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One Dimensional Quantification Of A Basin: A Tributary Of Kushkarni Nadi

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Abstract: Morphometric analysis is important in any hydrological investigation and it is inevitable in development and management of drainage basin. This paper shows on the one-dimensional quantification of a tributary Kushkarni river basin. The detail study suggests that the topographic region of this basin is almost mountain and the basin is a 3rd order river basin. The analysis reveals that the stream order varies from 1 to 3 and the total number of stream segments of all orders counted as 41, out of which the maximum area is covered by 1st order streams and the minimum by 3rd order.

Index Terms **- Linear Parameters, Bifurcation Ratio, Length Ratio, Law of Stream Length, Allometric Growth, Junction Angle.**

INTRODUCTION

Morphometric analysis refers as the quantitative evaluation of form characteristics of the earth surface and any landform unit. This is the most common technique in basin analysis, as morphometry form an ideal areal unit for interpretation and analysis of fluvially originated landforms where they exhibit and example of open systems of operation. The composition of the stream system of a drainage basin in expressed quantitatively with stream order, drainage density, bifurcation ration and stream length ratio (Horton, 1945). It incorporates quantitative study of the various components such as, stream segments, basin length, basin parameters, basin area, altitude, volume, slope, profiles of the land which indicates the nature of development of the basin. The measurement and mathematical analysis of the configuration of the earth's surface, shape, and dimension of its landforms is called morphometry. Morphometric studies involve evaluation of streams through the measurement of stream properties with the analysis of various drainage parameters namely ordering of streams, basin area, and perimeter of basin, length of drainage channels, drainage density, stream frequency, bifurcation ratio, texture ratio and circulatory ratio. The morphometric analysis was studied by different researchers **(Strahler, 1957; Strahler 1964; Clarke, 1966; Agarwal, 1998; Kumar et al., 2010**). Analysis of various drainage parameters namely ordering of the various streams and measurement of area of basin, perimeter of basin, length of drainage channels, drainage density (Dd), drainage frequency, bifurcation ratio (Rb), texture ratio (T) and circulatory ratio (RC) were studied in these aspects.

The basin morphometry includes the analysis of the characteristics of these aspects –

1. Linear aspects
2. Areal aspects
3. Relief aspects

In this study, linear morphometric aspects have been briefly analyzed with suitable illustrations and examples.

Linear Aspects of The Basin

Linear aspects of the basins are related to the channel patterns of the drainage network where in the topological characteristics of the stream segment in terms of open links of the network system are analyzed. This aspect gives the view of a) Hierarchy of stream segment b) Number and length of stream segments c) Relationship among sub aspects d) Related morphometric laws.

Importance

Each linear technique for measuring linear aspects has adequate hydro geomorphic and economic importance. Each stream segment has its own hydrogeomorphic potentiality. So, segregation of streams is necessary to uniquely identify the hydromorphic characters. If the numbers of 1st order streams are exaggerated in a basin that indicates creates ravine topography or erosion prone bad land topography sudden change of bifurcation ration indicates break of slope. It also intensifies the flood propensity in the foot hill regions as well as lower segment of the rivers because large number of stream segments coalesces to the master stream at a time. Hydrological potentialities are increasing with increasing stream order. So, during launch of any planning and development specially industrial plan, irrigation plan introduction of cropping pattern in the basin area not only hierarchical ordering of stream segment, sinuosity character assessment is necessary. Degree of meandering is more means, river is highly flood prone, there is tendency of excessive sedimentation etc. the length ratio and law of stream length describe regional change of stream length association as well as hydrological potentiality.

Study Area

The region selected for present study isa tributary of Kushkarni river basin of Santhal Pargana District, Birbhum District. It lies between 24° N to 24° 6’44’’ N latitude and 87° 20’ E to 87° 25’ E longitude (Fig. 1). Toposheet number is 73 M/5

