International Journal of Advance and Applied Research (IJAAR)
Peer Reviewed Bi-Monthly

ISSN – 2347-7075
Impact Factor – 0.899
Vol.6 No.3 Jan – Feb 2019

EXTRACTION OF MORPHOMETRIC CHARACTERISTICS OF ADULA RIVER BASIN AND MAHALUNGI RIVER BASIN USING DEM ANALYSES

Devidas Tambe[1], Rumana Khan[2]

[1,2]Department of Geography, University of Mumbai, Mumbai. MS India

Email: devidastambe@gmail.com

ABSTRACT:

The present study is carried out on drainage basin morphometric parameters based on DEMs analysis of Adula river basin and Mahalungi river Basin. Both rivers drain part of western upland Maharashtra. On map both the river basin looks similar reflects strong geological control. The main objectives of the study are to extract morphometric characteristics of Adula River basin and Mahalungi River basin and to highlight similarities and dissimilarities in morphometric characteristics of both rivers. We have extracted all the morphometric parameters of both river basins. We have use Geographic Information Science (GIS) to carry out analysis. The result indicates Adula river basin have all the morphometric parameters higher than Mahalungi river basin except area and mean bifurcation ratio. The high area resulted into the high mean bifurcation ratio. Both rivers are similar on many morphometric parameters. Further studies on land use land cover will be useful to understand effect of morphometric characteristics on agricultural activity.

KEYWORDS: Drainage basin, morphometric parameters, DEMs, Adula River, Mahalungi River and Pravara River.

INTRODUCTION:

Drainage basin Morphometric analysis based on Digital Elevation Models (DEMs) is one of the important techniques and technology to understand river basin characteristics. It gives insight into processes operating in drainage basin where fluvial deposits are limited and terrain is mostly erosion prone. The Adula and Mahalungi river basin are having these types of terrain conditions. Both the river has similar geographical and geological setup. They flow parallel to each other. The basins reflect strong geological control at first glance. Many studies are carried on similarity based on fractal dimension but similarities based on morphometric parameters are not studies in great depth. This study is carried out on extraction of morphometric characteristics of Adula and Mahalungi river basin using DEM analysis. The analysis will reflect whether both rivers on map look similar but on morphometric parameters how far they are looking similar.

STUDY AREA

The study area is defined in figure 1. The map shows location of Adula River and Mahalungi River in western upland Maharashtra. Both are tributaries of the Pravara River. They meet on left bank to the Pravara River near town Sangamner in Ahmednagar district of Maharashtra. Both rivers fall under rain shadow zones of Western Ghats. The highest elevations are found in western where both the rivers originate. The rivers gradually decrease their elevation to the eastward. Both the rivers flow towards east then they run towards south east and debouch into the Pravara River. The geology of the river is characterised be basalt rock. The terrain is dominated by erosion processes and depositional landscape is limited. Therefore, researchers have to depend on studies related to the elevation analyses. Therefore, topographic contours are helpful but for relatively flat terrain contours might not be useful. Digital Elevation Model like cartosat-1 has certain advantages. In this DEM every 30 meters there are elevation values. Therefore, we have used cartosat-1, 30-meter spatial resolution DEM. The river basins have tropical semi-arid type of monsoonal climate with characteristics of short rainy season followed by prolonged dry season. The region is characterised by escarpments, high hill slopes, bare surfaces, thin soil cover, sparse vegetation, isolated Badlands along lover reaches of the river and intensive agricultures activities along valley side. The basins are ideal geomorphologic laboratory for study of dry land geomorphology.

