Morphometric Analysis of Jallu Nadi, Taluka Nandgagaon Khandeeshwar, Dist. Amravati

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ABSTRACT-

Morphometric analysis of Jallu Nadi river, a sub-tributary of Bembla River has been done during the present study. The underlying rocks are homogeneous i.e. Decccan baslts. The results show the dendritic drainage pattern with highest stream order V. The mean bifurcation ratio is 3.58 indicative of negligible structural disturbance. The low values of drainage density (1.75) and length of overland flow (0.88) Indicate low permeability coupled with high runoff. Overall, the basin shows moderate to low slope, low infiltration and high runoff with moderate erosional activity.

Key Words: Morphometric Analysis, Jallu Nadi, Nandgaon Khandeshwar, Amravati

INTRODUCTION:

Morphomertic analysis of Drainage Basin is defined as a measurement of linear, areal and relief characters of that basin (Clarke 1966). The pioneer work on drainage morphometry was done by Horton 1932. The different parameters of drainage morphometry are useful to know the hydrological and morphological characteristics of any region and the relationship between morphometric parameters with the local geology, geomorphology and hydrological characters were established from the work of different workers like Strahler (1952); Chorley (1957). Morphometric analysis is a rigorous quantitative study of a drainage basin and channel network, which can provide the numerical data. A mathematical analysis of measurements of the configuration of topography whether in field or on toposheet is known as Morphometric Analysis. The analysis of drainage basin has a particular relevance to geomorphology taken either as a single unit or as a group of basins which comprises a distinct morphological region. Fluvially eroded landscapes are composed of drainage basin which provides convenient bases for the subdivision of the area.

The present study area is a part of Bembala river basin in Nandgaon Khandeshwar Taluka of Amravati district, Maharashtra. The area is covered in the Survey of India Topographical sheet Nos. 55H/9, 55H/10, 55H/13, 55H/14 and located about 35 Kms from district headquarter Amravati between Latitude $77^{0}40'0''$ to $77^{0}49'0''$ E and Longitude $20^{0}40'0''$ to $20^{0}52'0''$ N (Fig.1) The area is drained by Jallu Nadi which is as sub-tributary of river Bembala. In general, the climate of the area is hot and dry except during the rainy season. The aim of the present study is by analysing the development of each drainage basin greater understanding of the landscape as a whole can be achieved. A systematic description of the geometry of a drainage basin and its stream channel network (system) requires the measurement of various linear and aerial aspects of channel network to evaluate the behaviour of streams in the basin.

