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Morphometric Evaluation and Sub Basin Analysis in Hanur Watershed, Kollegal Taluk, Chamarajanagar District, Karnataka, India, using Remote Sensing and GIS Techniques

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Abstract The study area covers 1026 sq km comprising of 15 sub-watersheds, namely Saggiyam (SB-1), Mudoldoddi (SB-2), Halgapuram (SB-3), Deverabetta (SB-4), Mattugaudanadoddi (SB-5), Handgalli (SB-6), Manchepura (SB-7), Lokkanahalli (SB-8), Chinchalli (SB-9), Prakash palya (SB-10), Naripura (SB-11), Adugulpodu (SB-12), Ramayanadoddi (SB-13), Jodukara hatti (SB-14), Depudisahibradoddi (SB-15) which range in area from 16.87 to 180.02 sq km. Different morphometric parameters were evaluated to understand the drainage characteristics. The drainage pattern of these sub basins have been delineated using Geocoded FCC bands 2, 3 and 4, of IRS 1C and 1D (LISS 111+ PAN merged) on 1:50,000 scale and Survey of India Toposheets as reference. The morphometric parameters are computed using Arc Info and Arc View GIS software's. The drainage pattern of the study has shown dendritic to sub-dendritic drainage pattern with stream orders ranging from 4th to 5th order. The Drainage density ranges from 1.51 to 4.83 km/km^2 suggesting coarse to moderate drainage texture. The change in values of stream length ratio indicates their late youth stage of geomorphic development. The values of bifurcation ratio are ranging from 0.11 to 20.75 indicating that the study area is having strong structural control over the drainage pattern and all the sub basins fall under normal basin category. The values of form factor and circulatory ratio, suggest that the sub basins are elongated to circular in shape. Geographic Information System, when used with satellite images, could help in determining the morphometric parameters of watershed and river basins. It is concluded that remote sensing ground and GIS have been proved to be efficient tools in drainage delineation and updation.

Keywords *Morphometry; Dendritic; Drainage; Texture; Circularity Ratio; Elongation Ratio*

1. Introduction

Watershed is a basic hydrological unit; it helps in determining the runoff of the unit from the amount of total precipitation. Precipitation is a dynamic variable. It varies from one place to other and from time to time. Watershed management is necessary for low flow regions. Geoinformatics based morphometric calculation is a new technique used for watershed management. Geoinformatics is the combination of Remote Sensing, Geographical Information System and Global Positioning System (Bera, K. &

Bandyopadhyay, J., 2011). Morphometric analysis of watershed provides a quantitative description of the drainage system (Rao et al., 2010). The morphometric parameters are classified into three categories i.e. Linear, Relief and Arial morphometric parameters. Morphometric parameters have greater hydrological significances. More recent attempts on morphometric analysis using remote sensing techniques have been made by Rao et al., 2010; Kumar et al., 2010; Rekha et al., 2011; Pal. B. et al., 2012; Mishra et al., 2010, and Arun et al., 2005. The present study aims at the morphometric analysis on sub-basin level using remote sensing and GIS.

1.1. Study Area

The study area is spread over 1026 km^2. It comprises of fifteen sub-basins. This area is located between 770 51 to 770 301 East longitude and 110 451 to 120 151 North latitude. It is covered by 115 villages (Figure 1). The area is accessible by good road network. The morphometry based on remote sensing and GIS techniques can help in analyzing the hydrogeomorphic conditions of a basin (King, 1872; Foote, 1876; Rao et al., 1975; Mathur, 1977; Kale et al., 1990 and Malur and Nagedra, 1994). The study area enjoys a warm summer and dry winter. It is a semi-arid region with dry climate followed by very less humidity and scanty annual rainfall which is not exceeding 699 mm. Therefore, this area is considered to be one of the drought-prone zones of Chamarajanagar district, in Karnataka state.