A Tributary of Kushkarani Nadi map No-73 M/5

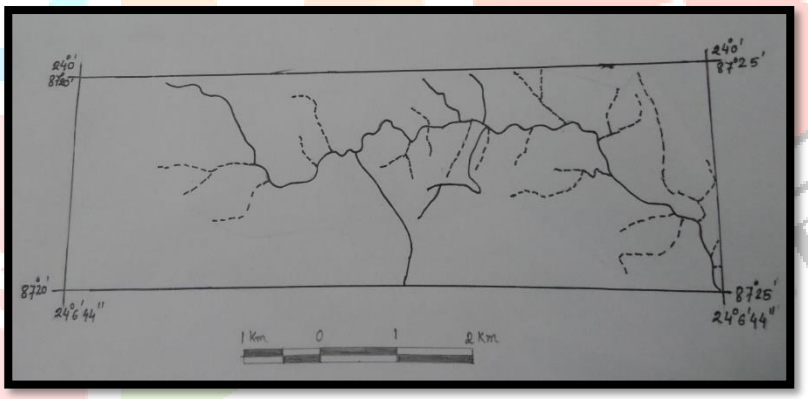

Fig. 1 Base map of a tributary of Kushkarni River Basin

OBJECTIVES

The main aim of the present study to find out the different aspect of linear morphometry, i.e. stream ordering, bifurcation ratio, law of stream number, length ratio, stream length, allometric growth, sinuosity indices, stream junction angle.

Sources of Data

Most of the data have been collected from toposheet, Survey of India, which is (R.F.: 1:50,000) and was surveyed in 1971-1972. The toposheet number 73 M/5.

METHODOLOGY

Table 1: Different parameters w.r.t. linear aspect

Aspect	Parameter	Formula	Reference
LINEAR	Stream Order	Hierarchical rank, (1+1=2,2+1=2,2+2=3)	Strahler,1964
	Bifurcation Ratio (Rb)	Rb=Nμ/Nμ+1 Nμ=Number of stream Nμ+1=Number of stream in next higher order.	Schumm,1956
	Mean Bifurcation Ratio (Rbw)	Rb1×n1+Rb2×n2…+Rbn×nn/n1+n2…nn	Strahler,1957
	Law of stream number (Nμ)	Nμ= Rb(K-μ) K=Highest order of the basin, μ=basin order	Horton,1945
	Length ratio (Rl)	Rl =Lμ/Lμ-1 Lμ= The total stream length of order μ; Lμ-1=Length in next lower order.	Horton, 1945
	Stream length (Lμ)	Length of the Stream	Horton, 1945
	Law of stream length (Lμ)	$L\mu = L1R_L (\mu-1)$ L1= Length of the 1st order.	Horton, 1945
	Sinuosity Indices	Actual Distance/Straight Distance	Muller, 1968
	Allometric Growth	Power regression	
	Law of Junction Angle (Aμ)	$A\mu = A1R_A(\mu-1)$ RA= Junction Ratio; Al = Angle of the 1st order.	Schumm, 1956

RESULT AND ANALYSIS

Stream Order

Stream ordering can be defined as a positional hierarchic of river segment within a drainage basin. **Gravelius, 1914,** for the first time had attempted to order a stream as 'Stream order is defined as a measure of the position of a stream in the hierarchy of tributaries'. In this ordering schemes here have been used "Strahler Scheme"-

1+1=2, 2+1=2, 2+2=3, 3+2=3, 3+3=4 (Fig. 2)

