International Journal For Technological Research In Engineering
Volume 6, Issue 8, April-2019 *ISSN (Online): 2347 - 4718*

WATERSHED PRIORITIZATION BASED ON MORPHOMETRIC ANALYSIS OF HEMAVATHY BASIN USING REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM

K.Balakrishna[1], Dr. H.B.Balakrishna[2]
[1]Research Scholar, [2]Professor and Head,
Department of Civil Engineering, Bangalore Institute of Technology Bangalore-560004, Karnataka, India.

Abstract: Water is very important and most essential for socio-economic development of the country, needs to conserve them with the development and management of water resources. The present study is made in assessing the morphometric characteristics of Hemavathy river basin at watershed level by dividing the drainage area into 46 sub watersheds, and prioritization using the Survey of India toposheets and satellite data, using remotely sensed data and ArcGIS software. Morphometric analysis of a watershed provides a quantitative description of a drainage system and in generation of parameters required for hydrological assessments is an important aspect of the watershed characterization. Form factor and elongation ratio show shape of watershed and terrain, bifurcation ratio about the structural control of drainage pattern, texture ratio about the type of soil. The value of the relief ratio gives relation with hydrologic characteristic of the watershed, ruggedness value in determining the proneness of areas to soil erosion and helps in association of relief and drainage density. The study shows the highest stream order was 7th order,8, 10,19,26,39,43 sub watersheds need immediate attention and prioritizing to take up for its planning and development. The Morphometric parameters of basin geometry can be measured and expressed either in terms of numerical values or in terms of ratios. By using measurement of different parameters of drainage network of the basin and its relief features, the surface characteristics of channel network can be achieved in better way.
Keywords: drainage density, GIS, Morphometric analysis, parameters, stream order, watershed.

I. INTRODUCTION

The Morphometric analysis of the river basin provides useful parameter for surface and groundwater resource management, runoff and geographic characteristics of the drainage system in watershed characterization and prioritization. It provides quantitative description of basin geometry in understanding structural controls, recent geological, geomorphic details of drainage basin [1]. The Morphometric analysis includes the estimation of morphometric parameters, linear aspects and aerial aspects, in the linear aspects the stream ordering, stream length, stream length ratio, and bifurcation ratio and in the aerial aspect the drainage density, stream frequency, form factor, circulatory ratio, and elongated ratio to understand nature of the drainage basin. [2]. Quantitative assessment using remote sensing with unique capabilities of capturing features of inaccessible areas and GIS is useful in water resource management and decision-making, with updated drainages in use [3].The morphometric analysis is a quantitative method which describes various topographic parameters useful for statistical and comparative study using GIS and remote sensing. The focus of this study is to evaluate morphometric parameters for Hemavathy basin watershed and highlightprioritization of sub-watersheds involves ranking in decision to be taken up for conservation management, taking into consideration the amount of soil loss [4]The morphometric parameters are computed using ArcGIS software.

II. AIM AND OBJECTIVES

The objectives of study are:
1. To understand various morphometric parameters by using topographic maps, satellite images and stream network.
2. Detailed Understanding of the morphometric behavior of the study area
3. Watershed prioritization and Quantitative assessment of hydrological parameters by ranking
of sub watersheds

III. STUDY AREA

Hemavathy river starts in western ghats in Chickmaglur district and flows through Chickmaglur, Hassan, Mandya and Mysore districts covers geographically between75°30'00" to 76° 15' 00"E longitude 12° 30' 00" to 12° 30' 00"N latitude, with watershed area of 2855km2. It is 245 km long and has a drainage area of about 5,698.65 km2. A large reservoir has been built on the river at Gorur in the Hassan district. In the entire Cauvery basin, the Hemavathy watershed is second largest in terms of area.

