July to Dec 2021

Peer Reviewed International Research Journal of Geography

Maharashtra Bhugolshastra Sanshodhan Patrika

MBP Vol-38 No.2, July-Dec 2021
(ISSN: 0971-6785) Impact Factor 4.567 Renew(IIFS)

महाराष्ट्र भूगोलशास्त्र संशोधन पत्रिका

Maharashtra Bhugolshastra Parishad
महाराष्ट्र भूगोलशास्त्र परिषद
www.mbppune.org.in

Peer Reviewed International Research Journal of Geography

Maharashtra Bhugolshastra Sanshodhan Patrika

MBP-Vol-38,No.2, July-Dec 2021

(ISSN: 0971-6785) Impact Factor 4.567 Renew(IIFS)

International Research Journal of Geography
Maharashtra Bhugolshastra Sanshodhan Patrika
ISSN : 0971-6785 (Impact Factor 4.567 Renew (IIFS)) Vol. 38, No.2, July-Dec 2021, pp 88-94

Morphometrical analysis of Pedhi River Basin Using GIS

Anand Rameshrao Dhote

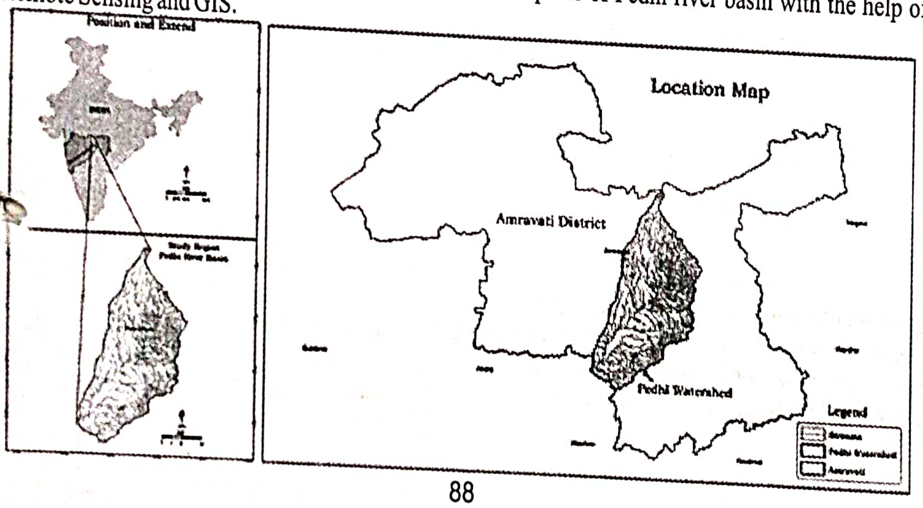
Abstract

In the present paper, an attempt has been made to study the quantitative geomorphology of Pedhi river basin it is sub-basin of Purna river of Maharashtra, India. Authors have evaluated the morphometric characteristics based on Survey of India toposheets at 1:50,000 scale, and LISS III image. GIS and image processing techniques were adopted to identify the morphological features and to analysis their properties. Various morphometric parameters like linear and aerial aspects of the river basin were determined and computed. The results indicated that the drainage area of basin is 1460.30 Km2, perimeter 187.78Km, basin length 71.05 Km, stream order of the basin is up to Six order, stream length 2226.71Km., stream segments are 2027, Sinuosity Index is 1.41, Stream length ratio, mean Stream length, bifurcation Ratio, mean bifurcation ratio, is computed. Areal aspects are drainage density 1.53, stream frequency 1.39, texture ratio 10.79, elongation ratio 0.34, circulatory ratio 0.52, form factor 0.29, constant of channel maintenance 0.656 also computed. All the linear and areal parameters of the basin indicate gentle slope, with highly permeable bedrock. The relief ratio of the basin characterizes less resistant rocks. The outcomes thus generated equip us with significant knowledge and may provide an input that is essential in decision making for watershed planning and drainage development of the watershed.

