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Study of Linear Morphometry Aspects of Upper Darna River Basin

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Abstract:

The present study highlights the assessment and importance of the linear aspects of Darna river basin. The main objectives of the paper is to study the morphometric analysis of Upper Darna River emphasising on the linear aspects of the basin. Strahler's stream ordering method and Statistical analysis such as exponential regression equation were applied for the present study. The result of this research shows that the streams of the basin area formed dendritic drainage pattern and number of streams decreases of a given order in a drainage basin systematically with increasing stream order. This study is important for understanding the characteristics and geo-hydrological behaviour of a basin for further planning.

Keywords: Morphometric Analysis, Linear Aspect, Geo-hydrological behaviour.

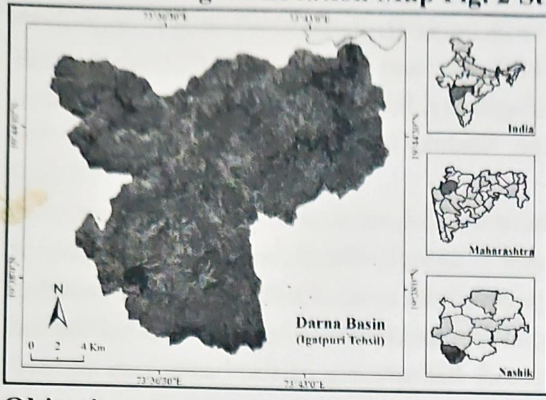
Introduction:

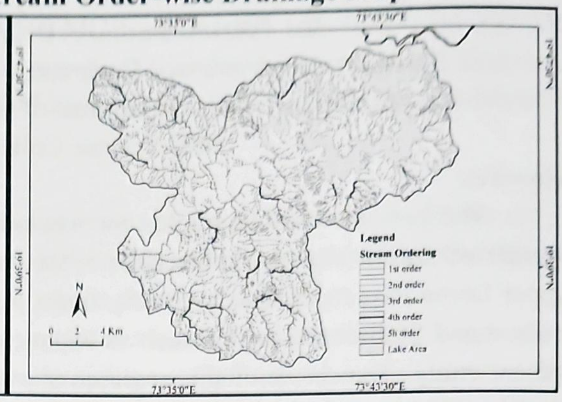
Morphometric analysis is a quantitative evaluation and mathematical analysis of the characteristics of the earth's surface. The morphometric study plays an important role in understanding the geo-hydrological behaviour and characteristics of a drainage basin in relation to the terrain feature (Hajam et.al 2013). A drainage basin can be expressed quantitatively using various linear, areal, and relief aspects. Linear aspects of the drainage basins are primarily related to the channel patterns of drainage network wherein the topological characteristics of the stream segments has beenanalysed (Kudnar, 2015). In morphometric analysis linear aspect (basin length, stream order, steam length, mean stream length, bifurcation ratio, and mean bifurcation ratio) of a watershed is computed to derive the general character of the watershed (Schumm, 1956; Strahler, 1957 and 1964). GIS and Remote Sensing techniques used to assess geo-hydrologic characteristics of various basins (Javed et al. 2009, Kiran et al. 2016, Malik et al. 2019). The present study highlights the assessment and importance of the linear aspects of Darna river basin.

Study Area:

The Darna River is an important tributary of Godavari River, which rises on northern slope of Kulung hill at an elevation of 1040 m (19° 59' N & 73° 63' E) in Sahyadri ranges of Nashik District, Maharashtra. The extension of the study area is in between 19°36' N to 19°48' N latitudes and 73°39' E to 73°44'E longitudes, which covers 389.6 sq. km area (Fig.1). The upper basin area of the Darna river is generally observed wander in nature and actual length of the Darna river in study area is approximately 58.93 km (Pathare, 2018).

Fig. 1: Location Map Fig. 2 Stream Order-wise Drainage Map





Objectives:

The present paper attempts to look into the morphometric analysis of Upper Darna River emphasising on the linear aspects of the basin.

Data and Methodology:

To accomplish the objectives of the present study quantitative data of linear aspects of morphometry obtained from Topographical maps. The number of the toposheets used for this study are 47 E/9, 47 E/10, 47 E/13and 47 E/14 based on 1:50000 scales (One inch toposheet) were published in 1977, 1975, 1976 and 1975 respectively. ArcGIS 9.2 Version and Global Mapper software have been used for geo-reference, rectification and digitization of contours and streams from topographical maps. Strahler's (1964) stream ordering method and Statistical analysis such as exponential regression equation were applied for the present study.

