Journal of Science and Technology

ISSN: 2456-5660 Volume 06, Issue 05, SEP-OCT 2021

www.jst.org.in *DOI: https://doi.org/10.46243/jst.2021.v6.i05.pp71-81*

Morphometric Analysis of Ur Basin of Tikamgarh District, Madhya Pradesh by Using GeoSpatial Technique

Vineesha Singh

Department of Earth Sciences, Barkatullah University, Bhopal

*Corresponding Author:vineeshabu17@gmail.com

To Cite this Article

*Vineesha Singh, "**Morphometric Analysis of Ur Basin of Tikamgarh District, Madhya Pradesh by Using GeoSpatial Technique**", Journal of Science and Technology, Vol. 06, Issue 05, Sep-Oct 2021, pp71-81.*

Article Info

Received: 05.10.21 *Revised: 07.10.21* *Accepted: 10.10.2021* *Published: 12.10.2021*

I. Abstract:

Geospatial technique is a integration of Remote Sensing (RS),Geographic Information System (GIS)and GPS Tools are most appropriate, cost effective and quick technique for estimation of morphometric properties over traditional methods. Geographical Information System (GIS) methods are now-a-days in usage for evaluating several terrain and morphometric parameters of the drainage basins. It is also well observed that remote sensing satellite data is emerging as the most effective, time saving and accurate technique for morphometric analysis of a basin. This technique is found relevant for the extraction of Ur river basin and its stream networks through SRTM (Shuttle Radar Topography Mission (DEM) in con-junction with remote sensing satellite data (Landsat 8, 2017 and georeferenced survey of Indian toposheet). Ur Basin is a tributaries of Dhasan River has been selected for morphometric analysis. The morphometric analysis of basin has been carried out using GIS softwares.The drainage network of Ur Basin was delineated using remote sensing data. Morpho-metric parameters viz; stream order, stream length, bifurcation ratio, drainage density, stream frequency, form factor, circulatory ratio, etc., are calculated. The drainage area of the basin is 1500.27 km^2 and shows sub-dendritic to dendritic drainage pattern. The stream order of the basin is mainly controlled by physiographic and lithological conditions of the area. The study area is designated as 7^{th} order basin with the drainage density value being as 1.72 km/km^2. The increase in stream length ratio from lower to higher order shows that the study area has reached a mature geomorphic stage.

Keywords: Morphometry parameters, Stream Order, SRTM, DEM, Geoprocessing.

II. Introduction

Morphometry is the quantitative and systematic analysis of the land forms of the earth surfaces. The quantitative analysis of drainage system is an important aspect of river basin characteristics. Generally Morphometric parameters derived from different sources viz. Survey of India topographic map (1:50,000), SRTM (Shuttle Radar Topographic Mission 30 m) and from DEM data. In India drainage and morphometric characteristics of many river basins have been studied using conventional methods[1,2,3,4,5,6].The morphometric studies involve the evaluation of stream parameters through the measurements of various stream properties[3].The morphometric parameters were categorized in to three Categories ie. Linear parameters, Areal parameters and Relief parameters. Drainage pattern provides information on the topography and underlying geological structures[7].Human induced alteration of the natural landscape since long time by means of urbanization, agriculture and natural vegetation has resulted in removal and replacement of natural vegetation and land cover with numerous human-induced practices of altered structure. As a result of which there is visible difference between old and new land-use & land-cover patterns which are composed of both the natural and human-induced environments[4,8,9].The different morphometric characteristics like linear parameters, areal or basin parameters and relief parameters are important for any river basin management and the variations in linear, areal, relief parameters within drainage were examined by computing and assessing morphometric parameters which outline the topographical, geological and hydrological states of watershed[10,11,12,13]. Many authors found remote sensing and GIS as an efficient tool to understand the morphometric behavior of any plain topographical area, groundwater delineation[14,15,16,11,12].Morphometric analysis of streams is an important aspect for characterization of watershed. Proper planning and management of watershed is very necessary for sustainable development[11,8].GIS technique are effectively used in recent times in determining quantitative description of basin geometry i.e., morphometric analysis. GIS provides an excellent means of storing, retrieving, manipulating and analysing geo-referenced drainage information[17,12,].

