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Geomatics Techniques Based Significance of Morphometric Analysis in Prioritization of Watershed

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Abstract: For enhancing groundwater and surface water resources in arid and semi-arid regions watershed management and sustainable development plans are essential. For preparing such plans, understanding the topographical features, erosion status, basin management and physiographic characteristics of the basin is essential. Analysis of morphometric parameters gives an identification of sub-watershed which is erosion prone and requires soil erosion control measures to preserve the land from further erosion. Quantitative description of basin geometry i.e. Morphometric analysis was done to find out the drainage characteristics of Kshipra River basin located in Madhya Pradesh of Central India using SRTM imageries and GIS techniques. In this analysis catchment was divided into 43 sub-watersheds. The Kshipra River basin is a fairly well-drained basin with a dendritic and parallel drainage pattern. The main stream of the basin is sixth order and lower order i.e. first order stream dominates the basin and stream segment development is affected by slope and local relief.
The results revealed that the SW28 (Sub-Watershed) has the highest priority while SW41 has the lowest priority which is based on Morphometric parameters. Thus one can say that Sub-watershed 28, 25, 2, 11, and 27 are erosion susceptible and require suitable water and soil erosion control measures to preserve the land from further erosion. It has been well proven in the study that for understanding and computation of various terrain parameters and analysis of basin, Geomatics techniques is an effective tool. Thus, present study finds utility of GIS in river basin evaluation, basin prioritization for soil and water conservation and natural resource management.
Keywords: Arcgis, GIS, Morphometric analysis, Prioritization, Soil erosion susceptibility.

I. INTRODUCTION

Geology, relief and climate are the primary determinants of running water ecosystems functioning at the basin scale (Lotspeich and Platts 1982). Water is the most important natural resource without which life can't imagine. But as population increases demand of water also increases. As the result it is very important to preserve this natural resource in proper and efficient way (sustainable manner). For management of natural resources, watershed is an ideal unit. It also helps in management of land and water resource for achieving sustainable development. Main important factors for planning and development of a watershed are physiography of land surface, drainage pattern, geomorphology of river, soil characteristics, land use/land cover of watershed region and available water resources. To prepare a comprehensive watershed development plan, it becomes necessary to understand the topography, erosion status and drainage pattern of the region (Reedevi, Wais, Han & Hmed, 2009) and for this Geomatices Techniques such as Remote Sensing and GIS are the most effective tools. Many studies have been carried out and they have shown very good results. It also helps in prioritization of sub-watersheds for providing the rank to individual sub-watersheds according to their soil erosion status. Morphometric Analysis could be used for prioritization of sub-watersheds by studying different linear and aerial parameters of the watershed even without the availability of soil maps (Biswas, 1999). It is also feasible to extract finer details of the surface and provide scope for micro level planning and management due to advancement in satellites and sensing technology,

Recent studies reveled that some of the model inputs related to land use and land cover, soil etc have been successfully derived from remotely sensed data and modeling was carried out in GIS environment (Pandey et al., 2009), (Chatterjee et al., 2013).

The present study aims for identification of erosion prone region and also determines the soil erosion susceptibility of drainage basin by prioritization of sub-watersheds based on Morphometric analysis using Geomatics techniques.

II. STUDY AREA

The Kshipra, also known as the Shipra or Avanti nadi, is a river of Madhya Pradesh state of Central India. The Kshipra River originates in the Vindhya Range and flows in a northerly direction across the Malwa plateau to join the Chambal River. Upstream of its confluence with the Chambal, the Kshipra has a catchment area of 5423.20 km^2. It is considered as sacred as the Ganga River by the Hindus. The holy city of Ujjain is located on the right bank of the Kshipra River. The total course of about 190 km flows through Indore, Dewas and Gwalior districts of the state; it finally joins the Chambal near Kalu-Kher village (23°53' N. and 75°31"). The Kshipra basin lies between latitudes 22°27ˈ29ˈˈ to 23°56ˈ40ˈˈN and longitudes 75°25ˈ04ˈˈ to 76°13ˈ19ˈˈE. The average elevation of the basin is about 500 m above mean seal level. The climate of the study area is semi-arid and receives an average annual rainfall of about 1400 mm. About 90% of annual rainfall of Kshipra basin occurs during the southwest and northeast monsoon season spanning over June to December. The average maximum and minimum monthly temperatures of the basin are 37° and 24°C, respectively.

The soils of the area are black, brown and bhatori (stony) soil. The geology classes include sandstone, shale of Mesozoic age; laterite and lateritic gravel having residual soft and porous soft rock of Cenozoic age; and epidote-hornblende gneiss and hornblende-biotite gneiss of Archaean age occupying the north, south and western part of the study area, respectively.

The Kshipra river basin caters to the drinking water and industrial needs of Ujjain city and irrigation needs of the villages along the river course. The erratic with wide spatial and temporal variations of rainfall and the increasing water demand result in over-exploitation of groundwater of the basin. Recharge into the aquifers of the basin is mainly from precipitation, flow through river beds, water bodies and return flow from irrigated fields.

