# Morphometric Analysis of Dev River from Nimblak to Dehre, Ahmednagar, Maharashtra

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*Abstract*— Analysis of drainage and elevation of their relative parameters have been precisely carried out for the Dev River Basin, which has contributed in numerous way's for the local surrounding area for the sustainable water resource development and management. The stream order ranges from first to fifth order. The drainage density in the area has been found to be low which indicates that the area possesses highly permeable soils and moderate vegetative cover. The bifurcation ratio varies from 2.00 to 5.50 and the elongation ratio reveals that the basin belongs to the elongated shaped basin category. The results obtained from analysis would be prime factor in the determination of characteristics such as size, shape, slope of distribution of catchment.
***Keywords:*** Drainage Morphometry, Dev River Basin

## I. INTRODUCTION

A complete understanding morphometry of the river basin is very first step in all-inclusive watershed development plan. Geomorphological characteristics of a river basin perform and vital role in watershed development plan of river basin. Conventionally morphometric analysis involves evolution of stream length, number of streams, bifurcation ratio, and density, it tends to laborious and inclusion of error may be there. The objective of this study is to compute the morphometric characterises of Dev river basin of size is 70.9 $Km^2$ by using manual technique. The data of basin is available in the form of hard copy of toposheet to a scale of 1:50,000. Extracting drainage network parameter manually would be tedious task. The calculated parameter can be conveniently used for watershed development plan.

Horton was the first geologist to explain the formation of streams and basins parameters (Horton, 1945). Horton's use of mathematical expression produce modern quantitative geomorphology. Measurable sets of geomorphologic properties explain linear, areal, and relief characteristics of the watershed. Relationships set is profitable to study the nature and behaviour of stream networks. Horton proposed Stream ordering schemes and then revised by Strahler (1952). Stream ordering includes applying a numerical value to a stream's position and size in the basin. First order streams is smallest segment further from the outlet of the basin. Increasingly larger downstream segments have larger values of stream order. Based on stream order and local languages, the smallest of these waterways are also sometimes called brooks and or creeks. River is known as lager waterways (at the highest level the stream order). Aerial relationships provide prime data on various characteristics such as regarding to the basin which include ponding of runoff. Differential elevations in the relief relationship also it provides corresponding elevational organization of various stream segments. Advance morphometric study involves prediction of erosion rates which is the function linear, aerial, relief relationship.

## II. REVIEW OF LITERATURE

Strahler (1954) Morphometric analysis provides quantitative description of the basin geometry to understand initial slope or inequalities in the rock hardness, structural controls, recent diastrophism, geological and geomorphic history of drainage basin.

Horton (1932) Evaluation of geometric factors and their mathematical relationship to hydrology was delayed by lack quantitative methods and procedures for measuring it. Much impetus however given to fluvial morphometry by Horton.

Jawahar Raj (1998) ; Kumaraswami (1998) ; Sreedevi (2001) et al., The morphometric analysis of a drainage basin is of great importance in understanding the hydrologic behaviour as well as hydro-geology and groundwater conditions of the area. A strong mutual relationship exists between morphological variables and hydrological characteristics. Such relation can be applied to both surface and groundwater regime. The detailed analysis of morphometric and morphological character indicate the role of the neo-tectonics in shaping the drainage basin (Raj et al., 1999)

Morisawa (1967), in his study rested the correlation of form ratios to runoff ratio and arrived at a measure of drainage basin outline form. It was deduced that circulatory and elongation ratios may be of value to hydrologist.

Chow (1964) introduced quantitative geomorphology with basic definitions, description and formulae. He gave a detailed account of meat, aerial and mad aspects of drainage basins and note on observed complex relations among hydrologic and geomorphic properties

STUDY AREA:-The DEV River is flowing through AHMEDNAGAR district of MAHARASHTRA state. The study area lying between the latitudes 19°8'30"N to 19°45'30"N and longitude 74°39'30"E to 74°45'E. The whole area can be obtained in single TOPOSHEET nos. E43C12, 47I/12. Covering the area of 70.9 sq.km, acquired from survey of INDIA. The area is approachable through the road link.