III. Objective of the study

The objective of the present study was to evaluate the linear, areal and relief morphometric characteristics of Ur river basin. To extract and delineate drainage morphometric characteristics (Linear, Aerial and Relief from the DEM, Analyse the linear, areal and relief aspects of the study area, Bring out the form and processes, and Finally assess the morphometric characteristics of the Ur river basin. Important Basin morphometric characteristics included in the study are: Area of watershed, perimeter, Bifurcation ratio, Elongation ratio,Circulatory ratio, Form factor, Stream order, Drainage density, Average slope of watershed, Drainage texture, Constant channel maintenance etc. On the basis morphometric analysis: (1). To understand the morphometric characteristics & behavior of the river basin. (2). To identify the hierarchical orders of the streams, their Length & nature (3). To analysis the various aspect like Basin Geometry,shape,Darinage texture of the Ur basin.

IV. Study Area

The Ur river is the tributary of the Dhasan river. This Ur river falls in the North East part of the Tikamgarh district.This catchment area of Ur River occupies the 30% of the total area of Tikamgarh district(Fig. 1). The study covers an area of about 1500.27sq.km. lying between 78º 48' E to 79º 20' E longitude and 24º35'N to 25º12' N latitude in Survey of India toposheet (Fig. 2).The study area is situated in between the 413 to 168 m. a msl. Mostly the drainage pattern is sub- dendritic to dendritic.

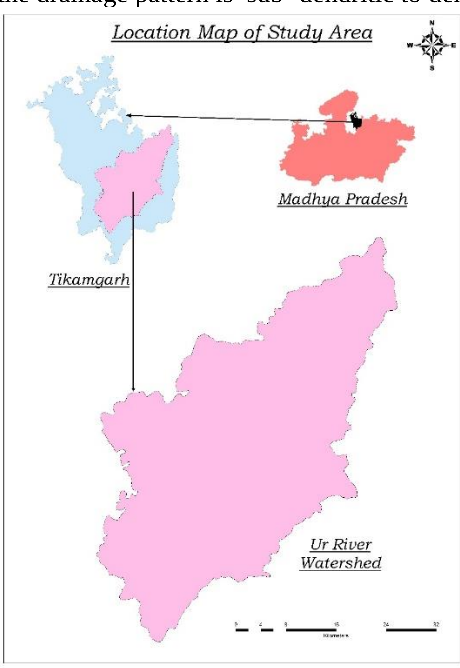

Fig 1. Location map of the Study area

Fig 2. Location of Ur Basin in the Tikamgarh district

V. Materials and Methods

In the study topographic map of survey of India of year 2003 and Landsat data 2017.These topographic maps were georeferenced and rectified in the Arc GIS software 10.3 Downloaded images are stacked and subset study area from AOI area of interest layer. The drainage extraction and stream ordering are done by ARC GIS-10.3. for Morphometric analysis..The Digital Elevation Model (DEM) has been generated from freely available Shuttle Radar Topography Mission (SRTM) 3 Arc second (30 meter resolution) by Geospatial Techniques. ArcGIS software was used for creating, managing and generation of different layer and maps. The Microsoft excel was used for mathematical calculation[19].

VI. 5.Results and Discussions

In the present study, the morphometric analysis for the parameters namely stream order, stream length, bifurcation ratio, stream length ratio, basin length, drainage density, stream frequency, elongation ratio, circularity ratio, form factor, relief ratio, etc. has been carried out using the mathematical formula given in Table 1. Drainage Texture analysis of Ur river basin and their geometry were discussed in detail and show in the table1 and drainage map with stream order shown figure 3. Morphometric parameters such as basin relief, basin shape and stream length also affect basin discharge shape strongly through their variable effects on lag time. The normal runoff is one of the most effective geomorphic activities in shaping the landscape of an area. The results of morphometric parameters obtained in the study area for Basin characteristics(Table 2).Theses parameters are as follows:

