Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 9, Issue, 6(E), pp. 27545-27549, June, 2018

ISSN: 0976-3031

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

GIS-BASED MORPHOMETRIC ANALYSIS OF SUB- WATERSHED OF GURUPURA RIVER, DAKSHINA KANNADA DISTRICT

Amulya G.V*., Lakhon Syngkon., Elizer Shadap., Rajesh Kumar and Haripadme M.P

Department of Civil Engineering, College of Engineering and Technology, Srinivas University, Mukka, Surathkal, Mangalore, Karnataka, India, PIN-575021

DOI: http://dx.doi.org/10.24327/ijrsr.2018.0906.2282

ARTICLE INFO

Article History:

Received 8th March, 2018
Received in revised form 27th April, 2018
Accepted 16th May, 2018
Published online 28th June, 2018

Key Words:

Morphometric analysis, Drainage basin, watershed, stream order.

ABSTRACT

Evaluation of the morphometric parameters requires preparation of drainage map, contour map, ordering of the various streams and measurements of catchment area, perimeter, relative relief, relief ratio, length of drainage channels, drainage density, drainage frequency, bifurcation ratio, texture ratio, circulatory ratio and constant channel maintenance, which help to understand the nature of the drainage basin. The present study involves the Geographic Information System (GIS) analysis techniques to evaluate and compare linear, relief and aerial morphometry of the sub-watershed. The study area chosen was Gurupura catchment which lies in Dakshina Kannada District. The study area geographically lies between 12°56˚ N longitude and 74°55^{0}E latitude. The originate of Gurupura River is in the Western Ghats and is a tributary of the Nethravathi River, which empties into the Arabian Sea, south of Mangalore Karnataka India. The catchment covers an area 141 Sq. km and is covered in Survey of India (SOI) Topo sheet numbers 57D/7, 57D/6, 57D/4, 57D/3, 57D/2, 57D/8 and D43V/15.

INTRODUCTION

Land and water resources are limited and their wide utilization is imperative, especially for countries like India, where the population pressure is increasingly continuous. Drainage basins, catchments and sub catchments are the fundamental units for administrative purposes to conserve natural resources. Watershed is a spatial unit with complex relations among its entities and is defined by stream pattern where the rainwater is collected through surface and subsurface run off and Culminated at the common point down the stream. In a watershed management programmed emphasis is laid on proper utilization of different resources for optimum production and minimum hazard to the environment. The behavior of any watershed is a function of its physiography, geology, climate, geomorphology, social set up, etc (Durga Rao, K.H.V. and Bhaumik, M.K, 2003).

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. Morphometric analysis requires measurement of linear features, gradient of channel network and contributing ground slopes of the drainage basin. Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of its landforms (Horton, R.E. 1945). 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. Most previous morphometric analysis was based on arbitrary areas or individual channel segments. Using watershed as a basic unit in morphometric analysis is the most logical choice. In fact, they are the fundamental units of the fluvial landscape and a great amount of research has focused on their geometric characteristics, including the topology of the stream networks and quantitative description of drainage texture, pattern and shape. The morphometric characteristics are the watershed scale may contain important information regarding its formation and development because all hydrologic and geomorphic process occur within the watershed.

The quantitative analysis of morphometric parameters is found to be of immense utility in river basin evaluation, watershed prioritization for soil and water conservation and natural resource management watershed level (Ramu, B.Mahalingam, P.Jayashree. 2013). Morphometric analysis of a watershed

Corresponding author:* **Amulya G.V
Department of Civil Engineering, College of Engineering and Technology, Srinivas University, Mukka, Surathkal, Mangalore, Karnataka, India, PIN-575021

provides a quantitative description of the drainage system which is an important aspect of the characterization of watersheds. 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 indifferent parts of the globe have been studied using conventional methods. Geographical Information System (GIS) techniques are now a days sued 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 (Strahler, A.N. and Strahler, A.H, 2002). In the present study stream number, order, frequency, density and bifurcation ratio are derived and tabulate on the basis of areal and linear properties of drainage channels using GIS based on drainage lines as represented over the topographical maps (Scale: 50,000).

