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Drainage Morphometric Analysis of Mariyala-Veeranapura Watershed, Chamarajanagar District, Karnataka, India

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ABSTRACT

An attempt has been made to study drainage morphometry and its influence on hydrology of Mariyala-Veeranapura watershed for detailed study data for preparing DEM, aspect grid and slope maps. Geographic information system was used in evaluation of linear, Arial and relief aspects of morphometric parameters. The study reveals that the elongated shape of area is mainly due to guiding effect of thrusting and faulting. In all forty one sub- basin in Mariyala-Veeranapura have been selected for the study. Quantitative morphometric analysis has been carried out for linear, relief, and aerial aspects for all the sub-basin. The streams up to fourth order can be seen in all the sub-basin. The morphometric analysis reveals that Nanjadevanapura sub-basin show lower value of drainage density, stream frequency, elongation ratio, relief ratio, infiltration number indicating highly permeable sub-soil materials under dense vegetation cover. Except Nanjadevanapura sub-basin all the other sub-basin showing fractured, resistant, permeable rocks and drainage network seems to be not affected by tectonic disturbances.

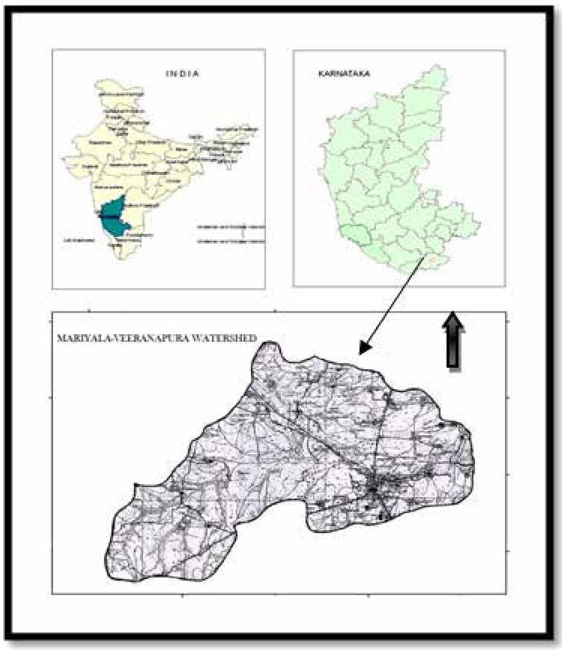
Keywords : Morphometric, Sub watershed, Drainage patterns, dendritic, stream patterns

INTRODUCTION:

Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of its landforms (Clarke, 1966). The quantitative analysis of drainage system is an important aspect of characteristic of watershed (Strahler, 1964). The morphometric study of the drainage basin is aimed to acquire accurate data of measurable features of stream network of the drainage basin. Drainage provides a basic to understand initialslope, inequalities in rock hardness, structural control, geological and geomorphologic history of the drainage basin.

Drainage patternrefers to spatial relationship among streams or rivers, which may be influenced in their erosion by inequalities of slope, soils, rock resistance, structure and geological history of a region. Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of its landforms (Clarke, 1966). This analysis can be achieved through measurement of linear, aerial and relief aspects of the basin and slope contribution (Nag and Chakraborty, 2003). The drainage basin analysis is carried out quantitatively for six sub-water sheds of Mariyala-Veeranapura watershed. The quantitative drainage analysis is done aspect wise such as linear aspects, aerial aspects, and relief aspects. The main objective of the present study to derive the different drainage characteristics of the Mariyala-Veeranapura watershed and to understand the relationship among them.

Study area: The Mariyala-veeranapura watershed is located about 5kms, from chamarajanagar town west. Mysore-chamrajanagar state high way and railway lines are passing in the North part of the watershed and chamarajanagar-Gundlupet district road is passing towards in the southern part of the watershed. The total extent of the micro watershed is 70 sq.kms. It lies between North Latitude 11051'' to 11058'' 30' and East Longitude 760 48'' 30' covered under survey of India toposheet NO.58A/13



MAP OF THE STUDY AREA

DATA USED AND METHODOLOGY:

Survey of India toposheet on 1:50.000 scale bearing No. 57A/13 has been used for drainage map. IMSD technical Guidelines (NRSA, 1995) have been used to delineate the sub-watershed boundary. Digital based drainage map was prepared by digitization and assign the stream order by layer concept in Cad Overlay 2000. Quantitative morphometric parameter such as stream length, bifurcation ratio and basin area have been analyzed through use of a Geographical information System using ARC/INFO environment.

RESULTS AMD DISCUSSION:

According to strahler's(1957) system of stream ordering, the drainage of Mariyala-Veeranapura watershed basins have classified and the main streams are found to be of 5th order streamsand the drainage patterns of the area are found to be mostly dendritic and sub dendritic. The basin could be further into sub basins, watershed and micro-watersheds based on geomorphology and surface water divided marks the highest evaluation on the area .For detailed qualitative analysis, the entire area is divided into 6 sub-basins and it is natural hydrogeological entity from which surface runoff flows to a defined drains, channels, stream or river particular point. The sub-basins have been named based on the tank and villages at the outlet. This analysis can be achieved through measurement of linear, aerial and relief aspects of the basin and slope contributions. In the present study, the morphometric analysis for the parameters namely stream order, stream length, bifurcation rations, stream frequency, elongation ratio, circularity ratio, from factor, relief ratio etc., have been carried our using the mathematical formulae.