Table 1. Formula for calculation of Morphometric Parameters with references

Sr. no	Parameter	Formula	Reference
A	**Linear Aspect**		
1	Stream number (Nu)	Order wise stream segments	Horton (1945)
2	Stream order	**Hierarchical rank**	Strahler(1964)
3	Stream Length(Lu)	**Length of all order stream**	Horton(1945)
4	Mean Stream Length (Lsm)	**Lsm=Lu/Nu**	Strahler(1964)
5	Stream Length ratio RL	**RL= Lu/Lu-1**	**Horton (1945)**
6	Bifurcation Ratio (Rb)	Rb =Nu/Nu+1	Schumn(1956)
7	Mean Bifurcation ratio(Rbm)	Rbm=Average of bifurcation Ratio of all orders	Strahler,1964
8	Rho Cofficient		Hortan,1945
B	**Aerial Aspect**		
9	Basin Perimeter (Km) P	GIS Analysis	Schumn,1956
10	Basin Area (Km2) A	GIS Analysis	Schumn,1956
11	Basin Length(Lb) (Km)	GIS Analysis	Schumn,1956
12	Form Factor (Rf)	Rf = A/Lu2	Hortan,1945
13	Elongation Ratio (Re)	Re=D/L=1.128√A/L	Schumn,1956
14	Drainage Texture	T = Dd x Fs	Smith,1950
15	Texture ratio (Tr)	Tr=∑Nu/P	Smith 1950
16	Circulatory ratio (Rc)	Rc= 4πA/P2	Miller,1953
17	Circulatory ration (Rcn)	Rcn = A / P	Strahler 1964

18	Lemniscate's (k)	k = Lb2 π/ (4A)	Chorley,1957
C	**Drainage Texture Analysis**		
19	Drainage density(Dd) (Km/Km2)	**Dd =∑Lu/A**	Hortan,1945
20	Stream frequency (Fs) (Km)2	**Fs=∑Nu/A**	Hortan,1945
21	Constant Channel maintenance (C) (Km)	C=1/Dd	Hortan,1945
22	Infiltration Number (If)	If = Fs (Dd)	Faniran (1968)
23	Infiltration Ratio	Ig=Dd*Ds	Zavoiance,1985
24	Length of Overland flow (Lg) (Km)	Lg=(1/Dd)*2	Hortan,1945
D.	**Relief aspect**		
25	Relief (R)	R = H–h	Hadley and Schumm (1961
26	Basin Relief(Bh) (m)	Bh=Hmax-Hmin	Schumn,1956
27	Relief Ratio (Rhl)	Rhl = H / Lb	Schumn,1956
28	**Ruggedness number (Rn)**	**Rn = Dd *(H /1000)**	**Strahler (1964)**

Table 2 Results of Morphometric Analysis of study

Sr. no	**Parameter**	**Value**
1	Basin Area A(Km)2	1500.275
2	Perimeter P (Km)	246.491
3	Basin order Nu	7
4	Drainage density Dd (Km/Km2)	2.002
5	Stream frequency Fs (Km)2	2.402
6	Relief Ratio Rr	3.468
7	Texture ratio(T) (Km)	11.201
8	Basin Length(Lb) (Km)	73.810
9	Basin Relief(Bh) (m)	255.947
10	Ruggedness number (Rn)	0.513
11	Mean Bifurcation ratio (Rb)	3.882
12	Form Factor (Rf)	0.275
13	Circulatory ratio (Rc)	0.310
14	Circulatory Ration (Rcn)	6.086
15	Elongation Ratio (Re)	0.7.98
16	Length of overland flow (Lg) (Km)	0.250
17	Constant channel maintenance (C) (Km)	0.499
18	Inflitration Ratio	0.833
19	Rho Cofficient	0.514

ISSN: 2456-5660 Volume 06, Issue 05, SEP-OCT 2021

www.jst.org.in *DOI: https://doi.org/10.46243/jst.2021.v6.i05.pp71-81*

20	Lemniscate's (k)	3.631
21	Basin Slope	3.467
22	Drainage Texture	4.810

5.1 Linear Aspects

The linear aspects of the parameters analysis comprises the parameter, length of overland flow, basin length, stream order, stream length, length ratio, bifurcation ratio.

5.1.1Stream Order

[20] Strahler, 1964 hierarchical order law has been followed for the delineation of the drainage stream order.(fig 3 and Table).Stream order or classification of streams is a useful indicator of stream size, discharge and drainage area[21].The number of streams (N) of each order (u) is presented in Table . Ur river is a **7th** order basin; it is observed that decrease in stream frequency as the stream order increases . There are 1 to 7 orders are present which are segmented as 1 order 2761 segments, 2nd order 661 segments, 3rd order 140 segments, 4th order 31 segments, 5th order 8 segments, 6th order 2 segments and 7th order 1 segment (Table 3).

