INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :6.514(2020); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:10, ISSUE:1(1), January :2021
Online Copy Available: www.ijmer.in

MORPHOMETRIC STUDY OF SAKALI NALA DRAINAGE BASIN THROUGH GIS

Satish V. Kulkarni
Department of Geology
Bharatiya Mahavidyalaya, Amravati

Abstract

The literal meaning of the term "Morphometry" is the measurement of forms introducing quantitative description for landform. The most dominant geomorphic systems of earth's surface are rivers and fluvial processes which leads to morphometric changes in drainage basin or the watershed. Wherein, rivers are generally controlled by geological nature of basin and its platform which equally influences on channel slope and demonstrates erosional and depositional signs of the river. Morphometric analysis is the measurement and mathematical evaluation of the earth's surface, shape and dimension of its landform. GIS techniques can be effectively used for the morphometric analysis of a drainage basin.

Keywords: Morphometric Study, GIS, Sakali Nala, Nandgaon Khandeshawar, Ner.

Introduction

The Geographical Information System (GIS) has emerged as one of the most effective tool to study the drainage basin. GIS is effectively used in the delineation of drainage pattern and in identification of various morphological characters as well as for analysis of basin. The present study area is Sakali Nala Basin which is sub-tributary of Bembala river. The area is covered under the Survey of India toposheets with number 55H/10, 55H/14, 55H/15, having scale of 1:50000 and bounded by Latitude: $77^0$36'00'' to $77^0$52'00'' and Longitude: $20^0$22'00''to $20^0$42'00''. Geographically, the Sakali Basin lies in Nandgaon Khandeshwar taluka of Amravati district and Ner taluka of Yavatmal district. Total area of the basin is calculated as 368 Km^2 (Fig.1). The GIS techniques have proved very helpful in understanding the various morphometric parameters like stream number, bifurcation ratio, area. Length of basin etc.

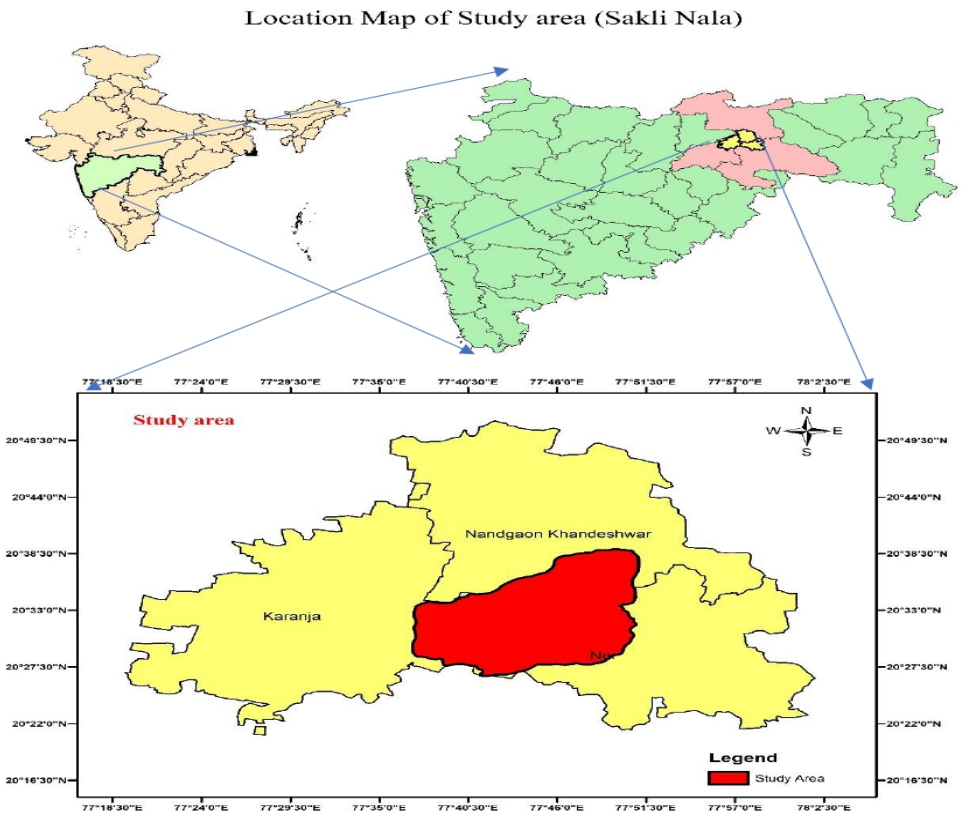

Fig. 1: Location Map of Sakali Nala Basin.

