Morphometric Analysis of Herle Nala Basin, Kolhapur District, Maharashtra, India.

A. A. Lole[1], S. B. Kore[1], R. S. Sagar[1], A. S. Dhokare[1], A. S. Bagade[1], S. S. Londhe[1]

Department Of Civil Engineering

Sanjay Ghodawat Institutes, Atigre-416118, Maharashtra, India

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Abstract -*Watershed development and management is the key factor for surface and ground water conservation. To prepare a watershed development plan, it becomes important to know the topography, lithology, erosional status and drainage pattern of the area. In the present investigation various morphometric parameters of the HerleNala basin are outlined. The HerleNala basin is 4th order and its different morphometric parameters are found to be useful for the proper land use planning and water resources management studies in the basin.The area consists of homogeneous rock material, which is structurally undisturbed based on dendritic drainage pattern in the area.*

Key Words:***Morphometric parameters, HerleNala***.

1. INTRODUCTION

Morphometry is defined as the measurement of the shape and mathematical analysis of drainage (Clarke, 1996). Morphometric studies in the field of hydrology were first initiated by Horton (1940) and Strahler (1950). Pawar and Raskar, (2011) has carried out morphometric analysis of Panchaganga river basin of Kolhapur district. Yadav and Sawant, (2011) has carried out morphometric parameter estimation of Sheri Nala basin, Sangli district. Jangle and Patil, (2010) has done morphometric parameter estimation of Nalganga river, Buldhana, Maharashtra. Nageswara and et. al., (2010) has carried out morphometric analysis of Gostani river basin in Andhra Pradesh.

Geo-spatial technologies, such as Geographic Information Systems (GIS) and Remote Sensing (RS), are efficient tools in delineation of watershed and drainage network for the water resources planning and management. In the present study attempt has been made to analysis the nature and structure of HerleNala basinby applying various morphometric techniques. The morphometric analysis of the drainage basin and channelnetwork play a important role for understanding the hydrological behavior of drainage basin and to analyze flood,geological and geo morphological structure. 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 watershed management studies have a special importance in the field of research, due to the increasing demand of water.

2. STUDY AREA

The HerleNala basin bounded between latitude 160 77' 03"N to 160 77' 48"N and longitude 740 29' E to 740 34' E in Survey of India Toposheet numbers 47 L/5 and 47 L/6 and having area of about 37.5 km2(Fig. 1). The HerleNala is the tributary of the Panchaganga River. 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 HerleNala basin shows well developed dendritic to sub dendritic type drainage pattern. (Fig.1). In the present paper the authors had made an attempt to morphometric analysis of HerleNala basin.

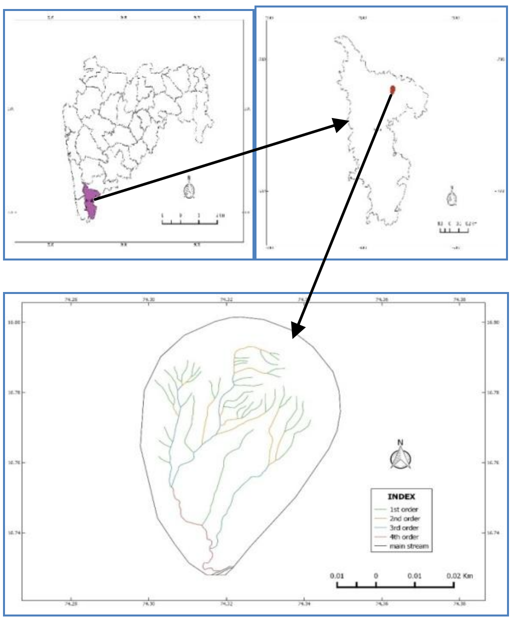

Fig1 -: Location Map and drainage map of the Study Area

3. METHODOLOGY

The study area which is located in the survey of India Toposheet Nos.47L/5 & 47L/6 is present in the Kolhapur district of Maharashtra and also uses the LISS-III satellite image. The data base is created using various techniques. The maps are prepared by Geo referencing and digitization from SOI Toposheet and LISS-III satellite image using QGIS 2.6.1 - Brighton software. The Survey of India Toposheet scale 1:50,000 and LISS-III satellite image are used for preparation of the watershed boundary, drainage map.Stream ordering method as suggested by the Strahler has been employed. The different morphometric parameters have been calculated by using formulae. For stream ordering method suggested by Strahler (1957) has been used.

