

Morphometric Estimation of Parameters of Uttar Mand River Basin, Satara District, Maharashtra, India.

Mr.S.S.Chokakkar¹, Mr.G.N.ChavanPatil², Dr.D.N.Mudgal³, Dr.A.Shreenivasa⁴

¹M.Sc., B.Ed, NET, PhD(Pur.) (Geology)- Assistant Professor, Civil Engineering Department,

²M.E. Civil(Construction Management) Assistant Professor, Civil Engineering Department,

³Professor & Director, Ashokrao Mane Group of Institutions, Vathar, At Po. Vathar tarf Vadgoan, Tal Hatkanangle, Dist: Kolhapur 416112

⁴Professor MSc., M.Phil, PhD Department of studies in Geology Karnataka University, Dharwad.

ABSTRACT : In the present investigation various morphometric parameters of the Uttar Mand river basin are outlined. The Uttar Mand river basin is 5th order and its different morphometrical parameters are found to be useful for the proper land use planning and water resources management studies in the basin. Dendritic drainage pattern in the area shows that the area consists of homogeneous rock material, which is structurally undisturbed. The Basin is passing through an early mature stage to old stage of the fluvial geomorphic cycle. The elongation and circulatory ratio reveals that the Uttar Mand river basin is highly elongated and flood flows are easier to manage than that of circulatory basins.

Keywords - Uttar Mand River Basin, Morphometric, Parameters, Watershed Management

1. INTRODUCTION

Land and water are two most feasible resources which are the basis of life on the surface of the earth.

Various studies have been conducted regarding morphometric analysis in different basins of India. At this moment computer based analysis are proving easier, time- effectual and most reliable results where software plays great role in analysing the huge data. In the present study software based analysis was carried out that was later verified in field study.

2. STUDY AREA

The study area lies between between latitude 17°20'12"N to 17°25'24"N and longitude 73°55'07"E to 74°5'7"E in Survey of India Toposheet numbers 47 G/15, 47 K/3 and having area of about 109 km² (Fig. 1). The Uttar Mand river is tributary of the Krishna river. The study area is covered by Deccan volcanic basalt of Upper Cretaceous to Lower Eocene age. The soil layer of the study area is fertile and used for agriculture purpose. The climate of the area comes across as an comical blend of the coastal and inland climate of Maharashtra. The temperature is about 10°C and 40°C.

The average annual rainfall of the area is 1000 mm to 2500 mm. The Uttar Mand river basin shows well developed dendritic to sub dendritic type drainage pattern. (Fig. 2). In this paper the authors had made an attempt to evaluate morphometric Parameters of Uttar Mand river basin.

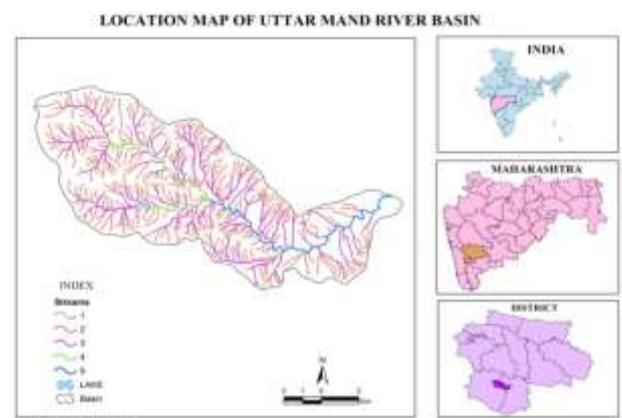


Figure 1 : Location Map of the Study Area

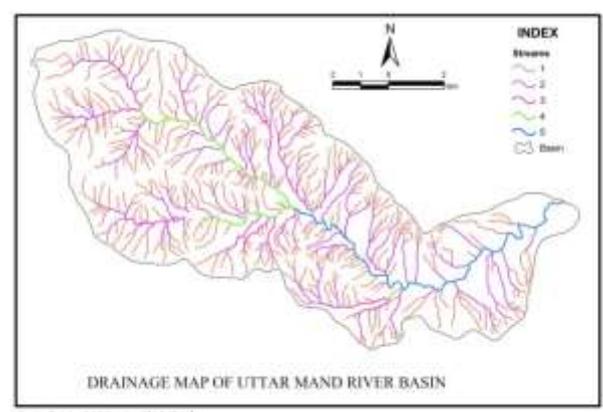


Figure 2 : Drainage map of the Study area

3. METHODOLOGY

The stream networks were previously digitised using toposheet and satellite imagery of the respected area using Arc GIS software. The Survey of India Toposheet numbers 47 G/15, 47 K/3 on the scale of 1 : 50,000 were used for the study. Stream ordering method as suggested by the Strahler has been employed. The calculation was operated using mathematical equations and different required parameters were calculated, by using formulae. For stream ordering method suggested by Strahler (1957) has been used.