Key words: *Quantitative geomorphology, Image processing techniques, Morphometric parameters.*

1.0 Introduction:

'Morphometry may be defined as the measurement and mathematical analysis of the configuration of its earth's surface and the shape and dimension of it landforms'(J.I.Clarke1970). A major emphasis in geomorphology over the past several decades has been on the development of quantitative physiographic methods to describe the evolution and behavior of surface drainage networks (Horton, 1945).Morphometric analysis of a watershed provides a quantitative description of the drainage system, which is an important aspect of the characterization of watersheds (Strahler, 1964). Remote sensing and GIS techniques are now a day used for assessing various terrain and morphometric parameters of the drainage basins and watersheds, as they provide a flexible environment and a powerful tool for the manipulation and analysis of spatial information. In present study an attempt was made to analysis liner and areal aspects of Pedhi river basin with the help of Remote Sensing and GIS.



Pedhi is an important
of Riddhapur 380 me
and the west, the chie
course passing by W
westwards and north-
journey outside the A

Study Region:

The Pedhi w
drainage basin of Am
latitude and 77°28' to
975 mm. The soils of
possess clayey texture

Objective: The main
the basin.

Objective: The main
the basin.

Materials And Meth
Data and Methodolo

In Present pa
55 H/5, and 9 and LISS
Attributes of various
basins are computed
through measurement
No. 1.

Sr. No.	Pa
1	Stre
2	Strea
3	Strea
4	Mean (Lsm
5	Strea Ratio
6	Bifurc (Rb)

Sr. No.	Parameter	Formula	Reference
7	Mean Bifurcation Ratio (Rbm)	Rbm = Average of bifurcation ratio of al order.	Strahler (1957)
		Areal Aspects	
9	Drainage Density (Dd)	D = —/A Where, D = Drainage density Lu = Total Stream Length of all orders A = Area of the basin (sq. km.)	Horton (1945)
10	Stream Frequency (Fs)	Fs = —/A Where, Fs = Stream Frequency Nu = Total Number of Streams of all order sA = Areal of the basin (Sq.km)	Horton (1945)
11	Texture Ratio (Rt)	Rt = —/P Where, Rt = Texture Ratio Nu = Total Number of Streams of all order s, P = Perimeter (km)	Horton (1945)
12	Elongation Ratio (Re)	Re = $\sqrt{A}$/— Where, Re = Elongation Ratio A = Area of the basin (Sq.km) π = 'Pi' value 3.14 Lb = Basin Length	Schumm (1956)
13	Circulatory Ratio (Rc)	Rc = —/2 Where, Rc = Circulatory Ratio π = 3.14, A = Area of the basin(Sq.km) P_2 = Square of the perimeter (km)	Miller (1953)
14	Form Factor (Ff)	Ff = A/— Where, Rf = Form Factor, A = Area of the basin(Sq.km) Lb_2 = Square of basin Length.	Horton (1945)

Results and Discussion

The various morphometric parameters such as liner and areal of the Pedhi river basin area were determined and are summarized in Tables No.1 and 2.

The linear aspects of drainage network

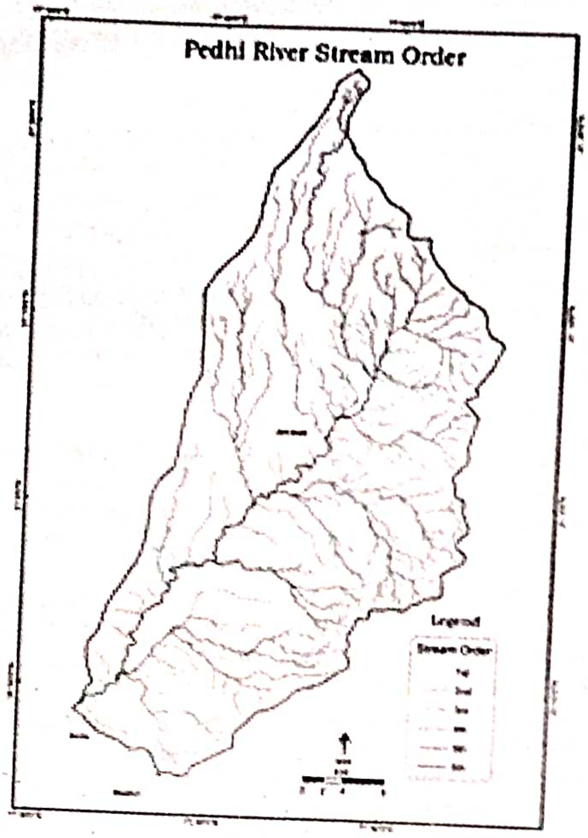
The linear aspects of drainage network such as stream order (Nu), stream number (Nu), stream length (Lu), Mean stream length (km) (Lsm), Stream length ratio (RL), Bifurcation ratio (Rb), Mean bifurcation ratio (Rbm) result have been presented in the Table No.1