4. RESULTS AND DISCUSSION

The drainage characteristics of HerleNala basin have been examined with reference to linear, aerial and relief aspects.

4.1. Linear Aspects of Drainage Basin

4.1.1. Stream Order (Su)

Stream ordering is the first step of quantitative analysis of the watershed.It has observed that the maximum frequency is in the case of first order streams. It has also noticed that there is a decrease in stream frequency as the stream order increases. The HerleNala basin is IVthorder stream (Table No – 1).

4.1.2. Stream Number (Nu)

The total of order wise stream segments is known as stream number. Horton (1945) states that the numbers of stream segments of each order form an inverse geometric sequence with order number.Individual counting of the streams in the river basin reveals the total number of the streams. Whole Herlenala basin has 44 streams, of which the first order stream having 31 segments. The second order stream having 8 segments. Third order stream having 4 segments and forth order having 1segment (Table No – 1).

4.1.3. Stream Length (Lu)

The total stream lengths of the HerleNala basin have various orders, which have been computed with the help of SOI topographical sheets and QGIS software. Horton's law of a stream length supports the theory that geometrical similarity is preserved generally in watershed of increasing order (Strahler, 1964). Author has been computed the stream length based on the low proposed by Horton (1945). The total stream length in HerleNala basin is 103.6 Km. (Table No. 1).

4.1.4. Mean Stream Length (Lu m)

Mean Stream length is a dimensional property revealing the characteristic size of components of a drainage network and its Contributing watershed surfaces (Strahler, 1964). It is obtained by dividing the total length of stream of an order by total number of segments in the order.

4.1.5. Stream Length Ratio (Lur m)

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 are developed where the formations at upstream side and are less permeable (Manu, 2008). Stream length ratio of HerleNala basin is given in Table No. 1.

4.1.6. Bifurcation Ratio (Rb)

The bifurcation ratio is the ratio of the number of the stream segments of given order 'Nu' to the number of streams in the next higher order (Horton (1945).The bifurcation ratiois not same from one order to its next order these irregularities are dependent upon the geological and lithological development of the drainage basin (Strahler1964). The bifurcation ratio is dimension less property and generally ranges from 3.0 to 5.0. The lower values of Rbare characteristics of the watersheds, which have suffered less structural disturbances (Strahler1964) In the present study, the bifurcation ratio ranges from 2 to 4 (Table No. 1) indicate that the watershed are not affect by any structural disturbances.

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 HerleNala basin is about 37.5sq.km which indicates that rain water 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. (Horton,1932).

$$Dd = Lu/A$$

Drainage density of the any basin reveals the terrain configuration that is properties of rock of the area. In the study are as outer half part of basin shows high drainage density which indicates region having on 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 sub soil material and area with low relief. (Geena2011). The overall drainage density (Dd) of the HerleNalabasin is 2.76km/sq.km.

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)

$$Fs = Nu/A$$

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 HerleNala basin is 1.17 High drainage density and high stream frequency in HerleNalabasin indicate larger run off from the basin. (Table No. 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. Regarding the HerleNala basin, the average constant of channel maintenance is 0.36 (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).

$$Rt = Nu/P$$

Texture ratio is an important factor in the drainage morphometric analysis which is depending upon the underlying lithology, infiltration capacity and relief aspect of the terrain (Nageswara, 2010). Smith(1950) has classified drainage density in to five different texture. Very coarse (<2), Coarse(2-4), Moderate(4-6), Fine(6-8) and Very fine (>8). In the present study texture ratio of the HerleNalabasin is 2.08, which indicate coarse texture and area under high relief and steep slopes.(Table2)