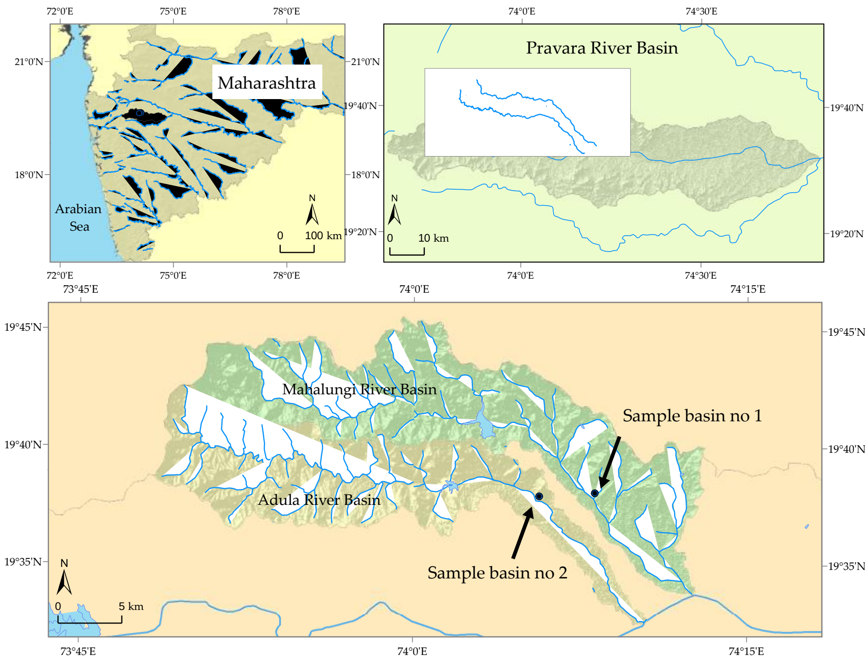

Figure 1 Location map of the study area.

Three-D diagram given in figure 2 gives three dimensional glimpses of the Adula river and the Mahalungi river. Both rivers express the significant elevation variations in three-D diagram. Both rivers show all characteristics of Mountain Rivers. It is visible in the figure 2 and further investigations are required to verify it.

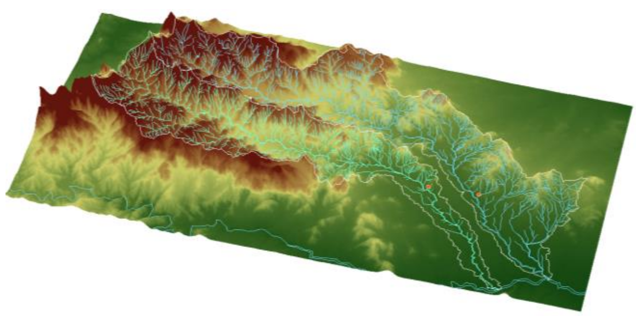

Figure 2 Three D view of Adula river and Mahalungi river.

RESEARCH OBJECTIVES

The research objectives of present research are- 1. To extract morphometric characteristics of Adula river basin and Mahalungi river basin. 2. To highlight similarities and dissimilarities in morphometric characteristic of both the river basins. 3. To draw conclusions on morphometric characteristics of both the river basins.

RESEARCH PROBLEM

The Deccan plateau is one of the significant landscapes in the peninsular India. There are many rivers flowing on Deccan Plateau shows significant geologic control. The Adula river and the Mahalungi river are two of them. They geographically and geologically look similar. We would like to verify how long they are similar. We have used morphometric parameters to check this similarity. This result will significantly help for further river basin management. The result will be helpful for the similar kind of rivers in the western upland Maharashtra.

LITERATURE REVIEW

Fractal dimension is one of the important parameters of morphometric analyses (Mandelbrot, 1967, 1975 and 1989). Recently many studies emerged on morphometric analyses. Minar et. Al (2016) have given overview on geomorphometry as a parametr for quantitative land surface analysis. Pike et. Al (2009) have given brief guide on geomorphometry. Digital geomorphometry is not usefull for drainage basin morphometry but it is usful with channel morphometry as well (Loczy et. Al 2009). Demoulin (2011) have integrated basin and river profile morphometry to understanding tectonic uplift. Taha et. al (2017) basin morphometry for flash flood haard onation using remote sensing and GIS techniques. Trauerstein (2012) have identified multiple controls on drainage basin morphometries in the western escarpment of the Peruvian Andes. Yalchin and Gul (2017) have used GIS based multi-criteria decision analysis approach for exploring geothermal resources for Arkarcay basin. Similarly, morphometry based comapriaion of river basin is also useful to compare the river basins. We have used novel approach to compare the river basin on morphometric parameters. The study is carried on Adula and Mahalungi river basin in Western Upland Maharashtra.