 

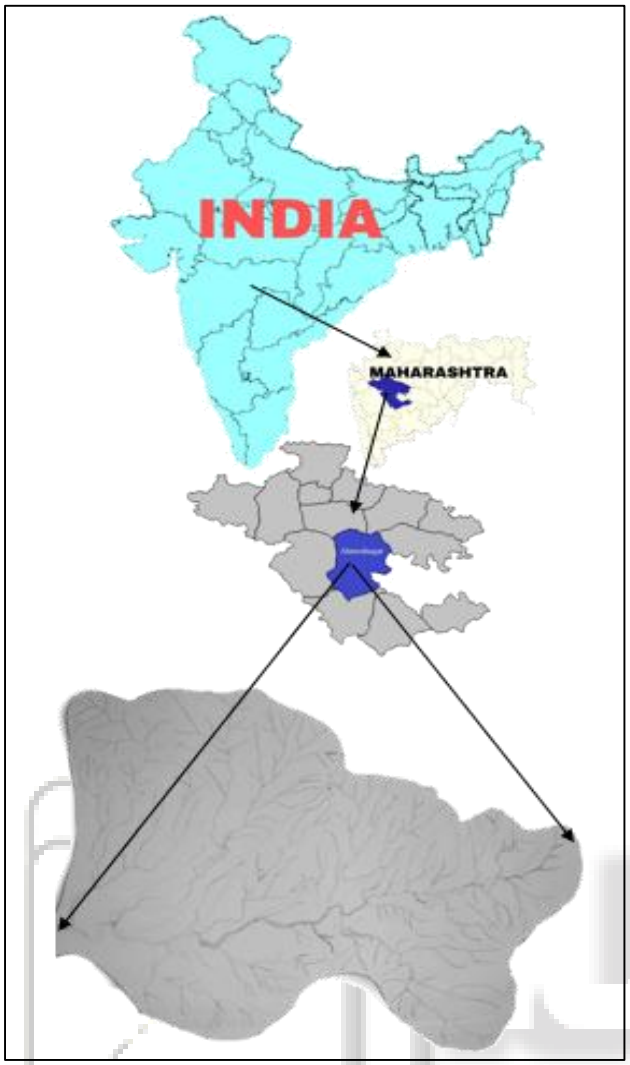


Fig. 1: Location map of dev river basin Ahmednagar, Maharashtra, India.

## III. METHODOLOGY

The methodology used consist of following step.

- Quantitative analysis of the drainage pattern obtained from toposheet.
- Lineaments studies.
- Field verifications of the interpreted geomorphic units.
- Finalization Of watershed development plan.

### *A. Morphometric Analysis:*

Morphometric analysis of a drainage basin is considered to be the most efficient method because it enableus to know the relationship with different aspects of the drainage pattern of basin, to make a comparative computation of different drainage basins developed in various geologic region and to define certain useful parameter of drainage basins in numerical terms. The most vital advantage of quantitative analysis is that many of the basin parameter calculated are in the form of ratio or dimensionless number

The morphometric parameters calculated include Stream order (u), stream number(Nu), Bifurcation ratio (Rb), Stream length(Lu), texture ratio(T), basin area(A), Form factor(Ff), stream frequency(Fs), Circularity ratio (Rc) and Drainage density (D) Etc.

*1) Stream Order (U):*

The first step in morphometric analysis of a drainage basin is the designation of stream order. In the present study, the channel segment of the drainage basin has been ranked according to Strahler's stream ordering system. According to Strahler (1964), the smallest fingertip tributaries are designated as order I. Where two first order channels join, a channel segment of order II is formed, where two of order II joins, a segment of order III is formed so onward, the trunk stream through which all discharge of water and sediment passes is therefore the stream segment of highest order. In the Dev river basin having up to V th stream order.