The quantitative morphometric analysis of the drainage basin is considered to be the most satisfactory method because it enables us:

1. To understand the relationship between different aspects of the drainage pattern of the same drainage basin:
2. For comparative evaluation of different drainage basins developed in various geologic and climatic regimes and
3. To define certain useful parameters of drainage basins in numerical terms.

Remote sensing and Geographical Information System (GIS) techniques have already been used for assessing various terrain and morphometric parameters of the drainage basins and watershed, as they provide a flexible environment and a powerful tool for the manipulation and analysis of spatial information particularly for the feature identification and the extraction of information for better understanding (Nag, S.K. 1998). In the present study, the GIS analysis techniques were used to evaluate linear, relief and aerial morphometric parameters of the sub-watersheds for the future development planning of the watersheds.

Study Area

The study area chosen was Gurupura catchment which is a part of Dakshina Kannada District. Dakshina Kannada District is situated in the southern part of the Deccan Peninsula and it forms the southern district of Karnataka state. The study area chosen was Gurupura catchment which lies in Dakshina Kannada District. The study area geographically lies between 12.938828^{0} N and 74.931107^{0}E.

The originate of Gurupura River is in the Western Ghats and is a tributary of the Netravati River, which empties into the Arabian Sea, south of Mangalore Karnataka India. It is also known as Phalguni River. The catchment covers an area 141 Sq. km and is covered in Survey of India (SOI) Toposheet numbers 57D/7, 57D/6, 57D/4, 57D/3, 57D/2, 57D/8 and D43V/15. The maximum length and width of the catchment is approximately equal to 16.14 km and 11.72 km respectively. Location map of the study area is shown in Fig.1.

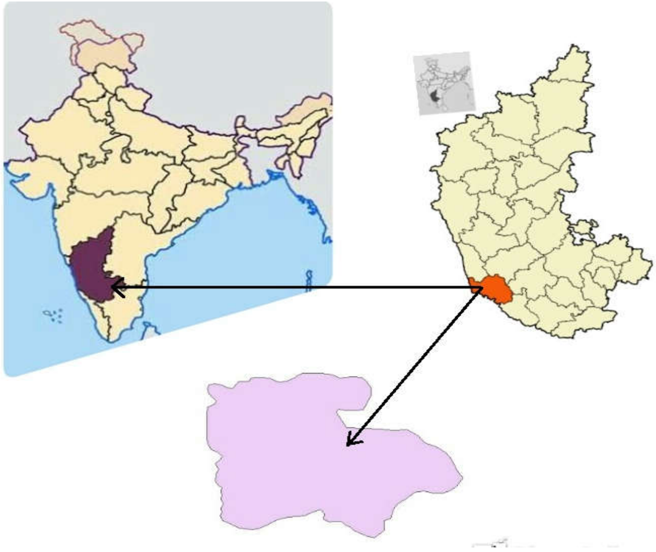


Figure 1 Location Map of a Study Area

METHODOLOGY

Linear Aspects

Linear aspects include the measurements of linear features of drainage such as stream order, stream length, stream length ratio, bifurcation ratio, length of overland flow and drainage pattern.

Stream order

The stream order is a measure of degree of stream branching within a watershed. In the drainage basin analysis, the first step is to determine the stream orders. In the present study, the channel segment of the drainage basin has been ranked according to Strahler's stream or ordering system. According to, the smallest fingertip tributaries are designated as order 1. Where two first order channels join, a channel segment of order 2 is formed; where two of order 2 join, a segment of order 3 is formed; and so forth. The trunk stream through which all discharge of water and sediment passes is therefore the stream segment of highest order.

Bifurcation ratio

The bifurcation ratio (R_b) may be define as the ratio of the number of the stream segments Nu of given order to the number of segments of the next higher order N(u+1).

$$R_b = \frac{N_u}{N_{(u+1)}}$$

Stream length

Length of the stream is an indication of the contributing area of the watershed. The length of the stream is an indication of the steepness of the drainage basin as well as the degree of drainage. Steep well drained areas generally have numerous small tributaries; whereas, in plains, where soils are deep and permeable, only relatively long tributaries (generally perennial streams) will be in existence. This factor thus gives the idea of the efficiency of the drainage network.

