Morphometric Analysis of Nethravathi Watersheds

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ABSTRACT
This study presents a comparative analysis of morphometric parameters for two watersheds of Nethravathi river flowing in Karnataka. Delineated watersheds from toposheet are subjected to their physical characterization, using parameters viz; stream order, stream length, bifurcation ratio, drainage density, stream frequency, form factor, circulatory ratio, etc. Both the watersheds- Bidarthala and Manjotti have fern-like drainage pattern i.e., dendritic type which indicates homogeneity in texture. Biderthala basin with a catchment area of 0.589 km^2 has been observed to have high drainage density and stream frequency indicating impermeable, dense vegetated region with mountainous relief, whereas Manjotti Hole of 0.28 km^2 basin area, has relatively low values of drainage density and stream frequency, which represents the sparse vegetated region with less relief. Manjotti watershed is more circular than Biderthala basin. Both the basins have low value of length of overland flow emphasising the short flow paths, more runoff, and less infiltration. Further, these parameters can also be related with the land use and cover profiles of the regions.

Keywords
Morphometric analysis, watershed, Biderthala Hole, Manjotti Hole, drainage density.

1. INTRODUCTION
Study of form and structure of a river – River Morphology, has been a subject of great interest and challenge to scientists and engineers with regard to river engineering, and is based on a proper understanding of the morphological features evolved over time. In geomorphology, morphometry is simply a quantification of morphology. Morphometric analysis is the study of physical characteristics of catchment; such as area, slope, shape, drainage pattern etc. Watershed is a natural hydrological entity from which surface runoff flows to a defined drain, channel, stream or river at a point. On the basis of size, they have often termed as a watershed, catchment and basin. Watershed analysis based on morphometric parameters is very important for watershed planning since it gives an idea about the basin characteristics regarding topography, soil condition, runoff characteristics, surface water potential, etc [3]. Quantitative approach of the morphometric analysis is best for comparative evaluation of different watersheds in various geomorphologic and topographical conditions.

The objective of this paper is to analyse watershed characteristics based on morphometric parameters of two streams located in uplands and lowlands westwards of Western Ghats. This has been achieved by using Survey of India (SOI) toposheets and an integrated remote sensing and GIS software QGIS v3.0.0-Girona.

Some of the morphometric parameters which have been studied in this paper are area, stream order, stream density, drainage density, relief, slope, length, shape etc.

2. STUDY AREA
Two streams of Nethravathi River at two different terrain conditions are the regions of interest for this study. Out of which, Bidarthala watershed is a forested watershed and the terrain consists of steep slopes. Runoff generated to the Biderthala Hole is from shola grasslands and forests. The region falls in Chikmangaluru dist., near Charmadi Ghats right above the district boundary of Dakshina Kannada. It is enclosed within the SOI Toposheet No. 48-O/3 between longitudes 13° 5' 30" N to 13° 8' 00" N and longitudes 75° 27' 00" E to 75° 29' 30" E (Fig 2). The second site is Manjotti watershed, having fairly flat terrain, is located in lowlands of Dakshina Kannada dist., enclosed within the SOI Toposheet No. 48-O/3 between longitudes 13° 1' 00" N to 13° 2' 00" N and longitudes 75° 18' 30" E to 75° 19' 30" E (Fig 2).

3. DATA
Length, area, and other primary details under consideration for the study regions are derived from SOI toposheet with the help of GIS package.

4. METHODOLOGY
In the present study, two watersheds, Biderthala Hole and Manjotti Hole have been identified with the help of Toposheet and integrated with GIS software (QGIS) to delineate the streams and catchment area. A detailed morphometric analysis is carried out then.