Stream Order (Nu):

Table No. 1 Liner aspect of Pedhi river basin

River Basin	Stream Oreder	Stream number (Nu)	Stream length In km.(Lu)	Log Nu	Log Lu
Pedhi River Basin	1	1522	1173.72	3.070	3.070
	2	364	508.24	2.706	2.706
	3	100	279.63	2.447	2.447
	4	34	159.83	2.204	2.204
	5	6	32.91	1.517	1.517
	6	1	72.39	1.860	1.860

Bifurcation Ratio (R_b)					Mean bifurcation ratio (R_{bm})
1st order/ 2ed order	2ed order/ 3ed order	3ed order/ 4th order	4th order/ 5th oSrder	5th order/ 6th order	
2.309	1.818	1.750	4.856	0.455	2.240



Stream Order (Nu):

In the drainage basin analysis the first step is to determine the stream orders. 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 1. Where two first order channels join, a channel segment of order 2 is formed; where two of order 2 join, a segment of order 3 is formed; and so forth. The trunk stream through which all discharge of water and sediment passes is therefore the stream segment of highest order. The study area is a 6th stream order of the basin. Map No. 3

Stream Number (Nu):

The law of stream numbers relates to the definite relationship between the orders of the basins and stream numbers. Inverse correlation in stream order and stream number, as the order of stream is increase number of stream is decrease. In study area highest numbers of streams are in the 1st order (1522), in 2ed it is 364, in 3rd it is 100, in 4th it 34 and in 5th it is 36 6th is one decrease as the order is decrease.

Stream Length (Lu):

Stream length is one of the most significant hydrological features of the basin as it reveals surface runoff characteristics streams of relatively smaller lengths are characteristics of areas with larger slopes and finer textures. Longer lengths of streams are generally indicative of flatter gradients, Generally, the total length of stream segments is maximum in first order streams and decreases as the stream order increases. The number of streams of various orders in the basin is counted and their lengths from mouth to drainage divide are measured with the help of GIS Software. Plot of the logarithm of stream length versus stream order (Figure 4b) showed the linear pattern which indicates the homogenous rock material subjected to weathering erosion Characteristics of the basin. Deviation from its general behavior indicates that the terrain is characterized by variation in lithology and topography. In study area number of stream is decrease as the order of the stream is increase.

Bifurcation Ratio (Rb):

The term bifurcation ratio (Rb) is used to express the ratio of the number of streams of an given order to the number of streams in next higher order (Schumn, 1956). Bifurcation ratios characteristically range between 3.0 and 5.0 for basins in which the geologic structures do notdistort the drainage pattern (Strahler, 1964). Strahler (1957) demonstrated that bifurcation ratio shows a small range of variation for different regions or for different environment dominates. The mean bifurcation ratio value is 2.240 for the study area (Table 2) which indicates that the geological structures are less disturbing the drainage pattern.

Areal Aspects of the Drainage Basin

Area of a basin (A) and perimeter (P) are the important parameters in quantitative morphology. The area of the basin is defined as the total area projected upon a horizontal plane contributing to cumulate of all order of basins. Perimeter is the length of the boundary of the basin which can be drawn from topographical maps. The aerial aspects of the drainage basin such as drainage density (D), stream frequency (Fs), texture ratio (T), elongation ratio (Re), circularity ratio (Rc) and form factor ratio (Rf) were calculated and results have been given in Table 3.

