MORPHOMETRIC ANALYSIS OF LAKSHMANTIRTHA RIVER BASIN AROUND HUNSUR TALUK, MYSORE, KARNATAKA, (INDIA)

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ABSTRACT

Morphometric analysis becomes important when watershed development and management plans are taken into consideration. Morphometric analysis was carried out on Laskmantirtha basin using satellite imageries and topographic maps on a scale map of 1:50,000 to determine its drainage characteristics. Remote sensing and GIS tools have proved to be an efficient tool in this study in drainage delineation and calculation of some of the aerial and linear parameters. The drainage pattern of the basin is dendritic and includes a sixth order stream. The development of stream segments in the area is more or less effected by rainfall. The erosional process of the basin is the result of the sub surface lithology. The shape parameters also reveal the elongated shape of the basin.

Key Words: Lakshmantirtha river, Shape parameters, Dissection intensity parameters, Morphometric analysis.

INTRODUCTION

Geology, geomorphology, structure and drainage patterns especially in hard rock terrains are the primary determinants of river ecosystem functioning at the basin scale\(^1-3\). Understanding the drainage pattern of an area gives a perspective view of the topography of the area which helps in the planning and development of water sheds and also provides an indication of the potential zones for obtaining ground water. Morphometric techniques are applied for interpretation of silent features of drainage networks. It incorporates a quantitative study profiles of land and the drainage basin characteristics of the concerned area\(^12\).

Objectives

In this paper the drainage characteristics of Lakmanthirtha river basin and the 10 watersheds were studied using the topographical sheets and satellite imageries to evaluate the hydrological conditions of the area.

Study area

The Lakshmantirtha River, a tributary to Cauvery basin, covers an area 1582 sq.km based on the toposheets of survey of India numbers 57D/3, 57D/4, 57D/7, 57D/8, 48P/15, 48P/16, 58A/1 on a scale of 1:50000
The basin area lies between latitudes 12° 25’ 35” to 11° 55’ 40” N and longitudes 75° 51’ 10” to 76° 25’ 43”. It originates in the hilly region at Srimangala in Virarajendrapet taluk of Kodagu District and flows easterly and joins the Cauvery River at KRS dam. The climate of the region is mainly influenced by its relief. In the southwestern part of the basin where the river actually originates, is a hilly region with a maximum elevation of 1600 m above mean sea level and the annual average rainfall is between 2200- 3200 mm. whereas when compared to the eastern part a sudden decrease in topography is noticed which lowers in northeastern part up to 760 m above mean sea with a average rainfall of 765 mm. The area exposes rocks of Sargur Group, PG-I of peninsular Gneissis complex, Charnockite suite of archaen age, acid and basic intrusive of Palaeoproterozoic and Chamundi granite.

MATERIAL AND METHODS

Morphometric analysis of Lakshmantirtha basin was carried out on the toposheets and satellite imageries (LISS plus pan merged data) in the scale of 1:50000. The toposheets were first georeferenced with ERDAS (9.1V) and a UTM projection system was given to them. This was followed by digitization of the drainage pattern and contours of the Lakshmantirtha basin by Mapinfo (V.8). The drainage network of the basin is analyzed per Horton law and stream ordering was made after Strahler. After digitization the aerial and linear parameters considered for morphometric analysis was studied with the help of Arcview (3.2a V) for the whole basin and subsequently for the 10 watersheds which were demarcated according to the water divider. Relief and topography analysis of the basin too was carried out with the help of the contour lines and its interval by using the tools of ArcGIS. In this paper the analysis have been grouped into five categories: 1) basic parameters, 2) derived parameters, 3) shape parameters 4) dissection intensity parameters and 5) height parameters. All the parameters have been discussed in detail.

RESULTS AND DISCUSSION

1. Basic Parameters:

Area, Perimeter and Basin Length: The total drainage area, perimeter and basin length are 1582 sq.km, 249 km and 72 km respectively and the values for then 10 watersheds are shown in Table 1.
Stream Order: In this paper stream ordering has been ranked according to Strahler’s which is popularly known as Stream Segment Method. The number of streams of each segment (Nu) of the order U is proposed in Table 1. Lakshmantirtha basin is designated as a sixth order stream. The details of stream characteristics confirm with Horton’s first law of stream numbers which states that the numbers of different orders in a given drainage basin tends closely to approximate an inverse geometric ratio. This means that there is a negative correlation between the stream order and stream number. This can be seen clearly in the linear regression graph (Fig. 2) where an almost straight line is formed when log values of Nu are plotted on y axis against stream order on x axis.