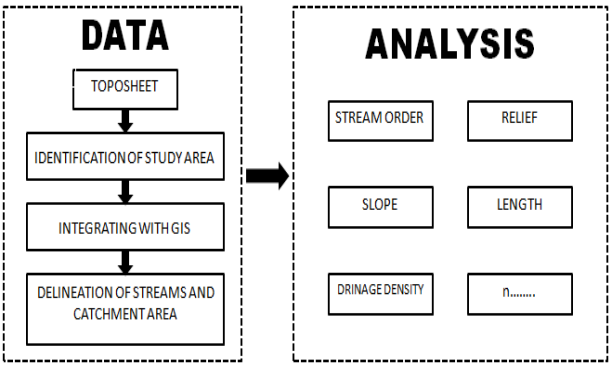

Fig 1:Flow Process

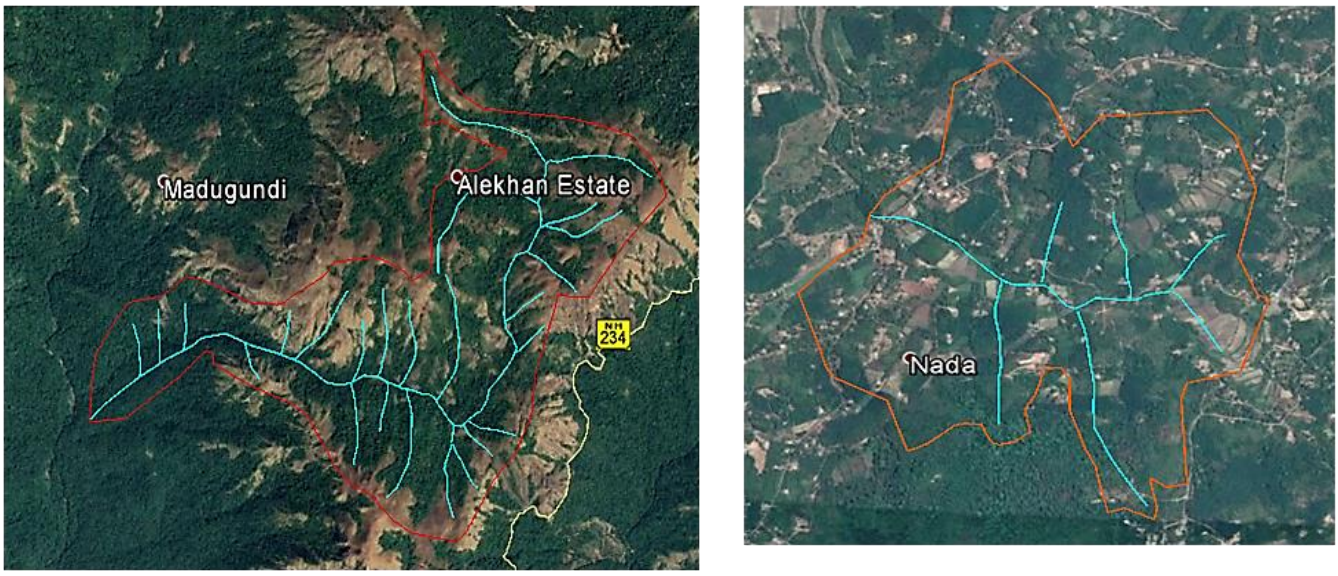

Fig 1: Biderthala Hole and Manjotti Hole

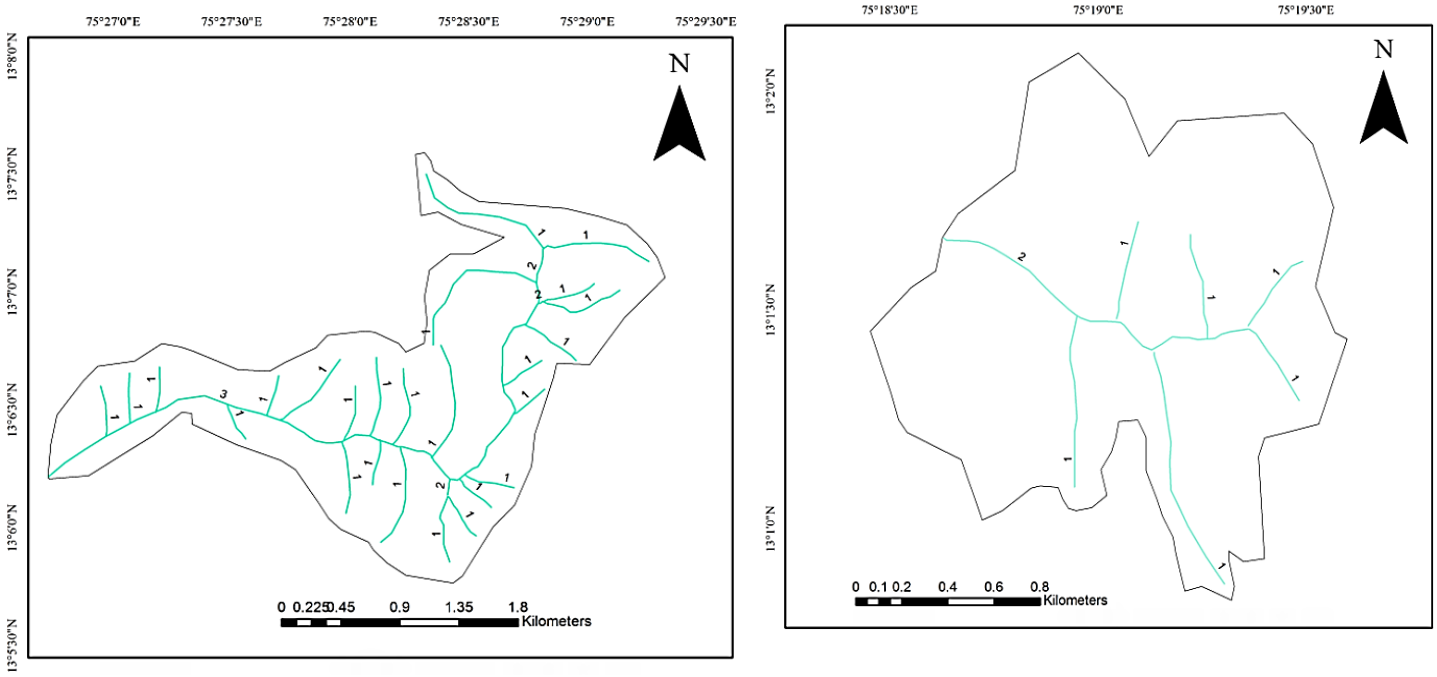

Fig 2: Stream order

Table 1. Morphometric Parameters

Class	Morphometric Parameter	Formula /Definition		References
LINEAR	Basin Length (L_b)	It is the longest length of the stream from catchment outlet to remotest point on the basin boundary.		[1]
	Basin Parameter (P)	Perimeter of basin		[1]
	Stream Order (U)	Hierarchical Order; unbranched fingertip streams near the catchment boundary are designated as 1st order; two 1st order streams join to form segments of 2nd order; and similarly, two 2nd order streams join to form a segment of 3rd order and so on.		[3]
	Stream Length (Lu)	Length of the stream		[4]
	Mean stream length (Lsm)	Lsm=Lu/Nu	It is the ratio of total length (Lu) of streams of given order to the total number of stream (Nu) segments of that order.	[4]
	Stream length ratio (Rl)	RL= Lu / Lu-1	It is the ratio of the mean stream length (Lu) of a given order to the mean stream length of previous lower order (Lu-1).	[4]
	Bifurcation Ratio (Rb)	Rb = Nu / Nu+1	It is the ratio of the number of stream segments of given order (Nu) to the number of segments of the next higher order (Nu+1).	[5]
RELIEF	Basin relief (Bh)	It is vertical distance between the lowest and highest points of basin.		[1]
	Relief Ratio (Rh)	Rh = Bh / Lb	The relief is ratio of basin relief (Bh) to the basin length (Lb).	[5]
