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MORPHOMETRIC ANALYSIS OF WATERSHED IN MIDDLE GODAVARI SUB-BASIN USING GIS

[1]G. Sreenivasa Rao, and [2]R. Anirudh
[1]Assoc. Prof., Department of Civil Engineering, M.V.S.R College of Engineering, Hyderabad, India. Email: gumpallisrinivas@gmail.com
[2]Research Assistant, EW-FWW & JNTUH, Hyderabad, India. Email: anirudhramaraju@gmail.com

ABSTRACT

Land, water and soil are inadequatenatural resourcesand their wide consumptionwith increasingpopulation is amajor area of concern. To reduce the gap between the demand and supply of resources it is important to conserve these resources for supportable progress. The morphometric analysis of the drainage and channel network are vital in understanding the hydrological and geological characteristics of the catchment. In the present study, morphometric analysis is carried out using Geographical Information System (GIS) to assess the characteristics of Kadam watershed of G-5 sub-basin of Godavari river basin. The analysis has revealed that the total number and length of stream segments is maximum in first order streams and decreases as the stream order increases. The bifurcation ratio between different stream orders varying revealing the geological control. The mean bifurcation ration is 3.41 which falls under normal basin category. The Drainage density showing coarse drainage of 3.0149 and texture shows fine drainage texture ranging between 32.6 to 0.0073 depending on streak orders. Hence the study also reveals that GIS is a competent tool in understanding and evaluating the basin characteristics.

Keywords: Morphometric Analysis, Kadam Watershed, RS, GIS, Form factor, circulation ratio, elongation ratio.

INTRODUCTION: Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of its landforms [1,2].Hydrologists and geomorphologists have recognized that certain relations are almost important between runoff characteristics, and geographic and geomorphic characteristics of drainage basin systems. Various important hydrologic phenomena can be correlated with the physiographic characteristics of drainage basins such as size, shape, slope of drainage area, drainage density, size and length of the contributories etc. [3].Geographical Information System (GIS) techniques are now-a-days in use for assessing various terrain and morphometric parameters of the drainage basins and watersheds, as it provides a flexible environment and an important tool for the manipulation and analysis of spatial information.Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimensions of its landforms [4]. A major emphasis in geomorphology over the past several decades has been on the development of quantitative physiographic methodsto describe the evolution and behaviour of surface drainage networks [5, 6, 7]. Various scholars have carried out morphometric analysis of river basins by using RS and GIS techniques. Shrimali et.al [8] have worked on Sukhana lake catchment in the Shiwalik hills for the delineation and prioritization of soil erosion areas by GIS and remote sensing.Nooka et al[9] have carried out study on check dam positioning by prioritization of micro watersheds using the sediment yield index (SYI) model and morphometric analysis using GIS.

The aim of the present study is to understand the morphometric characteristics of Kadam watershed of G-5 sub basin of Godavari basin, Adilabad District, Telangana State.

STUDY AREA: The area selected for present study is Kadam watershed of G-5 sub basin i.e., 'Middle Godavari' sub basin of Godavari River Basin. The Godavari basin is situated in the Deccan plateau covering large areas in the states of Maharashtra, Madhya Pradesh, Chhattisgarh, Orissa, Karnataka and Telangana. The Godavari basin extends over an area of 13,812 sq.km which is nearly 10% of the total geographical area of the country. Godavari catchment is divided in to eight sub basins. The Kadam watershed of River Godavari which lies between latitudes 19 05' and 19 35' North and longitudes 78 10' and 78 55' East in the state of Telangana. The areal extent of the study area is 2651 km2, which constitutes 7.4% of the sub basin area. The climate in the study area is semi-arid with an average rainfall of 765mm. The main geological formations of the sub basin are Deccan traps and gneiss. The formations have considerable effect on the runoff of the sub basin. the maximum temperature recorded in summer and winter as 41.3^0C and $15.^0$C respectively and the minimum temperature as 33^0C and 7^0C respectively.