4. RESULTS AND DISCUSSION

The digitisation of the basin has been done and various parameters of morphometry were calculated under major heads of linear, areal and relief aspects.

4.1. LINEAR MORPHOMETRIC ASPECTS

4.1.1. Stream Order (u)

The first step towards drainage basin analysis is the designation of stream order which shows the relative and hierarchical relationship between stream segments, their connectivity and the discharge having contributions of the basin. Stream order of drainage basin is the successive assimilation of the streams within a drainage basin. The ordering of the basin have been carried out by the method suggested by Strahler (1957). The Uttar Mand river basin is 5th Orders. (Table 1)

4.1.2. Stream Number (Nu)

Horton² stated that the numbers of stream segments of each order eventually form an inverse geometric sequence with the order number. The total number of streams in the study area is 533 as mentioned above. out of that 76.36% are the first order streams having 407 segments.

The second order stream segments are 99 and account for 18.6%, third order stream segments are 22 and accounted 4.12%, fourth order stream segments are 4 and account for 0.75% and fifth order stream segment is 1 and account for 0.18%. The logarithm of stream length of each order as a function of order is plotted and yields a set of points lying generally along a straight line. Relation between stream order (u) and stream number (Nu) show the straight line which indicate area without structural disturbance (Fig. 4).

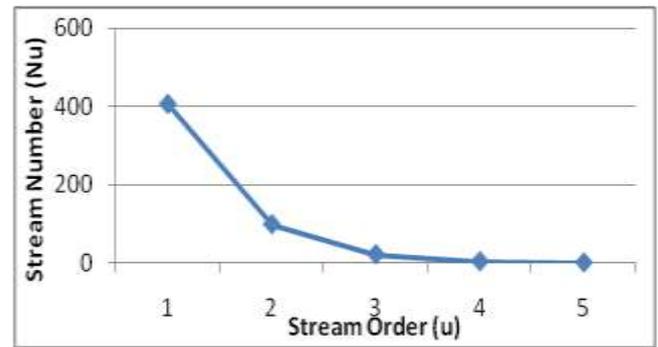


Figure 3: Relation between Stream Order (u) and Stream Numbers (Nu)

4.1.3 Bifurcation Ratio (Rb)

The bifurcation ratio can be defined as a ratio of the number of stream segments of given order to the number of segments of next higher order. It is the ratio of number and streams and any given order to the number streams in the text lower order (Horton, 1945).

$$Rb = \frac{Nu}{Nu + 1}$$

The significance of this ratio is that as the ratio is reduced so the risk and flooding within the basin increases. It also indicates the flood risk for parts and the basin. In the Uttar Mand river basin bifurcation ratio ranges from 4.11 to 4. The mean bifurcation ratio for Uttar Mand river basin is 4.52. This means that on average there are 4.52 times as many channel segments to any given order as of the next higher order. The average bifurcation ratio and the basin reveals that there appears to be no strong geological control in the development and the drainage, homogeneous nature of Lithology and drainage network in study area as well developed stage (Table 1).

4.1.4 Stream Length (Lu)

The stream network of Uttar Mand river basin was previously categorized into several orders, which were then computed using Arc GIS software using Survey of India toposheets as primary data. Study of the streams length with respect to the stream order is of significant importance. Stream length for the basin and the given order is inversely proportional to the stream order. Stream length of the basin indicates surface runoff characteristics. Stream are relatively smaller lengths and characteristics and area with greater slopes. Stream length of Uttar Mand river basin is measured with the help of rotometer. The total stream length in Uttar Mand river basin is 383.62 km (Table 1). The mean length of channel Lu and order U is the ratio of the total length to the number of streams of a given order. Mean length of channel segments of a given order is greater than that of the next lower order but less than that of the

next higher order. The logarithm and stream length of each order as a function of order is plotted (Fig.) and relation between stream order (u) and mean stream length (Fig.) yields a set of points lying generally along a straight line, that indicates no strong structural control in the area (Geena, 2011).

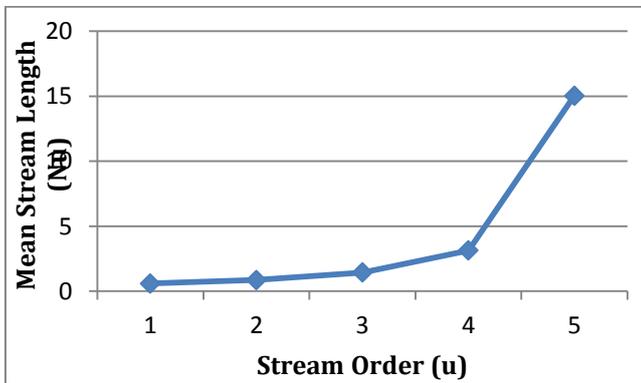


Figure 4 : Relation between Stream Order (u) and Mean Stream Length (Nu)

4.1.5. Stream Length Ratio (RI)

The ratio in between the average lengths of successive orders is stream length ratio (Horton, 1945). In the southern half part of basin large number of small streams is developed where the formations at upstream side and are less permeable (Manu, 2008). Stream length ratio of Uttar Mand river basin is given in Table 1.