Mean stream length

Mean stream length (Lsm) is a characteristic property related to the drainage network components and its associated watershed surfaces. This has been calculated by dividing the total stream length of order (u) by the number of streams of segments in that order. The deviation might be due to change in topographic elevation and slope of the basin.

$$\text{Lsm} = \frac{\sum_{i=1}^{N} L_u}{N_u}$$

Stream length ratio

Stream length ratio (RL) is the ratio of the mean length of the one order to the next order of the stream segments. Total stream length of a given order is inversely related to stream order, i.e., total stream length decreases from the lower order to the successively higher orders. This change might be attributed to variation in slope and topography, indicating the youth stage of geomorphic development in the streams of the study area.

$$R_l = \frac{L_u}{L_{(u+1)}}$$

Drainage Pattern

The drainage pattern is an indicator of landforms and bedrock type and also suggests soil characteristics and site drainage condition. The drainage pattern is the planitmetric arrangement of stream engraved into the land surface by a drainage system. The aggregate of drainage ways establishes a design on the earth's surface, adjusted to topographic, structural and lithological controls. The drainage pattern may reflect original slope, original structure, or the modification of the earth surface, including uplift depression, tilting and other structural elements like faulting, folding, warping and jointing. The drainage pattern of the study area is dendritic.

Areal Aspects

Area of a watershed (A) and perimeter (P) are the important parameters in quantitative morphology. The area of the watershed is defined as the total area projected upon projected upon a horizontal plane contributing to cumulate of all order of watersheds. Perimeter is the length of the boundary of the watershed which can be drawn from topographical maps. Watershed area is hydrologically important because it directly affects the size of the storm hydrograph and the magnitudes of peak and mean runoff. It is interesting that the maximum flood discharge per unit area is inversely to size.

Watershed shape factor

Watershed shape is the shape of projected surface on the horizontal plane of watershed map. The watershed shape has a significant effect on stream discharge characteristic for example; the elongated watershed having a high bifurcation ratio can be expected to have alternate flood discharge.

The shape of a watershed has a profound influence on the runoff and sediment transport process. The shape of the drainage basin also governs the rate at which water enters the stream. The quantitative expression of watershed can be characterized by form factor, compaction coefficient, circularity ratio, and elongation ratio.

Form factor

Form factor (R_f) may be defined as the ratio of the area of the watershed and square of the watershed length and is expressed as,

$$R_f = \frac{A}{L^2}$$

Compactness coefficient

Compactness coefficient of a watershed is the ratio of perimeter of watershed to circumference of circular area, which equals the area of the watershed. Compactness coefficient is used to express the relationship of a hydrologic watershed. The Cc is independent of size of watershed and dependent only on the slope. A circular watershed is the most hazardous from a drainage stand point because it will yield the shortest time of concentration before peak flow occurs in the watershed.

$$\text{Compactness coefficient} = \frac{p}{2\sqrt{\pi A}}$$

Circularity Ratio

The circulatory Ratio is mainly concern with the length and frequency of the stream, geological structure, land used, climate relief, and slope of the basin. It is the ratio of the area of the water shed to the area of circle having the same circumference as the perimeter of the watershed.

$$R_c = \frac{4\pi A}{P^2}$$

Elongation Ratio

Elongation ratio (Re) is defined as the ratio of diameter of a circle of the same area as the watershed to the maximum watershed length. It is a very significant index in the analysis of the watershed shapes which helps to give an idea about the hydrological character of the drainage basin.

$$R_e = \frac{2\sqrt{A}/\pi}{L}$$

Constant of channel Maintenance

The inverse of Drainage density is the constant of channel maintenance. It indicates the number of Sq.Km of watershed required to sustain one linear Km of channel and express as Sq.Km/Km.