Drainage Density (D)

Horton (1932) introduced that the drainage density (D) is an important indicator of the linear scale of landform elements in stream-eroded topography. Drainage densities can range from less than 5 Km/Km2 when slopes are gentle, rainfall low, and bedrock permeable (e.g. sandstones), to much larger values of more than 500 Km/Km2 in upland areas where rocks are impermeable, slopes are steep, and rainfall totals are high (Huggett, 2003). The drainage density (D) of the study area is 1.53 Km/Km2. In the present study, the density falls less than 5 Km/Km2, which indicates that the area has a gentle slope, moderate rainfall and permeable bedrock.

Table 3: Aerial aspects of the study area

Sr. No.	Morphometric Parameters	Result
1	Drainage density (D) (km/km2)	1.53
2	Stream frequency (Fs)	1.39
3	Texture ratio (Rt)	10.79
4	Elongation Ratio (Re)	0.34
5	Circulatory ratio (Rc)	0.52
6	Form factor (Rf)	0.29

Stream Frequency (Fs):

Stream frequency or channel frequency (Fs) is the total number of stream segments of all orders per unit area (Horton, 1932). It exhibits positive correlation with drainage density in the watershed indicating an increase in stream population with respect to increase in drainage density. The stream frequency value of the basin is 1.39

Stream Length (Lu):

Stream length is one of the most significant hydrological features of the basin as it reveals surface runoff characteristics streams of relatively smaller lengths are characteristics of areas with larger slopes and finer textures. Longer lengths of streams are generally indicative of flatter gradients. Generally, the total length of stream segments is maximum in first order streams and decreases as the stream order increases. The number of streams of various orders in the basin is counted and their lengths from mouth to drainage divide are measured with the help of GIS Software. Plot of the logarithm of stream length versus stream order (Figure 4b) showed the linear pattern which indicates the homogenous rock material subjected to weathering erosion Characteristics of the basin. Deviation from its general behavior indicates that the terrain is characterized by variation in lithology and topography. In study area number of stream is decrease as the order of the stream is increase.

Bifurcation Ratio (Rb):

The term bifurcation ratio (Rb) is used to express the ratio of the number of streams of an given order to the number of streams in next higher order (Schumn, 1956). Bifurcation ratios characteristically range between 3.0 and 5.0 for basins in which the geologic structures do notdistort the drainage pattern (Strahler, 1964). Strahler (1957) demonstrated that bifurcation ratio shows a small range of variation for different regions or for different environment dominates. The mean bifurcation ratio value is 2.240 for the study area (Table 2) which indicates that the geological structures are less disturbing the drainage pattern.

Areal Aspects of the Drainage Basin

Area of a basin (A) and perimeter (P) are the important parameters in quantitative morphology. The area of the basin is defined as the total area projected upon a horizontal plane contributing to cumulate of all order of basins. Perimeter is the length of the boundary of the basin which can be drawn from topographical maps. The aerial aspects of the drainage basin such as drainage density (D), stream frequency (Fs), texture ratio (T), elongation ratio (Re), circularity ratio (Rc) and form factor ratio (Rf) were calculated and results have been given in Table 3.

Drainage Density (D)

Horton (1932) introduced that the drainage density (D) is an important indicator of the linear scale of landform elements in stream-eroded topography. Drainage densities can range from less than 5 Km/Km2 when slopes are gentle, rainfall low, and bedrock permeable (e.g. sandstones), to much larger values of more than 500 Km/Km2 in upland areas where rocks are impermeable, slopes are steep, and rainfall totals are high (Huggett, 2003). The drainage density (D) of the study area is 1.53 Km/Km2. In the present study, the density falls less than 5 Km/Km2, which indicates that the area has a gentle slope, moderate rainfall and permeable bedrock.