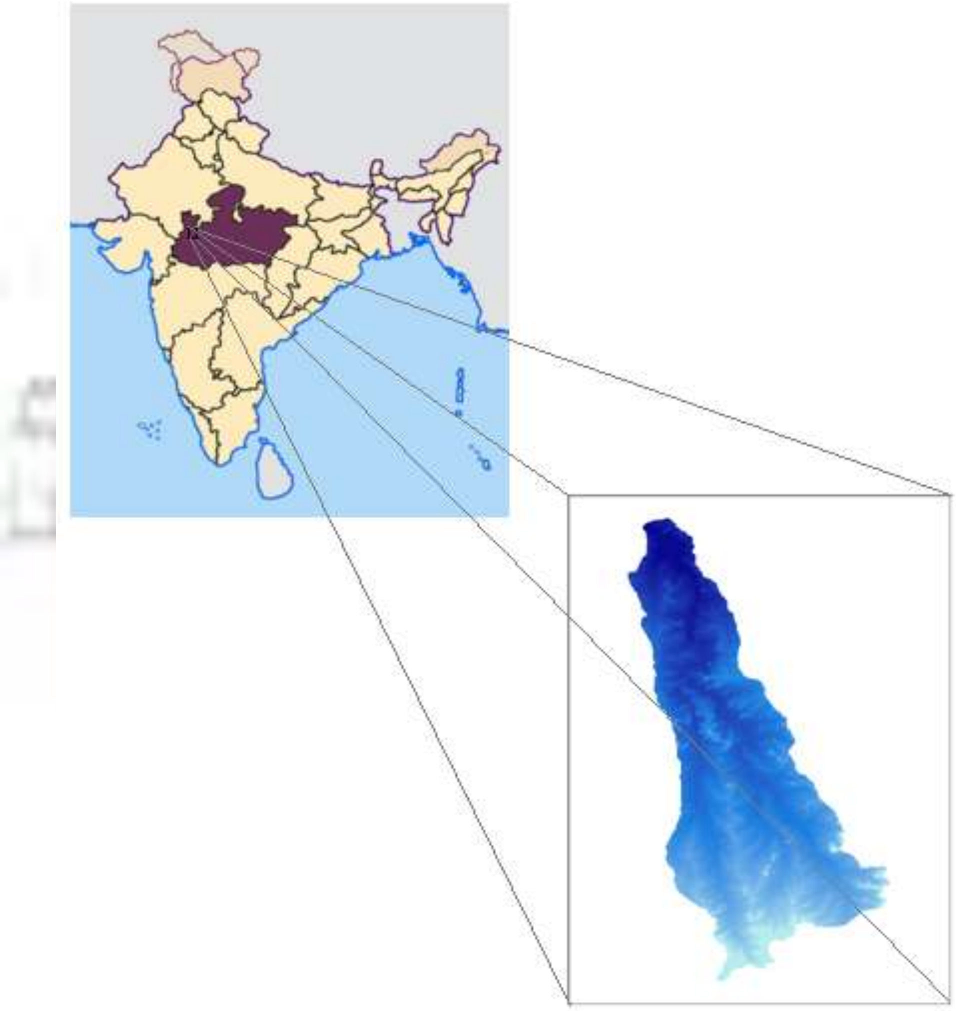

Figure 1: Location Map of Study Area - Kshipra Watershed

III. METHODOLOGY

The whole study carried out into three parts.

In first part, computation of number of streams, stream order and length of stream in the study area carried out using SRTM imagery along with extraction of area, perimeter of the basin in GIS environment (Using ArcGIS-10). For doing this, DEM and main outlet point are the two input parameters and use snap pour point tool for exact location of the outlet point.

The next part aims at characterizing the sub-watershed using various Morphometric parameters (linear as well as shape parameters). Thus hydrological behaviour and soil erosion in particular sub-watersheds is understood. After delineating the watershed area we divide whole watershed into 43 sub-watersheds (Figure 4 & 5).

Finally, on the basis of all Morphometric parameters sub-watersheds are prioritized.