$$C = \frac{1}{D_d}$$

Stream Frequency

Stream frequency is the total number of stream segments of all order per unit area. Hypothetically it is possible to have the basin of same drainage density differing in stream frequency and basin of same stream frequency deferring in drainage density.

$$S_f \frac{N_s}{A}$$

Relief Aspects

Relief aspects of drainage basin relate to the three-dimensional features of the basin involving area, volume and altitude of vertical dimension of landform where in different morphometric method are used to analyses terrains characteristic. Relief is the elevation differences between the highest and lowest point on the valley floor of the region. Relief aspects is an indicator of flow direction of water as it is an important factor in understanding the extend of denundational process that have under gone within the watershed. It comprises of watershed relief, Relief Ratio, Relative Relief, Ruggedness Number.

Watershed Relief

Difference in the elevation between the highest point of a watershed and the lowest point or the valley floor is known as the river watershed. The relief ratio may be defined as the ratio between the total relief of a watershed and the longest dimension of the watershed parallel to the main drainage line. Low value of relief ratios is mainly due to the resistant basement rocks of the basement low degree of slope.

Relief Ratio

The elevation difference between the highest and lowest point on the valley floor of a sub watershed is known as a total relief of that sub watershed. The relief ratio (Rh) of maximum relief to horizontal distance along the longest dimension of the watershed parallel; to the principal drainage line is termed as relief ratio. There is also a correlation between hydrological characteristics and the relied ratio of the drainage basin. The Rh normally increase with decreasing drainage area and size of sub watershed of a given drainage basin. It is noticed that high values of indicate step slope and high relief (m), while the lower values may indicate presence of basement rocks that are exposed in the form of small ridges and mounds with lower degree of slope.

$$R_f = \frac{H}{L}$$

Relative Relief

Relative relief is defined as the ratio of the maximum watershed relief of the perimeter of the watershed. It is compute as,

$$\mathrm{R_r} = \frac{\mathrm{H}}{\mathrm{P}}$$

Ruggedness number

Ruggedness number is the product of the watershed relief and the drainage density and usually combines slope steepness with its length. The low ruggedness values of watershed imply that area is less prone to soil erosion and have intrinsic structural complexity in association with relief and drainage density. High values of the ruggedness numbers in the watershed are because both the variables like relief and drainage density are enlarge. Extensively high values of ruggedness numbers occur for a high relief region with high stream density. It is computed as,

$$R_n = \frac{HD_d}{1000}$$

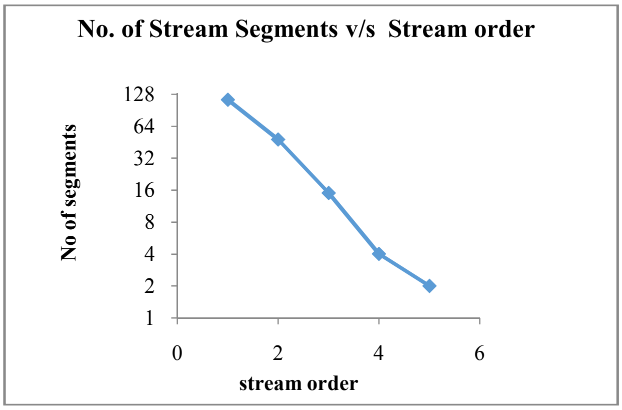
RESULT AND DISCUSSION

Table 1 Different morphometric Parameter of the catchment

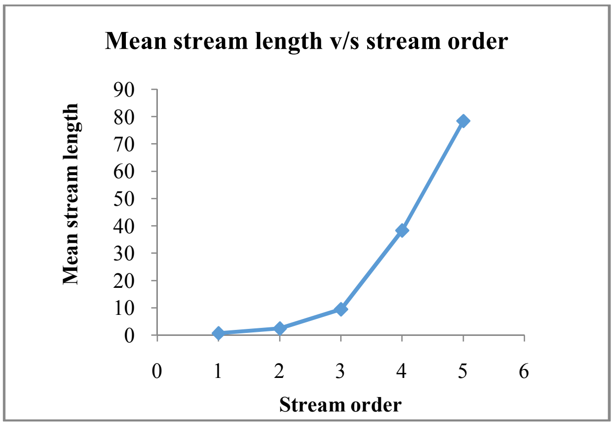
Stream order	No Of Streams Segments	Stream length in (Km)	Cumulative length in (Km)	Mean stream length	Bifurcation ratio
1	114	78.92	78.76	0.7	
2	48	37.82	116.74	2.43	2.35
3	15	25.18	141.88	9.45	3.2
4	4	11.47	155.35	38.3	3.75
5	1	4.33	157.68	78.36	4