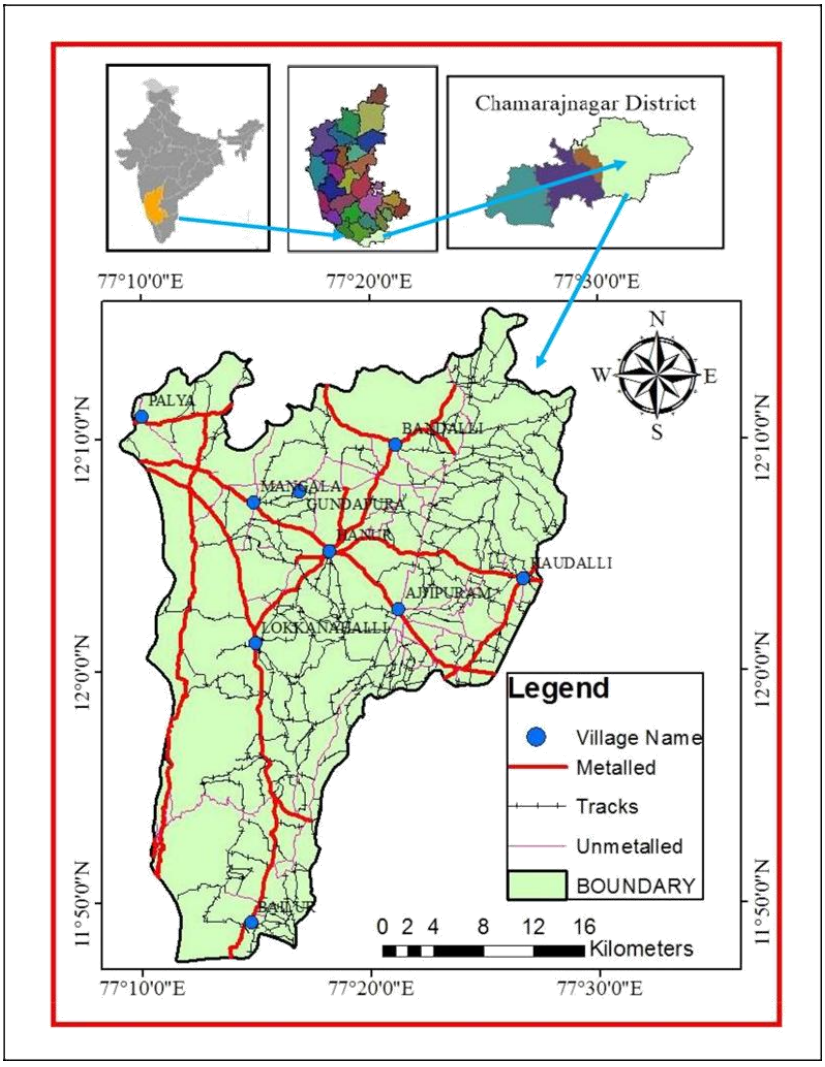

Figure 1: *Location Map of the Study Area*

1.2. Geology of the Area

This area falls into the Western Block of Proterozoic basins of Southern Karnataka. It comes under the semi-arid condition with weathered and fractured Charnockites, Hornblende/Amphibolite schist form the main aquifer in Hanur watershed. The weathered and fractured Charnockites, hornblende /Amphibolite schist gneisses occupying the total area and has limited recharge facilities. This area is a typical hard rock terrain.

2. Methodology

The drainage map (Figure 2) of the study area has been prepared from digital data of IRS 1C and ID of both LISS111 and PAN data of 2001. These satellite imageries had been geo-referenced and merged using image processing software ERADAS IMAGINE V.9.2 and the thus merged data were used in the present study. The drainage systems have been delineated using merged satellite data of geo-coded FCC of bands 2, 3, 4 on 1:50,000 scale and survey of India toposheets no- 57 H/4, 57H/7, 57H/8, 58E/1 and 58E/5 as reference. The morphometric parameters were computed using the formulae of different worker's presented in Table 1. For digitization; computation and output generation, the GIS software like Arc GIS V 9.2 was used.