*2) Stream Length ($L_u$):*

According to Horton, the mean length of the stream is the ratio of the length of the stream is of the stream of each order to the number of segments of the same order. In this study, it has been noticed that the length of the stream decreases with stream order indicating the characteristic size of components of drainage network and its contributing basin surface.

$$L_u = L_1 + L_2 + L_n$$

Therefore,

$L_u$=106.57+75.8+41.78+26.6+14.95

$L_u$=265.7km

*3) Bifurcation ratio ($R_b$):*

Bifurcation ratio is related to the branching pattern of a drainage network and is defined as the ratio between the total numbers of stream segments of one order to that of the next higher order in a drainage basin (Schumn, 1956). Also, It is relation between no. of streams of one order an of next higher order which was obtain by dividing no. of streams in one order by the no. of the stream in next highest order for all the orders of the stream. These calculations were also based on Strahler method. Bifurcation ratios are related to the structural control on the drainage (Nautiyal, 1994; Strahler, 1964; Chow, 1964). The bifurcation ratio can also show which parts of a drainage basin is more likely to flood. The bifurcation ratio is not same from one to another due to irregularities in the topographic feature of the drainage basin.

$$R_b = \frac{N_u}{N_u + 1}$$

*4) Stream Number ($N_u$):*

The counts of stream channel in its order are known as stream number. The number of the stream segments decreases as the order increases, the higher amount stream order indicates lesser permeability and infiltration. After assigning stream orders, the segment of each order are counted to get the number of segment of the given order (u). The stream lengths of the various segments are measured with the help of Rotometer/curvimeter. In the Study area, the total strains segment present 275 of which first order stream having 203 segments. The Second order stream segment are 56 and third order strain segment area 11 and the fourth order stream segment are 4.

### *B. Drainage Density (D):*

It is the ratio of the total length of all streams and area of the drainage basin. The result indicate high values in the plains indicating the drainage texture, low permeability and high relief whereas it is comparatively low in the hilly terrain showing steep scraps reflecting the coarser drainage texture.

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

 

Where,
D is the drainage density of study area,
Lu is the total length of stream of all order which is 265.7 Km
A is the area of study which is 70.9 Km2.
Therefore,

$$D = \frac{265.7}{70.9}$$

D=3.74

The drainage density (D) of study area is 3.74 km indicating low to moderate drainage density. It is suggested that the low drainage density indicated the basin is highly permeable subsoil and thick to moderate vegetative cover.

*1) Texture Ratio (T):*

Texture ratio (T) is the ratio of total no. stream of any order & perimeter of the area which it lays. It is an important factor in the drainage morphometric analysis which is depending on the underline lithology, infiltration capacity and relief aspect of the terrain. It is expressed by the formula,

$$T = \frac{N1}{P}$$

Where,
T is texture ratio of study area
N1 is the total number of first order streams which is 203,
P is perimeter of study area which is 36.75 Km, Therefore,

$$T = \frac{203}{36.75}$$

T = 5.52

*2) Stream frequency ($F_s$):*

Stream frequency or channel frequency is the total number of stream segments of all orders per unit area (Horton, 1932).The occurrence of stream segments depends on the nature and structure of rocks, vegetation cover, nature and amount of rainfall and soil permeability Also, It is ratio of total no. of streams of any order & the area of the basin in which its lies. Mathematically,

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

Where,
Nu = Total number of streams of all orders which is 275,
A = area of study which is 70.9Km$^2$.
Therefore,

$$Fs = \frac{275}{70.9}$$

Fs = 3.87

The stream frequency value of study area is 3.87

*3) Circularity Ratio ($R_c$):*

Miller (1953) defined a dimensionless circularity ratio as the ratio of basin area to the area of circle having the same perimeter as the basin. He described the basin of the circularity ratios range 0.4 to 0.5 which indicates strongly elongated and highly permeable homogenous geologic materials. The circularity ratio value (0.42) of the basin corroborates the Miller's range which indicating that the basin is elongated in shape, low discharge of runoff and highly permeability of the subsoil condition. It is influenced by the length and frequency of streams, geological Structures, land use/ land cover, climate, relief and slope of the watershed. Mathematically expressed as,