4.2. AERIAL ASPECTS OF DRAINAGE BASIN

4.2.1. Basin Area (A)

The area of Uttar Mand river basin is about 109.85 sq. km. which indicates that rainwater will reach the main channel more rapidly, where the water has much further to travel.

4.2.2. Drainage Density (Dd)

The drainage density has been found to be an important parameter which can be defined as total length of the streams of all orders/drainage area. Drainage density is defined as a ratio of total length of all streams to the total area of the basin. (Horton, 1932).

$$Dd = \frac{Lu}{A}$$

Drainage density of the any basin reveals the terrain configuration that is properties of rock of the area. In the study area southern half part of basin shows high drainage density which indicates region having non resistant or impermeable subsurface material and mountainous relief, whereas northern half part of basin

shows low drainage density which indicates region having highly resistant rock or highly permeable subsoil material and area with low relief. (Geena, 2011). The overall drainage density (Dd) of the Uttar Mand river basin is 3.49 km/sq.km (Table 2)

4.2.3. Stream Frequency (Fs)

The stream frequency of the basin is the ratio of total number of stream segments of all orders to the basin area. (Horton, 1945)

$$Fs = \frac{Nu}{A}$$

The stream frequency found in the study area shows a positive correlation with its calculated drainage density, indicating an increase in the stream population with the increase in drainage density. It is a good indicator of drainage pattern. Stream frequency has been calculated by the number of streams divided by the total area of basin in sq. km. The stream frequency of the Uttar Mand river basin is found to be 4.85. High drainage density and high stream frequency in Uttar Mand river basin indicate larger runoff from the basin. (Table 2)

4.2.4. Constant of Channel Maintenance (C)

The Constant of Channel Maintenance is the inverse of the drainage density. (Schumm, 1956). Therefore higher the drainage density lowers the constant of channel maintenance and vice versa. In the southern half part of the basin the value of Constant of channel maintenance is very low which indicate that only rocks are relatively impermeable or terrain is very steep. But in the northern half part of the basin the value of Constant of channel maintenance is relatively high which indicate the presence of little more permeable overlying material than southern part of the basin. Regarding the Uttar Mand river basin, the average constant of channel maintenance is 0.28 (Table 2)

4.2.5. Texture Ratio (Rt)

It is the ratio of total stream numbers to the total perimeter of the basin (Horton, 1945).

$$Rt = \frac{Nu}{P}$$

Texture ratio is an important factor in the drainage morphometric analysis which is depending on the underlying lithology, infiltration capacity and relief aspect of the terrain (Nageswara, 2010). Smith (1950) has classified drainage density into five different texture i.e. very coarse (<2), Coarse (2-4), moderate (4-6), fine (6-8) and very fine (>8). In the present study texture ratio of the Uttar Mand river basin is 6.95, which

indicate fine texture and area under high relief and steep slopes. (Table 2)

Table 1. Linear aspects of the drainage network of the study area.

River Basin	Stream Order (u)	Number of Streams (Nu)	Total length of streams in km (Lu)	Mean Stream Lengths
Uttar Mand	1	407	239.106	0.58
	2	99	85.201	0.86
	3	22	31.734	1.44
	4	04	12.534	3.13
	5	01	15.049	15.04
Total		533	383.62	

Bifurcation Ratio (Rb)				Mean Bifurcation Ratio
1st Order / 2nd Order	2nd Order / 3rd Order	3rd Order / 4th Order	4th Order / 5th Order	
4.11	4.5	5.5	4	4.52

4.2.6. Elongation Ratio (Re)

Elongation ratio is defined as the ratio of diameter of a circle of the same area as the basin to the maximum basin length (Schumm, 1956).

$$Re = \frac{2\sqrt{\frac{A}{\pi}}}{Lb}$$

It is the very significant index in the analysis of basin shape which helps to give an idea about hydrological characters of a drainage basin. The value of elongation ratio (Re) generally varies from 0.6 to 1.0 associated with a wide variety of climate and geology. Values close to 1.0 are typical of regions of very low relief whereas that of 0.6 to 0.8 are associated with high relief and steep ground slope (Strahler, 1964). These values can be grouped into three categories, namely circular (>0.9), oval (0.9-0.8) and elongated (< 0.7). The Elongation ratio of the Uttar Mand river basin is 0.59 which indicate basin is highly elongated. (Table 2)

4.2.7. Circulatory Ratio (Rc)

Circulatory ratio is the ratio of basin area to the area of circle having the same perimeter as the basin (Miller, 1953).

