REVIEW OF RESEARCH

'ANALYSIS OF MORPHOMETRIC PARAMETER OF MOR RIVER USING RS AND GIS TECHNIQUES'

Dr. Mrs. P. P. Jangle

Head, P. G. And Research Dept. of Geography,
M. J. College, Jalgaon Dist. Jalgaon (M.S)

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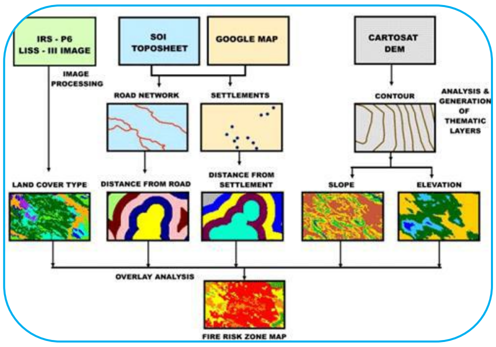

ABSTRACT:

River basin is an ideal unit to plan development and management of surface and groundwater conservation. For this purpose it becomes important to know morphometric characteristics of the river. Morphometric studies of rivers are very important to study the behavior of river, its erosion and deposition. Morphometric characteristic provides quantitative description of a river basin. The present study aims to assess the morphometric analysis of Mor river, a right bank tributary of river Tapi to prioritize the basin for its planning and development. It is proved that there is a good relationship existed among the morphometric parameter and terrain characteristics. The analysis and measurement of morphometric parameter is found to be of best immense utility in river basin evaluation and understanding the basin for natural resource management and planning at any scale.

KEYWORDS: *Quantitative, Morphometric, Parameter, Characteristics, Prioritize.*

INTRODUCTION

Morphometric analysis is an essential mean of geomorphic analysis of a river basin, Morphometric analysis though simple, have been applied for the analysis of area – height relationship,determination of erosional surfaces,slope relative relief and terrain characteristic as a whole .The morphometric analysis of different basins have been done by various scientists using conventional methods (Horton 1945, Smith 1950, Stralher 1957)and Remote sensing and GIS. Remote Sensing and GIS technology have been effectively used to compute basin morphometric characteristics by taking linear aerial and relief aspects of river Mor. Such analysis aided in understanding the hydrological, geological, and to topographical characteristics of Mor river basin.

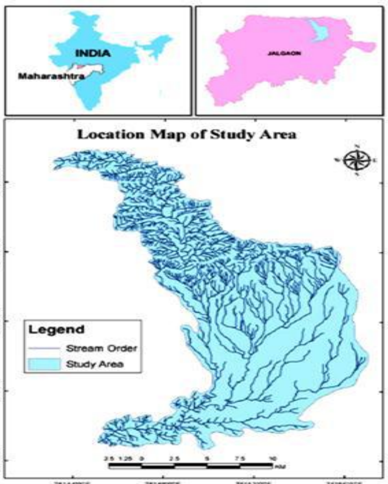

Fig. 1 Location Map of Study area

River Mor is the right bank tributary of river Tapi 21^0 4' 50'' to 21^0 21' 44'' North latitude and 75^0 44' 58'' East to 75^0 56' 17'' East longitude (Fig. 1). The approximate area of the river system is 333.74 sq.km. The length of the river is about 54.68 km. It meets to river Tapi near the village Anjale.

OBJECTIVES

1. To study the relationship between the basin parameter and the character of the study area.
2. To use the RS and GIS techniques for morphometric analysis of basin.

MATERIAL AND METHODS

Demarcation and delineation of Mor river basin and preparation of drainage map is based on 46 O/15, 46 O/16 on 1:50000 scale. DEM (Digital Elevation Model)or relief map (Fig.2) is preparedusing ArcGIS software. Morphometric parameters namely stream order (Na) (Fig. 3), stream length (Lu) Mean stream length , Mean Stream length (Lsm) Stream length ratio (Rl) Bifurcation ratio (Rb) Drainage Density (D), stream frequency (fs) form factor(rf) Circulatory ratio(Rc), Elongation ratio (Re) length of overland flow (Lg) have been imputed using GIS tools .