DATA, METHODOLOGY AND RESULTS:

Following two sections gives information on dataset, methodology and results on morphometric parameters of Adula River and Mahalungi River.

DATASETS:

We have utilized Cartosat-1 Digital Elevation Model (DEM) with 30-meter spatial resolution available from Bhuvan website. The DEM is freely available. This is one of important geospatial technology for morphometric analyses of the river basin. We have processed Cartosat-1 DEM with 30-meter spatial resolution in GIS software and detected watershed boundary, drainage network and further we have clipped DEM inside the watershed boundary of the River Adula and the River Mahalungi. Then we have calculated all the morphometric parameters given in the table 1 and table 3. We have also extracted stream order given in table 2 and table 4.

METHODOLOGY AND RESULTS ON MORPHOMETRIC PARAMETERS:

We have studied following morphometric parameters to understand morphometric characteristics of Adula and Mahalungi river basins. The area of river basins give contributing total flow accumulation in the river basin. The perimeter is another parameter of the river basin give the ruggedness of the river basin. It is called as watershed boundary expressed in kilometre. It also indicates the shape of the river basin. Length of the basin is important parameter in the calculation of the river basin elongation ratio. Schumm (1956) defined the basin length. According to Schumm (1956) elongation ratio is defined as the ratio of diameter of a circle of the same area as the basin to the maximum basin length. Miller (1953) introduced basin circulatory ratio and defined it as the ratio the basin area to the area of a circle having a circumference equal to the perimeter of the basin. Another morphometric parameter is the drainage density (D). It is simply the ratio of total channel segment lengths cumulated for all orders within a basin to the basin area. The maximum basin relief difference between highest point and the lowest point in the river basin. The relief ratio may be defined as the ratio between the total relief of a basin and the longest dimension of the basin parallel to the main drainage line (Schumm, 1956). According to Horton (1932) stream frequency means total number of streams in per square kilometres. Drainage texture is the relative spacing of drainage lines. It gives impression on lithology, infiltration capacity and relief aspect of the terrain. The infiltration number is the product of drainage density and stream frequency. Strahler (1953) defined bifurcation ration by multiplying the bifurcation ratio for each successive pair of orders by the total numbers of streams involved in the ratio and taking the mean of the sum of these values. The stream ordering is given by Horton but Strahler (1953) has given some modifications.

ADULA RIVER BASIN MORPHOMETRIC CHARACTERISTICS:

Table 1 represents morphometric parameters of Adula river basin. The area of the river basin is 222.50 sq.km., which shows it small river basin. The high length of perimeter is 140.08 km in relation to the area indicates, it is rugged terrain. The length of basin is high in relation to the area indicated it is elongated terrain. The elongation ratio is further indicating it is elongated basin both the values are low. The drainage density is moderate whereas basin relief is 846 meter which is very high. The relief ratio is 19.24 meters which is moderate. The stream frequency is 1.86 numbers per square kilometres. The stream frequency is high. Drainage texture is also very high. Infiltration numbers also very high. The mean bifurcation number is 4.95 which is also high. It also indicates the terrain is highly dissected and rugged. The basin stream order is 5 which moderated-to-high. It indicates the terrain is highly developed and evolved.

Morphometric Parameter	Value	Unit
Area in sq.km.	222.500435	Sq.km
Perimeter in km	140.0884773	km
length of basin	43.96	km
Elongation ratio	0.3829772	
Circularity ratio	0.142401864	
Drainage density	1.652801236	km/sq.km
Basin relief	846	Meter
relief ratio	19.24476797	Meter
stream frequency	1.86	number/sq.km
drainage texture	2,955275181	
infiltration number	1.125767847	
mean bifurcation ratio	4.953184592	
stream order	5th	order

Table Morphometric parameters of the Adula river basin.