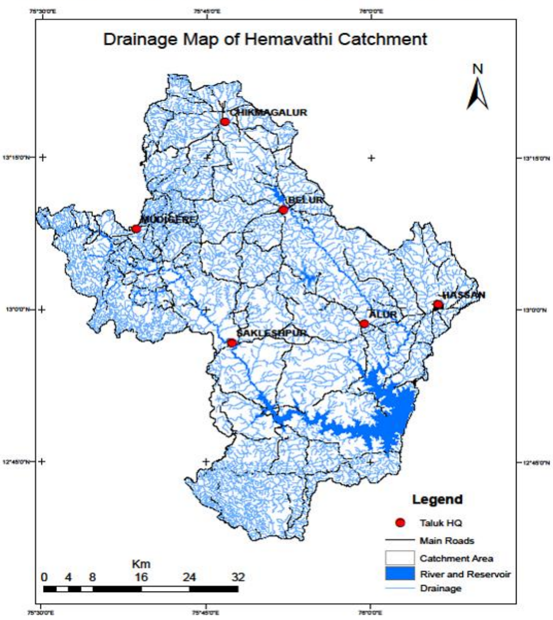
IV. METHODOLOGY

The base map is prepared using Survey of India (SOI) toposheet number57C/04, 57D/1, 57D/2, 48O/08, 48O/11, 48O/12, 48O/15, 48O/16, 48P/09, 48P/10, 48P/13 and 48P/14. The Topo maps are scanned and projected for delineating the required features. The Digitized maps are updated with the help of satellite imagery. The study is taken for quantitative analysis of drainage system, using the ArcGIS software. The thematic maps are derived from IRS Satellite series LISS III on 1:50000 scale and SOI toposheets as reference The drainage map prepared from the toposheet forms the base map for the preparation of thematic maps related to surface and groundwater. All the streams, River, tributaries and small stream channels shown on the toposheet are extracted to prepare the drainage map. The concept of stream order is used to calculate other indicators of drainage character of a watershed. Stream Order map has been prepared by using drainage map by assigning Stream orders for different stream segments. Figure 1 shows the Drainage map and Figure 2 shows the stream ordering map. The various parameters namely; linear, aerial and shape factors are estimated using suitable equations. Thehigh priority areas are delineated based on considering the important aerial and linear parameters by giving proper weight age. Aerial parameters are ranked in a decreasing order; higher values assigned a rank of six and lowest valued assigned as a rank of one, the linear parameters, are rated as rank one, the second lowest as rank two and so on. Based on these ranking, the compound value is calculated by averaging all the ranks of each sub-watershed. Based on the analysis sub-watershed with highest compound value is given a priority of 1, followed by sub-watersheds of other ranks. Table 1 shows methodology to compute morphometric parameters.

V. RESULTS AND DISCUSSIONS

The study taken for quantitative analysis of drainage system reveals the stream order, number, frequency, density, and bifurcation ratio categorized by the linear, areal and relief properties, morphometric parameters a helpful tool for identifying potential zonation. Table 2 shows Morphometric parameters of Hemavathy River basin. Table 3 shows different morphometric characters of Hemavathy river basin. In the present study, according to Strahler's method of stream ordering, the watershed forms the seventh order and hence designated as seventh order watershed. The stream ordering index size and scale afford an index of the amount of stream flow which can be produced by particular network.

Fig 1:Drainage Map of Hemavathi Catchment



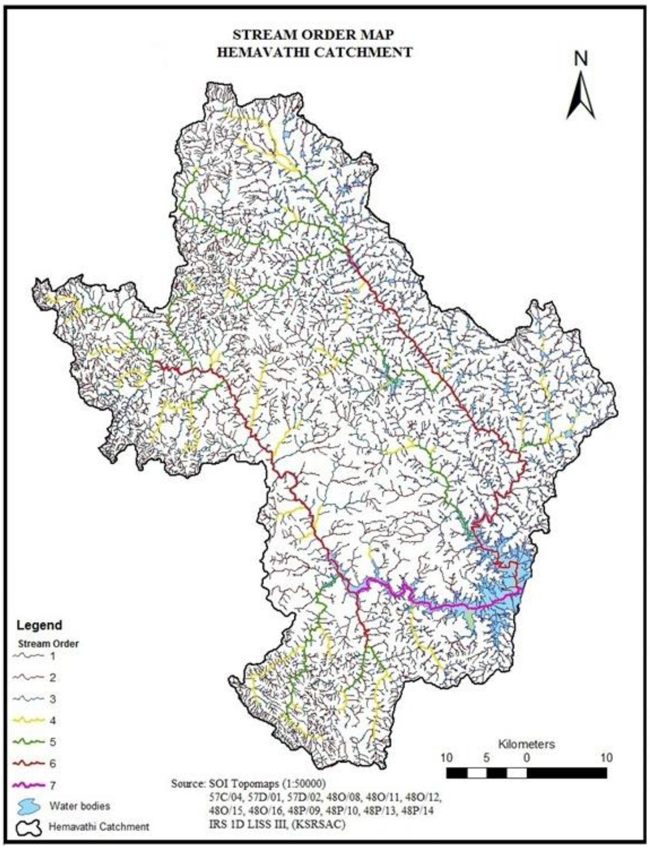


Figure 2 Stream order map of Hemavathy river basin(Scale has to be same)