A Tributary of Kushkarni Nadi Map NO-73 M/5

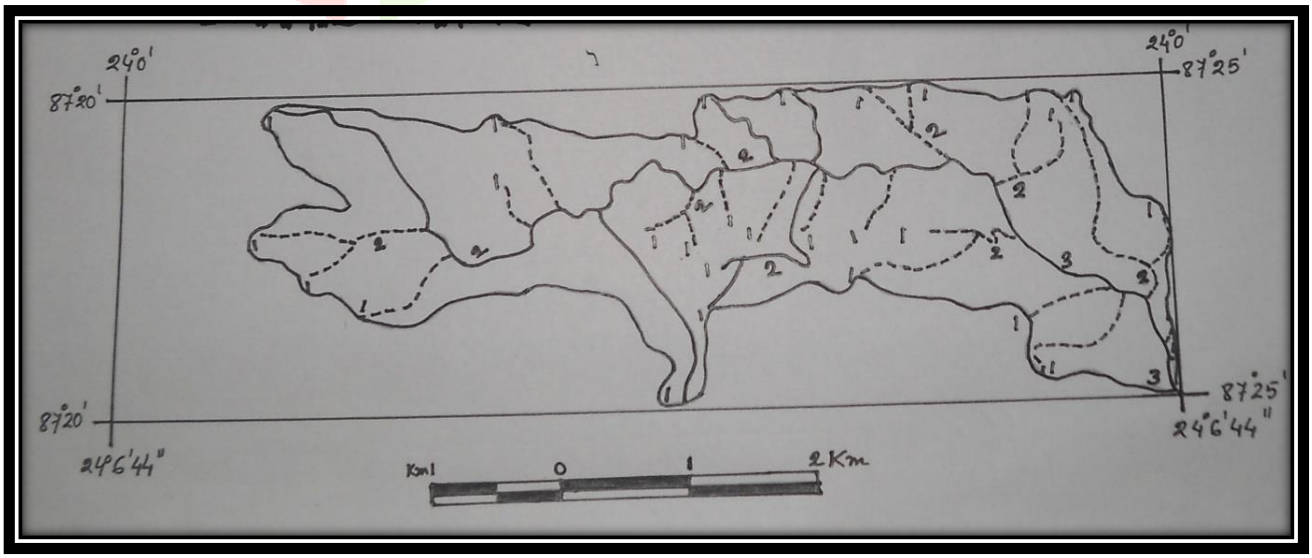

Fig. 2: Study Area map of a tributary of Kushkarni River Basin

Bifurcation Ratio

Bifurcation ratio (Rb) is defined as a ratio of the number of a given order (**Nμ**) to number of stream of the next higher order **(Nμ+1)** and is expressed in term of the following equation- Rb=**Nμ/Nμ+1.**

Table 1: Bifurcation ratio of different stream order

Stream Order	No. of Stream	Bifurcation Ratio (Rb)
1	30	-----
-----	-----	3.3
2	9	----
----	----	4.5
3	1	----

Average Bifurcation Ratio (Rbw) = Rb1× n1+ Rb2× n2……+ Rbn× nn/n1 + n2….nn
= 3.3×30+4.5×9/41 =3.4 (Table 1)

Here, the bifurcation ratio of the 2nd order stream is 3.3, 3rd order stream is 4.5. mean bifurcation ratio of the basin is 3.4. It means on an average 3.4 or 3 rivers are required to make the next order stream. This value also indicates that the basin is located at the fringe area of plateau region.

Law of Stream Number

According to R.E .Horton's law of stream number, the number of stream successively decreases with increasing stream order. The nature of increase will be arithmetic in case of stream order and geometric in case of stream number, if the bifurcation ratio remains constant.

Table 2: Stream Number in different order

Stream order	Number of stream
1	30
2	09
3	01

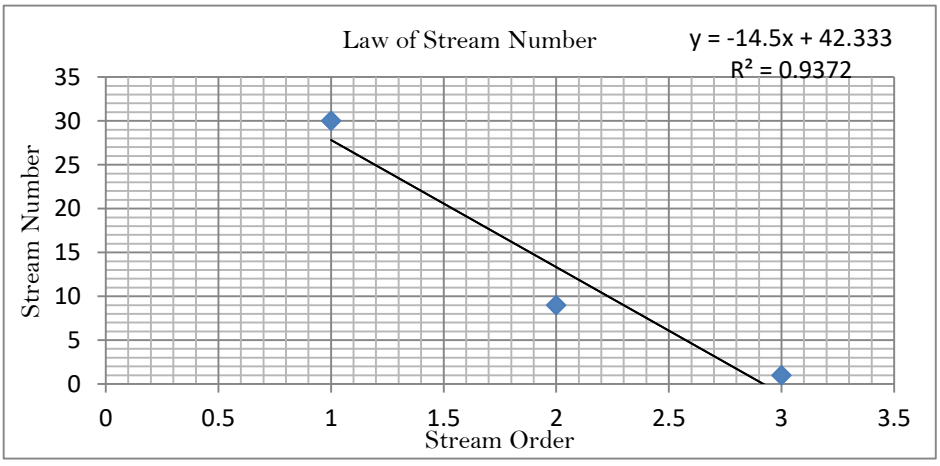

Fig. 3: Law of Stream number of a tributary of Kushkarni River Basin

Here, the number of stream successively decreases with increasing stream order (Table 2), as the R^2 value is =**0.9372 (Fig. 3)**. So it is near to 1. It represents the nature of the increases of stream number is near to geometric.

Length Ratio

The ratio between lengths of two successive stream order of a basin is called length ratio indicated in Table 3.