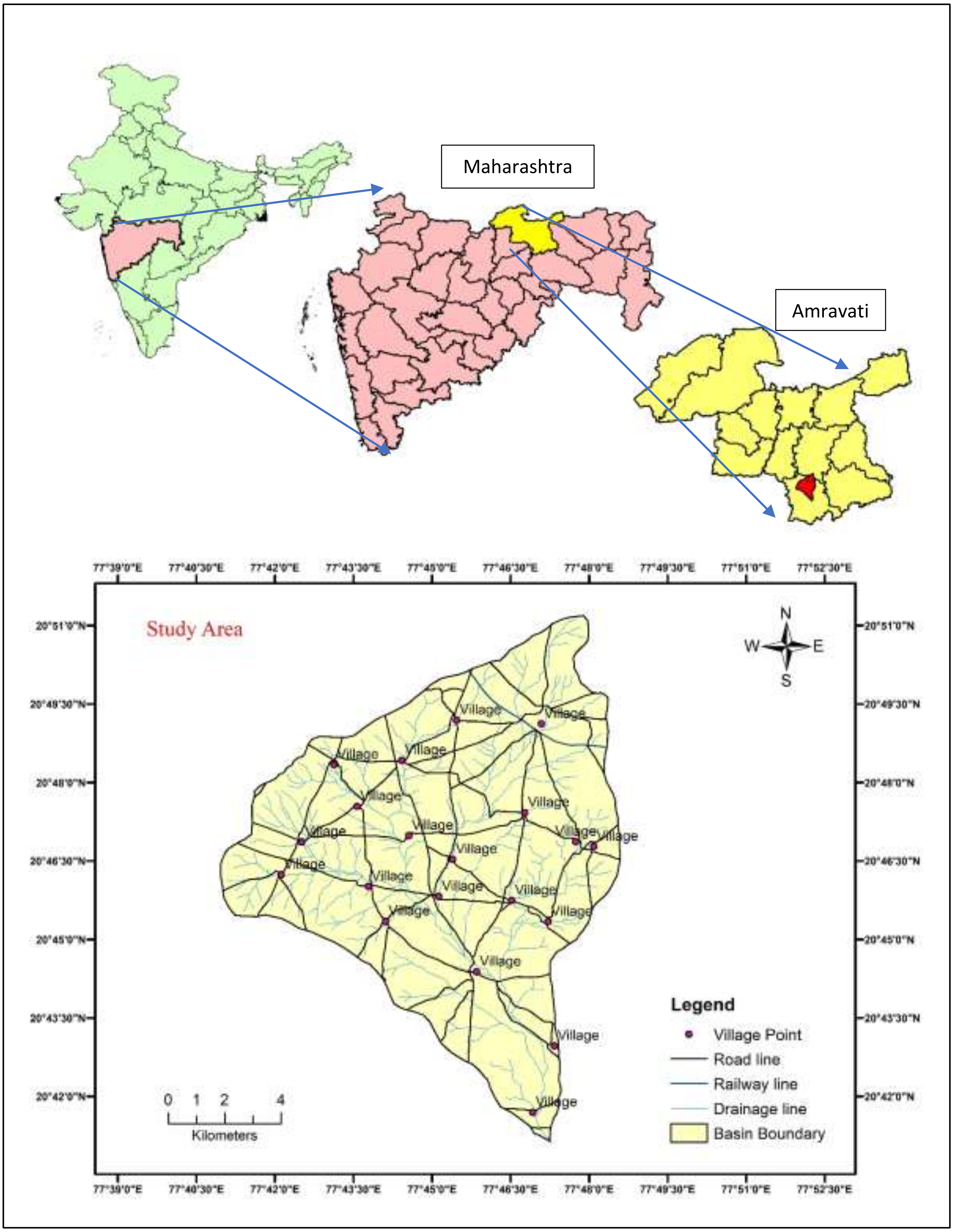

Figure:1. Location Map of the study area.

Methodology:

In order to analyse the drainage basin, the following sequence is adopted-

1. The analysis is usually carried out with a Survey of India Toposheet normally on scale of 1: 50000.
2. All the drainage basins to be analyzed are delineated i.e. drainage basin comprises an area drained by a given steam and its tributaries falling in the watershed.
3. The basins are numbered from North to South and are designated as Basin No. 1, 2, 3 etc. and also the basins are named after the main stream of that basin or sub-basin.

4. All the basins are then parted out by using GIS softwares from the toposheet to separate the drainages from all other features given on toposheet. (Fig. 2)
5. This is followed by the ordering of streams.

The different morphometric parameters have been determined using the conventional methods as prescribed by Horton (1945), Strahler (1957,1964), Schumm (1956) etc. (Table 1)

Table 1: Methods for calculating different morphometric parameters.

Sr. No.	Morphometric aspects	Parameters/Symbols	Formulae	References
1	**Linear aspect**	Stream order (*u*)	Hierarchical rank	Strahler (1964)
2		Total number of Stream (*N*u)	*N*u = total number of all the streams of a basin	Strahler (1964)
3		Bifurcation ratio (*R*b)	*R*b = (Nu/*N*u + 1); where, *N*u = number of streams of a particular order '*u*', *N*u + 1 = Number of streams of next higher order '*u* + 1'	Schumm (1956)
4		Mean bifurcation ratio (*R*bm)	*R*bm = mean of bifurcation ratios of all orders	Schumm (1956)
5		Stream length (*L*u)	*L*u = total length of streams (km) of a particular order '*u*'	Horton (1945)
6		Mean stream length (*L*um)	*L*um = *L*u/*N*u; where, *L*u = total length of streams (km) of a particular order '*u*', *N*u = Total number of streams of a particular order '*u*'	Horton (1945)
7		Stream length ratio (*R*l)	R_l = *L*um/*L*um + 1; where, L_u = mean stream length of a particular order '*u*', L_u + 1 = mean stream length of next higher order '*u* + 1'	Horton (1945)
8	**Areal aspect**	Basin area	*A* (Km^2)	Schumm (1956)
9		Basin Perimeter	*P (Km)*	
10		Stream frequency (*F*s)	*F*s = *N*/*A*; where, *N* = total number of streams of a given basin, *A* = total area of basin (km^2)	Horton (1945)
11		Drainage Density (*D*d)	*D*d = L/A; where, L = length of streams (km), A = Basin area (km^2).	Horton (1945)