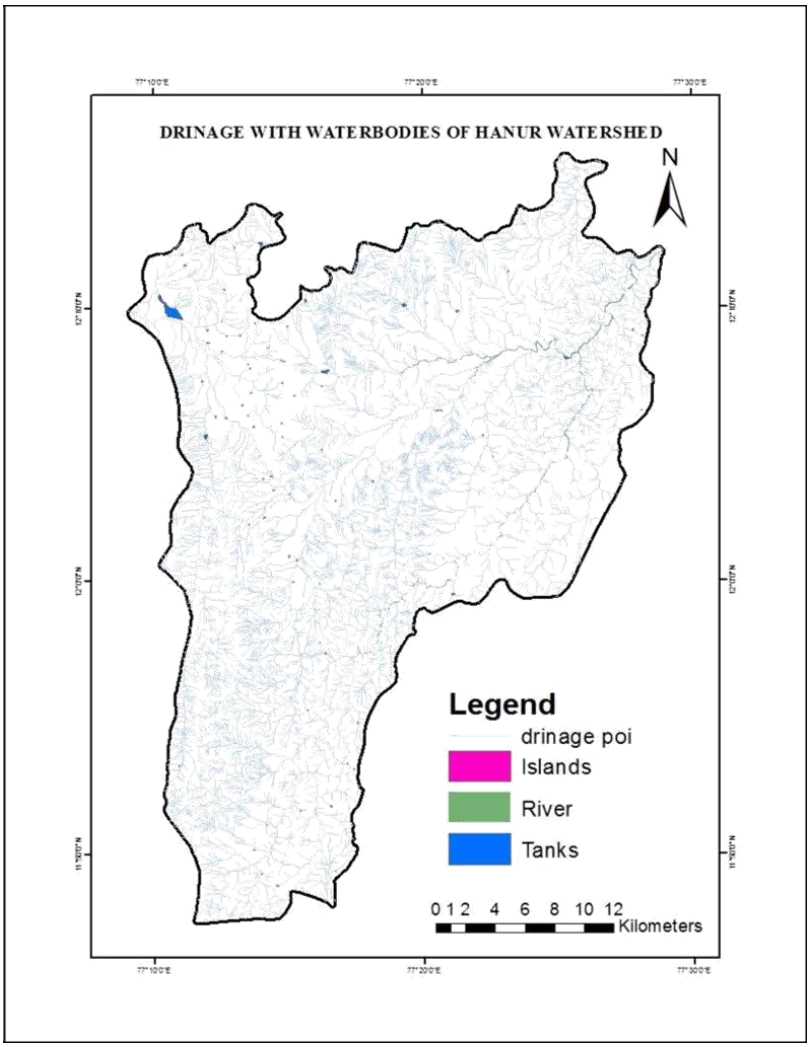

Figure 2: *Drainage Map of Study Area*

3. Basin Delineation

In the present study, the basin has been sub divided into 15 sub basins, which are named based on the important places at the outlet. They are namely Saggiyam (SB-1), Mudoldoddi (SB-2), Halgapuram (SB-3), Deverabetta (SB-4), Mattugaudanadoddi (SB-5), Handgalli (SB-6), Manchepura (SB-7), Lokkanahalli (SB-8), Chinchalli (SB-9), Prakash palya (SB-10), Naripura (SB-11), Adugulpodu (SB-12), Ramayanadoddi (SB-13), Jodukara hatti (SB-14), Depudisahibradoddi (SB-15) which range in area from 1026 sq km.

Table 1: *Methodology Adopted for Computations of 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, Lsm= mean stream Length Lu=total stream length of order 'U' Nu= Total no of stream segments of order 'u'	Strahler (1964)
4	Stream Length Ratio	Rl=Lu/lu-1, where, RL= stream length Ratio Lu= the Total no stream length of order 'u' Lu-1= the total stream length of its next lower order	Horton (1945)
5	Bifurcation Ratio (Rb)	Rb=Nu/Nu+1, where, Rb=Bifurcation Ratio Nu= Total no of stream segments of order 'u' Nu+1= Number of segments of the next higher order	Schumn (1956)
6	Mean bifurcation ration ((Rbm)	Rbm= Average of bifurcation ratios of all orders	Strahler (1964)
7	Relief Ratio (Rh)	Rh=H/Lb, where, Rh=Relief Ratio H= Total relief (Relative relief) of the basin in kilometers, Lb=Basin Length	Schumn (1956)
8	Drainage Density (D)	D=Lu/A, where, D=drainage Density Lu= total stream length of all orders A= Area of the Basin (Km)	Horton (1945)
9	Stream Frequency (Fs)	Fs=Nu/A, where, Fs=stream Frequency Nu=total no. of stream of all orders A= Area of the Basin (Km)	Horton (1945)
10	Drainage texture (Rt)	Rt=Nu/p, where, Rt=Drainage texture Nu=total no. of stream of all orders, p=perimeter (Km)	Horton (1945)
11	Form factor (Rt)	Rf=A/Lb2, where, Rf=from Factor A= Area of the Basin (Km),Lb^2=square of basin length	Horton (1945)
12	Circularity Ratio (Rc)	Rc=4* pa/p2, RC=circularity ratio	Miller (1953)

		p!=p! value 3.14, A= Area of the Basin (Km), p=square of the perimeter(km)	
13	Elongation ratio (Re)	Re=2v (A/P!)/lb where, Re= elongation Ratio, A= Area of the Basin (Km), p!=p! value 3.14, Lb= Basin Length	Schumn (1956)
14	Length of overland flow	lg=1/D*2, where, Lg=Length of overland flow D=Drainage Density	Horton (1945)

4. Morphometry

According to Clarke (1966), morphometry is the measurement and mathematical analysis of the configuration of the earth surface, shape and dimensions of the landforms. The morphometric analysis is carried out through measurement of linear, areal and relief aspects of the basin and slope contribution (Nag and Chakraborty, 2003). The measurement of various morphometric parameters namely- stream order, stream length (Lu), mean stream length (Lsm), stream length ratio (RL) bifurcation ratio (Rb), mean bifurcation ratio (Rbm), relief ratio (Rh), drainage density (D), stream circulatory ratio (Rc), elongated ratio (Re), length of overland flow (Lg) has been carried out and the data are presented in Table 2. In the present study, the satellite remote sensing data has been used for updation of drainages and the updated drainages have been used for morphometric analysis.

4.1. Linear Aspects

The linear morphometric parameters include the stream order, stream length, mean stream length, stream length ratio and bifurcation ratio, which were determined and results have been presented in Table 2.