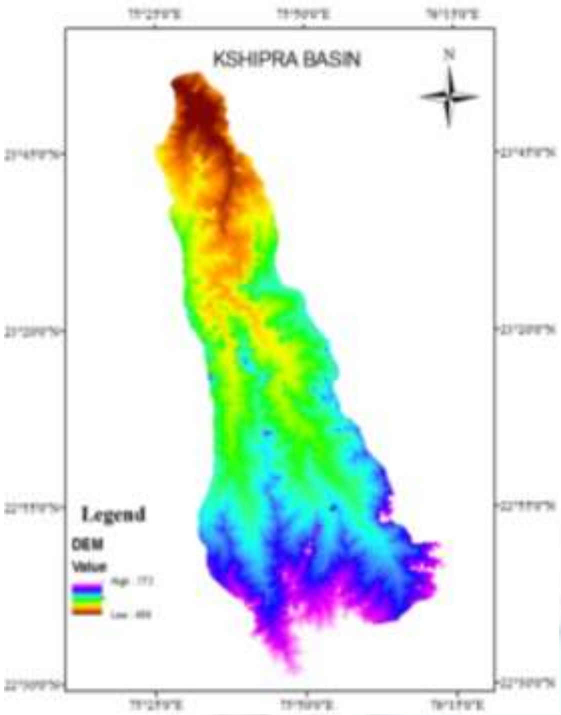

Figure 2: Digital Elevation Model for the Kshipra Watershed

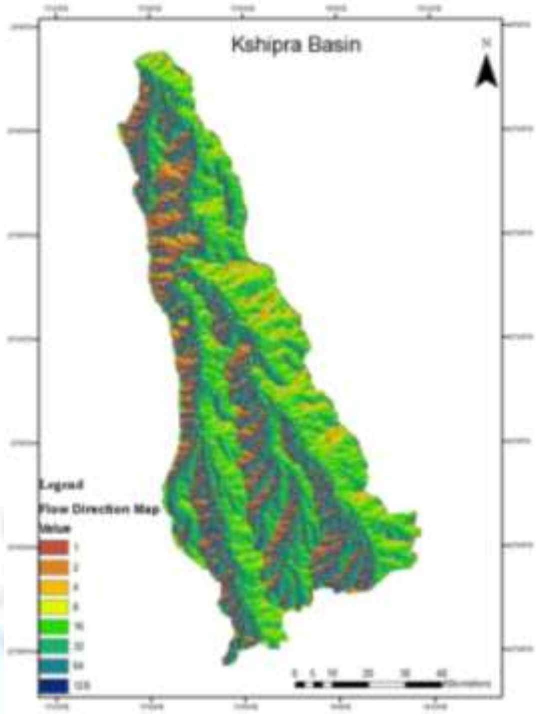

Figure 3: Flow Direction Map

IV. RESULT AND DISSCUSSION

The total drainage area of Kshipra River basin is 5423.20 Km^2. Is GIS environment, whole watershed divide into 43 sub-watersheds (Figure 4 & 5) with the help of stream order map and outlet points.

The details of stream characteristics confirm to (Horton 1932) ‘‘laws of stream numbers’’ which state that the number of streams of different orders in a given drainage basin tends closely to approximate an inverse geometric ratio. It also confirms to (Horton 1932) the ‘‘laws of stream length’’ which states that the average length of streams of each of the different orders in a drainage basin tends closely to approximate a direct geometric ratio.

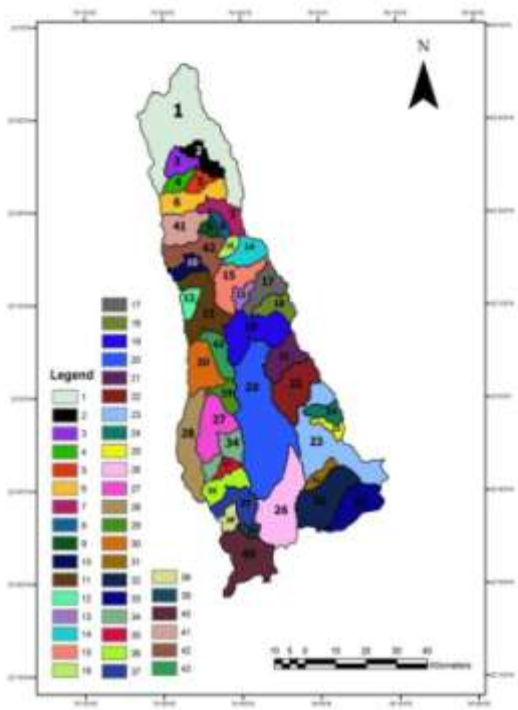

Figure: 4 Watershed with 43 Sub-watersheds in Raster form

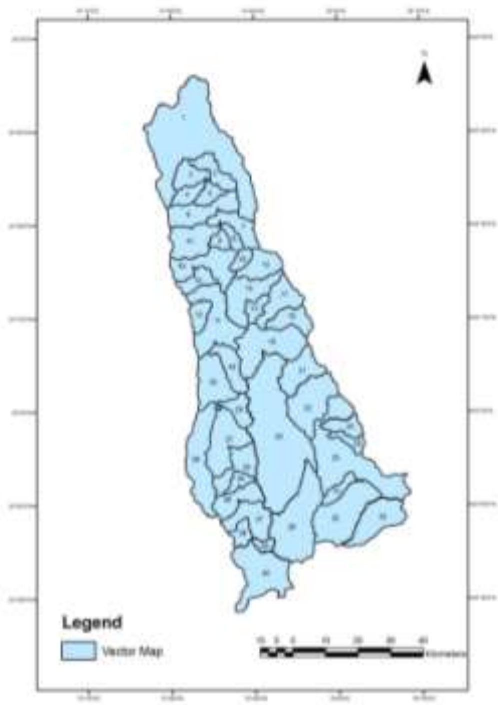

Figure: 5 Watershed with 43 sub-watersheds in Vector form

Stream order

The streams of the Kshipra River basin have been ranked according to the Strahler's (1964) stream ordering system. According to that the classification of streams based on the number and type of tributary junctions, has proven to be a useful indicator of stream size, discharge and drainage area (Strahler 1957).

Area (A)

The total drainage area of Kshipra River Basin is 5423.20 Km^2, and the area of 43 sub-watersheds is shown in Table 1. Sub-watershed 39 is the smallest sub-watershed (A=20.30 km^2) and Sub-watershed 1 is the biggest one (A=594.44 km^2).