Table 1 Methodology adopted for computation of morphometric parameters

Sl.No.	Morphometric Parameter	Formula	Reference
A	Drainage Network		
1	Stream Order(Su)	Hierarchical Rank	Strahler(1952)
2	Stream Number (Nu)	Nu = N1+N2+ …Nn	Horton(1945)
3	Stream Length (Lu) Kms	Lu = L1+L2 …… Ln	Strahler (1964)
4	Bifurcation Ratio (Rb)		Strahler (1964)
5	Mean Bifurcation Ratio (Rbm)		Strahler (1964)
B	**Basin Geometry**		
6	Basin Length (Lb) Kms	GIS Software Analysis	Schumm(1956)
7	Mean Basin Width (Wb)	Wb = A / Lb	Horton (1932)
8	Basin Area (A) SqKms	GIS Software Analysis	Schumm(1956)
9	Basin Perimeter (P) Kms	GIS Software Analysis	Schumm(1956)

10	Form Factor Ratio (Rf)	$Ff = A / Lb^2$	Horton (1932)
11	Shape Factor Ratio (Rs)	$Sf = Lb^2 / A$	Horton (1932)
12	Texture Ratio (Rt)	$Rt = N1 / P$	Schumm(1956)
13	Circularity Ratio (Rc)	$Rc = 12.57 * (A / P^2)$	Miller (1968)
14	Drainage Texture (Dt)	$Dt = Nu / P$	Horton (1945)
C	**Drainage Texture Analysis**		
15	Stream Frequency (Fs)	$Fs = Nu / A$	Horton (1932)
16	Drainage Density (Dd) Km / Kms^2	$Dd = Lu / A$	Horton (1932)
17	Constant of Channel Maintenance (Kms^2/ Km)	$C = 1 / Dd$	Schumm(1956)
18	Length of Overland Flow (Lg) Kms	$Lg = A / 2 * Lu$	Horton (1932)
D	**Relief Characterizes**		
19	Maximum Height of the Basin (Z) m	GIS Analysis / DEM	-
20	Total Basin Relief (H) m	$H = Z - z$	Strahler (1952)
21	Relief Ratio (Rhl)	$Rhl = H / Lb$	Schumm(1956)
22	Relative Relief Ratio (Rhp)	$Rhp = H * 100 / P$	Melton (1957)
23	Ruggedness Number (Rn)	$Rn = Dd * (H / 1000)$	Patton & Baker (1976)

Table 2.Morphometric Parameters of Hemavathy River basin

Sl No	Watershed parameters	Units	Values
1	Area of Watershed	Km²	2855.11
2	Perimeter of Watershed	Km	2080.43
3	Watershed highest order	No	7
4	Maximum length of sub Watershed	Km	15.27
5	Maximum width of sub Watershed	Km	10.63
6	Form factor		0.518
7	Shape factor		1.884
8	Cumulative stream segment	Km	9143
9	Cumulative stream length	Km	5058.32
10	Stream frequency	No/Km²	3.11
11	Drainage density	Km/Km²	1.8
12	Constant of Channel maintenance	Km²/Km	0.564
13	Length of Overland flow	Km	0.27
14	Bifurcation ratio		4.818
15	Stream length ratio		1.868
16	Circularity ratio		0.404
17	Elongation ratio		0.87
18	Compactness coefficient		1.65
19	Total relief of watershed	Km	0.76
20	Watershed relief ratio		0.018
21	Relative relief ratio		0.0046
22	Ruggedness number		0.00036

Table 3. Different Morphometric characteristic of Hemavathybasin (Line should be drawn)

Stream order	No of segments (Nu)	Total Stream length " L " (Km)	Bifurcation ratio (Rb) Nu/(Nu+1)	Mean length Lu (Km)	Cumulative length (m)	Stream Length Ratio (RL= Lu/(Lu1))	Drainage density Dd= ∑L /A (Km/Km²)
1	7821	2753.02		0.352	2753.02		1.80
2	985	1089.58	7.94	1.105	3842.60	3.139	
3	228	509.28	4.32	2.232	4351.88	2.019	
4	54	240.58	4.22	4.444	4592.46	1.990	
5	29	187.07	1.86	6.44	4779.53	1.449	
6	21	229.05	1.38	10.904	5008.58	1.693	
7	5	49.74	4.2	9.988	5058.32	0.915	