Sr. No.	Morphometric aspects	Parameters/Symbols	Formulae	References
12		Form factor (*F*f)	$Ff = A/L^2$; where, A = area of the basin (km^2), L = basin length (km)	Horton (1945)
13		Circularity ratio (*R*c)	$Rc = 4\pi A/P^2$; where, A = area of the basin (km^2), P = outer boundary of a drainage basin (km)	Miller (1954), Strahler (1964)
14		Elongation ratio (*R*e)	$Re = 2\sqrt{(A/\pi)}\ /L$ A= Area of drainage basin (km), L = basin length (km)	Schumm (1956)
15		Constant of Channel Maintenance (CCM)	$CCM = 1/D_d$; where, *D*d = drainage density	Strahler (1964)
16		Texture ratio (R_t)	$T = N1/P$ where $N1$ = the total number of first-order streams; P = the perimeter of watershed	Horton (1945) ,Schumm (1956)
17		Length of Overland Flow (Lg)	Lg = ½ Dd, where *D*d = drainage density	Horton (1945)
18		Drainage Texture (DRt)	DRt = Dd * Fs Where, DRt = Drainage texture Dd = Drainage density Fs = Stream Frequency	Smith (1950)
19	**Relief aspect**	Relative relief (*H*)	$H = R - r$, where, R = highest relief, r = lowest relief	Schumm (1956)
20		Relief ratio (*R*r)	$Rr = (H/L\ max)$; where, H = relative relief (m), L = length of basin (m)	Schumm (1956)
21		Dissection index (*D*i)	$Di = H/R$; H = relative relief (m), R = absolute relief (m)	Schumm (1956)
22		Ruggedness Number (*R*i)	$Ri = Dd * H/1000$, where, *D*d = drainage density, H = relative relief	Schumm (1956)