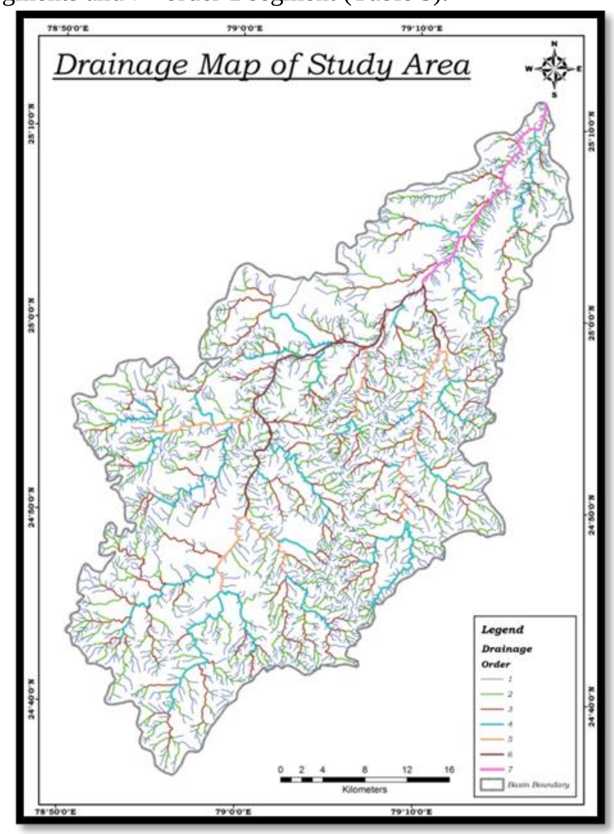

Fig 3.Drainage ordering map of the study area

5.1.2Stream number

The stream number is the count of the different order individually. In results from 1 to 7 order there are total number of 3604 segments of drainage (Table 3 and fig 4). The higher stream number shows the low infiltration rate in the area.

Table 3. Stream numbers

S.No.	Name of basin	Total Number of Stream	Streams

		(Nu)	Order(u)						
			I	II	III	IV	V	VI	VII
1	Ur River	3604	2761	661	140	31	8	2	1

Fig 4.Total Drainage Segments vs Total Length of the study area

5.1.3 Stream length

Stream length is a chronological development indicator and important hydrological feature of the basin which reveals the surface characteristic to the drainage pattern and runoff of the area. The number of streams of various orders in a basin is counted and their lengths are measured.(Table 4). The longer length shows the flat and low gradient and shorter length show the highly steep slopes and underlying terrain are present this region which comprises the high erosion value due to the steepness of the slope. According to Horton 1945, the lengths of the segments decrease as increase in order of the drainage system[22].

Table 4. Order -wise Stream Length

S.o.	Name of Basin	Total Stream Length(km.)	Order wise Stream Length(Lu) (km)						
			I	II	III	IV	V	VI	VII
1.	Ur River	3004.81	1644.50	653.52	365.91	208.88	62.83	44.69	24.45