Linear aspects: Stream order, stream length, mean stream length, stream length ratio and bifurcation ratio are linear aspects that were determined

Stream order: The primary step in any drainage basin analysis is order designation, stream orders and is based on a hierarchic ranking of streams. Ranking of streams has been carried out based on the method proposed by strahler (1964) (Table 1). It is observed that the maximum frequency is in the case of first order streams. It is also noticed that there is a decrease in stream frequency as the stream order increases.

Stream Length: Stream length is one of the most important hydrological feature of the basin as it reveals that the surface run-off behaviours, The number of streams of various orders in a sub-watershed is counted and their lengths from mouth to drainage divide are measured. The stream length (Lu) has been computed based on the low proposed by Horton (1945) for all the 25 sub-watersheds. Generally the total length of stream segments in maximum is first order streams and decreases as the stream order increases.

Mean Stream Length: The mean stream length is a dimensionless property, characterizing the size aspects of drainage network and its associated surface (Strahler, 1964). It is obtained by dividing the total length of stream of a order by total number of segments in the order.In the study area the mean stream length varies from 0.99 to 12.01 and mean stream length of any given order is greater than that of the lower order and less than of its next higher order in the entire sub–watersheds except which might be due to variation in slope and topography.

Stream Length Ratio: it is the ratio between the mean lengths of streams of any two consecutive orders. Horton's law (1945) of stream length states that the mean length of stream segments of each of the successive orders of a basin tends to approximate a direct geometric series, with stream lengths increasing towards higher stream order. All the sub-watersheds in the study area show variation in stream length ratio between streams of different order. Changes of stream length ratio from one order to another order indicating their late youth stage of geomorphic development (Singh and Singh, 1997)

Relief Ratio: Difference in the elevation between the highest point of a basin (on the main divide) and the lowest point on the valley floor is known as the total relief of the river basin. The relief ratio may be defined as the ratio between the total relief of a basin and the longest dimension of the basin parallel to the main drainage line (Schumm, 1956). The possibility of a close correlation between relief ratio and hydrologic characteristics of a basin suggested by scheme who found that sediments loose per unit area is closely correlated with relief ratios.In the

study area, the values of relief ratio vary from 1.7 (Veeradevanapura) to 12.5 (kulagana). It is noticed that the high values of Rh indicate steep slope and high relief (250 m), while the lower values may indicate the presence of basement rocks that are exposed in the form of small ridges and mounds with lower degree of slope (GIS 1981)

Sl.No	Morphometric Parameters	Formula	Reference
1	Stream order	Hierarchial rank	Strahler(1964)
2	Stream length (Lu)	Length of the stream	Horton(1945)
3	Mean stram length (Lsm)	Lsm= Lu/Nu Where, Lsm=Mean stream length Lu=Total stream length of order 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 tream 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 Nu=Total no. of tream segments of the order'u' Nu+1= Number of segments of the next higher order	Schumn(1956)
6	Mean Bifurcation ratio (Rbm)	Rbm=Average of bifurcation ratios of all orders	Strahler(1957)
7	Relief ratio (Rh)	Rh=H/Lb Where, Rh= Relief ratio H=Total relief (Relative relief) of the basin(km) Lb=Basinlength	Schumn(1956)
9	Stream frequency (Fs)	Fs=Nu/A Where, Fs= stream Frequency Nu= Total no. of streams of all orders A= Area of the basin(km2)	Horton(1932)
10	Form factor (Rf)	Rf=A/Lb2 Where, Rf=Formfactor A= Area ofthe basin(km2) Lb2=Square ofbasin length	Horton(1932)
11	Circularity ratio (Rc)	Rc= 4*Pi*A/P2 Where, Rc=Circularity ratio Pi='Pi'value i.e., 3.14 A=Areaof the basin(km2) P2=Square of the perimeter(km)	M iller (1953)
12	Elongation ratio (Re)	Re=2 _(A/Pi) /Lb Where, Re=Elongation ratio A=Areaof the basin(km2) Pi='Pi'value i.e., 3.14 Lb=Basin length	Schumn(1956)

Bifurcation Ratio: The bifurcation ratio (Rb) is the ratio of the number of the stream segments of given order 'Nu' to the number of streams in the next higher order (Nu+1) (Table 1). Horton (1945) considered the bifurcation ratio as index of relief and dissertation. Strahler (1957) demonstrated that bifurcation shows a small range of variation for different regions or for different environment except where the powerful geological control dominates. It is observed from the Rb is not same from one order to its next order these irregularities are dependent upon the geological and lithological development of the drainage basin. (Strahler 1964). The lower values of Rb are characteristics of the sub-watersheds which have suffered less structural disturbances (Strahler 1964) and the drainage pattern has not been distorted because of the structural disturbances (Nag 1998). In the present study, the higher values of Rb indicates strong

structural control on the drainage pattern, while the lower values indicative of sub-watershedsthat are not affect by structural disturbances. The mean bifurcation ratio (Rbm) may be defined as the average of bifurcation ratios of all order. In the present case, Rbm varies from0.41 to 8.18 and all sub-watersheds fall under normal basin category (Strahler 1957).