Results and Discussion:

1. Stream Ordering :

Extraction of stream orders of the basin is an important stage for morphometric analysis of drainage basin. It precisely explains the hierarchical relationship between stream segments, their connectivity and the discharge of the contributing Catchments area. Strahler's method were applied for this study and it has been find out that the study area shows that 6 is the highest stream order. The total numbers of streams in Darna basin are 1815 out of which 1380 are 1storder streams, 334 are 2nd order streams, 79 are 3rdorder streams, 18 are 4thorder streams, 3 streams are in 5thorder streamsand sixth order has 1 stream (Table1 and Fig. 2). In the Study area the drainage basin area streams formed dendritic drainage pattern and number of streams decreases as the stream order increases.

Table 1: Strahler's Scheme of Stream OrderingTable 2: Bifurcation Ratio and Stream Numbers

Sr. No.	Stream Order	Total Stream Number (Nu)
1	1st	1380
2	2nd	334
3	3rd	79
4	4th	18
5	5th	3
6	6th	1

Stream Order (u)	Stream Number (Nu)	Bifurcation Ratio (Rb)
1st	1380	-
2nd	334	4.13
3rd	79	4.23
4th	18	4.39
5th	3	06
6th	1	03

Total	1815	21.75

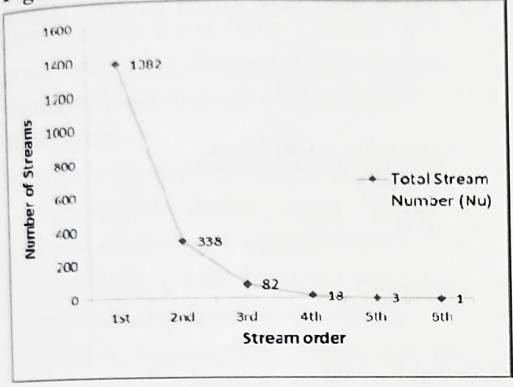
Source: Computed by researcher

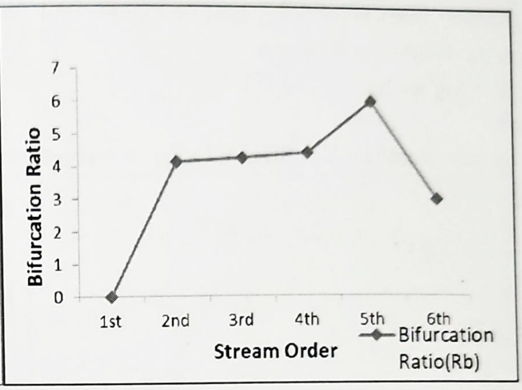
2. Bifurcation Ratio (Rb) :

According to Mesa (2006) bifurcation ratio is a measure of the degree of ramification of the drainage network. Bifurcation ratio is defined as a ratio of the number of streams of a given order to the number of streams of the next higher order. Bifurcation ratio is ranges in between 3 to 6 of the upper Darna River. Highest bifurcation ratio is 6 for 5th order basin (Table 2 and Fig. 4). The mean bifurcation ratio is 3.625 which show natural river system with uniformity respect to climate and type of rock and stage of the development of the river basin.

Mean Bifurcation of Upper Darna River (XRb) $= \sum Rb/n = 21.75/6 = 3.625$

Fig. 3 Number of Stream'sFig. 4 Bifurcation Ratio





3. Law of Stream Numbers:

The law of stream numbers relates to the definite relationship between the orders of the basinsand stream numbers. R.E. Horton's law of stream numbers states (1945), that the number of streamsegments of successively lower orders in a given basin tend to form a geometric series beginning withthe single segment of the highest order and increasing according to constant bifurcation ratio.The number of streams of a given order in a drainage basin systematically with increasingstream order (Fig.3).