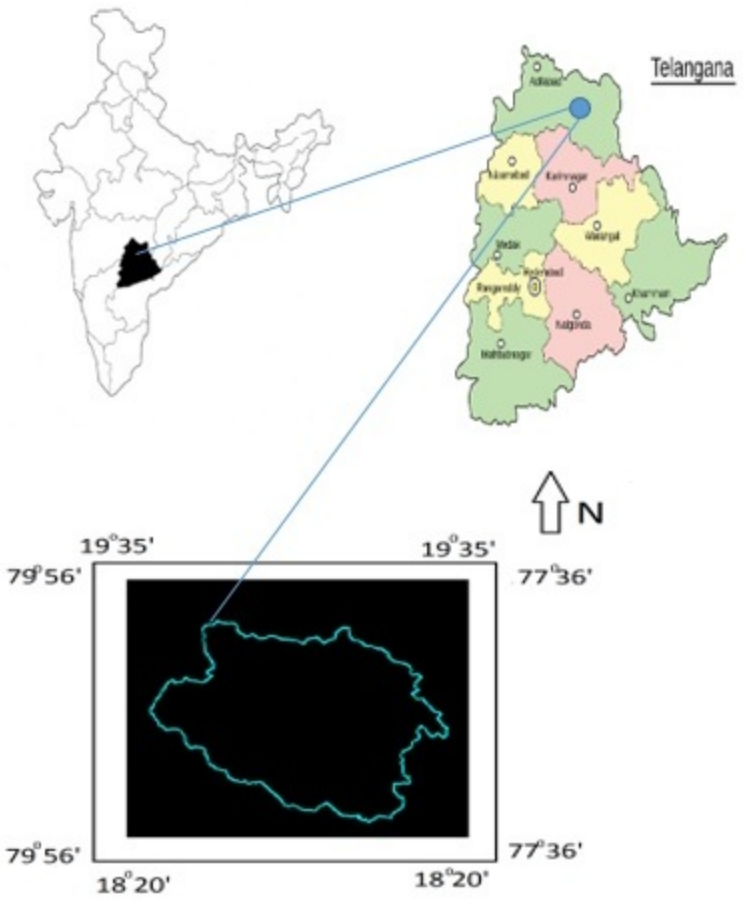

Fig 1: Location Map of Study Area

METHODOLOGY: Topographical maps were rectified/ referenced geographically and entire study area was delineated in GIS environment with the help of Arc-GIS 9.1 software Since, morphometric analysis of a drainage basin requires the delineation of all the existing streams, digitization of the drainage basin was carried out for morphometric analysis in GIS environment using Arc GIS 9.1. The attributes were assigned to create the digital data base for drainage layer of the basin. Various morphometric parameters were computed. The different morphometric parameters were determined by using the standard methodologies as shown in Table 1.

Flow chart showing the step by step procedure followed for Morphometric Analysis

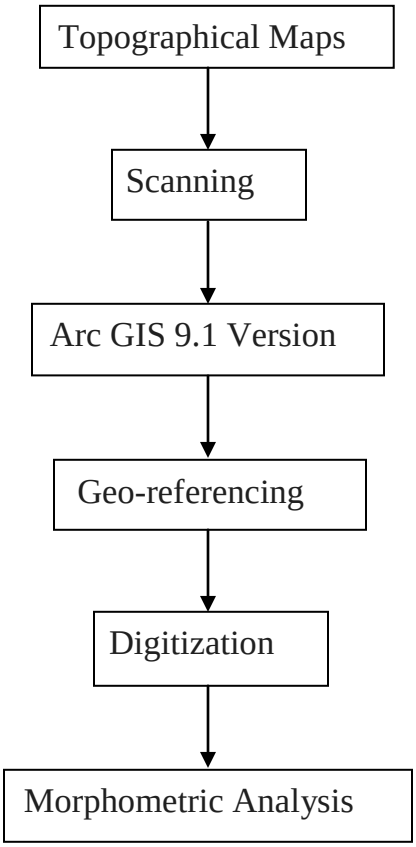

Table 1: Formulae and relationships for the computation of the morphometric parameters

Morphometric parameter	**Formula/Relationship**	**Reference**
Stream order	Hierarchical rank	Strahler,1964
Stream length	Length of stream	Horton,1945
Mean Stream length	Lsm=L_u/N_u,Where, L_u=Total stream length of order'u',N_u=Total no of stream segments of order u	Strahler,1964
Stream length ratio	RL= L_u/L_u-1, Where, L_u=Total stream length of order'u', L_u-1=the total stream length of its next lower order.	Horton,1945
Bifurcation ratio	R_b= N_u/N_u+1, N_u= total number of stream segments of order 'u', N_u+1= number pf stream segments of the next higher order.	Schumn,1956
Mean Bifurcation	R_{bm}= average of the bifurcation ratio of	Strahler,1957

ratio	all order	
Relief ratio	R_h= H/L_b, where H= total relief (relative relief) of the basin, L_b= basin length.	Schumn,1956
Drainage density	D= L_u/A, where A is the total area of the basin $(km)^2$, L_u is the total stream length of all orders.	Horton,1932
Stream frequency	F_s= N_u/A, Where N_u is the total number of streams of all order, A is basin area in km^2	Horton,1932
Drainage Texture	R_t= N_u/P, where N_u is the total number of streams of all order, P is the perimeter of the basin in km^2	Horton,1945
Form factor	R_f= A/L_b^2 is the square of the basin length (km), A is the basin area in km^2	Horton,1932
Circularity ratio	Re= 4π A/P^2, where A is the area $(km)^2$ and p is the perimeter (km) of the watershed	Miller,1953
Elongation ratio	$R_{e=}$ 2sqrt (A/π)/L_b, where A is the area $(km)^2$ and P is the perimeter (km) of the watershed	Schumn,1956