Table 3: Cumulative length & length ratio of different stream order

Stream Order	Length of the Stream (In cm)	Length of The Stream (In km)	Cumulative stream length (km.)	Length Ratio
1	40.9	20.45	20.45	5.93
2	06.9	03.45	23.9	1.97
3	03.5	01.75	25.65	------

Law of Stream Length

Horton's law of stream length (1945) states that "the cumulative mean length of stream segments of successive higher order increase in geometrical progression starting with the mean length of 1st order segments with constant length ratio (Table 4).

Table 4: Stream length in different order

Stream Order	Length of The Stream (Cm)	Length of the Stream (Km)
1	40.9	20.45
2	06.9	03.45
3	03.5	01.75

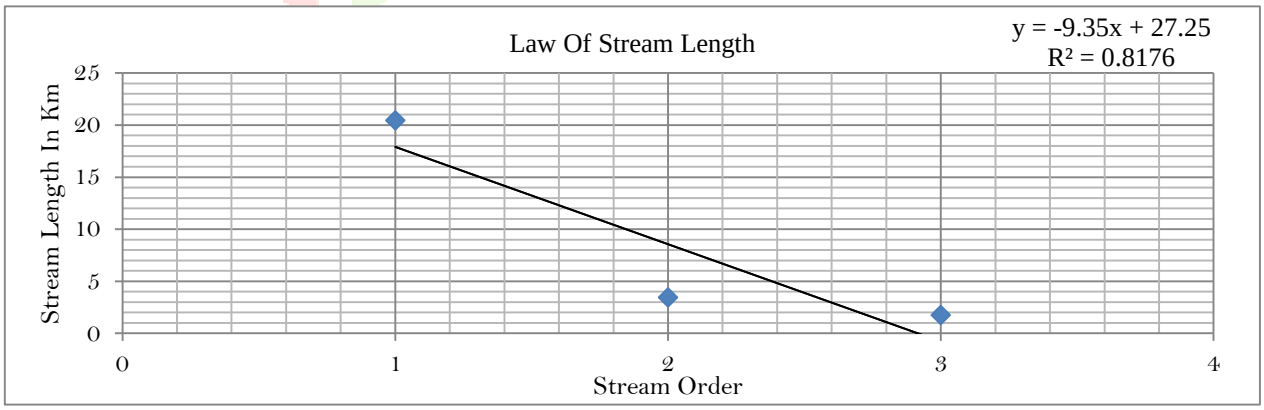

Fig. 4: Law of Stream Length of a tributary of Kushkarni River Basin

From Fig. 4, we can say that in this basin the length of the stream successively decreases with increasing stream order, but the nature of decreases of stream length is not geometric here, because the r^2 value is **0.8176**. So is near to geometric.

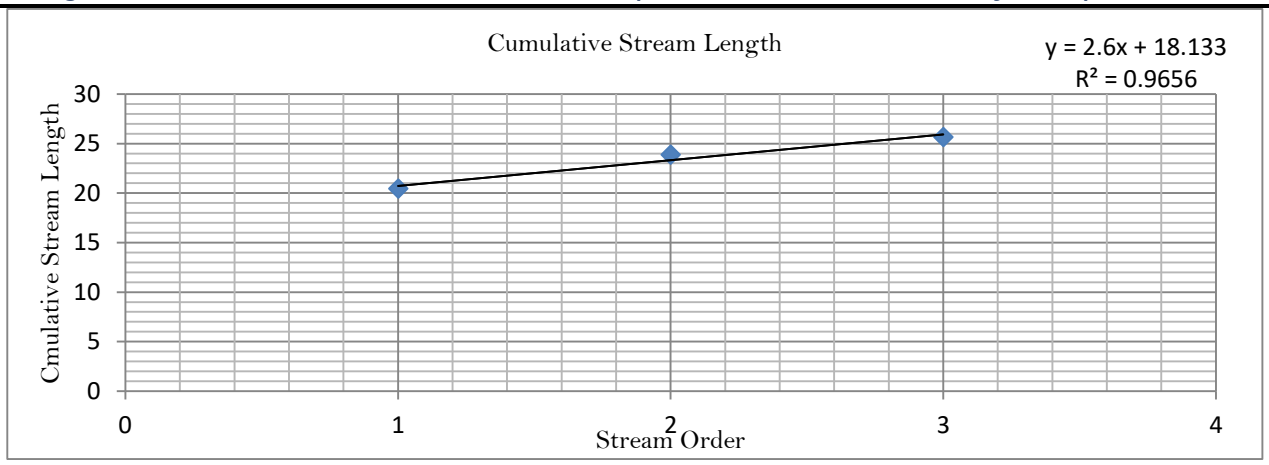

Fig 5: Cumulative length of a tributary of Kushkarni River Basin

Here, in Fig. 5, it can be concluded that cumulative length increases from 1st order to 2nd order and the R^2value is 0.9656. So it indicates that, the rate is near to geometric.