Perimeter (P)

Total length of the drainage basin boundary is called the perimeter of watershed. The perimeter of Kshipra river basin is 215.18 km and the perimeter of 43 sub-watersheds is shown in Table 1. Sub-watershed 1 has the highest value (P= 181.96 km) and the perimeter of Sub-watershed 39 is least from all other watershed.

Basin Length (L)

Maximum length of the watershed and sub-watersheds measured parallel to the main drainage line of watershed is called Basin Length. The basin length of Kshipra river basin is 806.621 km and Table 1 shows the values of basin length for all 43 sub-basins.

Maximum and minimum elevation (H, h)

Highest and lowest point of the basin and sub-basins give the maximum and minimum elevation for watershed and sub-watershed respectively. The maximum elevation of Kshipra basin is 773 m and the minimum elevation is 406 m. Maximum and minimum elevation for all 43 sub-watersheds is shown in Table 1.

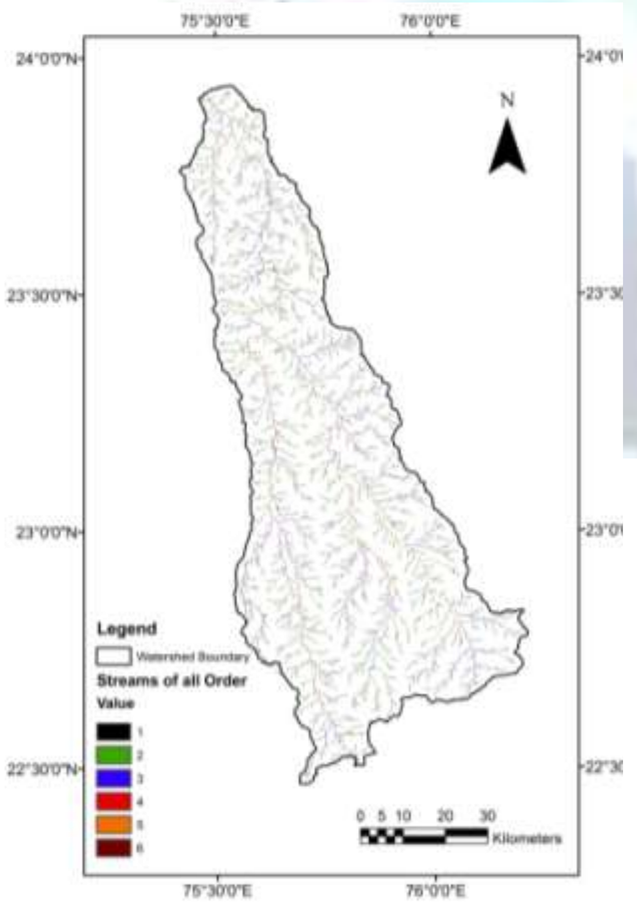

Figure 6: Stream Order Map

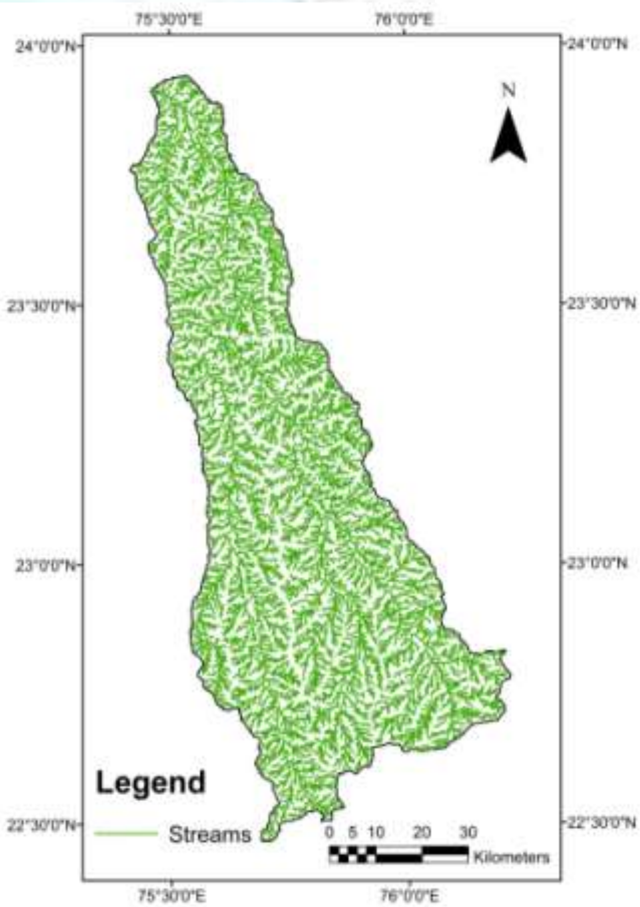

Figure 7: No of Stream map

Table No: 1 Basic Parameters required for Watershed

SW	Area (sq.km.)	Perimeter (km)	Basin Length (km)	Min Elevation(m)	Max Elevation(m)	Total Relief (m)
1	594.44	181.96	49.388	413	497	84
2	66.23	50.57	14.201	437	475	38
3	63.04	41 .488	13.808	434	485	51
4	42.90	37.63	11.096	441	491	50
5	39.45	33.18	10.581	434	473	39
6	123.35	70.08	20.216	445	494	49
7	79.02	56.35	15.698	449	504	55
8	27.83	29.35	8.677	453	513	60
9	27.21	24.42	8.568	455	507	52
10	51.76	42.40	12.345	460	498	38
11	185.45	94.63	25.485	466	507	41
12	46.01	32.76	11.546	468	511	43
13	35.98	32.42	10.040	468	497	29
14	83.94	43.72	16.246	461	513	52
15	136.38	69.36	21.403	461	519	58
16	28.73	24.47	8.835	465	513	48
17	100.05	57.77	17.950	475	518	43
18	73.14	44.92	15.023	476	522	46
19	207.01	81 .34	27.128	477	522	45
20	574.56	146.90	48.443	484	557	73
21	109.18	55.22	18.862	487	524	37
22	178.50	64.81	24.938	492	530	38
23	334.98	147.67	35.657	500	537	37
24	52.41	37.81	12.433	502	558	56
25	32.47	34.20	9.472	505	577	72
26	271.56	84.54	31.650	520	617	97
27	159.98	67.64	23.434	497	534	37
28	198.41	88.23	26.482	491	562	71
29	54.39	38.86	12.697	492	526	34
30	137.18	64.28	21.474	482	515	33
31	40.88	39.68	10.797	517	556	39
32	219.69	72.26	28.060	521	585	64
33	137.48	59.81	21.501	530	569	39
34	94.07	63.09	17.332	506	540	34
35	31.22	31 .72	9.263	511	542	31
36	85.83	54.39	16.452	522	556	34
37	104.45	61 .26	18.394	525	567	42
38	37.53	30.46	10.285	531	569	38
39	20.30	21 .84	7.254	543	576	33
40	206.99	82.99	27.126	543	676	133
41	113.38	52.38	19.271	455	491	36
42	138.06	79.81	21.552	455	507	52
43	77.78	51 .63	15.558	482	521	39

Derived Parameters

Derived parameters can be classified into two categories:

1. **Linear Parameters:**
- Drainage density (Dd)
- Stream frequency (Fs)
- Bifurcation ratio (Rb)
- Texture ratio (T)
- Length of Overland flow (Lo)

2. **Shape parameters:**
- Form factor (Ff)
- Circularity ratio (Rc)
- Elongation ratio (Re)
- Compactness coefficient (Cc)
- Drainage Texture (Dt)

Drainage Density (D_d)