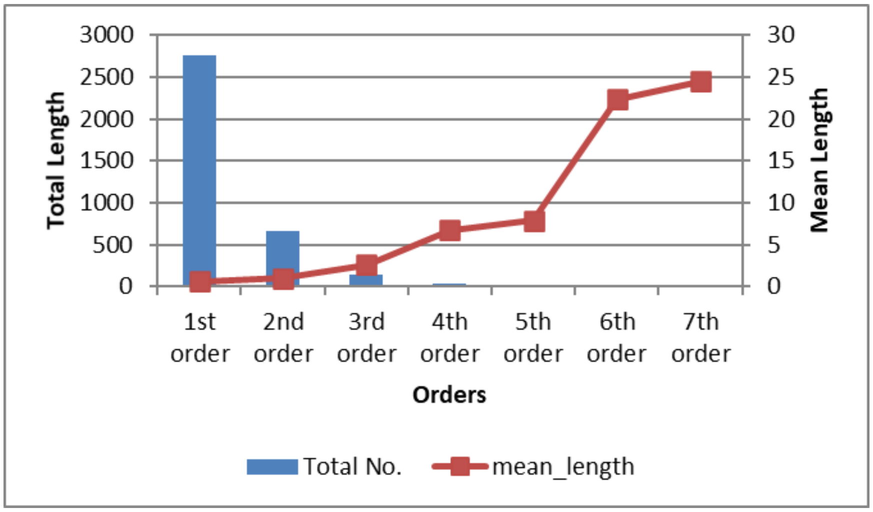

Fig 4. Mean Length vs Total Length of drainage segments of the study area

5.1.4 Stream Length Ratio

The length ratio (RL) is defined as the ratio of mean stream length (Lu) of segment of order u, to mean stream segment length (Lu-1) of the next lower order u-1.The stream length ratio has important relationship with the erosion of the area or basin. The value of mean stream length (0.59 to 24.45)and stream length ratio varies from 1.09 to 2.64 the high ratio value shows the high erosional activity (Table 5 and 6).

Table 5. Stream Length Analysis

S.No.	Name of Basin	Stream Length Ratio(RL)					
		II/I	III/II	IV/III	V/IV	VI/V	VII/VI
1	Ur River	1.65	2.64	2.57	1.16	2.84	1.09

Table 6. Mean stream Length Analysis

S.No.	**Name**	**Mean Stream Length (Lsm) (km)**						
		I	**II**	**III**	**IV**	**V**	**VI**	**VII**
1	Ur River	0.59	0.98	2.61	6.73	7.85	22.34	24.45

5.1.5 Bifurcation ratio

The term bifurcation ratio (Rb) was introduced by Horton (1932) to express the ratio of the number of streams of any given order to the number in the next lower order[23]. According to Strahler (1964), the ratio of number of streams of a given order (Nu) to the number of segments of the higher order (Nu+1) is termed as the Rb[20].The bifurcation ratio is defined as a ratio of the number of streams orders and they are varying from 2 to 4.7 because of the variation in the topography.The mean bifurcation ratio is observed 3.88 (Table 7)and weighted mean bifurcation ratio show in table 8.The relatively ratio is greater than 5 shows the structural control and lesser value than 5 indicates geomorphological control.

Table 7 . Bifurcation Ratio

S.No.	Name	Bifurcation Ratio (Rb)						Mean Bifurcation Ratio (Rbm)
		I/II	II/III	III/IV	VI/V	V/VI	VI/VII	
A	Ur River	4.17	4.72	4.51	3.87	4.0	2.0	3.88

Table 8 . Bifurcation Analysis

Bifurcation Analysis					
Order	**Total no.**	**Bifurcation Ratio**	**Streams used in ratio**	**Bifurcation Ratio x No. of Stream used in Ratio**	**Weighted Mean Bifurcation Ratio**
1st order	2761	4.177	3422	14293.710	4.284
2nd order	661	4.721	801	3781.864	
3rd order	140	4.516	171	772.258	
4th order	31	3.875	39	151.125	
5th order	8	4	10	40	
6th order	2	2	3	6	
7th order	1				
Total	3604	23.290	4446	19044.957	
Mean		3.882			

5.1.6 Length of Overland flow

The Length of overland flow, considered as a dominant hydrologic and morphometric factor, is the approximately one half of the reciprocal of drainage density (R.J. Chorley, 1969). Overland flow is the flow of surface water before it concentrates in definite streams. The length of overland flow is a measure of erodibility and in one of the independent variables affecting both the hydrologic and geomorphic features. The length of overland flow of river basin is 0.24 km, which shows gentle slopes in the valley and hence low surface runoff (Table 2).

5.1.7 Rho coefficient

The Rho coefficient value of Ur basin is 0.51. The higher value of Rho shows the higher water storage during flood during rain. It also shows the low infiltration rate of the area.

5.2 Aerial Aspects

Different morphometric parameters like drainage density, texture ratio, stream frequency, form factor, circularity ratio, elongation ratio ,constant of channel maintenance have been discussed in detail and are presented in Table 2.

5.2.1 Basin Area

All the stream flows originating in the area are being discharged through a single outlet in order to obtain the catchment area.Thus the catchment area can be measured by calculating area enclosed by the surface water divide.The area of the basin measured with the help of software.The basin area of the basin calculated as 1500.27 sq. km.(Table 3).