RESULTS: In the present study, the morphometric analysis has been carried out about parameters as stream order, stream length, mean stream length, bifurcation ratio, stream length ratio, mean bifurcation ratio, drainage density, drainage texture,stream frequency, elongation ratio, circularity ratio, form factor, relief ratio, using mathematical formulae as given in Table 1 and the results are summarized in Tables 2-4. The properties of the stream networks are highly important to study the landform making processes [14]. Morphometric parameters such as stream length also influence basin discharge pattern strongly through their varying effects on lag time. The natural runoff is one of the most potent geomorphic agencies in shaping the landscape of an area. The land area that contributes waterto the main stream through smaller ones forms its catchment area orthe drainage basin. The arrangement of streams in a drainage systemconstitutes the drainage pattern, that in turn reflects mainly structural/ or lithologic controls of the underlying rocks.

Table 2: Calculation of different morphometric parameters of study area

No. of Streams	Orders	Length of Streams (km)	Mean Stream Length	Stream Length Ratio
8848	1	4799.308383	1.843598972	0.335050204
2028	2	1608.009252	1.261186773	0.496173537
429	3	797.8516387	0.537693951	0.505561333
91	4	403.3629376	0.225603276	0.594777665
20	5	239.9112662	0.083364155	0.339015752
4	6	81.33369827	0.049180107	0.696891819
2	7	56.68078893	0.035285324	0.243228895
1	8	13.78640566	0.072535222	580.2995044

Table 3: Calculation of different morphometric parameters of study area

Orders	Bifurcation Ratio	Mean Bifurcation Ratio	Texture Ratio	Relief Ratio
1	4.362919132	3.41932064	32.61216165	0
2	4.727272727		7.474848985	
3	4.714285714		1.581218055	
4	4.55		0.33540989	
5	5		0.073716459	
6	2		0.014743292	
7	2		0.007371646	
8	1		0.003685823	

Table 4: Calculation of different morphometric parameters of study area

S.No.	Parameters	Calculated Value
1	Drainage density	3.014966325
2	Stream frequency	4.304863544
3	Form factor	0.516445852
4	Circularity ratio	0.452771801
5	Elongation ratio	0.811105915

The stream lengths of the various segments are measured with the help of GIS software. Stream length was computed on the basis of law proposed by Horton. The total stream length decreases with increasing stream order.The highest stream length of 4799.3 km is observed for the order 1 and the lowest stream length is observed for the order 8 with 13.78 km. The bifurcation ratio is the ratio of the number of stream segments of given order to the number of segments of next higher order. Bifurcation ratio is an index of relief and dissection. Bifurcation ratio for different sub-watersheds of the study area have been calculated, the bifurcation ratio for the stream order 2 is higher with the value 4.727 and 1 for the stream order 8. Horton has introduced drainage density (Dd) as an expression to indicate the closeness of spacing of channels. The stream frequency is defined as the total number of stream segment of all order per unit area [11]. The

stream frequency varies from basin to basin. The maximum stream frequency indicates the large number of stream availability. Circularity ratio is the ratio of the basin area to the area of a circle having the samecircumference perimeter as the basin, which is dimensionless andexpresses the degree of circularity of the basin [12]. Schumm [13] defined elongated ratio as the ratio of diameter of the circle of the same areain the basin to the maximum basin length.The ratio of the basin area to the square of basin length is called the formfactor. It is a dimensionless property and is used as a quantitative expression of the shape of basin form.