According to (Horton 1932), the drainage density is defined as the total length of streams per unit area divided by the area of the drainage basins. Low Dd occurs in regions of highly resistant and permeable subsoil materials with dense vegetation and low relief, whereas high Dd is prevalent in regions of weak, impermeable subsurface materials which are sparsely vegetated and have high relief (Strahler 1964). In the present study the Dd ranges from 0.02 to 11.01 km/km^2. The highest value of Dd is observed in SW8, while SW41 & SW 26 have the lowest. The Dd of the 43 sub-watersheds are shown in Table 3.

Stream Frequency (Fs)

Stream frequency (Fs) of a basin may be defined as the total number of stream segments of all orders within a basin and sub-basin area (Horton, 1945). Value of Stream frequency for all 43 sub-watersheds shown in Table 3 which shows a large variation in stream frequency values (0.68 for SW23 to 11.10 for SW28). It means sub-watershed with lower Stream frequency value have low relief and permeable surface while, sub-watersheds have higher stream frequency values show high relief, light vegetation and low conducting surface material.

Bifurcation ratio (R_b)

It is dimensional parameter that expresses the ratio of the number of streams of any given order (Nu) to the number in the next lower order (Nu+1) (Horton, 1945).

In general, lower values of Rb are characteristic of a watershed which has suffered less structural disturbances and where the drainage pattern has not been distorted by structural disturbances (Nag and Chakraborty 2003). Mean bifurcation ratio (Rbm) for the study area varies from 1.94 to 5.46, SW7 has the lowest value imply a smaller amount of structural disturbance, whereas SW11 has the highest, suggest that it has structurally controlled drainage pattern. Table 3 shows the Rb values of all 43 sub-watersheds.

Texture Ratio (T)

It is the ratio of the maximum watershed relief to the perimeter of the watershed (Gajbhiye et al. 2013).

Length of Overland Flow (L_o)

The Length of Overland Flow (L_o) is the length of water over the ground surface before it gets concentrated into definite stream channel (Horton, 1945). The length of overland flow is approximately equal to the half of the reciprocal of drainage density (Ziaur Rehman Ansari, 2012). Length of overland flow values of 43 sub-basins are varying from 0.01 for SW41 to 5.51 for SW38. Table-3 reveals the value of L_o for 43 sub-watersheds.

Form Factor (Ff)

According to Horton (1932) form factor is the ratio of the watershed area (A) to the square of its length (L). The value of Ff would always be less than 0.7854 (for a perfectly circular basin). The basins with higher Ff are normally circular and have high peak flows for shorter duration, whereas elongated basins with lower values of Ff have low peak flows for longer duration (Hortan, 1932) (Akram Javed, 2011). Table 4 shows the value of Ff for 43 sub-watersheds which is varying from 0.24 for SW1 and SW20 to 0.39 for SW40, suggesting that almost all sub-watersheds are more or less elongated watersheds.

