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Quantitative Morphometric Evaluation of Gulakamale Watershed

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Abstract- ***Morphometric analysis of the Watershed is considered to be the most satisfactory method because it enables in understanding of the relationship of various aspects within a drainage basin. In the present study Gulakamale watershed have been considered with an area of 67.313 km^2 with highest order stream of 5. The values of Stream frequency is 2.73, Form factor 0.516, Shape factor 1.94, Elongation Ratio 0.457, Circularity Ratio 0.581, Drainage density 2.36, Length of overland flow 0.376 for Gulakamale watershed.***

Key words: Watershed, GIS, Drainage density, Stream Frequency, Length of overland flow.

I. INTRODUCTION

Watershed is a natural hydrological entity from which runoff resulting from precipitation flows past a single point into large stream, river, lake or ocean. Thus, a watershed is the surface area drained by a part or the totality of one or several given water courses and can be taken as a basic erosional landscape element where land and water resources interact in a perceptible manner. Morphometric analysis provides quantitative description of the basin geometry to understand initial slope or inequalities in the rock hardness, structural controls, recent diastrophism, geological and geomorphic history of drainage basin (Strahler, 1964). Morphometric analysis requires measurement of linear features, gradient of channel network and contributing ground slopes of the drainage basin. . A major emphasis in geomorphology over the past several decades has been on the development of quantitative physiographic methods to describe the evolution and behavior of surface drainage networks (Horton, 1945). The influence of drainage morphometry is very significant in understanding the landform processes, soil physical properties and erosional characteristics. Drainage characteristics of many river basins and sub basins in different parts of the globe have been studied using conventional methods (Horton, 1945; Strahler, 1964). Geographical Information System (GIS) techniques are now a days used for assessing various terrain and morphometric parameters of the drainage basins and watersheds, as they provide a flexible environment and a powerful tool for the manipulation and analysis of spatial information.

II. MATERIALS AND METHODS

A Study Area

The study area chosen is Gulakamale watershed which lies in Bangalore district. The culvert with its longitude of 77^0 31’ 50.07” E and latitude of 12^0 47’ 50.07” N is situated over the two-lane district highway road near Kaggalipura village. The nearest national highway passing through to the watershed is NH 209. The location map shown in Figure.1, indicates some of the salient features in the vicinity of Gulakamale watershed. The watershed parameter details are tabulated in table 1.

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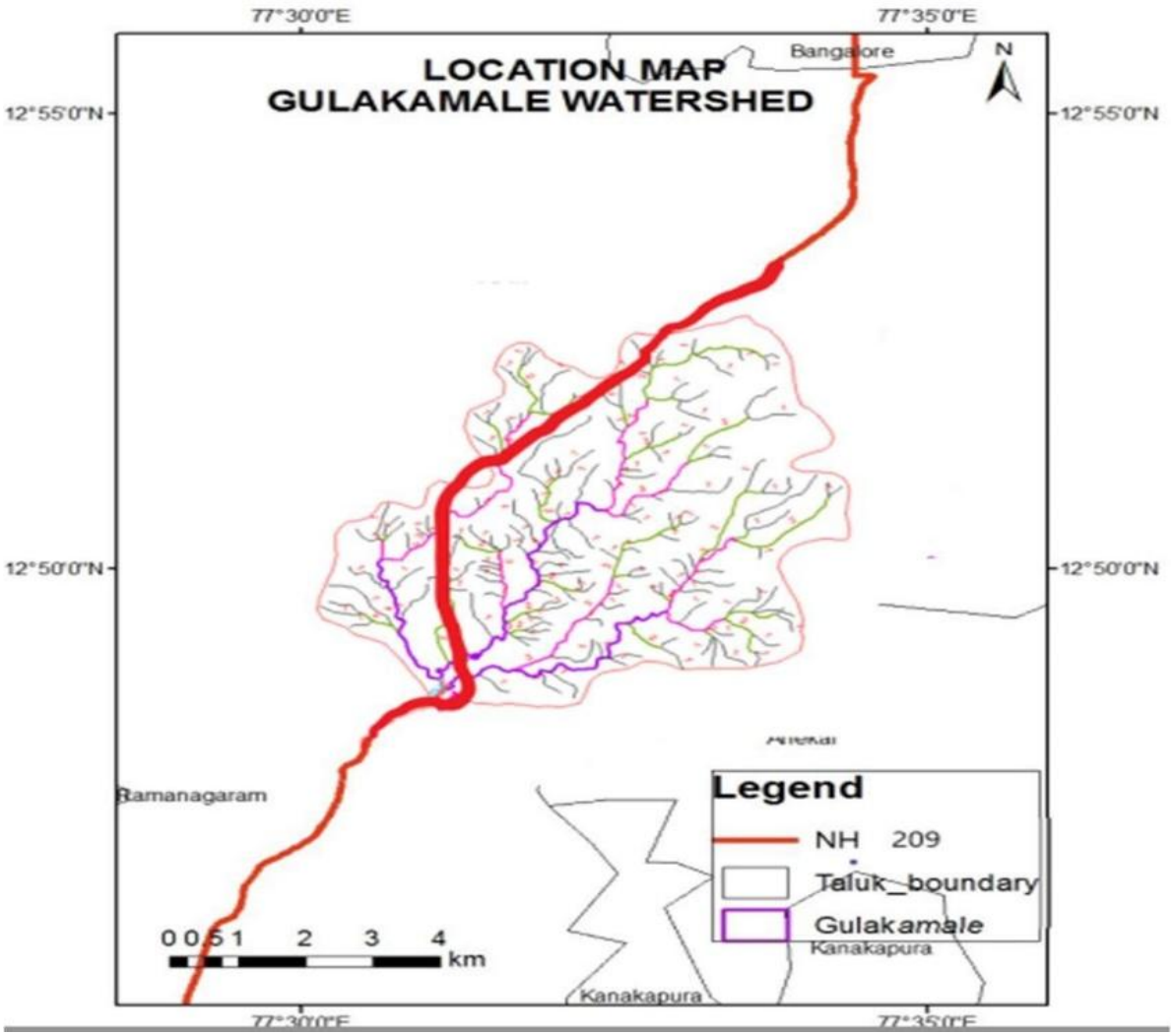