5.2.2 **Form factor**

The Form factor f of a drainage basin is defined as a ratio between the area of the basin (A) and the squared value of the basin length (L2) [22]. The value of form factor varies between greater than zero to one (in perfect circular shape), if Form factor value is higher it shows high-peak flow in shorter duration, whereas lower value of form factor indicates lower peak flow of longer duration of drainage basin[24], lesser form factor value indicates elongated shape of drainage basin. The value of Ur river basin in the study area is 0.27 (Table 1)which shows the elongation shape of basin.

5.2.3 Lemniscates

The lemniscates value to determine the slope of the basin. The value of lemniscates is 3.631 derived from the Chorey (1957) formula (Table 1)[25]. The value show the area is occupies the maximum area in its regions of inception with large number of streams of higher order.

5.2.4 Circulatory Ratio

Circularity ratio is the ratio of the basin area (*A*) to the area of a circle having the same perimeter (*P*) as the basin [26,20]. The values of circularity ratio vary from zero (for a line) to one (for a circle). The circularity ratio is influenced by stream length, stream frequency (*F*s), geological structures land cover, climate, relief and slope of the basin. It is an important parameter, which indicates the stage of the basin. Its low value indicates youth stage, medium value shows mature stage and high values indicate older stages of the tributaries in the basin [14,27,28]. The value is 0.310(Table 1).

5.2.5 Elongation Ratio (Re)

[29]Schumm (1956) defined elongation ratio (Re) as the ratio between the diameter of the circle of the same area as the drainage basin (D) and the maximum length of the basin (L).The values of elongated ratio vary from zero (highly elongated shape) to one (circular shape)[15], high elongation ratio of a basin indicates active denudational process with high infiltration capacity and low run-off in the basin. Whereas lower *R*e values indicate higher elevation of the basin susceptible to high head ward erosion along tectonic lineaments[4]. According to[20],values close to1.0 are typical of regions of very low relief whereas that of 0.6–0.8 are associated with high relief and steep ground slope The values of Re generally vary from 0.6 to 1.0 over a wide variety of climatic and geologic types. The value is 0.7.98(Table 2).

5.2.6 Basin Length

The distance from the river formed to its mouth is known as basin length which is 73.81 km

5.2.7 Drainage Density (Dd)

Horton (1945) defined Dd as the total length of channels (Lu) in a catchment divided by the area (A) of the catchment. Steam Frequency[22].

5.2.8 Constant Channel Maintenance(C)

Constant of channel maintenance (C) depends on slope of basin, nature of rocks, vegetation cover and the duration of erosion. Generally the higher C values of watershed indicate the higher permeability of rocks and vice versa[30,3127].The values of the basin is 0.499 respectively, expressing strong lithologic rocks with a surface of high permeability (Table 2).

5.3 Relief Aspects

5.3.1 Basin Relief:

Basin relief is the difference between the higher altitude and lower altitude of the area. The R controls the stream gradient and therefore influences floods patterns and the amount of sediment that can be transported[32].The basin relief of the Ur river watershed is 255.94 m.

5.3.2 Relief Ratio

The relief ratio is the parameter by which we can assume the overall physiology of the area. The value of 3.46 shows that there are higher relief and steeper slope(Table 3).

5.3.3 Ruggedness number

It is the product of basin relief and drainage density and its usually combines with the steeper slope with its length. The value of ruggedness number in Ur river is 0.51(Table 1).

5.3.4 Basin Slope

The slope of the basin is 3.46^0 which indicate that the basin have moderate slope. This moderate slope value shows the assessment of runoff generation, direction and volume(Table 2).

Table 9 Basin slope of the study area

S.No.	Name of the basin	Basin Area (A)(sq. Km.)	Basin Length(Lb)(Km.)	Constant channel maintenance(C)
1	Ur River	1500.27	73.81	0.499