Aerial aspect: Different morphometric parameters like drainage density, texture ratio, stream frequency, form factor, circularity ratio, elongation ratio and length of overland flow have been discussed detail.

Drainage density: Drainage density is the total length of all the streams in the basin to the area of whole basin. Drainage density in the study are varies between 1.17 and 3.07 indicating low drainage density. According to Nag (1998), low drainage density generally results in the areas of highly resistant on permeable subsoil material, dense vegetation, low relief and coarse drainage texture. High drainage density is resultant of weak or impermeable subsurface material, sparse vegetation, mountainous relief and fine drainage texture.

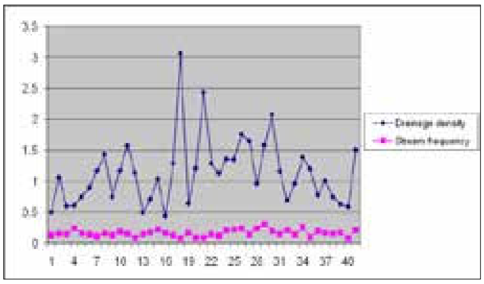


Fig. 3 Showing Drainage density V/S Stream frequency

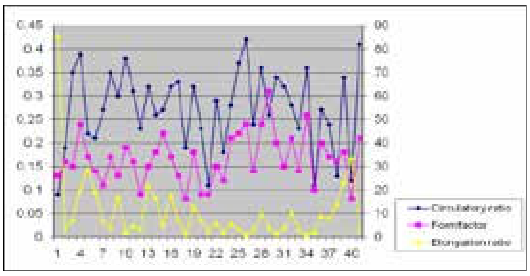


Fig .4: Circulatory ratio V/S Form factor V/S Elongation ratio

Stream frequency: Horton (1932) introduced stream frequency as the number of streams segment per unit area. It is obtained by dividing the total number of stream to the total drainage basin area. The low value of 0.08 observed in kulagana sub-watershed, while high value of 0.31 observed in Mariyalada hundi sub-watershed. Increase in stream population with respect to increase in drainage density has been noticed in all sub-watersheds.

Form factor: The ratio of the basin area to the square of basin length is called the form factor. It is a dimensionless property and is used as a quantitative expression of the shape of basin form. Lower values of form factor are observed in sub-watersheds leads to circular in shape

Circulatory ratio: Circulatory ratio is the ratio between the area of the basin and the area of the circle having the same perimeter as that of the basin. In the present study all the sub-watershed expect veeradevanapura shows less than 0.09 indicating that they are elongated, while veeradevanapura sub-watershed shows more or less circular and are characterized by high to moderate relief and drainages system is structurally controlled.

Elongation ratio: The shape of the any basin is conveyed by an elongation ratio (Re), it is the ratio between the diameter of the circle of the same area as the drainage basin and the maximum Schumm (1956)(Table 1). A circle basin is more efficient in the discharge of run-off than an elongation basin(Singh and Singh 1977). the values of Re generally vary from 0.6 to 1.0 over a wide variety o climate and geologic types values close to 1.0 are typical of regions of very low relief, where as values in the range 0.6 to 0.8 are usually associated with high relief and steep ground slope(Strahler 1964). These values can be grouped into 4 categories namely (a) circle (> 0.9), (b) Oval(0.9 to 0.8), (c) Less elongated (<0.7) the elongation ratio of sub-watershed of the study area varies from 0.21(Doddarayanapete) to 0.84 (Ramasamudra). The lowest Re (0.21) in the case of Doddarayanapete sub-watershed indicates high relief and steep slope, while very high values in Veeranapura sub-watershed (0.84) with low relief and remaining sub-watershed indicates that plain land with low relief and low slope.

CONCLUSION

Quantitative analysis of drainage network found the dendritic to sub dendritic drainage pattern with Third order streams in all sub-watersheds except Doddarayapete and Ramsamudra sub-watershed. Stream frequency of all sub-watersheds shows positive correlation with drainage density. The variation in values of bifurcation ratio among the sub-watersheds is ascribed to the difference in topography and geometric development. Doddarayapete sub-watershed shows coarse drainage texture results in higher value of drainage density, stream order, elongation ratio and less length of overland flow. Except Doddarayapete sub-watershed, all the other sub-watersheds showing fractured, resistance, permeable rocks and drainage network has not effected by tectonic disturbances.

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