4.2. Stream Order

The designated stream order is the first step in the drainage basin analysis. In the present study, ranking of stream has been carried out based on the method proposed by Strahler (1964). The order wise stream numbers, area and stream length of the 15 sub basins are presented in Table 2. Out of these sub basins Halgapuram, Deverabetta, Mattugaudanadoddi, Handgalli, Lokkanahalli, Chinchalli, Naripura and Jodukarahatti are found to be of 5th order, in Table 2. It is noticed that the maximum frequency is in case of first order stream. It is also observed that there is a decrease in stream frequency as the stream order increases.

4.3. Stream Length

Stream lengths have been measured from the highest elevation of drainage divide to the mouth of the river with the help of GIS software. This has been computed based on the law proposed by Horton (1945) for all the sub-basins of the study area. Usually, the total number and length of stream segment will be maximum in first order streams this may decreases as the stream order increases. The Lokkanahalli, Jodukarahatti, Naripura and Handgalli sub basins show variation from general observation (Table 2). This may be due to flowing of streams from high altitude, change in rock type and moderately steep slopes and probable uplift across the basin (Singh and Singh, 1997; Vittala et al., 2004; Chopra et al., 2005).

4.4. Mean Stream Length

Mean stream length (Lsm) is a characteristic property related to the drainage network components and it associated basin surfaces (Strahler, A.N., 1964). This has been calculated by dividing the total stream length of an order (u) by the number of streams of segments in that order. The mean stream length values of sub basins are presented in Table 2. It is seen that, Lsm values exhibit much variation from 0.03 to 7.55. It is observed that Lsm values of Manchepura and Halgapuram sub basins indicate that Lsm of the given order is greater than that of the lower order and less than that of its next order.

4.5. Stream Length Ratio

Stream length ratio (RL) is the ratio of the mean length of one order to the next lower order of the stream segments. The RL values of the sub basins are presented in Table 2. The stream length ratio between the streams of different orders of the study area has shown some variation. This variation might be attributed to the variation in slope and topography, indicating the late youth stage of geomorphic development in the streams of the study area (Singh and Singh, 1997; Vittala et al., 2004).

4.6. Bifurcation Ratio

According to Schumn (1956), the term bifurcation ratio (Rb) may be defined as the ratio of the number of the stream segments of given order to the number of segments of the next higher order. Bifurcation ratio shows a small range of variation for different regions or for different environments except where the powerful geological control dominates (Strahler, 1975). The Rb values of study area are shown in Table 2. It is seen that the Rb values are not uniform from one order to next order. These differences are depending upon the geological and lithological development of the drainage basin (Strahler, 1964). In the study area, the higher values of Rb indicate a strong structural control in the drainage pattern whereas the lower values indicate that the sub-basins are less affected by structural disturbances (Strahler, A.N., 1964; Nag, 1998; Vittala et al., 2004; Chopra et al., 2005). The Rb values in the sub basins of the study area range from 0.11 to 20.75 indicating that all the sub-basins are falling under regular basin category.

Table 2: *Different Parameters Morphometric Analysis of Hanur Watershed, Kollegal Taluk, Chamarajanagar District*

			Stream Orders						Stream length (KM)					
Sl. no	Sub Basin	Stream order	Total no of 1st order	Total no of 2nd order	Total no of 3rd order	Total no of 4th order	Total no of 5th order	ΣNu	Total length in 1st order	Total length in 2nd order	Total length in 3rd order	Total length in 4th order	Total length in 5th order	ΣLu
1	Saggiyam	IV	52	23	10	15	0	100	27.39	11.21	8.90	6.90	0.00	54.40
2	Mudoldoddi	IV	40	18	7	12	0	77	22.50	10.22	8.51	3.90	0.00	45.13
3	Halgapuram	V	84	40	13	19	1	157	42.85	22.20	5.39	10.13	7.55	88.12
4	Deverabetta	V	85	44	17	1	1	148	39.15	25.21	10.71	0.32	8.50	83.89
5	Mattugaudanadoddi	V	95	41	24	5	1	166	41.38	19.12	12.20	2.39	4.51	79.61
6	Handgalli	V	210	96	47	37	2	392	100.69	47.15	23.35	15.33	8.69	195.21
7	Manchepura	IV	92	44	4	36	0	176	42.70	21.73	14.45	1.42	0.00	80.31
8	Lokkanahalli	V	427	169	106	83	4	789	194.88	71.96	46.14	34.15	20.80	367.93
9	Chinchalli	V	131	47	37	22	1	238	55.47	22.34	15.22	7.14	4.10	104.27

10	Prakash palya	III	37	20	9	0	0	66	16.47	7.87	2.26	0.00	0.00	26.60
11	Naripura	V	246	103	58	54	3	464	143.31	47.52	30.30	21.58	6.09	248.80
12	Adugulpodu	IV	254	113	49	36	0	452	91.82	34.43	12.94	12.83	0.00	152.02
13	Ramayanadoddi	IV	165	76	41	30	0	312	72.79	27.19	17.20	9.39	0.00	126.56
14	Jodukarahatti	V	460	189	113	61	4	827	186.97	70.63	41.43	19.61	19.45	338.09
15	Depudisahibradoddi	IV	51	30	4	6	0	91	24.57	11.18	1.56	2.77	0.00	40.08