	Ruggedness Number (Rn)	Rn=Bh×Dd	Ruggedness number is the product of maximum basin relief (Bh) and drainage density (Dd)	[5]
AERIAL	Drainage Density(D_d)	Dd=L/A	Drainage density is the ratio of total length of streams (L_u) of all order to the basin area (A)	[4]
	Stream frequency (Fs)	Fs=N/A	It is the total number of stream segments of all orders (Nu) per unit area (A)	[4]
	Texture ratio (T)	T=Nu/P	Drainage texture ratio is the total number of stream segments of all orders (L_u) per perimeter of that area (A)	[4]
	Form factor (Rf)	Rf=A/(Lb)2	Form factor is defined as the ratio of the basin area (A) to the square of the basin length (L)	[4]
	Circulatory ratio (Rc)	Rc=4πA/P2	Circularity ratio is the ratio between the areas of a watershed to the area of the circle (A) having the same circumference as the perimeter of the watershed (P).	[6]
	Elongation ratio (Re)	Re=√(A/π)/ Lb	It is the ratio of the diameter of a circle of the same area (A) as the basin to the maximum basin length (L_b).	[5]
	Length of overland flow (Lg)	Lg=1/(2Dd)	It is the length of water over the ground surface before it gets concentrated into definite stream channel.	[4]
	Constant channel maintenance(C)	C=1/Dd	It is the inverse of drainage density.	[4]
	Shape Factor (SF)	SF= L_b^2/A	It is the ratio of the square of the basin length to the basin area. This factor is inversely proportional to form factor (Ff).	[1]
	Compactness coefficient(C_c)	C_c= 0.2821P/√A	It is the ratio of perimeter (P) of watershed to circumference of circle whose area is equal to area of watershed (A).	[1]

