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MORPHOMETRIC ANALYSIS STUDY OF LAXMI ODHA BASIN, SANGLI DISTRICT, MAHARASHTRA, INDIA.

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Abstract : Morphometric analysis provides us quantitative description of the basin. Morphometric analysis includes the linear aspects, areal aspects and relief aspects of a drainage basin through which a general perception about the physiography, geology, recent diastrophism, nature of rock material etc can be developed. In the present investigation various morphometric parameters of the LaxmiOdha basin are outlined. The Laxmi Odha basin is 6th 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 Laxmi Odha basin is highly elongated and flood flows are easier to manage than that of circulatory basins.

Keywords : Laxmi Odha, Morphometric Parameters, Drainage Basin, Stream Order.

I. INTRODUCTION

A drainage basin, alternatively described a catchment area, is in geomorphology and hydrology a region drained by a particular stream or by a river system. Drainage basins are considered as an open system as these receive the input or energy form the climate over the basin and lose energy output through the water and sediment lost by the basin [1]. The morphometric analysis and its characteristics of various basins have been studied by various scientists using conventional methods Horton, 1945 [2]; Smith, 1950 [3]; Strahler, 1957 [4]. The morphometric parameters have been used in various studies of geomorphology and surface water hydrology, such as flood characteristics, sediment yield and evolution of basin morphology. The basin management studies have a special importance in the field of research, due to the increasing demand of water. Yadav and Sawant [5], has carried out morphometrical parameter estimation of Sheri Nala basin, Sangli district. Pisal and Yadav [6] has been studied morphometric characters of Bhogavati river basin, Kolhapur district, Maharashtra. Babar and Shah [7] has successfully carried out Geological and Geomorphological Characteristics on Groundwater Occurrence in Deccan Basalt Hard Rock Area of Tawarja river Sub-Basin Latur, Maharashtra. Khadri [8] has proved that the geomorphic and morpho-tectonic evolution of landscape in the study area has been controlled by various parameters like hydro-geomorphological, lithological, structural, climatic and environmental factors. The landforms have been resulted from various geomorphic processes like erosion, deposition, faulting, upliftment, tilting and pediplanation.

II. STUDY AREA

The Laxmi Odha basin bounded between latitude $16^0 53'30.82''$N to $17^0 03'52.34''$N and longitude $74^0 32'17.40''$E to $74^0 46'08.39''$E in Survey of India Toposheet numbers 47 L/9 and 47 K/12 and having area of about 241 km^2 (Fig. 1). The Laxmi Odha is one of the major tributary of the river Krishna. The study area is covered by Deccan volcanic basalt of Upper Cretaceous to Lower Eocene age. The soil cover of the study area is fertile and important for agriculture purpose. The temperature

between 10^0C and 40^0C. The average annual rainfall of the area is 1200 mm. The Laxmi Odha basin shows well developed dendritic to sub dendritic type drainage pattern. (Fig. 2). In the present paper the authors had made an attempt to morphometric analysis study of Laxmi Odha basin.