Allometric Growth

`M. Morisawa (1957), M.J. Woldenberg (1966), A.N. Strahler (1969) have introduced the biological law of plants growth in the growth system of a river basin. This law in morphological system states that with successive increase of stream order, the length of a basin increase in a proportionate rate.

Table 5: Allometric growth of different stream order

Stream Order	Stream Number	Length of the Stream (Km)
1	30	20.45
2	09	03.45

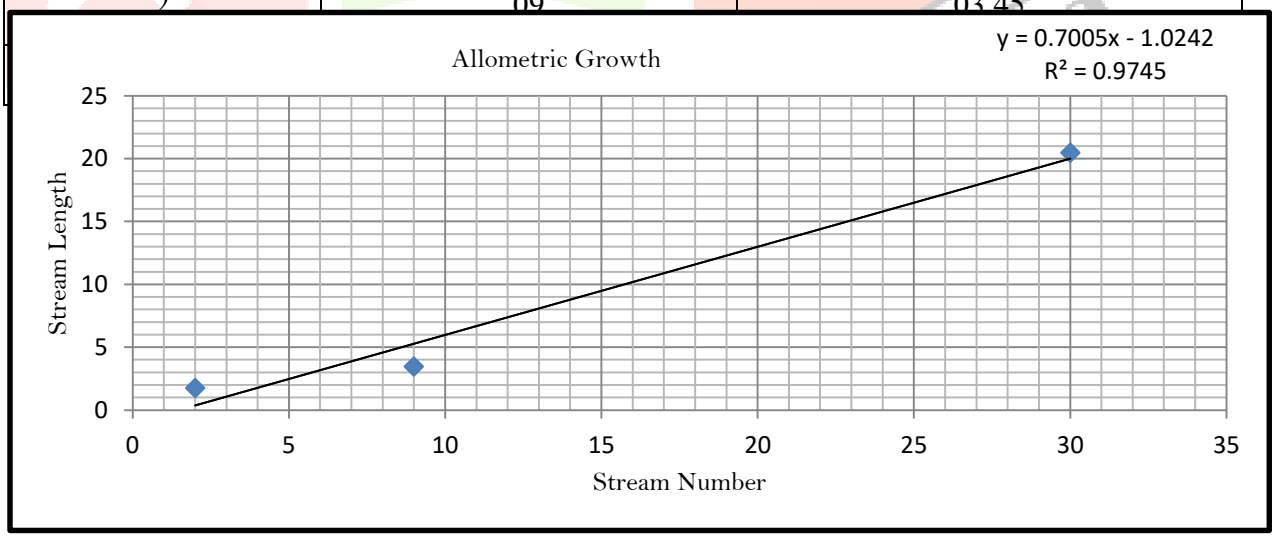

Fig. 6: Law of Allometric Growth of a tributary of Kushkarni River Basin

Here, the relationship between the stream number and stream length is positive. As R2 value is 0.9745. So it indicates that rate of increases of stream number and stream length is so similar to geometric.

Major Findings

- The tributary of Kushkarni river basin is a 3rd order river basin.
- As the average bifurcation ratio is 3.4, the topographic region of this basin is almost mountain region.
- Stream number successively decreases with increasing stream order.
- Cumulative length increases from 1st order to 2nd order.
- Length of the stream successively decreases with increasing stream order.
- The relation between stream number and stream length is positive.
- The sinuosity indices decrease from 1st to 3rd order.

CONCLUSION

Analyzing the tributary of Kushkarni basin area, in conclusion, it can be said that, this river is an upper part's tributary of Kushkarni River and the bifurcation ratio indicates that the nature of the topography of this region is almost mountain. In this basin the number of stream, stream length successively decreases with increasing stream order and the stream length and stream number increases with stream order almost in geometric rate. The detailed quantitative morphometry analysis of a tributary of Kushkarni river basin level enables to understand the relationships among the different aspect of the drainage patterns and their influence on land form processes, drainage and land erosion properties.

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