5. RESULTS

The following paragraphs describe the physical meaning and significance of various morphometric parameters calculated as per table 1. Further, values of these parameters obtained are tabulated in table 2

Morphometric Parameters are classified based on three aspects, viz., linear aspects, relief aspects, and aerial aspects, which are discussed below.

Table 2 Calculations

Class	Sl. No	Morphometric Parameter		River name	
				Bidarthala	Manjotti
LINEAR	1	Basin Length(L) km		7.042	2.248
	2	Basin Perimeter(P) km		15.265	8.415
	3	Stream Order(U)		3	2
		No. of segments	I	25	6
			II	3	1
			III	1	----
	4	Stream Length(L) km		19.702	4.888
		Stream length of segments	I	13.9	3.383
			II	0.595	1.505
			III	5.207	----
	5	Mean Stream Length(Lsm)	I	10.951	3.484
			II	0.646	1.525
			III	5.346	------
	6	Stream Length Ratio(RL)	II/I	0.042	0.444
			III/II	8.751	----
	7	Bifurcation Ratio (Rb)	I/II	8.333	6
			II/III	3	----
		Mean		5.665	6
RELIEF	8	Basin Relief (B_h)		0.727	0.02
	9	Relief Ratio/Slope (R_h)		0.103	0.00088
	10	Ruggedness No.(Rn)		24.317	0.349
AERIAL	1	Area (A)		0.589	0.28
	2	Drainage Density(D_d)		33.449	17.457
	3	Stream Frequency (F_s)		49.23	25
	4	Texture Ratio (T)		1.6	0.713
	5	Length of overland flow		0.0149	0.0286
	6	Constant Channel Maintenance(C)		0.029	0.057
	7	Form Factor (Rf)		0.0118	0.0554
	8	Shape Factor (SF)		84.74	18.05
	9	Compactness Coefficient		5.611	4.486
	10	Circulatory Ratio (Rc)		0.031	0.044
	11	Elongation Ratio(Re)		0.043	0.122

6. DISCUSSIONS

Biderthala Hole is a 3rd order stream having a contribution from a total number of 29 streams. Out of these, 25 are 1st order streams, 3 are 2nd order streams and 1 stream is of 3rd order, while the Manjotti Hole holds the 2nd order having 7 total number of streams, in which 6 are of 1st order and one 2nd order. Both have fern-like drainage pattern i.e., dendritic type which indicates homogeneity in texture (Fig 2). The stream length ratios of the two watersheds are 19.202 and 4.88 indicating steeper slope with high variation in topography and gentle slope with less variation in topography respectively. From table it can be noted that the mean bifurcation ratio, 5.666 for Biderthala Hole is less than 6 as that of the Manjotti Hole which means that the drainage pattern of Biderthala Hole is less controlled by the geologic structures (rock formations), while the drainage pattern in latter is less affected by the geologic structures [3].

The two basins discussed here have relief of 727 m and 20 m with indifferent slopes of 0.103 and 0.001 respectively, indicating steeper slope of Biderthala Hole compared to Manjotti Hole. Ruggedness number for these two streams are 24.317 and 0.349, directly indicating the high susceptibility of the Biderthala basin to soil erosion, while Manjotti basin endow less soil erosion.