VII. Conclusion

In the analysis of the Ur river basin by the Geo-spatial technique reveals the fact about the morphometric characters of drainage in the area. The area complies of Granite as a bedrock and shallow thickness of soil. Geo-spatial technique proves a very empirical part in the morphometric analysis. The slope, DEM, aspect and drainage density were also been co-related with the drainage density were also been co related with the drainage data for accuracy of the study. The Ur basin area has the gentle sloping in the plateau as the value shows of the overland flow. The high stream number shows the low infiltration rate in the area. The Basin area is elongated in the shape. The lemniscates value shows that the higher order drainage segments are occupies maximum area in the watershed. The bifurcation ratio value also shows the geomorphic control with the influence of the geological structures also. The analysis obtained from study is been aimed for the development and management of water resources in Ur river basin. The drainage network showed that the terrain exhibits dendritic to sub-dendritic drainage pattern. Drainage density varied between 0.39 and 0.43km/ km2and had very coarse to coarse drainage texture. The relief ratio ranged from 0.003 to 0.007.The mean bifurcation ratio varied from 4.24 to 6.10 and falls under normal basin category. The elongation ratio showed that all catchment elongated pattern. Thus, the remote sensing techniques proved to be a competent tool in morphometric analysis.

Reference:

[1] Krishnamurthy J, Srinivas G, Jayaram V and Chandrasekhar MG (1996) Influence of rock types and structures in the development of drainage networks in typical hardrock terrain. ITC Journal 3–4:252–259

[2]. Biswas S, Sudhakar S, Desai VR. Prioritisation of subwatersheds based on morphometric analysis of drainage basin:a remote sensing and gis approach. J Indian Soc Remote Sens.1999, 27:155–166. doi:http://dx.doi.org/10.1007/BF02991569.

[3]. Kumar R, Kumar S, Lohani AK, Nema RK and Singh RD (2000) Evaluation of geomorphological characteristics of a catchment using GIS: GIS India 9(3):13–17

[4]. Reddy, Gangalakunta P., Obi, Maji, Amal K., Gajbhiye, Kothiram S., Drainage morphometry and its influence on landforms characteristics in a basaltic terrain, central India- a remote sensing and GIS approach, International Journal of Applied Observation and Geoinformation, 6, 1-16, (2004).

[5]. Vittala SS, Govindaonah S and Home Gowda H (2004) Morphoinetrlc analysis of sub-watersheds in the Pawagada area of Tumkur district South India using remote sensing and GIS techniques. Journal of the Indian Society of Remote Sensing 32, 351-362

[6]. Saran S, Sterk G, Peters P and Dadhwal VK(2010) Evaluation of digital elevation model for delineation of hydrological response units in a Himalayan Watershed. Geocarto Int 25: 2,105-122

[7]. Tiwari, R.N., Bharti, S.L.(2011), Morphometric Study of Gangeo Area, Rewa District Madhya Pradesh, India., Gond. Geol. Mag: vol.26 (1), pp.49-56.

[8]. Manjare B. S., S. Khan, S.A. Jawadand, M. A. Padhye (2018) "Watershed Prioritization In Some Part Of Wardha River Basin, Maharashtra India Using Morphometric Parameters: An integrated study of Remote Sensing And GIS" Proceedings of International Conference Select Proceedings of ICWEES-2016, Water Science and Technology Library, (ISBN 978-981-10-5800-4 ISBN 978-981-