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

Where,
$R_c$= Circulatory ratio of study area,
$\pi$ = 3.14.
A = area of study which is 70.9 Km2.
P is perimeter of study area which is 36.75 Km.
Therefore,

$$R_c = \frac{4\times\pi\times70.9}{36.75^2}$$

$R_c$= 0.66

*4) Elongation Ratio(Re):*

Schumm (1956) used an elongation ratio,define as the ratio of diameter of circle of the same area as the basin to the maximum basin length.It is very significant index in the analysis of basin shape which helps given an idea about the hydrological character of a drainage basin. Matematically it is expressed by,

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

Where , Re = Elongated ratio
A = Area of Study
$\pi$ = 3.14
Lu = Total stream length.

$$Re = \frac{2\sqrt{\frac{70.9}{3.14}}}{14.95}$$

Re=0.63

*5) Form Factor(Ff):*

The form factor is the ratio of basin area to square of the basin length and is a quantitative expression of drainage basin outline. It indicates the flow intensity of a basin of a defined area (Horton, 1945).

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

Where,
Ff = form factor,
A = area of basin (km),
$Lb^2$ = square of the basin length

$$Ff = \frac{70.9}{14.95^2}$$

Ff=0.32

*6) Basin Area (Au):*

The area of basin is 70.9 sq. km. the basin size is small; it is likely that rainwater will reach the main channel more rapidly than in a larger basin, where the water has much further to travel. Lag time will therefore be shorter in the smaller basin. According to Gregory and Walking (1973), the 'L' is the longest length of the basin from the catchment to the point confluence.

| Stream am Order (U) | Number of Streams (Nu) | Total length of Streams in km (Lu) | Bifurcation Ratio (Rb) | Mean Bifurcation Ratio |
|---|---|---|---|---|
| I | 203 | 106.57 | - | |
| II | 56 | 75.8 | 3.69 | |
| III | 11 | 41.78 | 4.5 | 3.02 |
| IV | 4 | 26.6 | 2.2 | |
| V | 1 | 14.95 | 1.67 | |

Table 1: Stream order, Total Stream Length and Bifurcation ratio.

 

| Morphometric parameter | Formula | Values |
|---|---|---|
| Area (sq.km) | A | 70.9km2 |
| Perimeter (km) | P | 36.75km |
| Drainage density (km / km2) | D = Lu/A | 3.74 |
| Stream frequency | Fs = Nu/A | 3.87 |
| Texture ratio | T =N1/P | 5.52 |
| Circulatory ratio | Rc =4 $\pi$A/ P2 | 0.66 |

Table 2: Areal aspects of drainage basin.

## IV. RESULTS AND DISCUSSION

The results of different morphometric parameters are listed in Table 1 and Table 2. Dev river basins exhibits dendritic drainage pattern. Physiographic characteristics of drainage basins like drainage density, stream orders, size, shape, relief, area and length of streams can be correlated with various hydrologic processes. Drainage basin morphology attempts to explain and predict the long-term aspects of basin dynamics resulting in morphological changes within the basin. The total area of Dev basin is 70.9 km2 and areas of basins are presented in Table 1.The parameter of Dev basin is 36.75km perimeters are presented in Table 1. The length of Dev basin is 265.7 km and length of sub-watershed are shown in Table 1.

### *A. Stream Order(U):*

According to Horton quantitative method to analysing drainage basins which have become a standard technique for presenting data on drainage basins. It is based upon a hierarchy of stream ordering which was revised by Strahler such as fingertip tributaries are first order stream, two first orders combine to form a second order, two second order form a third and so on. The number of streams (Nu) in each order is presented in Table 1 for basin. Dev watershed is designated as a Fifth order basin. The maximum stream order frequency is observed in case of first order streams and then for a second order. Therefore, it is seen that there is a reduction in stream frequency as the stream order increase and vice versa.