Stream length: The stream length for all the watershed of various orders has been measured with the help of the tools on the Arcview software in kilometers on the topographical maps. The values of length (Lu) and total stream length (Lt) are shown in Table 1. In Fig. 2 we can see that there is a negative correlation between the Lu and stream order when regression line is fitted. This observation is on the basis of Horton’s law of stream numbers which has received verification by accumulated data from many localities. However there is a sudden increase in length of streams of order VI (watersheds 4, 6, 8 and 10) which could be due to variation in relief over which the segments occur. Mostly all streams rise from the hilly terrains. It is noticed that stream segments up to the 3rd order traverse the high altitudes zones, which are mainly characterized by steep slopes, while the 4th, 5th and 6th order stream segments occur in comparatively plain land.

2. Derived parameters:

Stream length ratio: Stream length ratio is defined as the ratio of mean length of one order to the next lower order of stream segment, 
\[ RL = \frac{L_{u+1}}{L_u} \]

The stream length ratio of the study area reveals that the values are different for different watersheds and are changing haphazardly from 1.70 to 4.46. These variations can be attributed to differences in slope and topographic conditions of the study area and has a relationship with surface flow discharge and erosional stage of basin. This change could also be attributed to the late youth or medium stage of geomorphic development.

Stream Frequency: Stream frequency of a basin is defined for all orders within a basin and the basin area, 
\[ F_s = \sum \frac{Nu}{A} \]

The Fs of the whole basin is 1.35 and that for the 10 watersheds are shown in Table 2. Temperature and rainfall are some important factors which affect the development of segments of a basin which in turn influence the stream frequency.

Bifurcation Ratio: Bifurcation ratio is defined as the ratio of the numbers of stream of a given order (Nu) to the number of streams of the next order (Nu+1), 
\[ R_b = \frac{Nu}{Nu+1} \]

Bifurcation ratio is a dimensional parameter indication of branching pattern of a drainage network. Chow stated that Rb ranges between 3-5 for watersheds, the geologic structure does not exercise a dominant influence on the drainage pattern. The Rb for the basin is 4.42 and the values of all the watersheds vary from 3.76-4.5 which. By seeing the results we can see that geological structure does not influence the drainage pattern.

RHO coefficient (RHO): Horton defined this parameter as the ratio between the stream length ratio and bifurcation
ratio, \( \text{RHO} = \frac{Rf}{Re} \). Horton stated that by calculating this value one could estimate how much water will be lost as runoff during flood period and also determine the amount of water which could be stored in a basin showing the drainage capacity of a basin. RHO is influenced by many external parameters like climate, anthropogenic factors and also by the geologic and geomorphologic conditions of the terrain. The value of RHO for the Lakshmantirtha basin is 0.38 and for the watersheds it varies from 0.41-1.06 (Table 2). Watershed 8 and 10 show higher values compared to the other watersheds, so there is a possibility that they may have a higher hydric storage during flood period and attenuate the erosion effects during elevated discharge.

3. Shape parameters:

   Elongation ratio (Re): Elongation ratio is the ratio between diameter of a circle of the same area to the basin length (L) (Schumm, 1956), \( Re = \frac{D}{2} = 1.126 \sqrt{A/L} \).

   The values of Re generally vary from 0.6 to 1.0 over a wide variety of climatic and geologic types. Values close to 1.0 are typical of regions of very low relief whereas values in the range of 0.6-0.8 are usually associated with high relief and steep ground slopes. The Value of Re for Laskhmantirdha basin is 0.62 and the values of Re for the watersheds are shown in Table 3. It can be seen that the basin has an elongated shape.

   Circularity index (Rc): According to (Miller, 1953, Strahler 1964) the circularity index is defined as the ratio of basin area (A) and the area of a circle with the same parameter as that of the basin (P), \( Rc = \frac{4\pi A}{P^2} \).

   The Rc of Lakshmantirtha basin is 0.32 while the Rc calculated for its 10 watersheds are shown in Table 3. The value of Rc of Lakshmantirtha basin clearly shows lack of circularity in shape. Circularity index is a significant ratio which explains the dendritic stage of a basin. The low, medium and high values of Rc are indicative of low, medium and old stage of a life cycle of a basin. It is evident from the values obtained for Rc (Table 3) that all the watersheds are in the medium or middle maturity stage while the sub watershed 7 is in its mature stage compared to the other watersheds.