Elongation ratio (Re)

It is the ratio between the diameter of a circle of the same area as the watershed and the maximum basin length (SCHUMM, 1956). Table 4 shows the value of Re for all 43 sub-watersheds. Regions of low relief have values around 1, while strong relief and sheer surface slopes have values in the range of 0.6–0.8.

Circularity ratio (Rc)

The circularity ratio (R_c) has been used as a quantitative measure and is expressed as the ratio of basin area (Au) to the area of a circle (Ac) having the same perimeter as the basin (Miller 1953); (Strahler 1957). For showing dendritic phenomenon of watershed it is very important ratio. Value of Rc of sub-watersheds varies from 0.19 (SW23) to 0.60 (SW16) as shown in Table 4.

Compactness Coefficient (Cc)

Compactness coefficient is used to express the relationship of a basin with that of a circular basin having the same area as the basin. A circular basin is the most hazardous from a drainage point of view because it will yield the shortest time of concentration before peak flow occurs in the basin (Nooka Ratnam et al.2005). Table 4 shows the variation in the values of Cc (from 0.01 to 0.06) in the study area.

Drainage texture (Dt)

The drainage texture depends upon a number of natural factors such as climate, rainfall, vegetation, rock and soil type, infiltration capacity, relief and stage of development (Smith 1950). The soft or weak rocks unprotected by vegetation produce a fine texture, whereas massive and resistant rocks cause coarse texture. Sparse vegetation of arid climate causes finer textures than those developed on similar rocks in a humid climate. The texture of a rock is commonly dependent upon vegetation type and climate (Dornkamp 1971). Based on the values of Dt, it is classified into coarse, intermediate, fine and ultra-fine (Smith 1950).

Drainage texture values of the sub-watersheds lie between 0.05 (SW41) and 84.50 (SW8). The Dt of the 43 sub-watersheds is shown in Table 4.

Table No: 2 Formulae for different Basin parameters with their references

S. No.	Parameters	Formulae	References
1	Stream Order	Hierarchial rank	Strahler (1964)
2	Stream Length	Length of the stream	Horton (1945)
3	Mean Stream Length	Lsm = Lu/Nu	Strahler (1964)
4	Stream Length Ratio	RL = Lu/(Lu -1)	Horton (1945)
5	Bifurcation Ratio	Rb = Nu/Nu+1	Schumm (1956)
6	Mean Bifurcation Ratio	Rbm = average of bifurcation ratios of all order	Strahler (1957)
7	Drainage Density	Dd = Lu/A	Horton (1945)
8	Drainage Texture	T = Dd * Fs	Smith (1950)
9	Stream Frequency	Fs = Nu/A	Horton (1945)
10	Elongation Ratio	Re = D/L = 1.128√(A/L)	Schumm (1956)
11	Circulatory Ratio	$Rc = 4\pi A/P^2$	Strahler (1964)
12	Compactness Coefficient	Cc = 0.2821 P/√A	Strahler (1957)
13	Form Factor	$Ff = A/L^2$	Horton (1945)
14	Length of Overland flow	$Lo = 1/2D_d$	Horton (1945)
15	Relief	R = H-h	Hadley and Schumm (1961)
16	Relief Ratio	Rr = R/L	Schumm (1963)

Table No: 3 Linear Parameters of the Basin

SW	D_d	F_s	R_b	T	Lo
1	0.16	6.01	5.21	1.97	0.08
2	2.84	3.93	3.60	0.91	1.42
3	2.80	4.95	2.62	1.01	1.40
4	2.77	6.10	3.31	0.82	1.38
5	2.97	2.19	3.29	1.08	1.49
6	0.46	2.38	2.44	0.94	0.23
7	1.76	4.17	1.94	0.75	0.88
8	11.01	5.85	2.22	0.75	4.70
9	2.47	2.61	2.83	0.90	1.23
10	1.65	2.78	3.29	0.73	0.83
11	0.30	4.33	5.46	1.08	0.15
12	0.93	3.84	2.76	1.01	0.46
13	4.67	3.25	2.90	0.65	2.33
14	8.80	3.74	3.92	1.37	4.40
15	0.29	3.50	5.11	1.30	0.14
16	1.37	4.16	2.79	0.78	0.69
17	1.34	2.84	3.43	1.23	0.67
18	1.91	4.49	2.35	1.34	0.95
19	1.45	1.48	3.12	1.57	0.73
20	0.14	7.24	2.96	1.49	0.07
21	1.01	2.31	2.98	1.07	0.50
22	0.40	1.42	3.86	1.42	0.20
23	0.10	0.68	2.87	0.95	0.05
24	5.08	5.39	3.83	0.74	2.54
25	5.12	7.53	3.04	0.73	2.56
26	0.03	5.21	5.20	1.14	0.01
27	1.69	4.29	3.64	1.09	0.85
28	1.41	11.10	4.96	1.09	0.71
29	0.87	4.53	3.63	1.00	0.44
30	0.28	4.33	1.96	1.09	0.14
31	1.07	5.53	3.89	0.66	0.54
32	0.14	3.24	5.36	1.36	0.07
33	1.96	3.42	3.42	1.30	0.98
34	3.89	1.00	2.64	0.63	1.94
35	4.74	3.19	2.92	0.88	2.37
36	1.16	3.78	1.77	0.90	0.58
37	2.04	1.44	2.44	1.09	1.02
38	10.03	4.23	2.20	0.79	5.51
39	2.10	3.62	2.28	0.82	1.05
40	0.22	4.33	3.34	1.17	0.11
41	0.02	2.44	2.16	1.36	0.01
42	1.45	1.67	3.31	0.79	0.72
43	1.31	6.65	5.37	1.07	0.66