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 0.6to1.0 associated with a wide variety of climate and geology. Values close to 1.0 are typical of regions of very low relief where as that of 0.6to0.8 are associated with high relief and steep ground slope (Strahler, 1964). The Elongation ratio of the HerleNalabasin is 0.828 which indicate high relief and steep ground slope. (Table 2)

4.2.7. Circulatory Ratio (Rc)

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

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

Circulatory ratio of HerleNalabasin is 1.00 which is below 1.5 and shows strongly elongated basin with semi permeable homogeneous lithology. (Table 2)

4.2.8. Form Factor Ratio (Rf)

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

$$Rf = A/Lb^2$$

The Form Factor Ratio value of the HerleNalabasin is 0.538 (Table No. 2)which is very near 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 flow sine long at basins is easier to manage than that of the circular basins (Geena, 2011).

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 HerleNalais 270 meters. (Table 3)

4.3.2. Relief Ratio (Rh)

When basin relief (H) is divided by maximum basin length (Lb) gives the relief ratio (Schumm, 1954). The relief ratio of HerleNala basin is 32.35, which indicates that the basin has strong relief and steep slope. The higher stream frequency values show that the permeability of rocks is less at upstream to the middle portion of the Here basin. Theinfiltration is mainly through fracturesand joints, which are the extension of the surface joints. But the permeability of rocks increases towards downstream side where the rocks are weathered. (Table3)

4.3.3. Roughness Index (Rn)

Ruggedness number is the product relief of basin (H) and drainage density (Dd). The ruggedness number of HerleNalabasin is 745.2 (Table 3) which indicate both relief and drainage density are high.

Table No: 1- Linear aspects of the study area.

Nala basin	Stream order	No. of Streams (Nu)	Total length of Streams in Km (Lu)	Mean Stream Length	Stream Length Ratio (Rl)	Log Nu	Log Lu
Herle	I	31	54.1	1.74	1.02	1.49	1.73
	II	8	20.1	2.51	1.05	0.90	1.303
	III	4	20	5	1.05	0.60	1.30
	IV	1	9.4	9.4	1.12	0.00	0.97
Total		44	103.6				
Bifurcation Ratio (Rb)							
1st Order / 2nd Order	2nd Order / 3rd Order		3rd Order / 4th Order	**Mean Bifurcation Ratio**			
3.875	2		4	3.29			

Where, Lu = Total Stream length of all orders.
Nu = Total number of streams of all orders
N1=Total number of first order stream
(π= 3.1415)

Table No: 2-Aerial Aspects of the study area.

Morphometric Parameters	Symbol / Formula	Calculated Value
Maximum elevation in the area (mts.)	E_{Max}	810
Minimum elevation in the area (mts.)	E_{Min}	540
Basin Relief (mts.)	H = Max. Elevation – Min. Elevation	270
Relief Ratio (Rh)	Rh = H/Lb	32.35
Roughness Index (Rn)	Rn = H x Dd	745.2

Table No: 3 Relief aspects the of study area.

Morphometric Parameters	Symbol/ Formula	Calculated Value
Area (sq.km)	A	37.5
Perimeter(km)	P	21.706
Drainage Density	Dd = Lu/A	2.76
Stream Frequency	Fs =Nu/A	1.17
Texture Ratio	Rt =Nu/P	2.08
Basin Length(km)	Lb	8.347
Elongation Ratio	$Re = \frac{2\sqrt{\frac{A}{\pi}}}{Lb}$	0.828
Circulatory Ratio	$Rc = \frac{4\pi A}{P^2}$	1.00
Form Factor Ratio	$Rf = A/Lb^2$	0.538
Constant of Channel Maintenance	C = 1/Dd	0.36

5. CONCLUSION

The morphometric study of HerleNala Basin indicates that, the basin is forth order basin. 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 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. The elongation ratio, circulatory ratio and form factor reveals that the HerleNala basin is highly elongated and flood flows are easier to manage than that of circulatory basins. The study also reveals that the texture of HerleNala basin is coarse and basin is highly elongated. The drainage basin size analysis reveals that the flooding is lesser.

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