Table 3: Aerial aspects of the study area

Sr. No.	Morphometric Parameters	Result
1	Drainage density (D) (km/km2)	1.53
2	Stream frequency (Fs)	1.39
3	Texture ratio (Rt)	10.79
4	Elongation Ratio (Re)	0.34
5	Circulatory ratio (Rc)	0.52
6	Form factor (Rf)	0.29

Stream Frequency (Fs):

Stream frequency or channel frequency (Fs) is the total number of stream segments of all orders per unit area (Horton, 1932). It exhibits positive correlation with drainage density in the watershed indicating an increase in stream population with respect to increase in drainage density. The stream frequency value of the basin is 1.39

Texture Ratio (T):

Texture ratio (T) is an important factor in the drainage morphometric analysis which depends on the underlying lithology, infiltration capacity and relief aspect of the terrain. In the present study the texture ratio of the basin is 10.79 which falls within the fine drainage texture.

Drainage texture can be classified into four categories viz:

i) Coarse drainage texture : < 4
ii) Intermediate drainage texture : 4 - 10
iii) Fine drainage texture : 10-15
iv) Ultra fine drainage texture : > 15

Elongation Ratio(Re):

Elongation ratio is a very significant index in the analysis of basin shape which helps to give an idea about the hydrological character of a drainage basin. The elongation ratio varies from 1.275 when the basin shape is a circle, to 1.128 when it is a square, and decreases in proportion to increasing elongation, reaching a minimum of approximately 0.200. The results of the present study indicated a value of 0.34 which indicate elongation of the basin.

Circularity Ratio(Rc):

Miller (1953) defined a dimensionless circularity ratio (Rc) as the ratio of basin area to the area of circle having the same perimeter as the basin. Circulatory ratio of the present study area is 0.52. The ratio is equal to unity when the basin shape is a perfect circle, decreasing to 0.785 when the basin is a square, and continues to decrease to the extent to which the basin becomes elongated, Miller (1953).

Form Factor Ratio (Rf)

The form factor will be comparatively higher, if the basin is wider. Consequently, much narrower basins have low form factor values. The low form factor is indicated in the elongated basin and high form factor is indicated in the wider basin (Gregory & Walling, 1985). The calculated value of form factor for the catchment is 0.29 Sparse to dense vegetation along with some current jhumming, gentle to moderately steep slope and low to high relief characterize the low value of form factor. Form factors greater than unity are considered as anomaly in the basin shape. The value indicates narrow and elongated basin.

Conclusion:

Morphomatric analysis of Pedhi river basin shows 1st to 6th order of stream,and it is passing through an early mature stage to old stage of the fluvial geomorphic cycle. The basin shows dendritic type drainage pattern. The larger number of first order streams points to uniform lithology and noble slope gradient. Lower value of bifurcation ratio indicates that the drainage of Pedhi river basin is underlined by uniform materials and the streams are usually branched systematically. The drainage density of the Pedhi river basin is 1.53 Km/Km2. It is less than 5 Km/Km2, which indicates that the basin has a gentle slope, moderate to low relief. Texture ratio of basin falls within the fine drainage texture. elongation ratio and circularity index and form factor shows that the basin is elongated shaped. For the analysis of morphomatric parameters topographical maps and LISS III image are used and this types of analysis is very useful for watershed planning and management.

Reference:

1. Chougale S. Jagdish B. Sapkale (2017): Morphometric Analysis of Kadvi River basin, Maharashtra Using Geospatial Techniques. Current World Environment, Vol. 12, No. (3) 2017, Pg. 635-645.
2. Horton, R.E.(1945):" Erosional development of streams and their drainage basins: Hydrophysical approach to Quantitative morphology". Bull. Geol. Soc. Am. Vol. 56 pp. 275-370. In Olav Slaymaker (2004) (ed.) Fluvial geomorphology, Routledge, USA and Canada.
3. Joji V. S., Nair A. S. K., Baiju K. V.(2013): "Drainage Basin Delineation and Quantitative Analysis of Panamaram Watershed of Kabani River Basin, Kerala Using Remote Sensing and GIS". Journal Geological Society of India, Oct. 2013, Vol. 82,

4 Kale, V.S. and Gupta, A. (2001): Introduction to Geomorphology. New Delhi, Orient Longman. Random channel networks. J Geol 77:397–414.