Table Cont…

		Linear Parameters											
		Stream Length Ratio						Bifurcation Ratio					
Sl. no	Sub Basin	II/I	III/II	IV/III	V/IV	Basin area in (A)Kms	Basin Length (LB)	I/II	II/III	III/IV	IV/V	Mean bifurcation ratio	Length of over head (Lg)
1	Saggiyam	0.40	0.79	0.77	0	33.22	11.25	2.26	2.3	0.66	0	1.3	0.41
2	Mudoldoddi	0.45	0.83	0.45	0.00	28.80	6.07	2.22	2.57	0.58	0	1.34	1.28
3	Halgapuram	0.51	0.24	1.87	0.74	47.19	11.11	2.1	3.07	0.68	19	6.21	1.07
4	Deverabetta	0.64	0.42	0.02	26.53	55.25	6.65	1.93	2.58	17	1	5.62	1.32
5	Mattugaudanadoddi	0.46	0.63	0.19	1.88	52.18	12.38	2.31	1.70	4.80	5	3.45	1.31
6	Handgalli	0.46	0.49	0.65	0.56	106.16	15.10	2.18	2.04	1.27	18.5	5.99	1.09
7	Manchepura	0.50	0.66	0.09	0	47.67	11.38	2.09	11	0.11	0	3.3	1.19
8	Lokkanahalli	0.36	0.64	0.74	0.60	180.02	21.65	2.52	1.59	1.27	20.75	6.53	0.98
9	Chinchalli	0.40	0.68	0.46	0.57	56.42	12.82	2.78	1.27	1.68	22	6.93	1.08
10	Prakash palya	0.47	0.28	0	0	16.87	4.02	1.85	2.22	0	0	1.01	1.27
11	Naripura	0.33	0.63	0.71	0.28	108.01	14.94	2.38	1.77	1.07	18	5.8	0.86
12	Adugulpodu	0.37	0.37	0.99	0	64.10	22.98	2.24	2.3	1.36	0	1.47	0.84
13	Ramayanadoddi	0.37	0.63	0.54	0	50.82	12.2	2.17	1.85	1.36	0	1.34	0.80
14	Jodukarahatti	0.37	0.58	0.47	0.99	156.99	25.51	2.43	1.67	1.85	15.25	5.3	0.93
15	Depudisahibradoddi	0.45	0.13	1.77	0	19.39	5.23	1.7	7.5	0.66	0	2.46	0.97

Table cont….

		Aerial Parameters											
							Mean Stream length (Lsm)						
Sl. no	Sub Basin	Drainage Density	Stream Frequency (fs)	Form factor	Elongation Ratio	Circulatory ratio	I	II	III	IV	V	Drainage texture (Rt)	Perimeter
1	Saggiyam	4.83	3.01	0.26	1.88	0.49	0.52	0.48	0.89	0.46	0	3.43	29.13
2	Mudoldoddi	1.56	2.67	0.78	3.02	0.55	0.56	0.56	1.21	0.32	0	3	25.61
3	Halgapuram	1.86	3.32	0.38	2.70	0.44	0.51	0.55	0.41	0.53	7.55	4.28	36.67

4	Deverabetta	1.51	2.67	1.24	5.29	0.58	0.46	0.57	0.63	0.32	8.5	4.28	34.50
5	Mattugaudanadoddi	1.52	3.18	0.34	2.68	0.45	0.43	0.46	0.51	0.47	4.51	4.37	37.93
6	Handgalli	1.83	3.69	0.46	4.47	0.27	0.47	0.49	0.49	0.41	4.34	5.59	70.10
7	Manchepura	1.68	3.69	0.36	2.66	0.49	0.46	0.49	3.61	0.03	0	5.05	34.82
8	Lokkanahalli	2.04	4.38	0.38	5.29	0.48	0.45	0.42	0.43	0.41	5.2	11.51	68.50
9	Chinchalli	1.84	4.21	0.34	2.80	0.55	0.42	0.47	0.41	0.32	4.10	6.64	35.84
10	Prakash palya	1.57	3.91	1.04	2.67	0.43	0.44	0.39	0.25	0	0	2.99	22.06
11	Naripura	2.30	4.29	0.48	4.60	0.54	0.58	0.46	0.52	0.39	2.03	9.29	49.91
12	Adugulpodu	2.37	7.05	0.12	1.77	0.19	0.36	0.30	0.26	0.35	0	7.07	63.86
13	Ramayanadoddi	2.49	6.13	0.34	2.65	0.51	0.44	0.35	0.41	0.31	0	8.84	35.29
14	Jodukarahatti	2.15	5.26	0.24	3.91	0.35	0.40	0.37	0.36	0.32	4.86	11.10	74.44
15	Depudisahibradoddi	2.06	4.69	0.70	2.36	0.48	0.48	0.37	0.39	0.46	0	4.04	22.47

4.7. Aerial Aspects

The Aerial morphometric aspects include parameters like drainage density, texture ratio, stream frequency, form factor, circulatory ratio, elongation ratio and length of the overland flow. The values of these parameters have been evaluated and presented in Table 2 and discussed and interpreted, in the following sections.

