.00	0.47	0.56	17.21	1.47	3.49	7.03	0.29	0.14
13	0.35	2.86	0.27	0.67	7.12	1.94	2.54	4.52	0.39	0.20
14	0.34	2.95	0.39	0.66	4.91	1.62	2.33	4.04	0.43	0.21
Catchment	**0.23**	**4.94**	**0.44**	**0.53**	**12.40**	**1.55**	**4.23**	**7.76**	**0.28**	**0.14**

Table 4: Relief Aspects of Jaisamand Sub-Basins

Basin/ Sub-Basin	Elevation (M)		Relief (M)	Relief Ratio	Ruggedness Number
	Max.	Min.			
Sub-basin-1	558.00	335.00	223.00	0.01	1.09
Sub-basin-2	503.00	334.00	169.00	0.02	0.80
Sub-basin-3	610.00	353.00	257.00	0.01	1.18
Sub-basin-4	493.00	355.00	138.00	0.01	0.49
Sub-basin-5	404.00	308.00	96.00	0.01	0.47
Sub-basin-6	476.00	305.00	171.00	0.01	0.70
Sub-basin-7	485.00	346.00	139.00	0.01	0.52
Sub-basin-8	434.00	284.00	150.00	0.01	0.42
Sub-basin-9	693.00	280.00	413.00	0.02	4.75
Sub-basin-10	441.00	288.00	153.00	0.01	0.48
Sub-basin-11	509.00	326.00	183.00	0.00	0.53
Sub-basin-12	490.00	317.00	173.00	0.01	0.60
Sub-basin-13	487.00	283.00	204.00	0.01	0.52
Sub-basin-14	369.00	286.00	83.00	0.01	0.19
Jaisamand catchment	**693**	**280**	**413**	**0.00123**	**1.74**

Table 5: Prioritization Result of Sub- Basins Based on Morphometric Analysis

Sub-Basin No.	Bifurcation Ratio	Drainage Density	Stream Frequency	Texture Ratio	Circulatory Ratio	Form Factor	Elongation Ratio	Compactness Constant	Compound Parameter	Final Priority
Sub-basin-1	13	3	1	1	1	13	13	13	7.25	**7**
Sub-basin-2	10	4	4	13	2	6	6	12	7.13	**6**
Sub-basin-3	4	5	5	6	3	9	9	11	6.50	**4**
Sub-basin-4	7	8	8	7	6	4	4	8	6.50	**4**
Sub-basin-5	1	2	2	9	12	12	12	2	6.50	**4**
Sub-basin-6	5	6	6	8	9	10	10	5	7.38	**8**
Sub-basin-7	8	7	7	4	4	3	3	10	5.75	**2**
Sub-basin-8	6	12	12	10	7	7	7	7	8.50	**10**
Sub-basin-9	11	1	3	2	6	3	3	8	4.63	**1**
Sub-basin-10	14	10	11	11	11	11	11	3	10.25	**12**
Sub-basin-11	9	11	10	5	8	8	8	6	8.13	**9**
Sub-basin-12	3	9	9	3	5	5	5	9	6.00	**3**
Sub-basin-13	2	13	13	12	13	1	1	1	7.00	**5**
Sub-basin-14	12	14	14	14	10	2	2	4	9.00	**11**