Table No: 4 Shape Parameters of the Basin

SW	F_f	R_c	R_e	C_c	D_t
1	0.24	0.23	0.46	0.01	0.27
2	0.33	0.33	0.57	0.03	8.10
3	0.33	0.46	0.51	0.03	6.52
4	0.35	0.38	0.46	0.04	7.48
5	0.35	0.45	0.76	0.04	8.58
6	0.30	0.32	0.73	0.02	1.17
7	0.32	0.31	0.55	0.03	6.12
8	0.37	0.41	0.47	0.05	84.50
9	0.37	0.57	0.70	0.05	8.06
10	0.34	0.36	0.68	0.04	3.32
11	0.29	0.26	0.54	0.01	1.01
12	0.35	0.54	0.58	0.04	2.13
13	0.36	0.43	0.63	0.04	12.46
14	0.32	0.55	0.58	0.02	17.94
15	0.30	0.36	0.60	0.02	1.31
16	0.37	0.60	0.55	0.05	3.78
17	0.31	0.38	0.67	0.02	4.15
18	0.32	0.46	0.53	0.03	7.37
19	0.28	0.39	0.93	0.01	4.63
20	0.24	0.33	0.42	0.01	0.20
21	0.31	0.45	0.74	0.02	1.80
22	0.29	0.53	0.95	0.01	1.19
23	0.26	0.19	1.37	0.01	0.24
24	0.34	0.46	0.49	0.03	9.78
25	0.36	0.35	0.41	0.05	14.82
26	0.37	0.48	0.49	0.01	0.06
27	0.27	0.44	0.55	0.01	5.18
28	0.29	0.32	0.34	0.01	4.30
29	0.28	0.45	0.53	0.03	2.19
30	0.34	0.42	0.54	0.02	0.72
31	0.30	0.33	0.48	0.04	2.71
32	0.35	0.53	0.63	0.01	0.32
33	0.28	0.48	0.61	0.02	6.67
34	0.30	0.30	1.13	0.02	5.13
35	0.31	0.39	0.63	0.05	14.57
36	0.36	0.36	0.58	0.02	2.47
37	0.32	0.35	0.94	0.02	4.36
38	0.31	0.51	0.55	0.04	29.68
39	0.35	0.54	0.59	0.06	6.72
40	0.39	0.38	0.54	0.01	0.48
41	0.28	0.52	0.72	0.02	0.05
42	0.31	0.27	0.87	0.02	2.71
43	0.30	0.37	0.44	0.03	2.76

Table No: 5 Different parameters with their ranking and final Priority of sub-watershed

SW	Shape Parameters					Linear Parameters					Cp	Final Priority
	Ff	Re	Cc	Rc	Dt	Dd	Fs	Rb	T	Lo		
1	1	5	1	2	43	38	41	4	39	38	21.2	18
2	27	21	24	9	17	10	17	14	9	10	15.8	3
3	28	11	25	30	21	11	26	33	15	11	21.1	17
4	33	6	31	18	12	12	19	18	11	12	17.2	7
5	35	37	32	27	25	9	15	20	8	9	21.7	22
6	16	35	12	7	18	32	23	34	34	32	24.3	27
7	24	17	26	6	7	18	3	42	16	18	17.7	9
8	41	7	38	23	8	1	16	38	1	1	17.4	8
9	42	33	39	42	15	13	6	29	10	13	24.2	26
10	31	32	33	14	4	20	37	21	24	20	23.6	24
11	9	14	2	3	26	34	5	1	35	34	16.3	4
12	32	22	34	39	22	30	28	31	30	30	29.8	38
13	37	28	35	25	2	7	21	27	6	7	19.5	12
14	23	23	13	41	39	3	36	8	3	3	19.2	10
15	15	26	14	15	34	35	1	6	32	35	21.3	19
16	40	18	40	43	9	24	18	30	23	24	26.9	35
17	20	31	15	19	33	25	9	15	22	25	21.4	20
18	26	12	27	31	36	17	2	36	12	17	21.6	21
19	6	39	3	21	42	21	8	22	19	21	20.2	15
20	2	3	4	10	41	39	42	25	41	39	24.6	28
21	18	36	16	28	23	29	40	24	31	29	27.4	37
22	10	41	5	37	40	33	13	10	33	33	25.5	32
23	3	43	6	1	19	41	29	28	40	41	25.1	31
24	30	9	28	32	6	5	38	11	7	5	17.1	6
25	38	2	41	12	5	4	14	23	4	4	14.7	2
26	4	10	7	33	31	42	30	5	42	42	24.6	28
27	11	19	8	26	27	19	11	12	17	19	16.9	5
28	8	1	9	8	28	23	12	7	21	23	14	1
29	29	13	29	29	20	31	24	13	29	31	24.8	29
30	14	15	17	24	29	36	22	41	36	36	27	36
31	34	8	36	11	3	28	35	9	26	28	21.8	23
32	5	29	10	38	37	40	27	3	38	40	26.7	34
33	13	27	18	34	35	16	4	16	14	16	19.3	11
34	21	42	19	5	1	8	43	32	18	8	19.7	13
35	39	30	42	22	14	6	10	26	5	6	20	14
36	22	24	20	16	16	27	34	43	28	27	25.7	33
37	19	40	21	13	30	15	33	35	20	15	24.1	25
38	36	20	37	35	10	2	20	39	2	2	20.3	16
39	43	25	43	40	13	14	7	37	13	14	24.9	30
40	7	16	11	20	32	37	32	17	37	37	24.6	28
41	17	34	22	36	38	43	31	40	43	43	34.7	39
42	12	38	23	4	11	22	39	19	27	22	21.7	22
43	25	4	30	17	24	26	35	2	25	26	21.4	20