4.7.1. *Drainage Density*

Horton (1932) introduced the term drainage density (Dd). It is an important indicator of the linear scale of land form elements in stream eroded topography. It is the ratio of total channel segment length of all orders within a basin to the basin area. The drainage density is expressed in terms of Km/Km^2. The drainage density indicates the closeness of spacing of channels, thus providing a quantitative measure of the average length of stream channel for the whole basin. It has been observed from drainage density measurement made over a wide range of geologic and climatic type that a low drainage density is more likely to occur in region of highly resistant and highly permeable subsoil material under dense vegetative cover and where the relief is low. High drainage density is the resultant effect of weak or impermeable subsurface material, sparse vegetation and mountainous relief. Low drainage density leads to coarse drainage texture while high drainage ranging density leads to fine drainage texture (Strahler, A.N., 1964). The drainage density (Dd) of study area is from 1.51 to 4.83 Km/Km^2 as shown in Table 2. The High drainage density indicates that the basin has highly impermeable land surface, steep slopes and limited vegetation cover and limited erosion.

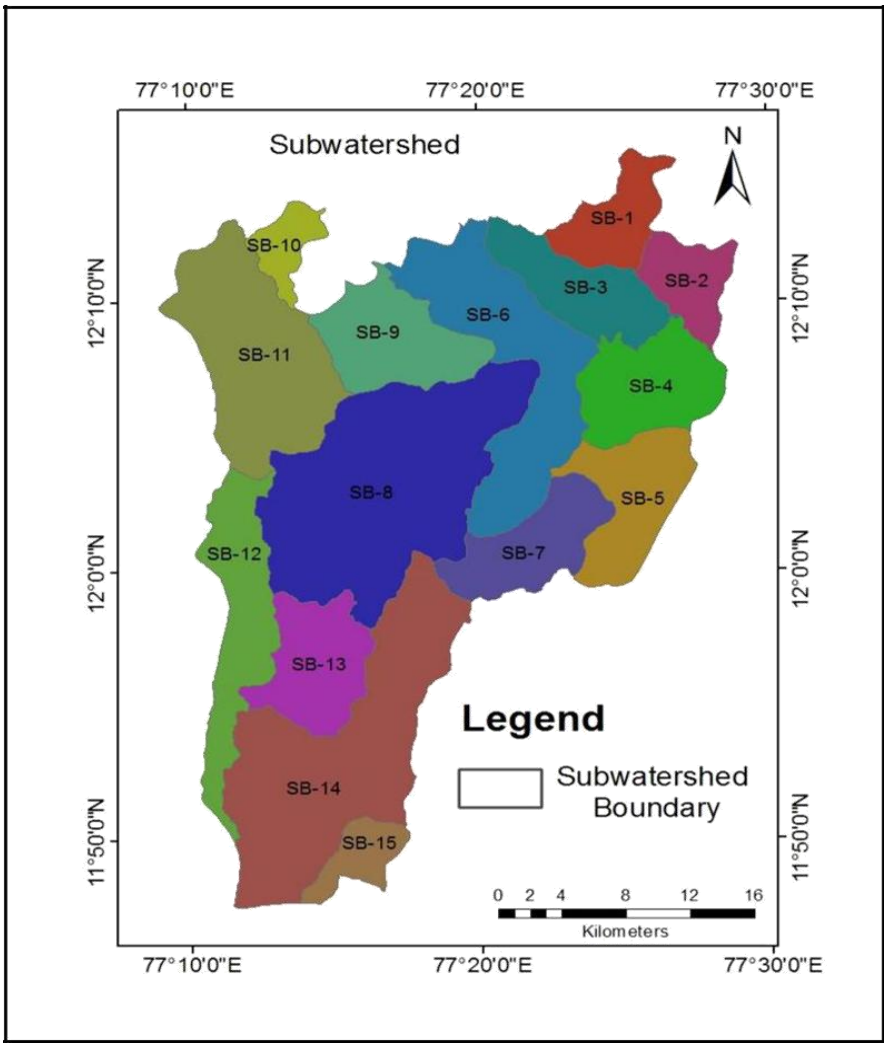

Figure 3: sub watershed Map of Hanur watershed

4.7.2. *Stream Frequency/Channel Frequency*

The total of stream segments of all orders per unit area is known as stream frequency (Fs) (Horton, 1932). It is possible to have basins of same drainage density with differing stream frequency and basins of the same frequency differing in their drainage density. The Fs values of the sub-basins of the study area are presented in Table 2. It is noted that the values of Fs vary from 2.67 to 7.05. It is also seen that the drainage density values of the sub-basins exhibit +ve correlation with the stream frequency suggesting that there is an increase in stream population with respect to increasing drainage density.