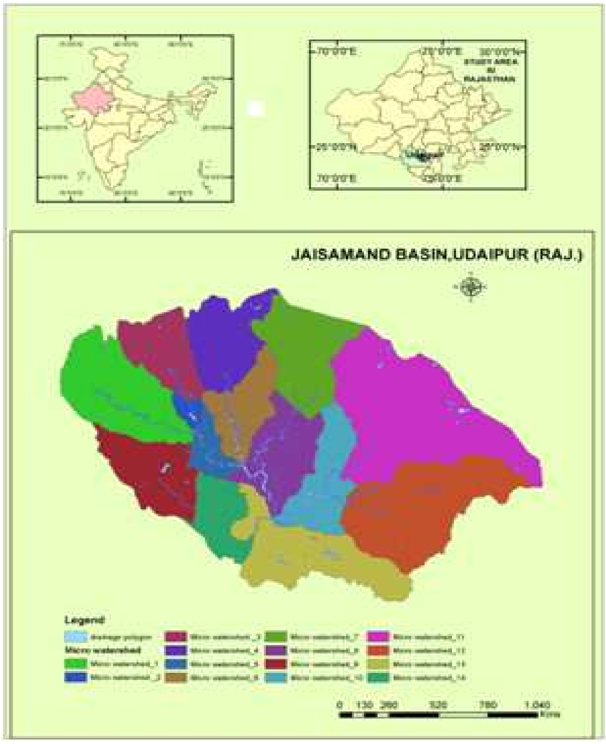

Figure 1: Location Map of Study Area

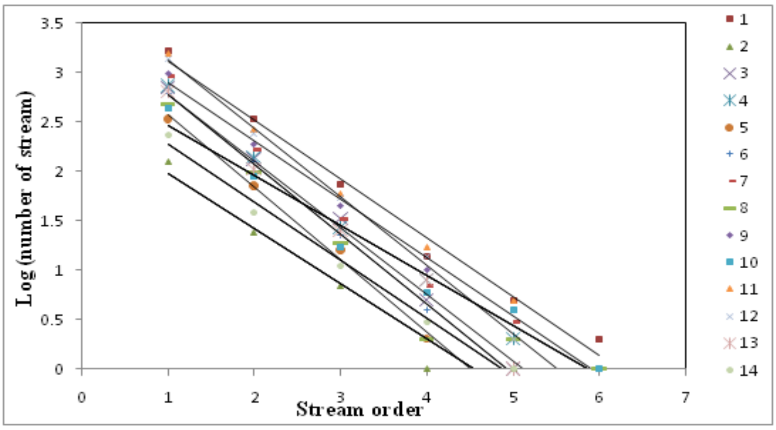

Figure 2: Relationship between Log (Number of Stream) and Stream Order

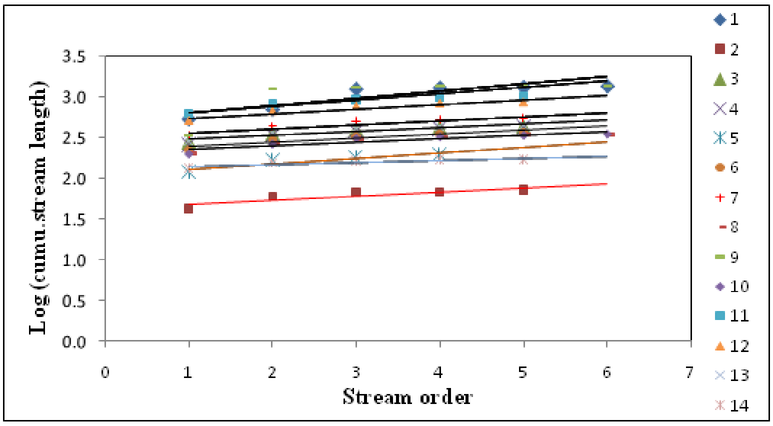

Figure 3: Relationship between Log (Number of Stream Length) and Stream Order

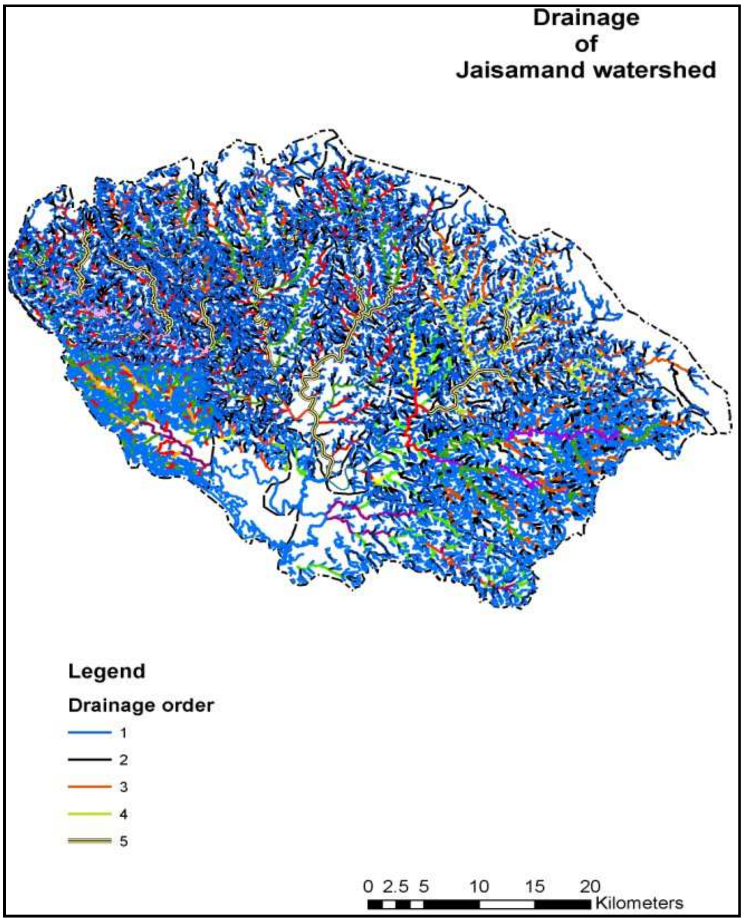

Figure 4: Drainage Map of Jaisamand Catchment

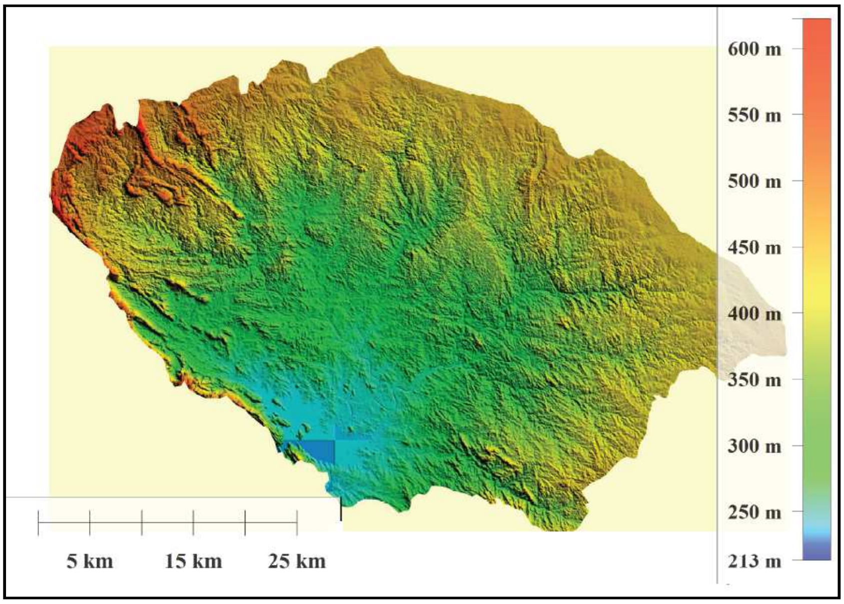

Figure 5: Topographical Elevation Map of Study Area

CONCLUSIONS

Watershed prioritization is one of the most important aspects of planning for implementation of its development and management programmes. The present study demonstrates the usefulness of GIS for morphometric analysis and prioritization of the sub-basins of Jaisamand catchment of Rajasthan, India. The morphometric characteristics of different sub-basins show their relative characteristics with respect to hydrologic response of the watershed. Results of prioritization of sub-watersheds show that sub-basin 9, 7, and 12 are more susceptible to soil erosion. Therefore, immediate attention towards soil conservation measures is required in these sub-basins to preserve the land from further erosion and to alleviate natural hazards.

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