Table 2 gives information on stream orders, respective streams numbers and bifurcation ratio of Adula river basin. It also gives information on length of all rivers in given basin in kilometres. The table is useful to calculate the mean bifurcation ratio and drainage density. It is also helpful to understand distribution of the distribution of number of streams in the various orders. From given table it can be understood that first order streams are high in number and they rapidly decrease as order decrease. Total numbers of streams are very high in number and they are well distributed. The distribution of streams indicates that the terrain is fully developed and well evolved.

Order	number	ratio
1	323	4.681159
2	69	3.631579
3	19	9.5
4	2	2
5	1	
Stream length	367.749	km

Table 1 Table of Stream orders and respective stream numbers of Adula river basin.

The scatter plot and trend line in figure 3 shows steam order and respective stream numbers. The correlation is 0.672, which is moderate. The scatter pot indicates that first order streams are in high numbers in proportion to the other orders. That means terrain in highly dissected in upper reach than lower reaches that is why the points in scatter gram are mostly away from the trend line. The river is 5th order river. This order indicated that the terrain is fully evolved.

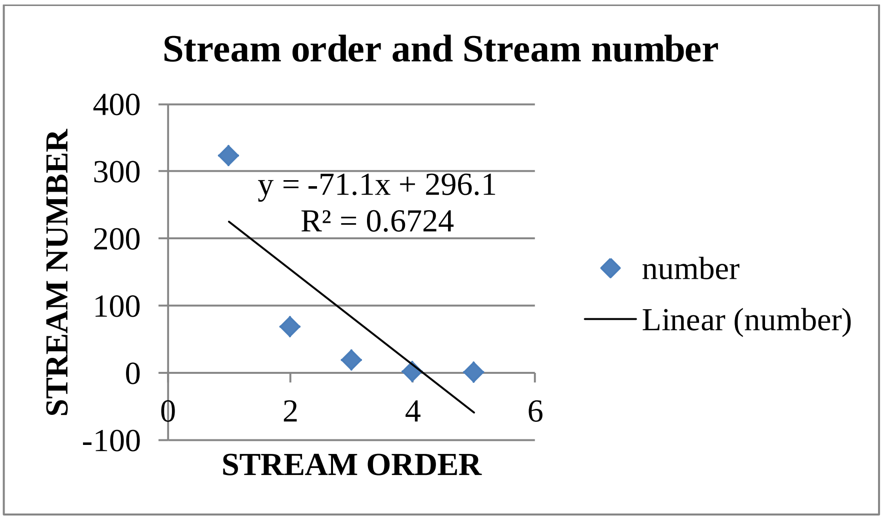

Figure 3 Scatter gram, regression and correlation coefficient for Adula River basin.

MAHALUNGI RIVER BASIN MORPHOMETRIC CHARACTERISTICS:

Table 3 gives morphometric characteristics of Mahalungi river basin. The area of river basin is 286.10 square kilometre. The value indicates it is smaller size river basin. But it is suitable for extensive morphometirc analyses. The perimeter of river basin is 138.80 km. The high perimeter in comparison to the total area indicated that the basin is dissected and fully developed. The basin length (44.45 km) and elongation ratio (0.42) indicate that the basin is elongated. The circularity ratio value is 0.186, which indicates that the basin is not circular. The drainage density is 1.18 km/sq.km, which is moderate. The basin relief is 822 metres. The high basin relief indicates high erosion power of the river, resulting into the high sediment load in such a small river basin. It indicates that Mahalungi river basin is having very high channel slope. The relief ratio is 18.49 meter which is also high. The stream frequency is 1.066 umber/sq. km. This value is also high. The drainage texture is 2.197 that indicated drainage spacing in the river basin is not high. The density of the streams is very high. The infiltration number is 0.901 which is high. The mean bifurcation ratio is very high. The mean bifurcation ratio value is 9.72449. It indicates that erosion process is very high in Mahalungi river basin. The total stream numbers are high number. The landscape is erosion prone. The river is 4th order in the stream order.