   Form factor: According to Horton form factor of a basin is defined as the ratio between the area of a basin and the squared basin length, \( Ff = \frac{A}{L^2} \).

   Rf value of the basin is 0.30 and the value for the watersheds is shown in Table 3. The index of Ff shows the inverse relationship with square of axial length and a direct relationship with peak discharge. From the shape parameter analysis, one thing which is very clear is that all the 3 above mentioned factors indicate an elongated shape of the basin which in turn has an effect on the discharge characteristic of the basin. Flood takes a longer time to travel in an elongated basin when compared to a circular basin.

4. Parameters for Dissection Intensity:

   Drainage density: R.H Horton defined the drainage density as the ratio of total length of all stream segments in a given drainage basin to the total area of that basin, \( Dd = \frac{L_s}{A} \).

   Dd is an indicator of basin dissection. The parameters like resistance to erosion of rocks, infiltration capacity of land and climate conditions influence the drainage density. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture. Drainage density of the Lakshmantirtha basin as a whole is 1.33 and those of the 10 watersheds are shown in Table 3. The Dd of the watersheds and the basin are all less than 5 which is a characteristic feature of course
Drainage system and reveals to some extent the permeable nature of the sub strata. It is noted that drainage density exhibits positive and high correlation (0.869) with Fs values of the watersheds and the basin. This was estimated by using the SPSS (V.16) statistical software. These are moderately well drained streams, having a higher runoff when compared to its infiltration rate indicative of a medium dissected topography. 10.

**Drainage texture (T):** An important geomorphic concept is drainage texture which defines the relative capacity of drainage line. According to Smith many parameters like soil type, infiltration capacity have a bearing on drainage texture. Based on value of T, the drainage texture can be classified in the following categories for 4 and below as Coarse, 4 to 10 as Intermediate, 10 to 15 as Fine and above 15 as Ultra fine (bad land topography). The T of the Laskmantirtha basin as whole is 1.79 while that of the 10 watersheds are shown in Table 3. The T values of all the watersheds are below 4 and belong to the coarse texture.

5. **Height parameters:**

Relief: Basin relief is the different between the highest and lowest point of a basin. Basin relief has an influence on the channel slope which controls the flood pattern and the amount of sediments which get transported. The values of relief for the basin and the watersheds are shown in Table 4.

**Relief ratio:** Relief ratio is a dimensionless height-length ratio between basin relief and basin length. The Rr normally increases with drainage area and size of watersheds of a given drainage basin. Rr of the basin is 0.011 and that of the watersheds are shown in Table 4. The relief ratio of the basin and the watersheds are low which are characteristic feature of low resistance rocks. Watershed 2 has the highest relief value (0.037) which is a characteristic feature of a hilly region and the low values of Rr for the remaining watersheds represent moderate relief with Pedi plains and valley regions.

**Gradient ratio:** Gradient ratio represents the channel slope of the basin by which one can calculate the amount of runoff of the basin. The basin has a gradient ratio of 0.0097 and the values for the 10 watersheds are presented in table 4 which show a moderate gradient.

**CONCLUSION**

Morphometric analyses of the Laskmantirtha basin and its 10 watersheds exhibit a dendritic pattern. The variation in stream length ratio is due to change in slope and topography. The geomorphic development of the basin is in its late youth and medium stage. The mean bifurcation ratio (4.42) indicates that the drainage pattern in not much influenced by the geological structure. Lower order streams mostly dominate the basin and are more in number which provide a sufficient superficial draining to the upper order streams. The development of the stream segments in the basin are more or less affected by rainfall. The Dd of the basin as well as those of the watersheds, reveal that the nature of the subsurface is permeable. This is a characteristic feature of coarse drainage as the Dd is less than 5.0. The shape parameters also reveal the elongated shape for the basin. Due to this characteristic, the basin will tend to have lesser flood peaks but longer lasting flood flows compared to round basins. This particularly is very important while
considering the management and reservoir projects and a progressive land use pressures\textsuperscript{19}. In fact the importance of such analyses is emphasized since based on interpretation of its results one can locate the suitable site for artificial recharge and construction of check dams. Based on our results we can conclude that for efficient management purposes check dams can be constructed in flat lands with less steep slopes which are characterized features of 4\textsuperscript{th}, 5\textsuperscript{th} and 6\textsuperscript{th} order streams.

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