Negative Exponential Functional Model:	**Example: (1)** Number of stream segments of 1 order,
$N\mu = Rb^{(k-u)}$	$N\mu = 3.625^{(6-1)}$
Where,	$N\mu = 3.625^{5}$
$N\mu$ = Number of stream segment of a given order	$N\mu = 625.95$
Rb= Constant bifurcation ratio	**Example: (2)** Number of stream segments of 2 order,
μ= Basin Order	$N\mu = 3.625^{(6-2)}$
k = Highest order of the basin.	$N\mu = 3.625^{4}$
	$N\mu = 172.67$

Table 3: Hypothetical Stream Number (Negative Exponential Functional Model)

Stream Order (u)	Number of Stream Segments	Bifurcation Ratio (Rb) Constant

Table 4: Law of Stream Numbers (Strahler's)

Stream Order(X)	Number of Streams	X^2	log of Y	X.log Y

1	625.95	3.625
2	172.67	3.625
3	47.63	3.625
4	13.14	3.625
5	3.625	3.625
6	1	3.625
Total	864.015	

	(Y)			
1	1380	1	3.139879	3.139879
2	334	4	2.523746	5.047493
3	79	9	1.897627	5.692881
4	18	16	1.255273	5.02109
5	3	25	0.477121	2.385606
6	1	36	0	0
∑X= 21	**∑Y=1815**	**∑ X² =91**	∑ logY = 9.293646	∑X.log Y = 21.28695

The regression lines involving negative exponential function model have been drawn for same sample basins on the following equation.

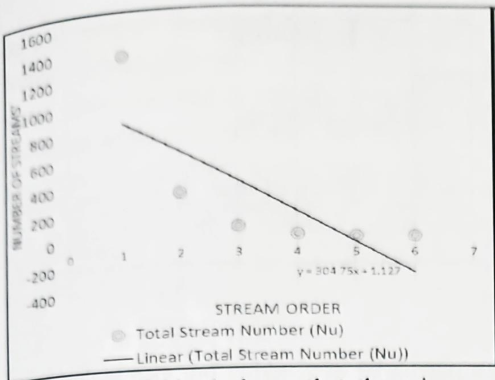
Log Y = log a - bx

Where,

Y = Stream Number; X = Stream Order; a = constant; b = Regression co- efficient.

$\overline{X} = \frac{\sum X}{n}$	$b = \frac{-67.4449}{105}$
$= \frac{21}{6} = 3.5$	$b = -0.64233$
$\overline{Y} = \frac{\sum Y}{n}$	$\log a = \log \overline{Y} - b\overline{X}$
$= \frac{1815}{6} = 302.5$	$\log a = 1.548941 - (-0.64233)*4$
$\log \overline{Y} = \frac{\sum \log Y}{n}$	$\log a = -0.64233 - (-2.56933)$
$= \frac{9.2934}{6} = 1.548941$	$\log a = 1.926996$
$b = \frac{n\sum X.\log Y - \sum X.\ \sum \log Y}{n\sum X^2 - (\sum X)^2}$	$Y = a + bX\ (X=1)$
	$Y = 304.75 + 1.127\ X\ 1$
$b = \frac{6\ X\ 21.28695 - 21\ X\ 9.293646}{6\ X\ 91 - (21)^2}$	$Y = 299.627$ Antilog 1.3376
$b = \frac{127.7217 - 195.1616}{546 \quad 441}$	$Y = a + bX\ (X=6)$
	$Y = 298.5 + 1.127\ X\ 6$
	$Y = 298.5 + 6.762 = 305.262$ Antilog 3.7462

Fig. 5 Stream Order VS Stream Number **Fig. 6** Mean Stream Length VS Stream Order



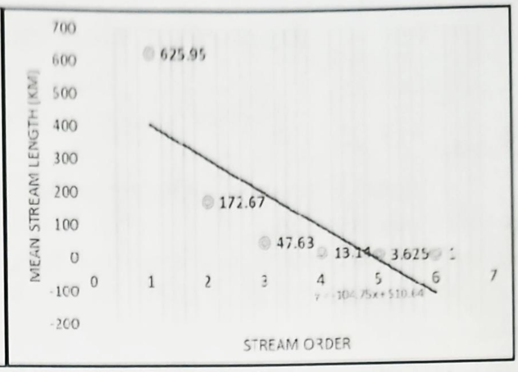


Figure 5 and Table 4 shows that there is negative correlation between stream order and stream number.Figure 6 and Table 3 shows the proportion of increase of mean length of stream segments a given order in a drainage basin increases means low stream order has more length and length decreases as per increase of stream order.

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