Morphometric Parameter	Value	Unit
Area in sq.km.	286.1015225	Sq.km
Perimeter in km	138.808	km
length of basin	44.453	km
Elongation ratio	0.429461445	
Circularity ratio	0.18650085	
Drainage density	1.182429919	km/sq.km
Basin relief	822	Meter
relief ratio	18.4914404	Meter
stream frequency	1.066055145	number/sq.km
drainage texture	2.197279696	
infiltration number	0.901579982	
mean bifurcation ratio	9.724494189	
stream order	4th	order

Table 2 Morphometric parameters of the Mahalungi river basin.

The table 4 is stream order table of the Mahalungi river basin. It gives information of order of the river with respective stream numbers, bifurcation ratio and stream length in kilometre. It can be seen from the table that total stream segments are 305. It indicates that the terrain is highly dissected. The stream numbers are proportionally distributed. There is uniformity in the distribution. The table is used in the calculation of bifurcation ratio and to understand stream order and stream number relation.

Order	number	ratio
1	180	1.782178
2	101	4.391304
3	23	23
4	1	
Total	305	29.17348
Stream length in km	338.295	km

Table 3 Table of Stream orders and respective stream numbers of Mahalungi river basin.

The scatter plot and trend line in figure 4 shows, stream order and stream number relation in Mahalungi river basin. The trend line shows association between these two parameters. The points are very close to trend line and correlation is 0.95, which is very high. It also indicates that drainage network is proportionally well developed throughout all stream orders.

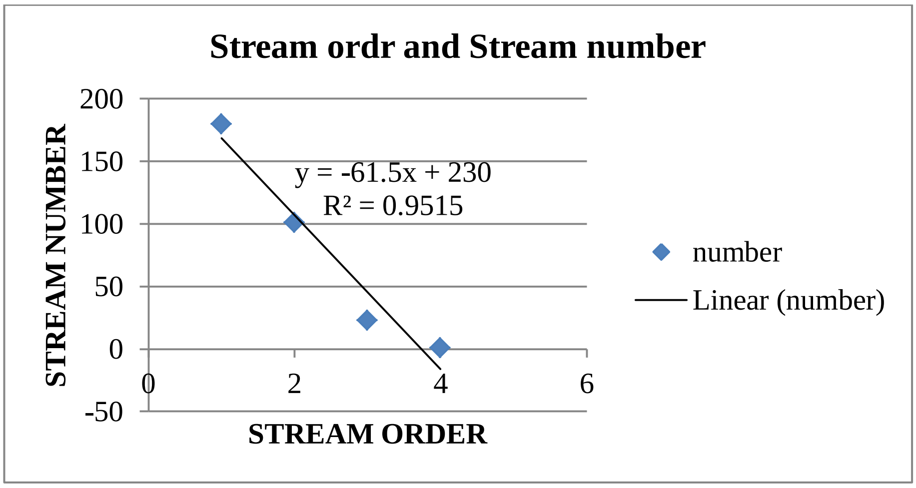

Figure 4 Scatter gram, regression and correlation coefficient of Mahalungi river basin.

DISCUSSION AND CONCLUSION

This study is carried out to highlights similarities and differences in the Adula river basin and Mahalungi river basin from morphometric perspectives.

The result indicates that the rivers look similar on the map, they have same geographical and geomorphologic setup and they show similarities and differences in many aspects from perspective of morphometric analysis. Following differences and similarities can be highlighted from table 1 and 3 of the morphometric parameters of the Adula River and the Mahalungi River. The Mahalungi river basin is quite larger than Adula river basin but the perimeter of both the river is almost the similar. Basin length of both the river is also same. There are small differences in elongation ratio and circularity ratio. Drainage density is high in Adula river basin than Mahalungi river basin. Further basin relief and relief ratio are almost same in both the river basin. Stream frequency is considerable high in Adula river basin than Mahalungi river basin. Drainage texture and infiltration number is also high in Adula river basin than Mahalungi river basin. The considerable differences can be seen in mean bifurcation ratio. The mean bifurcation of Mahalungi river basin is very high with compare to Adula river basin. The Adula river basin is one order higher than Mahalungi river basin. Therefore, it can be concluded that the Adula river basin have all the morphometric parameters higher than Mahalungi river basin except area and mean bifurcation ratio. The high area resulted into the high mean bifurcation ratio. The lower area but similar characteristics resulted Adula river basin into the high energy and high stream power river basin. Further studies along with morphometric analysis on land use land cover in both the river basin would be interesting.