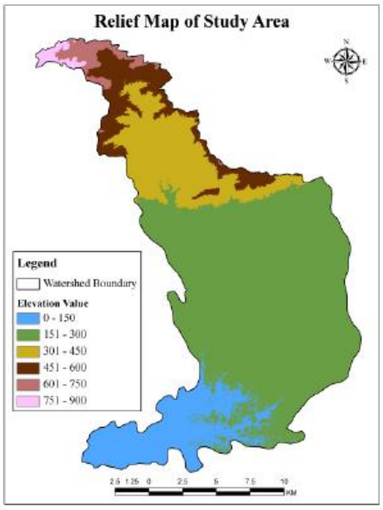

Fig. 2 Relief Map

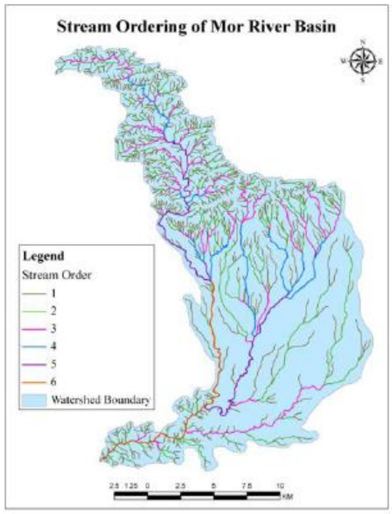

Fig. 3Stream Ordering Map

RIVER ANALYSIS

A. LINEAR ASPECTS

i. Stream Order (Su):

Stream order of drainage basin is the successive assimilation of thestreams within a drainage basin. The ordering of the basin has been carriedout by the method suggested by Strahler (1957). The designation of streamorder is the first step in the drainage basin analysis. It is defined as ameasure of the position of a stream in the hierarchy of tributaries (Leopoldet al., 1964). There are 752 streams linked with 6 orders of streams. Spreadover an area of 333.73sq.km. A perusal of data indicates that the Morstream which is the trunk stream in Mor drainage basin is of the Sixthorder.According to Strahler (1964), the smallest fingertip tributaries aredesignated as order 1. Where two first order channels join, a channelsegment of order 2 is formed and where two of order 2 joins, a segment oforder 3 is formed, so on and so forth. The trunk stream through which alldischarge of water and sediment passes is therefore the stream segment ofhighest order. The study area is a sixth order drainage basin. It is observedthat there is a decrease in stream frequency as the stream order increases.First order streams constitute 75.53% (maximum proportion) of the totalnumber of streams and the proportion contributed decreases with theincrease in stream order. Thus the law of lower the order higher the numberof streams is implied throughout the catchment.

ii. Stream Number (Nu):

After assigning stream orders, the segments of each order are counted toget the number of segments of the given order (u). Individual counting ofthe streams in the river basin reveals the total number of the streams.Whole Mor river basin has 752 streams, of which 75.53% are the first order streams having 568 segments. The second order stream segments are140 and account for 18.61%, third order stream segments are 33 andaccounted 4.38%, fourth order stream segments are 8 and account for1.06% and fifth order stream segment is 2 and account for 0.26% and thelast sixth stream order is only 1 and account for 0.13% of total drainagestreams. Relation between stream order (u) and stream numbers (Nu)shows the straight line, which indicates area without structural disturbance.