Figure 1: Location of Gulakamale watershed

Table 1: Watershed parameters

WATERSHED PARAMETERS	
Area	67.313 km^2
Perimeter	38.145 km^2
Length	11.42 km
Width	5.70 km
Maximum elevation	924 m
Minimum elevation	735 m

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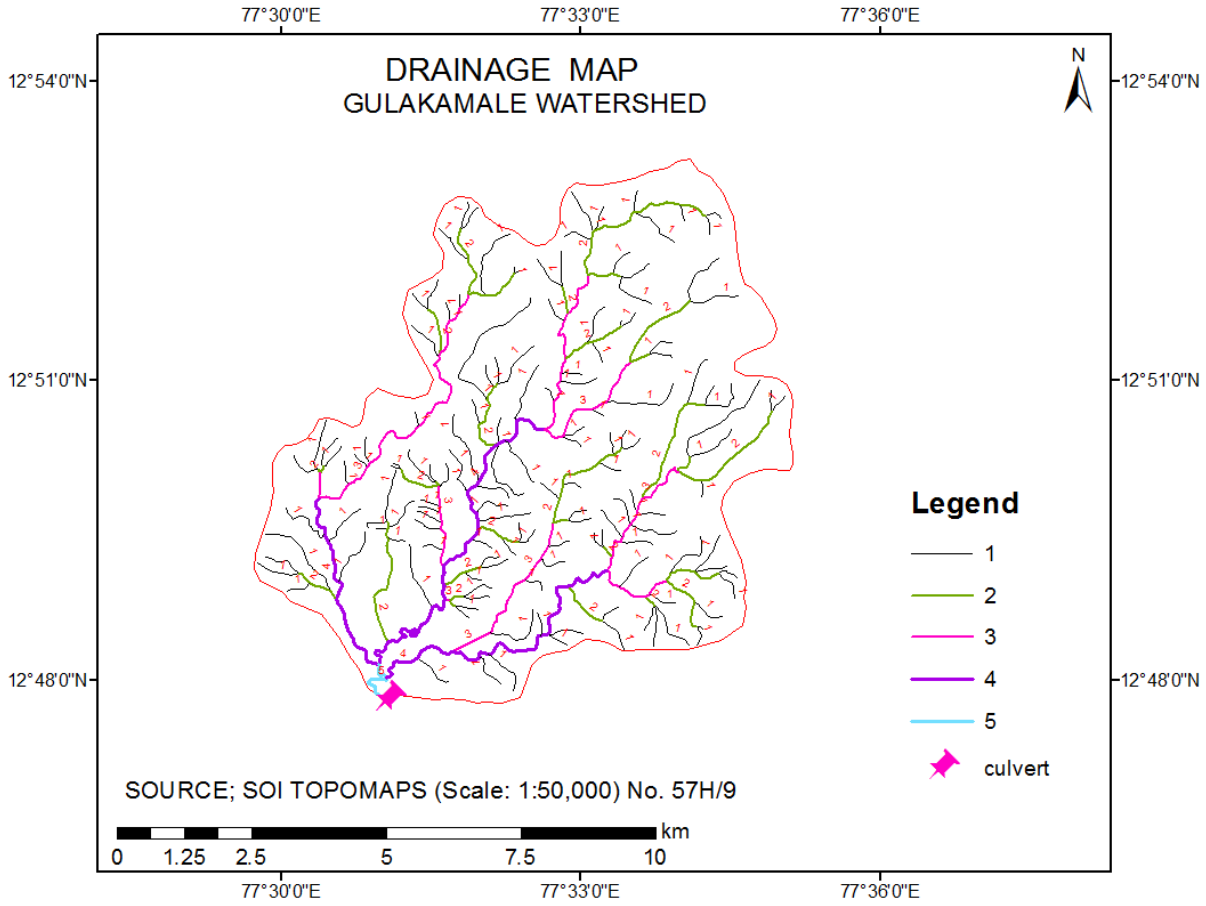