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

It is influenced more by the length, frequency and gradient of streams of various orders than slope conditions and drainage pattern of the basins (Strahler, 1957). Circulatory ratio of Uttar Mand river basin is 0.40 which is below 0.5 and shows strongly elongated basin with semi permeable homogeneous lithology. (Table 2)

4.2.8. Form Factor Ratio (Rf)

Form Factor Ratio is the dimensionless ratio of the basin area to the square of basin length (Horton, 1932).

$$Rf = \frac{A}{Lb^2}$$

The Form Factor Ratio value of the Uttar Mand river basin is 0.28 which is very nearer to zero and thus represents highly elongated in shape. In this elongated basin with low form factor will have a flatter peak flow of longer duration. Flood flows in elongated basins are easier to manage than that of the circular basins (Geena, 2011). (Table 2)

Table 2. Aerial Aspects of the drainage network of the study area.

Morphometric Parameters	Symbol Formula	Calculated Value
Area (sq. km)	A	109.85
Perimeter (km)	P	58.27
Drainage Density	$Dd = \frac{Lu}{A}$	3.49
Stream Frequency	$Fs = \frac{Nu}{A}$	4.85
Texture Ratio	$Rt = \frac{N1}{P}$	6.95
Basin Length (km)	Lb	19.71
Elongation Ratio	$Re = \frac{2\sqrt{\frac{A}{\pi}}}{Lb}$	0.59
Circulatory Ratio	$Rc = \frac{4\pi A}{P^2}$	0.40
Form Factor Ratio	$Rf = \frac{A}{Lb^2}$	0.28
Constant of Channel Maintenance	$C = \frac{1}{Dd}$	0.28

Where, L_u = Total Stream length of all orders.

N_u = Total number of streams of all orders

N_1 = Total number of 1st order streams.

$\Pi = 3.14$

5. CONCLUSION

The morphometric study of Uttar Mand river indicates that the basin is fifth order basin and is passing through an early mature stage to old stage of the fluvial geomorphic cycle. The basin shows dendritic type drainage pattern. Mean length of channel segments of a given order is greater than that of the next lower order but less than that of the next higher order. The relation between stream order and mean stream length, yields a set of points lying generally along a curve line, that indicates no strong structural control in the area. The average bifurcation ratio of the basin reveals that there appears to be no strong geological control in the development of the drainage, homogeneous nature of lithology and drainage network in study area is well developed stage. The southern half part of the basin is under high relief which shows steep slopes with high drainage density, high stream frequency, low constant of channel maintenance and less permeable subsurface lithology. The northern half part of the basin is under low relief as compare to the southern part which shows gentle slopes with low drainage density, low stream frequency, high constant of channel maintenance and highly permeable subsurface lithology. The elongation ratio, circulatory ratio and form factor reveals that the Uttar Mand river basin is highly elongated and flood flows are easier to manage than that of circulatory basins. The study also reveals that the texture of Uttar Mand river basin is very fine and basin is highly elongated. The drainage basin size analysis reveals that the flooding is lesser.

6. ACKNOWLEDGEMENTS

The authors are very much thankful to Management and Director of A.M.G.O.I, Vathar, Dist-Kolhapur for their constant encouragement and support.

REFERENCES

Journal Papers:

1. Geena G. B. and Ballukraya P. N., Morphometric analysis of Korattalayar River Basin, Tamil Nadu, India : A GIS approach, Int. Jou. of Geomatics and Geoscience, Vol. 2, No. 2, 2011, 383 - 391.
2. Thakur, B.R. (2006), Quantitative Analysis of Solani Watershed Using Remote Sensing and GIS

Techniques, Punjab Geographer, Vol . 1, No. 2, PP. 85-98

3. Horton K. G. Smith, Standard for grading texture of erosional topography, Ame. J. Soc., 5 (298) 1950, 655-668.
4. Schumm S. A., The relation of drainage basin relief to sediment loss, Pub. International Association of Hydrology, IUGG, Tenth Gen. Assembly, Rome, 1, 1954, 216-219.
5. Singh, Savindra (2002), Geomorphology, Prayag Pustak Bhawan, Al lahabad.

Books :

1. Parbin Singh. Principles of Engineering Geology.
2. Robert B. Johnson. Principles of Engineering Geology.
3. K.M.Banger Principles of Engineering Geology.