Biderthala basin with a catchment area of 0.589 km^2 has been observed to have high drainage density of 33.333 km/km^2, and high stream frequency of 49.23 indicating impermeable, dense vegetated region with mountainous relief, whereas Manjotti Hole of 0.28 km^2 basin area, has drainage density of 17.457 and stream frequency of 25, represents the sparse vegetated region with less relief. The texture ratios of both the basins are 1.6 and 0.713 respectively, indicating moderate to low infiltration capacity and stage development of stream segments [4]. Form factor (Ff), shape factor (Sf), circulatory factor (Rc), elongation ratio (Re), and compactness coefficient (Cc) are the shape index parameters. It can be noticed from the table 2 that Rf, Sf, Cc, and Re values of Biderthala Hole are more than Manjotti Hole, but in case of circulatory ratio (Rc), it is quite opposite which means that basin of Biderthala Hole is more elongated than basin of Manjotti Hole, whereas Manjotti watershed is more circular than Biderthala basin. Both the basins have low value of length of overland flow (Lg) of 0.0149 and 0.0286 emphasising the short flow paths, more runoff, and less infiltration. The constant channel maintenance (C), provides information of the number of square feet of watershed surface required to sustain one linear foot of stream. The values C of the two present study areas are 0.029 and 0.057 respectively. The value C of Biderthala basin is 0.029 means that on an average 0.029 sq.ft surface is needed in basin for creation of one linear foot of the stream channel. The similar is true for Manjotti Hole.

7. CONCLUSION

Morphometric analysis of two watersheds of Netravathi river viz. Biderthala and Manjotti throws light on typical landform processes, soil physical properties and erosional characteristics of watersheds. Both of these watersheds are contributed primely by first order streams. Biderthala watershed is undulating and falls in wet Sahyadri ranges. The possibility of overland flow at Biderthala is less when compared with Manjotti. Although, these parameters derived from morphometric analysis are helpful in characterizing the basin, more investigation should concentrate on field studies too. Moreover, the effect of land use/ land cover on these parameters is never be neglected as the future water demand of Nethravathi river is ever increasing and same as elsewhere.

8. REFERENCES

[1] Subramanya K, Engineering Hydrology (2013) 169-173

[2] Srinivas Vittala S et al. Morphometric analysis of sub-watersheds in the pavagada area of tumkur district, south india using remote sensing and gis techniques, Journal of

the Indian Society of Remote Sensing, 32, No. Vol. 4, 2004

[3] STRAHLER, A.N. (1964) Quantitative geomorphology of drainage basins and channel networks.In: V.T. Chow (Ed.), Handbook ofApplied Hydrology. McGraw-Hill, New York, pp.4.39-4.76.

[4] HORTON, R.E. (1945) Erosional development of streams and their drainage density: hydrophysicalapproach to quantitative geomorphology. Geol. Soc. Amer. Bull., no.56, pp.275-370.

[5] SCHUMM, S.A. (1956) Evolution of drainage systems and slopes in Badlands at Perth Amboy, New Jersey. Bull. Geol. Soc. Amer., v.67, pp.597-646.

[6] .Miller,V.C.,1953, "A quantitative geomorphic study of d rainage basin characteristics in the Clinch Mountain are a, Varginia and Tennessee", Project NR 389-042, Te ch. Rept. 3.,Columbia University, Department of Geolo gy, ONR, Geography Branch, New York.

[7] Nageswara Rao.K et al., Morphometric Analysis of Gostani River Basin in Andhra Pradesh State, India Using Spatia l Information Technology,International journal of geomat ics and geosciences volume 1, no 2, 2010, 179-186.

[8] Chandrashekar H, Lokesh K V, Sameena M, Roopa J and Ranganna G 2015 Proc. Int. Conf. on Water Resources, Coastal and Ocean Engineering (Mangalore) vol 4 ed G S Dwarakish (Elsevier Procedia) 1345 – 1353.

[9] Rai P K, Mishra V N and Mohan K 2017 Remote Sens. Appl. Soc. Environ.7 9-20.

[10] S Sukristiyanti et al 2018 IOP Conf. Ser.: Earth Environ. Sci. 118 012028.

[11] Altaf F, Meraj G, Romshoo SA. Morphometric Analysis to Infer Hydrological Behavior of Lidder Watershed, Western Himalaya, India. Geogr J. 2013, 1-14. doi:http://dx.doi.org/10.1155/2013/178021.