Table 1. Stream Order and Stream Number

Stream order	Stream number
1	568
2	140
3	33
4	8
5	2
6	1

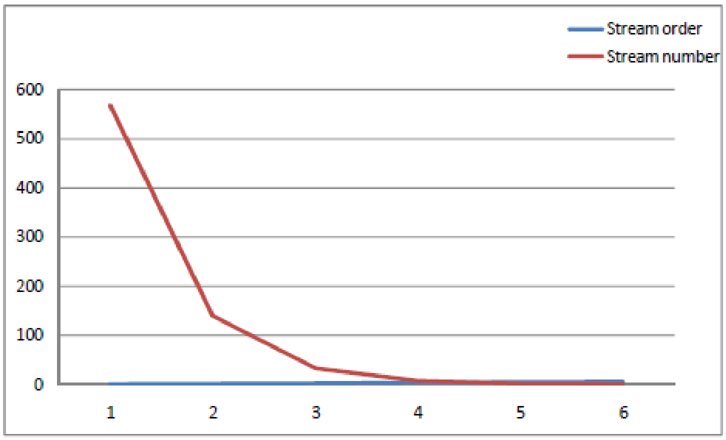

Fig.4 Relation between Stream orders and Stream numbers

iii. Bifurcation Ratio

It is the ratio of number of streams of any given order to the number ofstreams in the next lower order (Horton, 1945).

$$Rb = \frac{N\mu}{N\mu + 1}$$

Table 2. Relationship between Stream Order, No. of Streams and Bifurcation ratio

Stream order (µ)	Stream number (Nµ)	Bifurcation Ratio (Rb)
1	568	4.05
2	140	4.24
3	33	4.1
4	8	4
5	2	2
6	1	-

The significance of this ratio is that as the ratio is reduced so the risk offlooding within the basin increases. It also indicates the flood risk for partsof the basin. In the Mor river basin bifurcation ratio ranges from 4.05 to 2.The mean bifurcation ratio for Mor river basin is 2.05. This means that onan average, there are 2.05 times as many channel segments to any givenorder as of the next higher order.

The average bifurcation ratio of the basinreveals that there appears to be no strong geological control in thedevelopment of the drainage, but in the northern part of the study areaSatpura range affects to the basin and the homogeneous nature of lithology anddrainage network in study area is well developed stage.

iv. Stream length:

Table3. Relationship between Stream Order and Stream Length

Stream order	Stream length
1	418.58 km
2	182.05 km
3	103.68 km
4	45.52 km
5	36.07 km
6	22.70 km