The bifurcation ratio is a dimensional property and it ranges between 3 and 5 for watersheds in which the geologic structures do not distort the drainage pattern. It is observed from the Table 1 that the R_b is not same from one order to next order. These irregularities are dependent on the geological and lithological development of the watershed. The lower values of R_b are characteristics of watersheds which have suffered less structural disturbances and drainage patterns has not been distorted because of structural disturbances. In the present case the values of R_b varies from 2.35 to 4 (less than 5) for the watershed and hence these have not suffered any structural disturbances.

In graph 1, deviation of the stream numbers indicates the effects of various factors. This is mainly due to the structural, underlying rock and unfavorable conditions for the development of the stream network.



Graph 1 Stream segments V/S Stream Order



Graph 2 Mean stream length v/s stream order

In graph 2, the deviation of the mean stream lengths from the straight line shows that the law of drainage composition, geometric regularity is not maintained and the valley is not fully developed. This may be due to the structural control, difference in geological structure and immature landform of the area.

The drainage density reflects the land use, affects the infiltration and watershed response time between precipitation and discharge. From the table 2, the drainage density of the area varies from 1.12 to 2.49 km/km^2 indicating that the area is coarse texture. The Elongation Ratio is 0.46 which is found out to be Circular in Shape

Table 2 Different morphometric Parameter of the Gurupura catchment

SL NO	Watershed parameters	units	value
1	Watershed area	Sq.Km	141
3	Maximum Length Of Water shed	Km	16.41
4	Cumulative Stream Segments		183
5	Cumulative Stream Lengths	Km	157.72
6	Drainage Density	Km/Sq.Km	1.12
7	Constant Of Channel Maintenance	Sq.Km/Km	0.89
8	Stream Frequency	No/Sq.Km	1.3
10	Elongation Ratio	-	0.46
11	Bifurcation Ratio	-	3.4

CONCLUSION

The result obtained on the basis of stream and drainage basin analysis provides information for an improved understanding of hydrological characteristics in the Gurupura River. The extract values were mapped and analyzed using GIS in order to characterize the stream networks and drainage basin systems. The lower values of R_b are characteristics of watersheds which have suffered less structural disturbances and drainage patterns has not been distorted because of structural disturbances.

References

Durga Rao, K.H.V. and Bhaumik, M.K. 2003. Spatial expert support system in selecting suitable sites for water harvesting structures - A case study of Song watershed, Uttaranchal, India. *Geocarto International*, 18(4), 43-50

Horton, R.E. 1945. Erosional development of streams and their drainage basins: Hydrophysicai approach to quantitative morphology. *Bull. Geological Society of America*, 56, 275-370.

Nag, S.K. 1998. Morphometric analysis using Remote Sensing techniques in the Chaka sub-basin Purulia district, West Bengal. 3. Indian Society of Remote Sensing, 26(1&2), 69-76.

Ramu, B.Mahalingam, P.Jayashree. 2013. "Morphometric analysis of Tungabhadra drainage basin in Karnataka using GIS" *journal of engineering, computers & applied science.*

Strahler, A.N. and Strahler, A.H. 2002. A text book of Physical Geography. 2nd ed., John Wiley & Sons Publishers, New York, 748.

How to cite this article:

Amulya G.V *et al.*2018, Gis-Based Morphometric Analysis of Sub- Watershed of Gurupura River, Dakshina Kannada District. *Int J Recent Sci Res.* 9(6), pp. 27545-27549. DOI: http://dx.doi.org/10.24327/ijrsr.2018.0906.2282

****