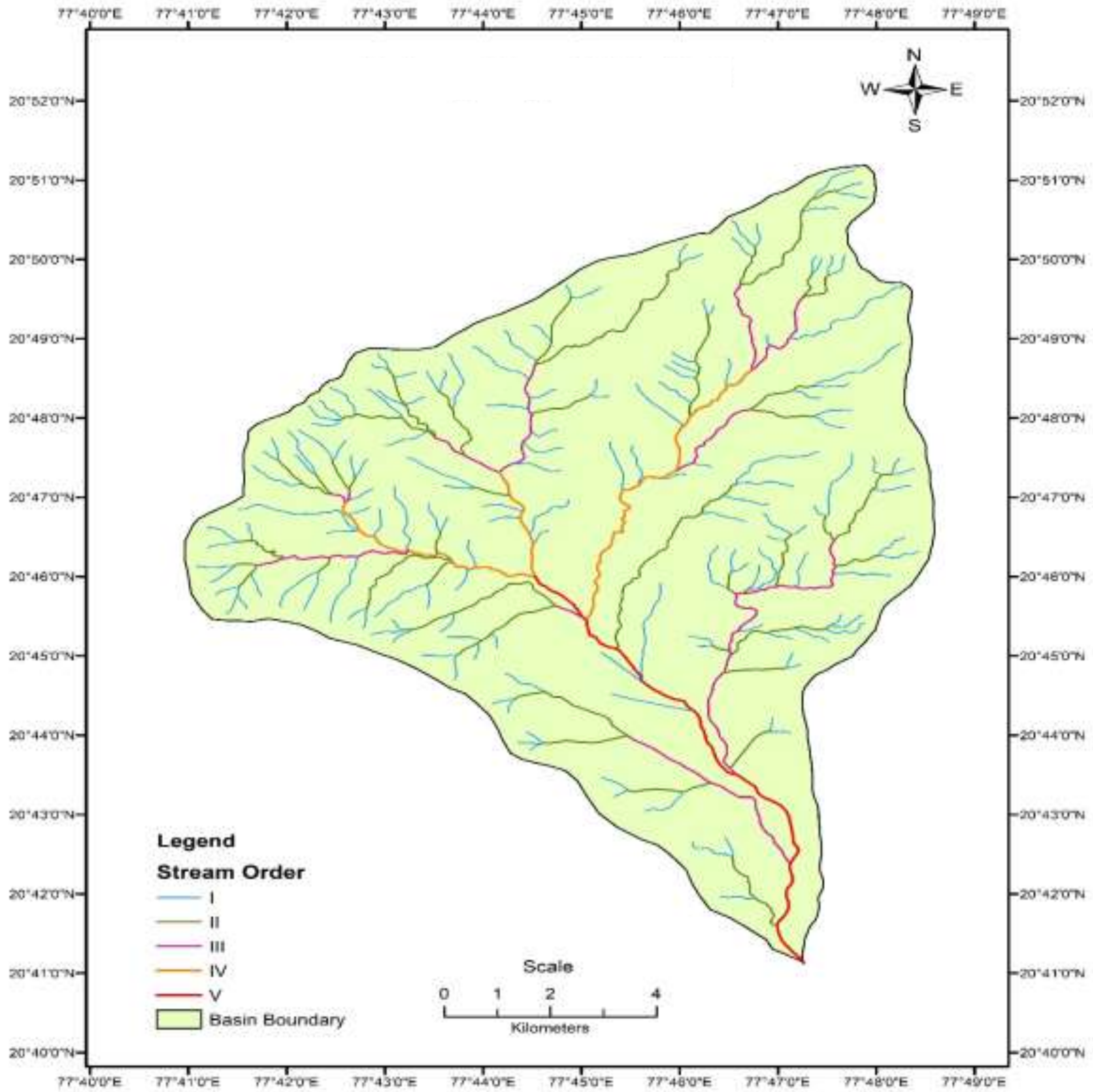

Figure:2. Drainage Map of the Jallu Nadi.

RESULT AND DISCUSSION:

Morphometric analysis is the measurement and mathematical analysis of the configuration of the shape and various dimensions of the basin. The parameters can be divided into three categories viz. Linear Aspects, Areal Aspects and Relief Aspects (Clarke,1966).

LINEAR ASPECTS:

1. Stream Order (u):

The first step in the process of morphometric analysis is to designate the stream order which is based on hierarchical ranking of streams. In the present study for ordering of stream Strahler's system modified by Horton has been followed. The study area shows the stream ordering up to fifth (V) order.

2. Total Number of Stream (Nu):

The total stream number is defined as the total count of the channel streams of all the orders. In the present study the stream number is 221 differentiated into I order (160), II order (42), III order (14), IV order (04) and V order (01).

3. Bifurcation Ratio (Rb):

It is the ratio of number of streams of a given order to the number of streams of the next higher order (Schumm, 1956). The bifurcation ratio is an indicator of structural control on the drainage in area. Higher values indicate a strong control while low values point out less effect of structural controls. In the present study bifurcation ratio ranges from 3.00 to 4.00.

4. Mean Bifurcation Ratio (Rbm):

The simple arithmetic means of all the bifurcation ratios. In the present study the mean bifurcation ratio is found to be 3.58 which reflects that the study area has homogenous rock type.

5. Stream length (Lu):

Stream length is calculated according to law proposed by Horton (1945) and the total length of individual stream of each order represents the stream length. Generally, the total length of streams is maximum in the lower orders (I Order) and it decreases as the stream order increases. The stream length for different orders in the study area are I order stream 111.27 Km., II order 61.13 Km., III order 27.33 Km., IV order 14.77 Km. and for V order 11.29 Km. Thus, the total stream length of all the streams is 225.79 Km.

6. Mean Stream Length (Lum):

Mean stream length of given stream order is obtained by dividing the total stream length by the total number of streams of that order. It is a dimensionless property. For the present study area, the mean stream length is, Ist order 0.695, IInd order 1.455, IIIrd order 1.952, IVth order 3.693 and Vth order 11.292.

7. Stream length ratio (Rl):

Stream length ratio is the ratio between stream length of one order to the next lower order. The stream length ratio found out for the present study area is I order stream (0.550), II order (0.446), III order (0.540) and for IV order (0.764).

AREAL ASPECTS:

8. Basin Area (A):

The total area drained by a given stream network and all the streams of that system discharged through a single outlet is called Area of Basin. The area of present area basin is calculated as 128.73 Km^2.

9. Basin Perimeter(P):

The total length of the boundary of the drainage by which the basin is delineated is called as Basin perimeter. In the present study the basin perimeter is found to be 52 Km.

10. Stream Frequency (Fs):

According Horton (1932) the total number of stream segments of all orders per unit area is known as stream frequency. The stream frequency for present area is calculated as 1.72Km^2.

11. Drainage Density (Dd):

Drainage density is defined as the ratio of total length of all the stream of the basin per unit area of the drainage. The drainage density for the study area is found to be 1.75 Km/Km^2. The value of drainage density is on the lower side indicating low to moderate infiltration and higher runoff.