Stream Length

This factor gives the idea of the efficiency of the drainage network. The total stream lengths of the watershed have various orders, which are computed with the help of SOI topographical sheets and ArcGIS software. As seen high values of first-order streams is an indication of possibility of sudden flash floods after heavy rainfall in the downstream segments. Fig. 3 shows typical regression of stream order on number of stream segments for individual watershed.Fig.4 shows typical regression of stream order on mean stream length for individual watersheds

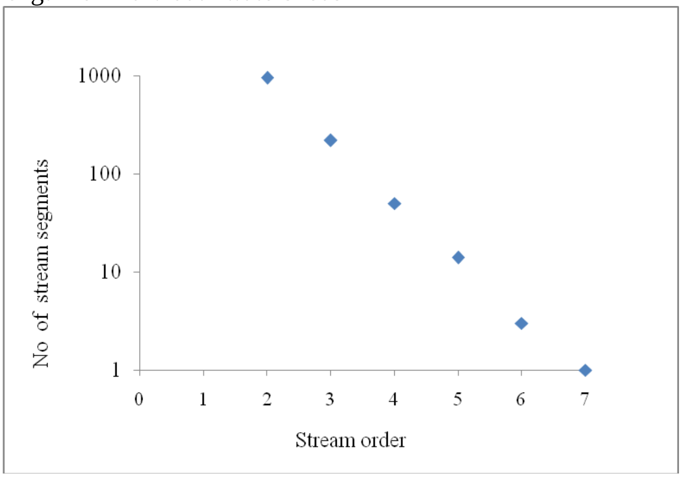


Fig 3. Regression of stream order

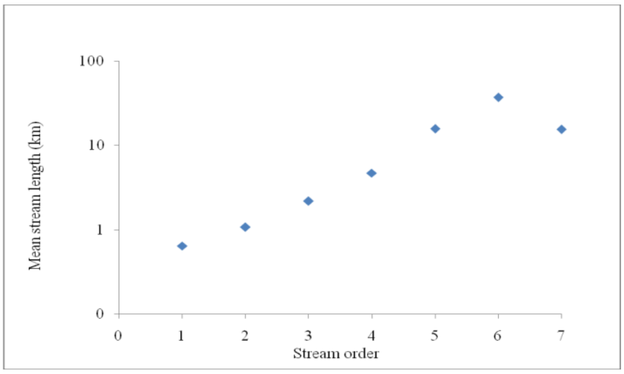


Fig. 4. Regression of stream order on mean stream length for Hemavathy River basin

Bifurcation ratio

Bifurcation ratio of streams indicates stream behavior within the watershed. It is observed that Rb is not same from one order to its next order these irregularities are dependent upon the geological and litho logical development of the drainage basin. In the study the mean value for the catchment was 4.818 which indicate normal basin category and a natural river system have strong structural control on the drainage pattern, with uniformity in respect to climate, rock type and stage of development.

Length of overland flow

Length of overland flow is the flow of water over the surface before it becomes concentrated in definite stream channels. The length of overland flow is a measure of erodibility; the speed of the unconcentrated overland flow is much less than when concentrated in to the stream variable, affecting both the hydrologic and physiographic development of the drainage basin. In the study area value of length of overland flow varies from 0.17 to 0.50(km 2/km) in the sub watersheds. The shorter the length of overland flow, the quicker the surface runoff from the streams.

5.2 Areal Aspects

Drainage density

The drainage density indicates better quantitative expression to the analysis of landform, as an indirect indicator to explain, those variables as well as the morphogenesis of landform of the area of watershed. The analysis showed that the average drainage density for the catchment was 1.80km/km2the low value of drainage density influences greater infiltration and hence the wells in this region will have good water potential leading to higher specific capacity of wells. In the areas of higher drainage density, the infiltration is less and surface runoff is more.

Stream frequency

Stream frequency is the total number of streams in a drainage basin divided by the area of the drainage basin area expressed as number of stream segments per unit area. In the present study, these values varyfrom0.89 to1.02, maximum frequency is observed in the first-order streams. Figure 3 shows the regression of drainage density on stream frequency; drainage density of sub watersheds shows positive correlation with stream frequency indicating of increase in stream population with increasing drainage density.