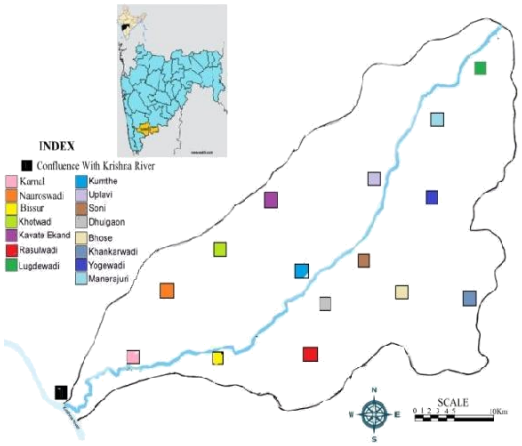


Figure 1. Location Map of the study area

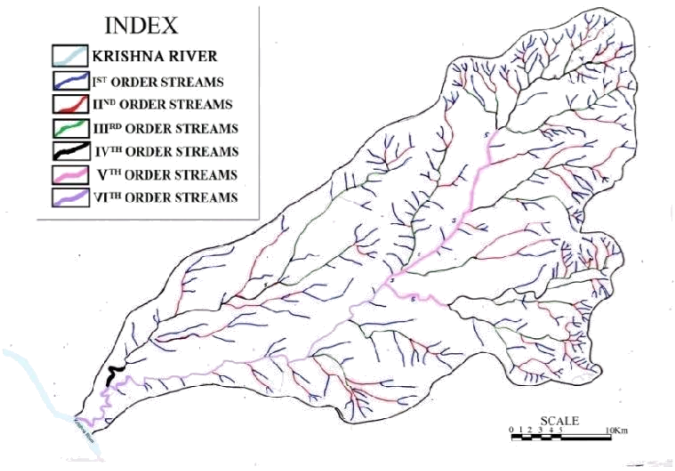


Figure 2. Drainage Map of the study area

III. METHODOLOGY

The survey of India Toposheet numbers 47 L/9 and 47 K/12 on the scale of 1 : 50,000 were used in study of different morphometric parameters and for preparation of different maps like Location Map, Drainage Map, etc. Stream ordering method as suggested by the Strahler [4] has been employed. The different morphometric parameters have been calculated by using standard formulae. India-WRIS WebGIS (version 4.0) application used to calculate different parameters like Basin area, length etc.

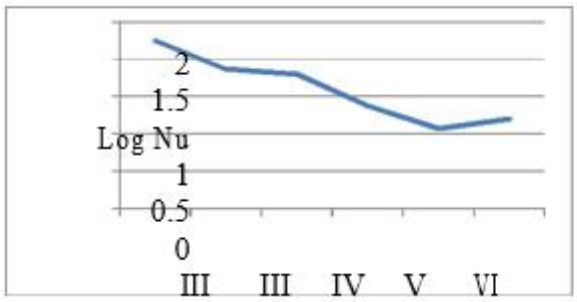
IV. RESULTS AND DISCUSSIONS 4.1. Linear Morphometric Aspects

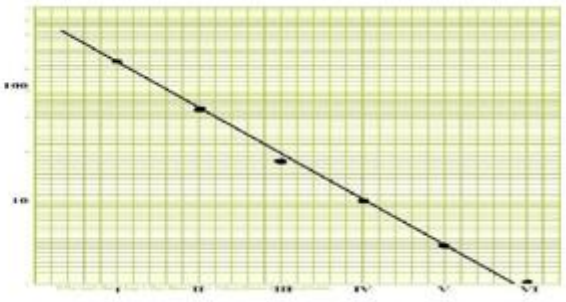
4.1.1. Stream Order (u)

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 [4]. The Laxmi Odha basin is 6th order basin. (Table 1)

4.1.2. Stream Number (Nu)

Whole Laxmi Odha basin has 432 streams, of which 71.5% are the first order streams having 309 segments. The second order stream segments are 83 and account for 19.2%, third order stream segments are 25 and accounted 5.8%, fourth order stream segments are 10 and account for 2.3%, fifth order stream segments are 4 streams and accounted 0.9% and sixth order stream segment is 1 and account for 0.2%. (Table 1). The total number of stream segments is found to decrease as the stream order increases in all the sub basins. 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 (Fig. 3). Relation between stream order (u) and stream numbers (Nu) shows the straight line which indicate area without structural disturbance (Fig. 4).





Stream

Order

Figure 3. Regression of logarithm of Streams number of Vs. stream order

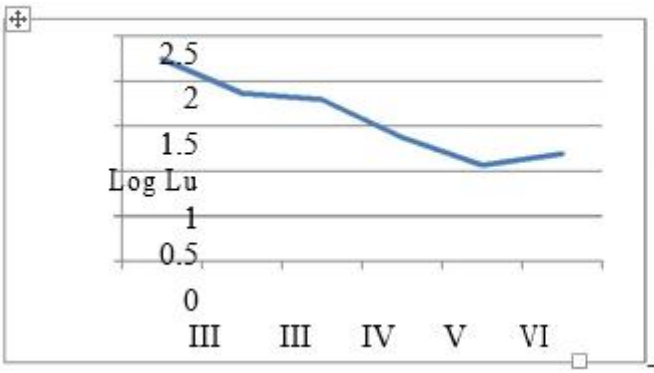
Figure 4. Relation between stream order and stream numbers