12. Form factor (Ff):

Form factor may be defined as the ratio of the area of basin and square of the length of basin (Horton, 1932). It is expressed as A / L^2 where A is the area and L is the length of the basin. The value of form factor comes out to be 0.49. The result shows that the shape of basin is elongated.

13. Circularity Ratio (Rc):

The ratio of area of the basin to the area of the circle having same circumference as the basin perimeter is termed as the circularity ratio (Miller, 1953). For the present study area, the circulatory ratio is found to be 0.6 therefore the basin is elongated.

14. Elongation ratio (Re):

It is the ratio between the diameters of the circle of the same area as the basin to the maximum basin length. The values of the elongation ratio generally vary from 0.6 to 1.0. The Re value for present basin is calculated as _0.76_indicating that the basin is less elongated.

15. Constant of Channel Maintenance (CCM):

Constant of channel maintenance is the area of a basin surface needed to sustain a unit length of stream channel. It depends on the rock type, permeability, Climatic condition as well as vegetation. Schumm (1956) defined as the inverse of drainage density. The CCM calculated for the study area is $0.571 Km^{-1}$.

16. Texture ratio (Rt):

This is defined as the ratio od total number of first order streams to basin perimeter i.e. $Rt = N1/P$, where N1 is the number of first order streams and P is the perimeter of the basin. The values of texture ratio calculated as 3.08. Smith (1950) classified drainage texture in to five classes namely very coarse (<2), Coarse (2-4), moderate (4-6), fine (6-8) and very fine (>8). In the present study the value falls in very coarse.

17. Length of Overland Flow (Lg):

Horton (1945) defined as Length of overland flow as equal to half of the reciprocal of drainage density i.e. Lg = ½ Dd. In the present study area, the length of overland flow is calculated as 0.88.

18. Drainage Texture (DRt):

Drainage texture is an aggregate of product of drainage density and stream frequency. The drainage texture of the study area is found to be 3.01.

RELIEF ASPECTS:

19. Relative Relief (H):

It is also called as Basin relief and it is the difference between the highest elevation point and lowest elevation in the area. In the present study the relative relief comes out to be 62 km above mean sea level.

20.Relief Ratio (Rr):

Relief ratio is defined as ratio between maximum relief (H) and horizontal distance along the longest dimension of the basin parallel to the principal drainage line (Schumm, 1956). Relief ratio measures the overall steepness of the basin and is an indicator of the degree of erosion. The relief ratio is calculated as 20.47.

21. Dissection Index (Di):

Dissection index is defined as the ratio between relative relief to its absolute relief. The dissection index for the present study area is found to be 0.175.

22. Ruggedness Number (Rn):

Ruggedness number is defined as the product of basin relief and drainage density. It is a dimensional number and useful to combine steepness of slope with its length (Strahler,1968). The ruggedness number is calculated as 0.11.

Table 2: Calculated values for the morphometric parameters for Jallu Nadi.

Sr. No.	Parameters	Values
1	Stream Order	V^{th} Order
2	Total stream Number	221 Nos.
3	Bifurcation Ratio	3 to 4
4	Mean Bifurcation Ratio	3.58
5	Stream Length	225.79 Km
6	Mean Stream Length	0.695 to 11.29 Km
7	Stream Length Ratio	0.550 to 0.764 Km
8	Basin Area	128.73 Km^2
9	Basin Perimeter	52 Km
10	Stream Frequency	1.72 Km^2
11	Drainage Density	1.75
12	Form Factor	0.49
13	Circulatory Ratio	0.6
14	Elongation Ratio	0.76
15	Constant of Channel Maintenance	0.571
16	Texture Ratio	3.08
17	Length of Overland flow	0.88
18	Drainage Texture	3.01
19	Relative Relief	62 Km
20	Relief Ratio	20.47
21	Dissection Index	0.175
22	Ruggedness Number	6.11

CONCLUSION:

The Study and analysis of various parameters of a drainage basin are the best representatives of underlying geology, geomorphology, slope, and climate of the area. Meticulous study of morphometry of a sub-basin reveals drainage pattern which further infers to lithological nature. In the given study area shows that the basin has V^{th} Order as highest order. The low values of drainage density points that the area has low permeability. The values of circularity ratio and elongation ratio shows that basin is nearly elongated. In the overall the study revels that the area has low infiltration and high runoff. It is suggested that there should be more efforts to increase the infiltration rate by various means at micro level.

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