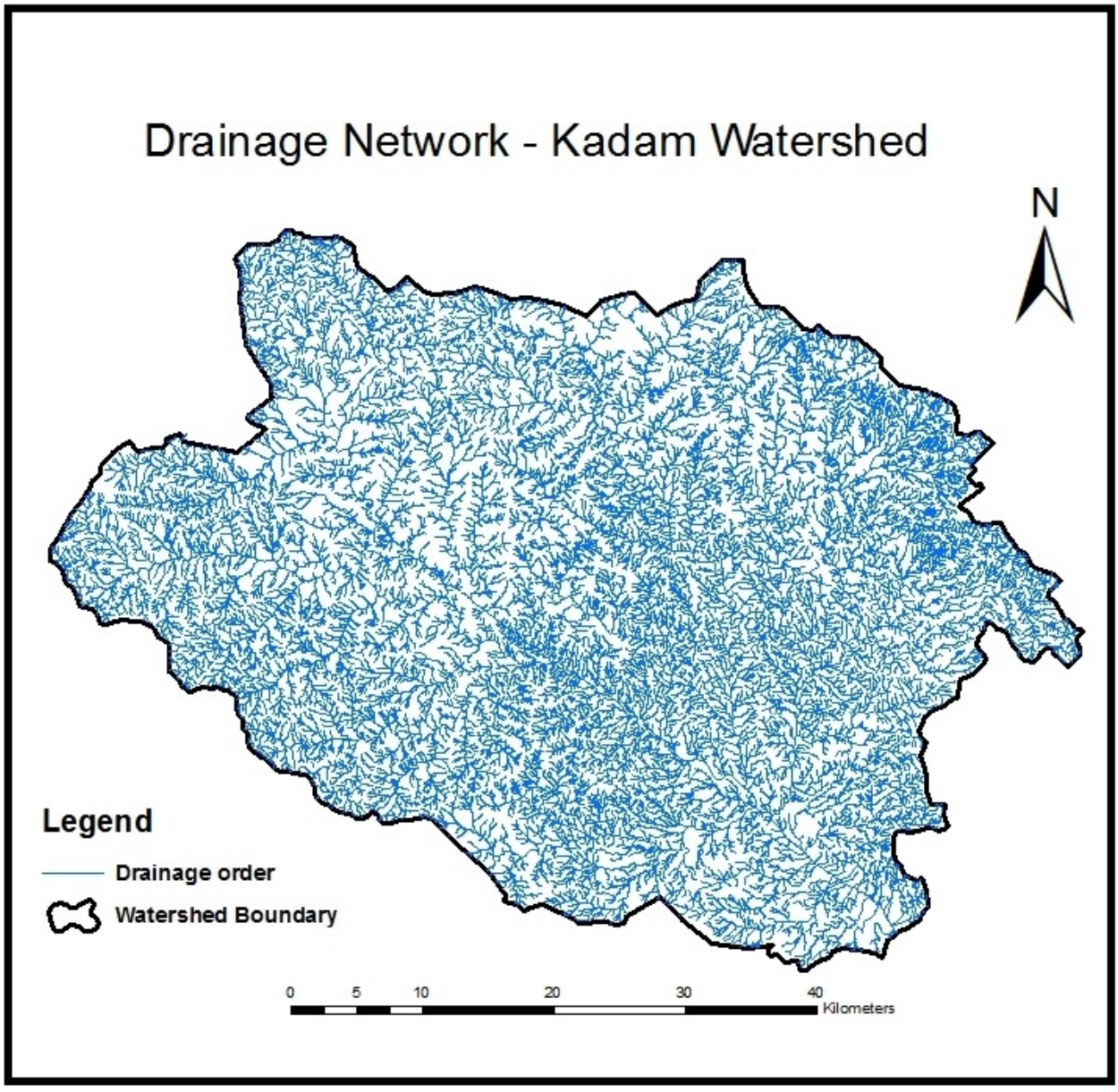

Fig 2: Drainage network map of Kadam Watershed

CONCLUSION:

The quantitative analysis of morphometric parameters is of immense utility in river basin evaluation, watershed analysis for soil and water conservation and natural resource management at micro level. The morphometric parameters evaluated using GIS helped to understand various terrain parameters such as nature of bedrock, infiltration capacity, runoff, etc.The study reveals that GIS based approach in evaluation of drainage morphometric parameters at river basin level is more appropriate than the conventional methods. GIS based approach facilitates analysis of different morphometric parameters and to explore the relationshipamong the drainage basin morphometry and topographical, geological, lithological, structural, biogeographical, pedological and hydrological aspects. The texture ratio for the stream order 1 is higher with a value of 32 and the lowest value of texture ratio is for the stream order no. 1. The drainage density in watersheds of the study area showing value of 3.014 suggesting low to moderate drainage density ultimately depicting considerably permeable sub-soil throughout the study area. It is noted that the Rf values in all the watersheds indicate that all the watersheds are more or less elongated to sub-circular in shape. Relief ratio indicates that the discharge capability of these watersheds is zero. From the above study, it is understood that the morphometric analysis plays a major role in determining the fluvial landforms in a basin and sub-basin scale. These studies are very important in planning and management of drainage basin.

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