REFERENCES:

1. Demoulin, A. (2011). Basin and river profile morphometry: A new index with a high potential for relative dating of tectonic uplift. *Geomorphology*, *126*(1), 97–107. https://doi.org/https://doi.org/10.1016/j.geomorph.2010.10.033
2. Horton, R. E. (1932). Drainage-basin characteristics. *Eos, Transactions American Geophysical Union*, *13*(1), 350–361. https://doi.org/https://doi.org/10.1029/TR013i001p00350
3. Lóczy, D., Kis, É., & Schweitzer, F. (2009). Local flood hazards assessed from channel morphometry along the Tisza River in Hungary. *Geomorphology*, *113*(3), 200–209.

https://doi.org/https://doi.org/10.1016/j.geomorph.2009.03.013

4. Mandelbrot, B. B. (1967). How long is the coastline of Britain? Statistically self-similarity and fractal dimensions. *Science*, *156*, 636–638.
5. Mandelbrot, B. B. (1975). Stochastic models for the Earth's relief, the shape and fractal dimension of coastlines and number area rule for islands. *National Academy of Sciences of the United States of America*, 72: 3825-3828-72: 3825-3828.
6. Mandelbrot, B. B. (1989). Fractal Geometry: What it is, what does it do? *Royal Society A*, 423: 3-16.
7. Miller, V. C. (1953). *A Quantitative Geomorphic Study of Drainage Basin Characteristics in the Clinch Mountain Area. , Proj. NR, Technical Repor*.
8. Minár, J., Krcho, J., & Evans, I. S. (2016). Geomorphometry: Quantitative Land-Surface Analysis☆. In *Reference Module in Earth Systems and Environmental Sciences*. Elsevier. https://doi.org/https://doi.org/10.1016/B978-0-12-409548-9.10260-X
9. Pike, R. J., Evans, I. S., & Hengl, T. (2009). Chapter 1 Geomorphometry: A Brief Guide. In T. Hengl & H. I. Reuter (Eds.), *Geomorphometry* (Vol. 33, pp. 3–30). Elsevier. https://doi.org/https://doi.org/10.1016/S0166-2481(08)00001-9
10. STANLEY A SCHUMM. (1956). EVOLUTION OF DRAINAGE SYSTEMS AND SLOPES IN BADLANDS AT PERTH AMBOY, NEW JERSEY. *GSA Bulletin*, *67(5)*, 597–646.
11. Strahler, A. (1953). Revision of Hortons' Quantitative Factors in Erosional Terrain. *Transactions, American Geophysical Union*, *34*, 345–365.
12. Taha, M. M. N., Elbarbary, S. M., Naguib, D. M., & El-Shamy, I. Z. (2017). Flash flood hazard zonation based on basin morphometry using remote sensing and GIS techniques: A case study of Wadi Qena basin, Eastern Desert, Egypt. *Remote Sensing Applications: Society and Environment*, *8*, 157–167. https://doi.org/https://doi.org/10.1016/j.rsase.2017.08.007
13. Trauerstein, M. (2012). Multiple controls on drainage basin morphometries in the Western Escarpment of the Peruvian Andes. *Quaternary International*, *279–280*, 500. https://doi.org/https://doi.org/10.1016/j.quaint.2012.08.1710

14. Yalcin, M., & Kilic Gul, F. (2017). A GIS-based multi criteria decision analysis approach for exploring geothermal resources: Akarcay basin (Afyonkarahisar). *Geothermics*, *67*, 18–28. https://doi.org/https://doi.org/10.1016/j.geothermics.2017.01.002