V. CONCLUSION

For the morphometric analysis of Kshipra basin, evaluation of drainage parameters and their influence on landforms and soil-erosion charcteristics is calculated using remotely sensed data and GIS techniques. In this study it was observed that Geomatics techniques are more appropriate than other available conventional methods. Quantitative morphometric analysis at sub-watershed level helps in establishing the relationship among various aspects of drainage characteristics and also useful in finding out their effect on soil erosion.

The result of this analysis shows that sub-watershed 28 and 25 are prone to relatively higher land and soil erosion. If one summarize the whole morphometric analysis then one can assign rank to the individual sub-watershed and can prepare the final priority map as shown in figure 8. In Figure 8 number shows in bracket are the rank of sub-watershed according to their compound value in morpgometric value. Hence, sub-watersheds which are severly effected, suitable water and soil erosion control measures are required to control the soil erosion and preserve the land from further erosion and this can be done by providing soil and water conservation structures such as Check Dam, Groyne, Drop Structure. Consequently, Geomatics techniques can be effectively used for systematic analysis of morphometric parameters and in water-land resources evaluation and their management.

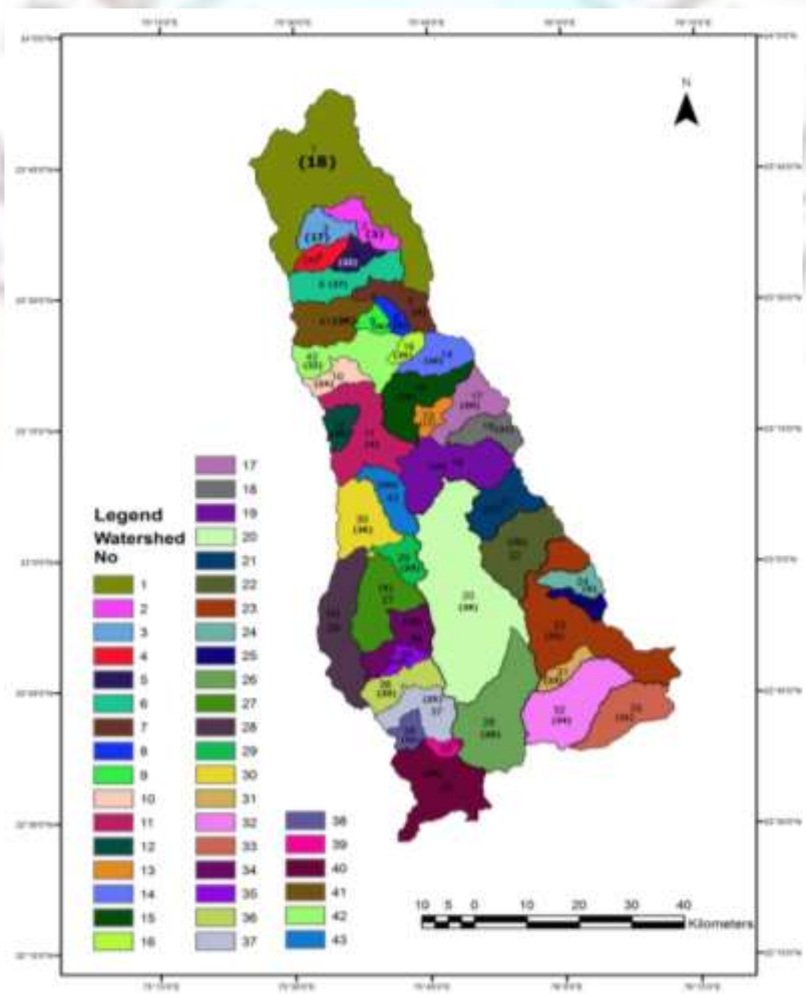

Figure 8: Final Map with Priority of the sub-watersheds

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