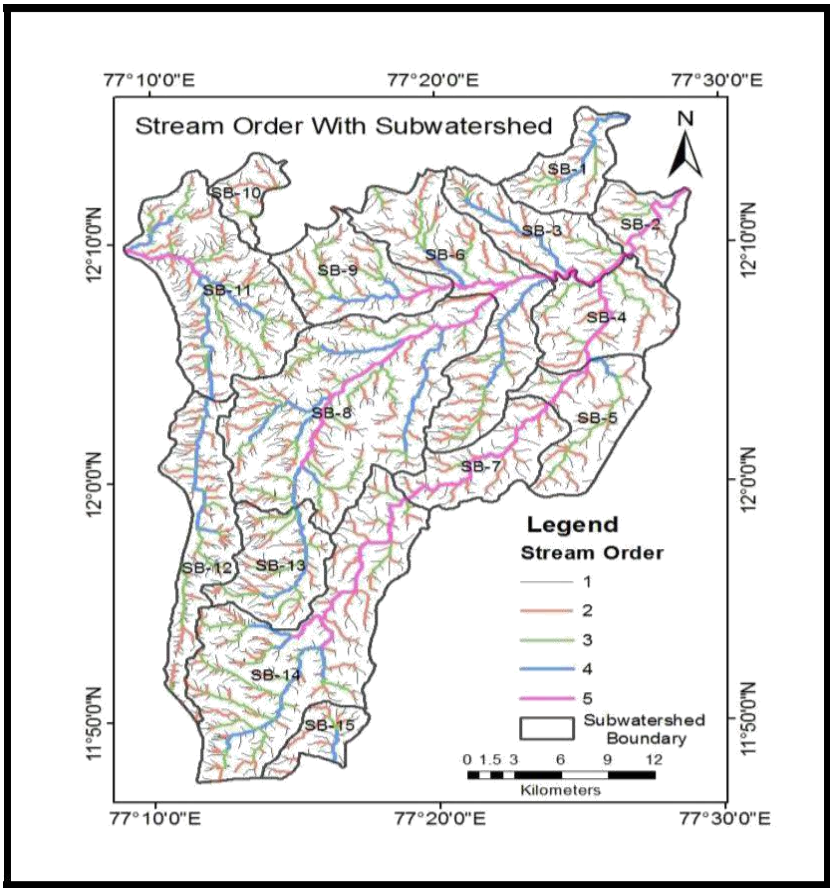

Figure 4: *Stream order with sub watershed*

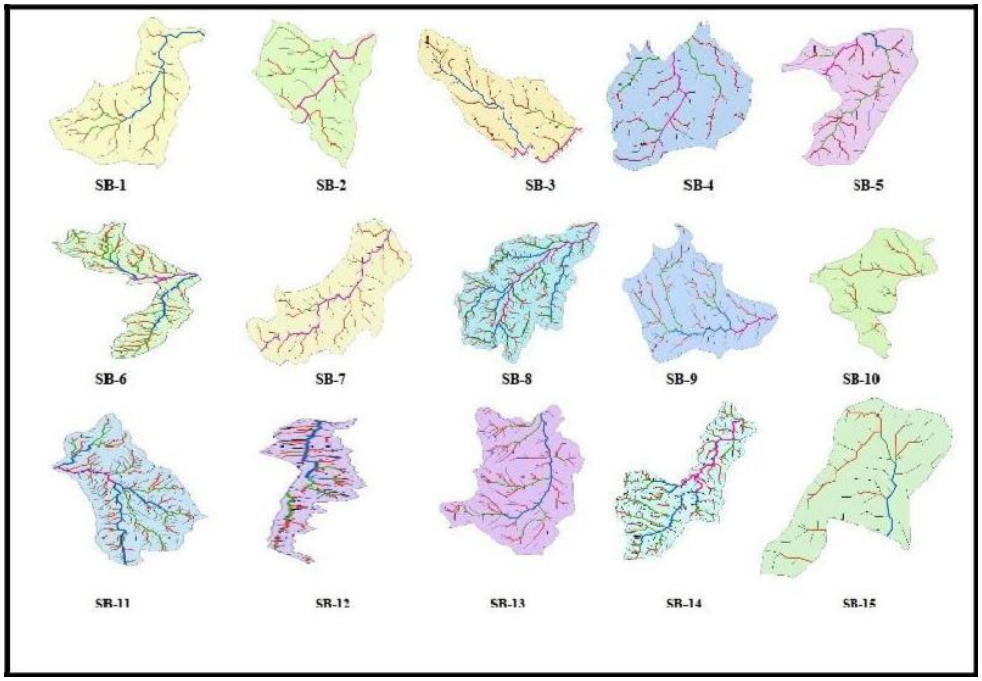

Figure 5: *Major 15 sub basins of Hanur Watershed*

Saggiyam (SB-1), Mudoldoddi (SB-2), Halgapuram (SB-3), Deverabetta (SB-4), Mattugaudanadoddi (SB-5), Handgalli (SB-6), Manchepura (SB-7), Lokkanahalli (SB-8), Chinchalli (SB-9), Prakashpalya (SB-10), Naripura (SB-11), Adugulpodu (SB-12), Ramayanadoddi (SB-13), Jodukara hatti (SB-14), Depudisahibradoddi (SB-15)