4.1.3. Bifurcation Ratio (Rb)

The significance of this ratio is that as the ratio is reduced so the risk of flooding within the basin increases. it also indicates the flood risk for parts of the basin. In the Laxmi Odha basin bifurcation ratio ranges from 2.5 to 4. The mean bifurcation ratio is 3.20. This means that on an average, there are 3.20 times as many channel segments to any given order as of the next higher order. 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. (Table 1)

4.1.4. Stream Length (Lu)

Stream length for the basin of the given order is inversely proportional to the stream order. Stream length of the basin indicate surface runoff characteristics. Streams of relatively smaller lengths are characteristics of area with greater slopes. Stream length of Laxmi Odha and its tributaries is measured with the help of rotometer. The total stream length in Laxmi Odha basin is 370 km. (Table 1). The mean length of channel Lu of 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 of stream length of each order as a function of order is plotted (Fig. 4) and relation between stream order (u) and mean stream length (Fig. 5), yields a set of points lying generally along a straight line, that indicates no strong structural control in the area. (Geena, 2011).,



Stream Order

Figure 5. Regression of logarithm of mean stream length vs stream order

Figure 6 : Relation between stream order and stream length

4.1.6. Stream Length Ratio (R*l*)

In the southern half part of basin large number of small streams are developed where the formations at upstream side and are less permeable [9]. Mean Stream length ratio of Laxmi Odha basin is 2.37 (Table 1).

4.2. Aerial Aspects of Drainage Basin 4.2.1. Basin Area (A)

Basin area is the direct outcome of the drainage development in a particular basin. The area of Laxmi Odha basin is about 241 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)

Drainage density is defined as a ratio of total length of all streams to the total area of the basin. [10]. Drainage density of the any basin reveals the terrain configuration that is properties of rock of the area. In the study area NE half part of basin shows high drainage density which indicates region having non resistant or impermeable subsurface material and mountainous relief, whereas SW 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 [11]. The overall drainage density (Dd) of the Laxmi Odha basin is 1.53 (Table 2)

4.2.3. Stream Frequency (Fs)

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 value of the Laxmi Odha basin is 1.80. Low drainage density and Low stream frequency in Laxmi Odha basin indicate less runoff from the basin. (Table 2)

4.2.4. Constant of Channel Maintenance (C)

Higher the drainage density lowers the constant of channel maintenance and vice versa. In the NE 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 SW 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 NE part of the basin. Regarding the Laxmi Odha basin, the average constant of channel maintenance is 0.65 (Table 2)

4.2.5. Texture Ratio (Rt)

Texture ratio is an important factor in the drainage morphometric analysis which is depending up on the underlying lithology, infiltration capacity and relief aspect of the terrain (Nageswara, 2010). Smith [3] 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 Laxmi Odha basin is 3.74, which indicate coarse texture and area under low relief and gentle slopes. (Table 2)

4.2.6. Elongation Ratio (Re)

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 [13]. These values can be grouped into three categories, namely circular (>0.9), oval (0.9-0.8) and elongated (< 0.7). The lower value of the elongation ratio indicates that particular watershed is more elongate than others. (Pal and Debnath, 2012). The Elongation ratio of the Laxmi Odha basin is 0.62 which indicate basin is highly elongated. (Table 2)

4.2.7. Circulatory Ratio (Rc)

It is influenced more by the length, frequency and gradient of streams of various orders than slope conditions and drainage pattern of the basins. Circulatory ratio of Laxmi Odha basin is 0.44 which is below 0.5 and shows strongly elongated basin with semi permeable homogeneous lithology. (Table 2)

4.2.8. Form Factor Ratio (Rf)

The Form Factor Ratio value of the Laxmi Odha basin is 0.30 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. (Table 2)

4.2.12. Drainage Texture (Dt)

Drainage texture is on the underlying lithology, infiltration capacity and relief aspect of the terrain. Dt is

total number of stream segments of all orders per perimeter of that area. Smith [3], has classified drainage texture into five different textures i.e., very coarse (<2), coarse (2 to 4), moderate (4 to 6), fine (6 to 8) and very fine (>8). In the present study, the drainage texture of the basin is 5.24
(Table 2). It indicates that category is moderate drainage texture.