10-5801-1 eBook), Hydrologic Modeling Editors, Vijay P. Singh, Shalini Yadav, Ram Narayan Yadava, Springer Nature Singapore Pte Ltd. 2018, pp 353-366.
[9]. Shrivatra J.R. , Manjare B.S., Paunikar S.K. (2021a) A GIS-based assessment in drainage morphometry of WRJ-1 watershed in hard rock terrain of Narkhed Taluka, Maharashtra, Central India., Remote Sensing Applications: Society and Environment 22 (2021) pp., 1-13.
[10]. Manjare B. S., Padhye, M.A., Girhe S. S. (2014a) Morphometric Analysis of a Lower Wardha River sub basin of Maharashtra, India Using ASTER DEM Data and GIS". Proceedings of Geo-Enabling Digital India, 15th ESRI India User Conference New Delhi 2014, pp.1-13.
[12]. Manjare, B.S. Padhya Mithilesh and Kelawade Ankita (2020)Morphometric analysis of Erai River Basin in Sedimentary landscape, Central India: A geospatial approach Indian Journal of Geosciences, Volume 74, No. 4 October - December, 2020; pp. 417 – 432.
[13]. Shrivatra J.R., Manjare B.S. and Paunikar S.K. (2021b) Morphometric Analysis Based Prioritization of Sub-Watersheds of WRJ-1Watershed of Narkhed Taluka, Nagpur District, Maharashtra Using Geospatial Techniques, Journal of Geosciences Research Vol. 6, No.2, July, 2021 pp. 242-250.
[14]. Sreedevi P.D. , Subrahmanyam K., Ahmed Shakeel. Ahmed. The significance of morphometric analysis for obtaining groundwater potential zones in a structurally controlled terrain. Environmental Geology (2005) 47:412–420. DOI 10.1007/s00254-004-1166-1
[15]. Bali R, Agarwal KK, Ali SN, Rastogi SK, Krishna K.Drainage morphometry of Himalayan Glacio-fluvial basin, India: hydrologic and neotectonic implications. Environ Earth Sci.2012, 66:1163–1174. doi:http://dx.doi.org/10.1007/ s12665-011-1324-1.
[16]. Manjare B.S., Jakate V, Aparajit N., (2014b) Morphometry Using Remote Sensing And GIS Techniques Of Kedar River Sub Basins of Purna River Basin, Buldhana District, Maharashtra, IJPRET, 2014; ISSN: 2319-507X Volume, 2 / Issue: 1, pp. 1-8.
[17]. Reddy GPO, Maji AK, Gajbhiye KS (2002) GIS for morphometric analysis of river basins. GIS India 11(9): 9-14.
[18]. Shrivatra J.R., Manjare B.S. and Paunikar S.K. (2021b) Morphometric Analysis Based Prioritization of Sub-Watersheds of WRJ-1Watershed of Narkhed Taluka, Nagpur District, Maharashtra Using Geospatial Techniques, Journal of Geosciences Research Vol. 6, No.2, July, 2021 pp. 242-250.
[19]. Gajbhiye, S., Mishra, S.K. and Pandey, A., Prioritization of Shakkar River catchment through Morphometric Analysis using Remote Sensing and GIS techniques. Journal of Emerging Technology in Mechanical Science and Engineering, , 2013a,4(2),129-142.
[20]. Strahler AN. 1964. Quantitative geomorphology of drainage basins and channel networks. In: Chow VT, editor. Handbook of applied hydrology. New York (NY): McGraw Hill; p. 39–76.
[21]. Strahler, A. N. (1957). Quantitative analysis of watershed geomorphology. Transactions American Geophysical Union, 38:913-920.
[22]. Horton RE. 1945. Erosional development of streams and their drainage basins; hydrophysical approach to quantitative morphology. Geol Soc. America Bull. 56:275–370.
[23]. Horton RE. Drainage-basin characteristics. Trans Am Geophys Union.1932,13:350–361.
[24]. Chopra R, Dhiman RD and Sharma EK (2005). Morphometric Analysis of sub watersheds in Gurdaspur District, Punjab using Remote Sensing and GIS Techniques. *Journal of Indian Society of Remote Sensing* 33(4) 531-539.
[25]. Chorley, R.J., Donald, E.G., Malm. and Pogorzelski, H.A., A new standard for estimating drainage basin shape, American Journal Science,1957, 225, 138-141.
[26]. Miller VC (1953) A quantitative geomorphic study of drainage basin characteristics in the Clinch Mountain area, Virginia and Tennessee, Project No. NR 389-402, Tech. Rep 3, Columbia University,Dept. of Geology, ONR, New York
[27]. Kumar A, Jayappa K, Deepika B. 2011. Prioritization of sub-basins based on geomorphology and morphometric analysis using remote sensing and geographic information system (GIS) techniques. Geocarto Int. 26:569–592. doi:http://dx.doi.org/10.1080/10106049.2011.606925.
[28]. Yadav SK, Singh SK, Gupta M, Srivastava PK. 2014. Morphometric analysis of Upper Tons Basin from Northern Foreland 10106049.2013.868043.
[29]. Schumm SA (1956) Evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersey. Geol Soc Am Bull 67:597–646
[30]. Pakhmode V, Kulkarni H, Deolankar S. 2003. Hydrological-drainage analysis in watershed-programme planning: a case from the deccan basalt, India. Hydrogeol J. 11:595–604.
[31]. Rao NS. 2009. A numerical scheme for groundwater development in a watershed basin of basement terrain: a case study from India. Hydrogeol J. 17:379–396.
[32]. Hadley RF, Schumm S. Sediment sources and drainage basin characteristics in upper Cheyenne river basin. US Geol Surv Water-supply Pap.,1961,1531-B:137–198.