4.7.3. *Drainage Texture*

Drainage texture (Rt) is the total number of stream segments of all orders per perimeter of that area (Horton, 1945). It is one of the important concepts of geomorphology which depicts the relative spacing of drainage lines. Drainage lines are numerous over impermeable zones than permeable horizons. According to Horton (1945), infiltration capacity as a single important factor also influences the drainage density and stream frequency. The values of drainage texture ratio of the study area vary from 3.00-11.51. According to Smith (1950), five different drainage textures have been classified based on the drainage density. The drainage density less than 2 indicates very coarse, between 2 and 4 is related to coarse, between 4 and 6 is to moderate, between 6 and 8 is related to fine and greater than 8 is related to very fine drainage texture. In the study area Saggiyam, Mudoldoddi and Prakash palya sub basins have shown coarse and Halgapuram, Deverabetta, Mattugaudanadoddi, Handgalli, Manchepura and Depudisahibradoddi sub basins are moderate and Chinchalli and Adugulpodu sub basins have shown fine and Lokkanahalli, Naripura, Ramayanadoddi and Jodukarahatti sub basins have shown very fine drainage textures.

4.7.4. *Form Factor*

Form factor (Rf) may be defined as the ratio of the area of the basin and square of basin length (Horton, 1932). 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 shape. Rf values of the study area are shown in Table 2. It is noted that the Rf values vary from 0.12 to 1.24. The values of 0.78 to 1.24 are seen in Mudoldoddi, Prakash palya and Deverabetta sub basins which indicates circular shape and remaining sub basins are of elongated in shape.

4.7.5. *Circulatory Ratio*

The circulatory ratio (Rc) is mainly concerned with the length and frequency of streams, geological structures, land use/land cover, climate, relief and slope of the basin. It is the ratio of the area of the basins to the area of circle having the same circumference as the perimeter of the basin. In the study area, the Rc values are ranging from 0.19 to 0.58. The values are more than 0.5 which indicates that they are more or less circular in shape and are characterized by the high to moderate relief and the drainage system are structurally controlled.

4.7.6. *Elongation Ratio*

Elongation ratio is the ratio between the diameter of the circle of the same area as the drainage basin and the maximum length of the basin. The elongation ratio values of the sub basins vary from 1.77 to 5.29. The elongation ratio values generally exhibit variation from 0.6 to 1.0 over a wide variety of climatic and geologic types. In the study area, all 15 sub basins are showing the elongation ratio greater than 1.0, indicating their lower relief.

5. Conclusion

From the Morphometric study, it is seen that the basin forms the dendritic to sub-dendritic drainage pattern with stream orders ranging from 4th to 5th orders. The Average bifurcation ratio is calculated for the watershed as 3.87. The value of Rb in the present case indicates that this watershed has

higher values of Rb indicating a strong structural control in the drainage pattern; the high drainage density indicates the presence of weak or impermeable subsurface material, sparse vegetation and mountainous relief. Drainage textures have been classified based on the drainage density. The drainage density less than 2 indicates very coarse, between 2 and 4 is related to coarse, between 4 and 6 is moderate, between 6 and 8 is fine and greater than 8 is very fine drainage texture. In the study area Saggiyam, Mudoldoddi and Prakash palya sub basins are coarse and Halgapuram, Deverabetta, Mattugaudanadoddi, Handgalli, Manchepura and Depudisahibradoddi sub basins are moderate and Chinchalli and Adugulpodu sub basins are fine and Lokkanahalli, Naripura, Ramayanadoddi and Jodukarahatti sub basin is very fine drainage textures. The Rf values vary from 0.12-1.24. The values of 0.78 to 1.24 are seen in Mudoldoddi, Prakashpalya and Deverabetta sub basins indicating that they are circular in shape and remaining sub basins are elongated in shape. In the study area, the Rc values are ranging from 0.19 to 0.58. The values are more than 0.5 which indicating that they are more or less circular in shape and are characterized by the high to moderate relief and the drainage system were structurally controlled. The elongation ratio values generally exhibit variation from 0.6 to 1.0 over a wide variety of climatic and geologic types. In the study area, all 15 sub basins showed the elongation ratio greater than 1.0 indicating that they have lower relief.

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