Mishra A., Dubey D.P. and Tiwari R. N. (2011): Morphometric Analysis of Tons basin, Rewa district, Madhya Pradesh, based on watershed approach. Earth Science India, Vol 3(III) July, 2011pp 171-180.

5 M. Rudraiah, S. Govindaiah, S. Srinivas Vittaia (2008): Morphometry using Remote Sensing and GIS Techniques in the Sub-Basins of Kagna River Basin, Gulburga District, Karnataka, India. J. Indian Soc. Remote Sens. (December 2008) 36:351–360.

6 Nag S. K. and Lahiri A. (2011): Morphometric analysis of Dwarakeswar watershed, Bankura District, West Bengal, India, using spatial information technology. International Journal of Water Resources and Environmental Engineering Oct 2011, Vol. 3 (10) 2011.

7 Nageswara Rao.K, Swarna Latha.P, Arun Kumar.P, Hari Krishna.M (2010): Morphometric Analysis of Gostani River Basin in Andhra Pradesh State, India Using Spatial Information Technology, International Journal of Geomatics and Geosciences, Volume 1, No 2, 2010.

Nimkar A.M., Despande S. B., Babrekar P. G.,(1992): Evaluation of Salinity Problem in Swell-Shrink Soils of a Part of the Purna Valley, Maharashtra.

8 Nisha Sahu, G. P. Obi Reddy, Nirmal Kumar, M. S. S. Nagaraju, Rajeev Srivastava, S. K. Singh(2017)'Morphometric analysis in basaltic Terrain of Central India using GIS techniques: a case study'. Appl Water Sci (2017) 7:2493–2499.

9 Olav Slaymaker (2004) (ed.) Fluvial geomorphology, Routledge, USA and Canada.

Pareta K., Pareta Upasana (2012): Quantitative Geomorphological Analysis of a Watershed of Ravi River Basin, H.P. India. International Journal of Remote Sensing and GIS. Vol. 1, Issue 1, pp 41-56.

10 Pisal P.A., Yadav A. S., Chavan A. B. (2013): Morphometric analysis of Bhogavati river basin, Kolhapur district, Maharashtra, India. Journal of Mechanical and Civil Engineering, pp 01-08.

11 Praveen Kumar Rai, Kshitij Mohan, Sameer Mishra, Aariz Ahmad, Varun Narayan Mishra (2017)" A GIS-based approach in drainage morphometric analysis of Kanhar River Basin, India". Appl Water Sci (2017) 7:217–232.

12 Rao Liaqat A. K., Ansari Ziaur Rehman and, Yusuf Alia (2011): "Morphometric Analysis the geohydrological characteristics of four sub-watersheds of Etmadpur area of Agra district, Uttar Pradesh" Volume 1 Issue 2, October 201.

13 Praveen Kumar Rai, Prafull Singh, Varun Narayan Mishra, Anisha Singh, Bhartendu Sajan, and Arjun Pratap Shah. (2019)" Geospatial Approach for Quantitative Drainage Morphometric Analysis of Varuna River Basin, India". Journal of Landscape Ecology (2019), Vol: 12 / No. 2.

14 Strahler AN (1950): "Equilibrium theory of erosional slopes approached by frequency distribution analyses." Am. J. Sci. 248:673-696, pp 800-814.

15 Thakur, B.R.(2006): 'Quantitative analysis of Solani watershed using remote sensing and GIS techniques' Punjab Geographer, vol-1, no.2 october 2006, pp.85-98.

16 Thakurdesai S.C., Pise S.K.(2016):" A Study of Relief and Slope of Upper Kundalika River Basin, Raigad, Maharashtra." International Journal of Interdisciplinary Research in Science Society and Culture(IJIRSSC) Vol: 2, Issue:1, (June Issue), 2016.

***Anand Rameshrao Dhote**
Department of Geography,
Yuvashakti Arts and Science College Amravati