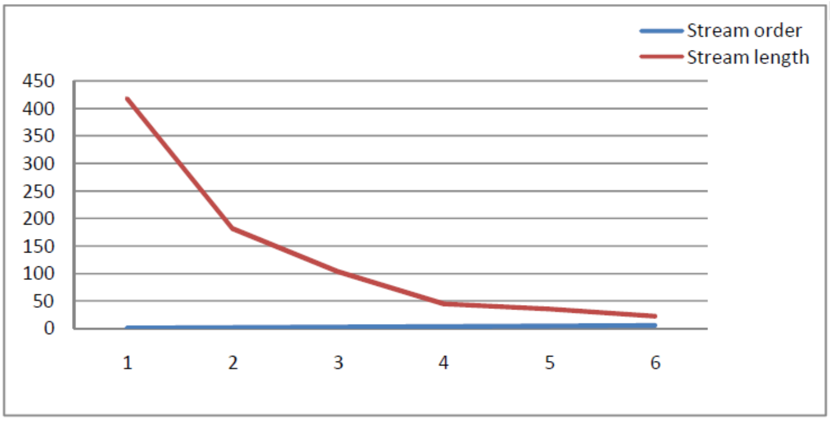

Fig.5 Relation between Stream Orders and Stream Length

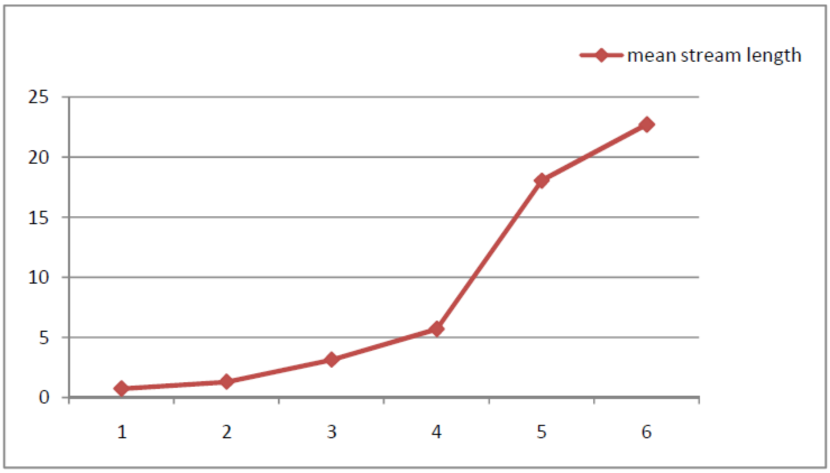

Fig.6 Relation between Stream orders and Mean stream length

Study of the stream length with respect to the stream order is ofsignificant importance. Stream length for the basin of the given order isinversely proportional to the stream order. Stream length of the basinindicates surface runoff characteristics. Streams of relatively smallerlengths are characteristics of area with greater slopes. Stream length of Morriver and its tributaries is measured with the help of GIS

Software. The totalstream length in Mor river basin is 808 km. The mean length of channel Luof order U is the ratio of the total length to the number of streams of a givenorder. Mean length of channel segments of a given order is greater than thatof the next lower order but less than that of the next higher order.

v. Stream length ratio (Rl):

The stream length ratio can be defined as the ratio of the mean streamlength of a given order to the mean stream length of next lower order andhas an important relationship with surface flow and discharge (Horton,1945). The RL values between streams of different order in the basin revealthat there are variations in slope and topography.

$$Rl = \frac{total\ stream\ length\ of\ order\ (Lu)}{the\ total\ stream\ length\ of\ its\ lower\ order\ (Lu-1)}$$

Table 4. Relationship between Stream Order, Stream Length and Stream Length Ratio

Stream Order	Stream Length	Stream Length Ratio
1	418.58 km	-
2	182.05 km	0.43
3	103.68 km	0.56
4	45.52 km	0.43
5	36.07 km	0.79
6	22.70 km	0.62

It is noticed that the RL between successive stream orders of the basinvary due to differences in slope and topographic conditions (Sreedevi1999). The values of RL vary haphazardly from 0.43 to 0.79. Since the Morstream basin shows changes in RL from one order to another, it is deducedthat it is characterized by the late youth to early mature stage of geomorphicdevelopment (Singh and Singh, 1997).

B. AREAL ASPECTS OF DRAINAGE AREA

i. Drainage Density:

Horton (1932), introduced the drainage density (Dd) is an importantindicator of the linear scale of land form elements in stream erodedtopography. It is the ratio of total channel segment length cumulated for allorder within a basin to the basin area, which is expressed in terms ofKm/Km2.The drainage density, indicates the closeness of spacing ofchannels, thus providing a quantitative measure of the average length ofstream channel for the whole basin. It has been observed from drainagedensity measurement made over a wide range of geologic and climatic typethat a low drainage density is more likely to occur in region and highlyresistant of highly permeable subsoil material under dense vegetative coverand where relief is low. High drainage density is the resultant of weak orimpermeable subsurface material, sparse vegetation and mountainous relief.Low drainage density leads to coarse drainage texture while high drainagedensity leads to fine drainage texture (Strahaler, 1964).

$$Drainage\ Density\ (d) = \frac{total\ stream\ length\ of\ all\ order\ (Lu)}{total\ area\ (A)}$$

$$d = \frac{808.6}{333.7}$$

d = 2.42 sq. km

The drainage density (Dd) of study area is 2.42 Km2 indicating moderatedrainage densities. The Moderate drainage density indicates the basin ishighly permeable subsoil and vegetative cover. As well as the study areanorthern half part of basin shows high drainage density which indicatesregion having non resistant or impermeable subsurface material andmountainous relief, whereas southern half part of basin shows low drainagedensity which indicates region having highly resistant rock or highlypermeable subsoil material and area with low relief.

ii. Stream frequency:

The stream frequency (Fs) or channel frequency or drainage frequencyof a basin may be defined as the total number of stream segments within thebasin per unit area (Horton, 1945). The Fs of the whole basin is 2.25 km2.It mainly depends on the lithology of the basin and reflects the texture ofthe drainage network.It is an index of the various stages of landscape evolution. Theoccurrence of stream segments depends on the nature and structure ofrocks, vegetation cover, nature and amount of rainfall and soil permeability.The stream frequency of the study area shows positive correlation with thedrainage density. This indicates that the stream population increases withthe increase of drainage density. Greater the drainage density and streamfrequency in a basin, the runoff is faster, and therefore, flooding is morelikely in basins with a high drainage and stream frequency (Kale and Gupta,2001).

$$fs = \frac{total\ no.\ of\ streams\ of\ all\ orders\ (Nu)}{total\ area\ (A)}$$

$$fs \quad \frac{752}{333.7} \quad =$$

fs =2.25

Drainage frequency obtained for the Mor river valley show the variationfrom north to southward. Stream frequency in northern area is greater thansouthern because of the hilly area of Satpura ranges.

iii. Texture ratio:

It is the ratio of total stream numbers to the total perimeter of the basin(Horton, 1945). The drainage texture is considered as one of the importantconcept of geomorphology which shows the relative spacing of thedrainage lines (Chorley et al., 1957). The drainage density less than 2indicates very coarse, between 2 and 4 as coarse, between 4 and 6 asmoderate, between 6 and 8 as fine and greater than 8 as very fine drainagetexture (Smith, 1939).

$$T = \frac{total\ no. of\ 1st\ order\ streams\ (N1)}{perimeter\ (P)}$$

Table 5. Relationship between Stream Order and texture Ratio

Stream Orders	Texture Ratio
1	3.829
2	0.943
3	0.222
4	0.053
5	0.013
6	0.006

In the present study, it was found that the drainage density values arevariable and suggests that the study area falls into very coarse to coarsetexture category and indicates good permeability of sub-surface material inthe study area except the first order streams. The drainage texture values are3.829 (1st order streams), 0.943 (2nd order streams), 0.222 (3rd orderstreams), 0.053 (4th order streams), 0.013 (5th order streams), 0.006 (6^{th}order stream). Low drainage density leads to very coarse drainage texturewhile high drainage density leads to coarse drainage texture that in turndepends on the infiltration capacity of the mantle rock or bed rock(Smith, 1939; Thornbury, 1969).

iv. Form factor ratio:

Quantitative expression of drainage basin outline form through aform factor ratio (Rf), which is the dimensionless ratio of basin area to thesquare of basin length (Horton, 1932). Basin shape may be indexed bysimple dimensionless ratios of the basic measurements of area, perimeterand length (Singh, 1998).

$$Rf = \frac{area\ of\ the\ basin\ (A)}{basin\ length\ sq.(Lb)}$$

$$Rf = \frac{333.73}{54.68 * 54.68}$$

$Rf = 0.11$

The form factor value of the basin is low, 0.11 which representselongated shape. The elongated basin with low form factor indicates thatthe basin will have a flatter peak of flow for longer duration. Flood flows ofsuch elongated basins are easier to manage than of the circular basin.

v. Circulatory Ratio:

The circularity ratio (Rc) has been used as a quantitative measure forvisualizing the shape of the basin and is expressed as the ratio of basin area(A) to the area of a circle (Ac) having the same perimeter as the basin(Miller 1953; Strahler 1964). It is affected by the lithological character ofthe basin. The ratio is more influenced by length, frequency (Fs), andgradient of streams of various orders rather than slope conditions anddrainage pattern of the basin. It is a significant ratio, which indicates thedendritic stage of a basin. Its low, medium and high values are indicative ofthe youth, mature and old stages of the life cycle of the tributary basins.

$$Rc = \frac{4\pi A}{P2}$$

$$Rc = \frac{4 * 3.14 * 333.73}{148.34 * 148.34} = 0.19$$

The calculated Rc value for the study area is 0.19 which indicate thatthe drainage basin is more or less elongated and is characterized by mediumto low relief. It shows that the study river basin is partially controlled by thestructural disturbances.

vi. Elongation ratio:

Elongation ratio (Re) is defined as the ratio of diameter of acircle of the same area as the basin to the maximum basin length (Schumm,1956). It is a very significant index in the analysis of basin shape whichhelps to give an idea about the hydrological character of a drainage basin.