### *B. Stream Number (Nu):*

According to Horton's principle the number of streams is negatively correlated with the order such as stream numberdecrease with increase in stream order. The number of streams (Nu) in each order is presented in Table 1. The total stream length 275 are identified in the entire Dev river basin, out of which 73.81% (203) is 1st order stream,20.36% (56) 2nd order, 4% (11) 3rd order, 1.75% (4) 4th order, 0.36% (1) 5th order. During the calculation, it is noticed that the number of streams gradually decrease with increasing stream order.

### *C. Stream Length (Lu):*

According to Horton (1945), stream length refers to total length of stream segments in each consecutive orders. If the bedrock and formation is permeable than small number of relative longer streams are formed, while a large number of streams of smaller length are developed where the bedrocks and formation are less permeable. The result of order-wise stream length of Dev Basin as listed Table 1. Total streams length of Dev Basin 1st order 106.57 km, 2nd order 75.8, 3rd order 41.78 km, 4th order 26.6 km, 5th order 14.95 km.

### *D. Bifurcation Ratio (Rb):*

Bifurcation ratio determines drainage network which exists in the form branches. It is a dimensionless property and shows the degree of integration prevailing between streams or various orders in a drainage basin. According to Horton (1945), the bifurcation ratio varies from a minimum of 2 in "flat or rolling drainage basins" and 3 or 4 in "mountainous or highly dissected drainage basins". The bifurcation ratio range between3.0 - 5.0indicates substantial structural control on drainage basin. The mean Rb value of the Dev Basin is 3.02.

### *E. Stream Frequency (Fs):*

A high stream frequency characterized by high surface runoff, steeper surface, impermeable subsurface material, spare vegetation and high relief setting. The stream frequency of Dev Basin is 3.87 per km2.

### *F. Drainage Density (D):*

The poorly drained basin has a drainage density 3.74. Drainage density is ameasure of how frequently streams occur on the land surface. It reflects a balance between erosive forces and the resistance of the ground surface. It is closely related to climate, litho-logy, and vegetation. In drainage density analysis, intermittent and ephemeral streams should be incorporated, because most of them performed during floods and bring flood water.

### *G. Form Factor (Fr):*

The value of form factor is in range, from 0.1 - 0.8. Lesser the value of form factor, more elongated will be the basin. The basins with high form factors 0.8, have high peak flows of shorter duration, whereas, elongated drainage basin with low form factors have a lower peak flow of longer duration. The form factor of the Dev Basin is 0.32.Which is between 0.25 and 0.36 are elongated shape. Flood flows in elongated basins are easier to manage than the watersheds developed towards rectangular to circular shape. The morphological characteristics of a watershed have powerful impacts on watershed hydrology.

### *H. Circulation Ratio (Rc):*

Circulatory ratio is influenced by the lithology of the basin, stream frequency and gradient of various orders. Dev Basin has Cr value 0.66.This indicate that these sub-watersheds are more or less circular in shape and highly permeable homogenous geologic materials.

### *I. Elongation Ratio (Re):*

This ratio usually runs from 0.6 to 1.0 in a broad range of climatic and geological setting. The Re values from 0.6 to 0.8 are associated with strong relief and steep group slope. The ratio gives an idea about the hydrological behaviour or character of the basin such as circular basin is more efficient in the discharge of runoff than an elongated basin, whereas, time of concentration of runoff is less in elongated basin which leads peak runoff. The elongation ratio of the Dev Basin is 0.63 while the sub-basins of values are range between 0.55 - 1, which is less elongated basin with high

 

relief. The lower part of the Dev Basin is comparatively elongated with lower values than the upper and central area of the basin.

## V. CONCLUSION

The present study on Morphometric analysis made the task easier of the evaluation of morphometric parameters and their analysis. For the integrated decision making process in flood management, soil erosion assessment and water resource management the morphometric parameters such as drainage density, stream frequency & bifurcation ratio plays vital role. In simple words, the quantitative evaluation of morphometric parameters is essential tool in river basin analysis in terms of soil and water conservation and natural resource management.

Based on the study the morphometric analysis the basin can be easily managed in flood period, because the basins are in elongated forms. More check-dam may be constructed to store the precipitated water, for the use of agriculture, settlement and for high yield of groundwater potentials even in dry area.

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