Form factor

Form factor is the ratio of basin area to square of the basin length. The analysis showed that Form factor in the study area vary from 0.30 to 0.96 The watershed with high form factors have high peak flows of shorter duration, whereas elongated watershed with low form factor indicating them to be elongated in shape and flow for longer duration,

Circulatory ratio

Circularity ratio is the ratio of watershed area to the area of a circle having the same perimeter of the watershed. In the present study Circularity ratio Rc values ranges from 0.10 to 0.60,basin of the circularity ratios range 0.4 to 0.5, indicates strongly elongated and highly permeable homogenous geologic materials, which indicates the watersheds are elongated to more elongate.

Elongation ratio

Elongation ratio is the ratio of diameter of circle of the same area as the basin to the maximum basin length. Elongation ratio values of the watershed vary from 0.60 to 1.50. The varying

slopes of watershed can be classified with the help of the index of elongation ratio, In the study area, the sub watersheds which fall in high priority category are 8,9,14,19,21-24,40,42 consist of low elongation ratio, resulting in greater run-off, less infiltration and high relief conditions.

5.3 Relief aspects

Watershed relief is the difference in elevation between the remotest point in the water divide line and the discharge point of the watershed. The difference in elevation between the remotest point and the discharge point is obtained from the available contour map. Difference in the elevation between the highest point of a watershed and the lowest point on the valley floor is known as the total relief of the river basin.

Relief ratio

The relief ratio is the ratio between the total relief of a basin and the longest dimension of the basin parallel to the main drainage line. In the study area, the value of relief varies from 30m to 650m which indicates that there are enough slopes for the runoff to occur. The relative relief ratios are ranging from 0.042 to 0.002. It has been observed that areas with low to moderate relief and slope are characterized by moderate value of relief ratios. The relief ratio increases overall the sharpness of the drainage basin and it is an indicator of intensity process operating as the shape of the watershed.

Ruggedness number

Ruggedness number is the product of the watershed relief and drainage density and usually combines slope steepness with its length. It is computed as 0.00096using the equation.

VI. CONCLUSIONS

Remote sensing and GIS have proved to be efficient tool in drainage delineation and adoption in the present study and these updated drainages have been used for the morphometric analysis. GIS based approach facilitates analysis of different morphometric parameters and to explore the relationship between the drainage morphometry and properties of landforms, soils and eroded lands. From the morphometric analysis of the drainage network of all the sub watersheds we will come to know the drainage pattern and variation in the stream length. The bifurcation ratio relates the topography and geometric development. The relation between drainage density and drainage population can be found out by drainage frequency. The elongation ratio gives us the shape of the watersheds. This study provides the information for watershed development priority such as land and water resources development and also helps in identifying the suitable site for water harvesting structures. More the drainage density, less the infiltration and more runoff from the watershed. The relief aspect shows that the watershed has enough slopes for runoff to occur from the source to the mouth of watershed.

Acknowledgment
We all authors thanks to Karnataka state remote sensing application center (KSRSAC), Bangalore for providing the computer lab and other facility. We also thanks to water resources department, Government of Karnataka for providing required data for the study.

REFERENCES

[1] Strahler, A.N.(1964)Quantitative geomorphology of drainage basins and channel networks: V.T. Chow (Ed.), Handbook of Applied Hydrology. Mc Graw-Hill, New York, pp.4.39-4.76.
[2] Vijitha H. and Satheesh R. (2006) GIS Based Morphometric Analysis of two major upland sub-watersheds of Meenachil river in Kerala, Journal of the Indian Society of Remote Sensing, Vol.34, pp.181-185.
[3] 3.Rudraiah, S., Govindaiah, S, Srinivas vittala (2008) Morphometry using remote sensing and GIS techniques in the sub basins of Kagna river basin, in Gulbarga district, Karnataka, Journal of Indian Society of Remote Sensing, Vol. 36, No. pp 351-360.
[4] 4.Srinivasa Vittala, S., Govindaiah and Honne Gowda, H(2008) Prioritization of sub-watersheds for Sustainable development and management of natural resources: An integrated approach using remote sensing, GIS and socio-economic data, Current Science, Vol 95, No 3, pp 345-354.
[5] 5. Horton, R.E. (1945) Erosional development of streams and their drainage density: hydro physical approach to quantitative geomorphology. Geol.Soc. Amer. Bull., no.56, pp.275-370.