Figure 2: Stream order Map of Gulakamale watershed

B Methodology

DEM data is used to calculate the flow direction a staple for determining many important hydrologic parameters stream network is determined by using Arc GIS tools. Drainage map is as shown in Figure 1. Quantitative morphometric analysis was carried out for different mini watersheds for linear aspects, areal aspects and relief aspects. The analysis was carried out using Arc GIS. The detailed list of various morphological characteristics derived for Table 2 is used for calculating the morphometric parameters of the Gulakamale watershed.

Table 2: Formulae adopted for computation of Morphometric parameters

Sl no	Morphometric parameters	Formula	Refrence
1	Stream order	Hierarchial 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	RL = Lu / Lu – 1 Where, RL = Stream length ratio Lu = The total stream length of the 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	Schumn (1956)

		Nu = Total no. of stream segments of order 'u' Nu + 1 = Number of segments of the next higher order	
6	Relief ratio (Rh)	Rh = H / Lb Where, Rh = Relief ratio H = Total relief (Relative relief) of the basin (km) Lb = Basin length	Schumn (1956)
7	Drainage density (D)	D = Lu / A Where, D = Drainage density Lu = Total stream len gth of all orders A = Area of the basin (Sq km)	Horton (1932)
8	Stream frequency (Fs)	Fs = Nu / A Where, Fs = Stream frequency Ns = Total no. of streams segments A = Area of the basin (Sq km)	Horton (1932)
9	Form factor (Rf)	Rf = A / Lb Where, Rf = Form factor A = Area of the basin (Sq km) Lb = basin length	Horton (1932)
10	Circularity ratio (Rc)	$Rc = (4 * Pi * A)^{1/2} / P^2$ Where, Rc = Circularity ratio Pi = 'Pi' value i.e., 3.14 A = Area of the basin (Sq km) P^2 = Square of the perimeter (km)	Miller (1953)
11	Elongation ratio (Re)	Re = 2 (A/Pi)½ / Lb Where, Re = Elongation ratio A = Area of the basin (Sq km) Pi = 'Pi' value i.e., 3.14 and Lb = Basin length	Schumn (1956)

III. RESULTS AND DISCUSSION

Quantitative Morphometric analysis were carried out for Gulakamale watershed. The results of Morphometric characteristics are presented in Tables 3 and 4.

Table 3: Showing linear characteristics

Stream order (Su)	Number of streams (Nu)	Stream length (Lu)(km)		Mean stream length (km) Lsm	Stream length ratio (Lur)	Bifurcation ratio (Rb)
1	145	89.56		0.62	-	-
2	27	30.19		1.12	0.55	5.37
3	8	20.12		2.52	0.44	3.375
4	3	17.27		5.75	0.44	2.67
5	1	1.15		1.15	5.00	3.0

Table 4: Morphometric characteristics of Gulakamale watershed

Sl.No	Morphometric Characteristics	Result	Unit
Linear aspects			
1	Stream order(Highest)	5	Number
2	Total number of Stream segments	184	Number
3	Total Stream length	159.3	km

4	Stream length ratio	0.44-5.0	-
5	Bifurcation ratio	2.67-5.37	-
Areal aspects			
6	Basin area	67.313	sq.km
7	Basin length	11.420	km
8	Basin perimeter	38.145	km
9	Compactness coefficient	1.31	-
10	Circulatory ratio	0.581	-
11	Elongation ratio	0.457	-
12	Form factor	0.516	-
13	Shape factor	1.94	-
14	Constant of channel maintenance	0.423	-
15	Drainage density	3.63	km/km^2
16	Length of overland flow	0.376	km
17	Stream frequency	2.73	Number/km^2
Relief aspects			
18	Highest elevation	924	m
19	Lowest elevation	735	m
20	Total basin relief	189	m
21	Relative Relief ratio	0.0049	-
22	Relief ratio	0.0017	-
23	Ruggedness number	0.446	-

IV. CONCLUSIONS

Important areal parameters have been analyzed and results are presented in Table 3 and 4. The total area of the drainage basin is 65.313 km^2. The length of the basin is 4.402 km. Basin perimeter is the outer boundary of the drainage basin that encloses its area as 20.485 km using ArcGIS software.

Basin possesses high drainage density i.e., 3.63 km/ km^2, which is indicative of less permeable material, sparse vegetative cover and moderate to high relief. The Stream frequency of the watershed is 2.73 per km^2. The circulatory ratio of the basin is 0.58, which is indicative of lack of circulatory and indicates the dendritic stage of a watershed.

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