4.2.18. Drainage Intensity (Di)

This study shows a low drainage intensity of 1.17 for the basin, (Table 2). This low value of drainage intensity implies that drainage density and stream frequency have little effect on the extent to which the surface has been lowered by agents of denudation. With these low values of drainage density, stream frequency and drainage intensity, surface runoff is not quickly removed from the basin, making it highly susceptible to flooding, gully erosion and landslides.

4.3. Relief Aspects of Drainage Basin 4.3.1. Basin Relief (H)

The vertical distance difference between point of maximum elevation and minimum elevation is the relief of basin. The basin relief of Laxmi Odha is 322 meters. (Table 3)

4.3.2. Relief Ratio (Rh)

When basin relief (H) is divided by maximum basin length (Lb) gives the relief ratio. The relief ratio of Laxmi Odha basin is 11.41, which indicates that the basin has moderate relief and gentle slope. Low value of relief ratios are mainly due to the resistant basement rocks of the basin and low degree of slope. (Table 3)

4.3.3. Ruggedness Number (Rn)

Ruggedness number is the product relief of basin (H) and drainage density (Dd). The ruggedness number of Laxmi Odha basin is 492.66 which indicate both relief and drainage density are low. Such lower values are expected in a semi plane region of sub-tropical climate with low rainfall. (Table 3)

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

Stream Order (u)	Stream Number (Nu)	Stream Length in km (Lu)	Mean Stream Lengths	Stream Length Ratio (R*l*)	Log Nu	Log Lu	Bifurcation Ratio
I	309	179	0.58	-	2.48	2.25	3.72
II	83	75	0.90	1.55	1.91	1.87	3.32
III	25	63.5	2.54	2.82	1.38	1.80	2.5
IV	10	24.5	2.45	0.96	1.08	1.38	2.5
V	4	12	3	1.22	0.60	1.07	4
VI	1	16	16	5.33	0.20	1.20	-
Total	432	370					
Mean	72	61.66667	4.245	1.98	1.27	1.59	2.67

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

Morphometric Parameters	Symbol / Formula /Method	Calculated Value
Area (sq. km)	A	241 Km^2
Perimeter (km)	P	82.41 Km

Drainage Density		1.53
Stream Frequency		1.8
Texture Ratio		3.74
Basin Length (km)	Lb	28.2 Km
Elongation Ratio	— / —	0.62
Circulatory Ratio		0.44
Form Factor Ratio		0.30

Constant of Channel Maintenance	C = 1/Dd	0.65
Drainage Texture (Dt)	Dt = _ Nu /	P 5.24
Drainage Intensity (Di)	If = Fs/Dd	1.17

Where, Lu = Total Stream length of all orders.
N_1 = Total number of 1st order streams.
of the basin,
Nu = Total number of streams of all orders
Lcm = Straight length from the basin mouth to the centre of mass
Wcm = Width of the basin at the centre of mass and perpendicular to Lcm.
Π = 3.14

Table 3. Relief aspects of drainage network of study area

Morphometric Parameters	Symbol / Formula	Calculated Value
Maximum elevation in the area (mts.)		860 mts
Minimum elevation in the area (mts.)		538 mts
Basin Relief (mts.)	H = Max. Elevation – Min. Elevation	322 mts
Relief Ratio (Rh)		11.41

Ruggedness Number (Rn)		492.66

V. CONCLUSION

The quantitative analysis of morphometric parameters is found to be of immense utility in river basin evaluation, watershed prioritization for soil and water conservation, and natural resources management at micro level. The morphometric analysis carried out in the Laxmi Odha basin shows that the basin is having low relief of the terrain and elongated in shape. Drainage network of the basin exhibits as mainly dendritic type which indicates the homogeneity in texture and lack of structural control. The linear pattern of the graphical representation indicates the weathering erosional characteristics of the area under study. The morphometric parameters evaluated helped us to understand various terrain parameters such as nature of the bedrock, infiltration capacity, runoff, etc.

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