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

$$Re = \frac{\sqrt{333.73}/3.14}{54.68} = 0.10$$

Values of Elongation Ratio near to 1.0 are typical of regions of morerelief (Strahler, 1964). The value of Elongation Ratio in the study area wasfound to be 0.10 which is indicating relatively low relief of the terrain andelongated shape of the drainage basin.

vii. Length of overland flow:

Length of overland flow is defined as the length of flow path,projected to the horizontal, non channel flow from point on the drainagedivide to a point on the adjacent stream channel (Horton, 1945). Horton, forthe sake of convenience, had taken it to be roughly equal to half thereciprocal of the drainage density.

$$Lg = \frac{1}{2} * drainage\ density$$

$$Lg = \frac{1}{2} 2.42 = 1.21\ km$$

Overland flow is significantly affected by infiltration andpercolation through the soil, both varying in time and space (Schmid,1997). In this study, the length of overland flow of the Mor drainage basinis 1.21 km, which shows medium surface runoff in the study area. Surfacerunoff in Mor river basin in extremely affected by Satpura ranges, whichare settled in the northern part of study area.

viii. Constant channel maintenance:

The Constant of Channel Maintenance is the inverse of thedrainage density. (Schumm, 1956). Therefore higher the drainage densitylowers the constant of channel maintenance and vice versa.

$$C = \frac{1}{drainage\ density\ (Dd)}$$

$$C = \frac{1}{2.42} = 0.41$$

In the northern half part of the river basin the value of Constantof channel maintenance is very low which indicate that only rocks arerelatively impermeable or terrain so the slope in river valley is steep. But inthe southern half part of the river basin the value of Constant of channelmaintenance is relatively low because of the plateau region and plane valleyregion. Itindicates the presence of little more permeable overlyingmaterial than northern part of the basin. Related to the Mor river basin, theaverage constant of channel maintenance is 0.41.

C. RELIEF ASPECTS

i. Basin relief (mts):

Basin relief generally refers to the vertical distance differencebetween point of maximum elevation and minimum elevation is the riverbasin. It is calculated by pointing out the maximum elevation throughoutthe catchment area and also minimum elevation in catchment area.

H = Max. Elevation – min. Elevation
H = 620 – 207
H = 413 mts

The basin relief of Mor river is 413 mtrs from M.S.L. Study area havemaximum elevation in northern part in Satpura range and the minimumelevation among catchment area is identified in plateau region near thevillage.

ii. Relief ratio (Rh):

Relief Ratio is the ratio between basin relief and maximumbasin length (Schumm, 1954). The Relief Ratio normally increases withdecreasing drainage area and size of watersheds of a given drainage basin(Gottschalk, 1964). Relief ratio measures the overall steepness of adrainage basin and is an indicator of the intensity of erosion processoperating on slope of the basin (Schumm, 1956).

$$Rh = \frac{H}{Lb}$$

$$Rh = \frac{413}{54.68} = 7.55$$

The relief ratio of Mor river basin is 7.55, which indicates thatthe basin has more and less steepness and relief. Near about fifty percentstudy area carries the hilly region and has elevation between 600 to 500mts. which cause more steepness to river basin. Southern part of the basinis made up of plain region which shows less relief.

CONCLUSIONS

The advancetechniques likeremote sensing and GIS have been proved to be more accurate and efficient tool in morphometric parameters. The Bifurcation ratio, length ratio and stream order of basin indicates that the basin is sixth order basin with dendrite type of drainage pattern with homogeneous nature and there is partially structural or tectonic control Dem of the study area shows moderate to high relief, low runoff and high infiltrations with early maturity stage of erosional development Drainage Density, texture... ratio, circulatory ratio and elongation ratio shows that texture of basin is moderate and shape of the basin is elongated. The whole morphometric analysis indicates that the study area is having good ground water potential

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Dr. Mrs. P. P. Jangle
Head, P. G. And Research Dept. of Geography, M. J. College, Jalgaon Dist. Jalgaon (M.S)