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :6.514(2020); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:10, ISSUE:1(1), January :2021
Online Copy Available: www.ijmer.in

Method

The morphometric examination of the basin is achieved through computation linear, aerial relief and gradient of channel network and contributing ground slope basin. The various basic parameters in the morphometric analysis can be grouped as linear, areal and relief aspects. The various parameters studied for the present area using GIS environment. The different parameters have been calculated according to conventional methods given by Horton (1945), Strahler (1956), Schumm (1957)

Result and Discussion

The results of various parameters of the present study are as follows:

1. Stream Order (U)

The primary step in drainage basin analysis is to designate order. Herein, the number of streams gradually decreases with increase in stream order. Strahler (1964) noted that the number of for the stream segment of any given order will be fewer than for the next lower order but more numerous than for the next higher order. The fluctuation in the number of stream order is aftermath of variation in the physiographic conditions. In the present study the result calculated as 5th order as highest order.

2. Stream Number (NU)

The count of stream channel in given order is termed as stream number. Horton's law states that "the number of streams of different orders in a given basin tends closely to approximate as inverse geometric series of which the first term is unity, and the ratio is the bifurcation ratio". The stream frequency is inversely proportional to stream order and stream number is directly proportional to size of contributing basin and to the channel dimension. Higher the stream number indicates lesser permeability and infiltration. It leads to inference that several streams usually up rise in geometric progression as stream order increases. The variation in rock structure in the basin are responsible for disparity in steam frequencies of each other.

Order	I	II	III	IV	V	VI	TOTAL
No. of stream (Nu)	501	111	29	06	02	01	630

3. Stream Length (LU)

Stream length is the total length of stream segment of each of the consecutive order in the basin tends approximate a direct geometric series in which the first term is the average length of the first order. It's the quantification of hydrological characteristics of bedrock and the drainage extent. When bedrock is of permeable character then only subtle number of relatively longer streams are formed in a well-drained basin area. On the other hand, when the bed rock is less permeable then large number of smaller length of streams in the basin are produced.

Order	I	II	III	IV	V	VI	TOTAL
Total length of stream (Nu)	353.98	137.25	75.36	41.14	17.16	7.31	632.20

4. Mean Stream Length (LSM)

Mean stream length reveals the size of component of drainage network and its contributing surface. It is directly proportional to the size and topography of drainage basin. The present study area has a mean stream length of ___0.97__Km.

Order	I	II	III	IV	V	VI
Mean Stream Length Lsm=Nu/Nu-1	0.38	0.55	0.54	0.42	0.42	--

5. Bifurcation Ratio (RB)

Horton (1945) considered bifurcation ratio as an index of relief and dissection. According to Strahler (1957), bifurcation ratio exhibit, subtle fluctuation for different region with varied environment except where powerful geological control dominates. According to Schumm (1956), bifurcation ratio is the ratio of number of stream segment of given order to the number of segments in the next order, it is dimensionless property and indicates the degree of integration prevailing between streams of various orders in drainage basin. Strahler significantly marked that geological structures do not affect drainage pattern if bifurcation ratio is in between 3.0 to 5.0. The bifurcation ratios calculated for the present study area are as shown in the given table.

Order	I	II	III	IV	V	VI
Bifurcation Ratio (Rb) Rb=Nu/Nu+1	0.57	0.48	0.38	0.80	1.17	--

6. Stream Length Ratio (RI)

Horton (1945, p.291) states that the length ratio is the ratio of the mean (Lu) of segments of order (So) to mean length of segments of the next lower order (Lu-1),

Horton (1945, p.291) states that the length ratio is the ratio of the mean (Lu) of segments of order (So) to mean length of segments of the next lower order (Lu-1),

Horton (1945, p.291) states that the length ratio is the ratio of the mean (Lu) of segments of order (So) to mean length of segments of the next lower order (Lu-1),

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :6.514(2020); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:10, ISSUE:1(1), January :2021
Online Copy Available: www.ijmer.in

Horton states that mean stream length ratio is theratio of the mean of segments of order (Lu) to mean length of segments of next lower order (Lu-1). For the present studies the values of stream length ratio ranges 0.85 to 1.74.

7. Mean Bifurcation Ratio (RBM)

The simple arithmetic mean of the bifurcation ratios of all the order is termed as mean bifurcation ratio. The mean bifurcation ratio of the present study area is calculated as 0.68.

8. Area of Basin (A)

The total area drained by a given stream network and all the streams of that system discharged through a single outlet is called Area of Basin. The area of present area basin is calculated as 368.50 Km^2.

9. Basin Length (LB)

The horizontal distance along the largest dimension of the basin parallel to the principal drainage line is defined as basin length which comes out to be 28.8 Km.

10. Basin Perimeter (P)

The total length of the boundary of the drainage by which the basin is delineated is called as Basin perimeter. In the present study the basin perimeter is measured as 83.92 Km.

11. Drainage Density (DD)

Drainage density is the computation of the total stream length in a given basin area to the total area of the basin. The measurement of drainage density is a useful numerical measure of landscape direction and runoff potential. According to Strahler (1964) drainage density is directly proportional to basin relief. A high drainage density indicates weak basin and impermeable subsurface material and high relief. Whereas low drainage density manifests weak coarse drainage texture, high potential runoff and potential erosion of basin area. The drainage density for the present study area is calculated as 1.72.

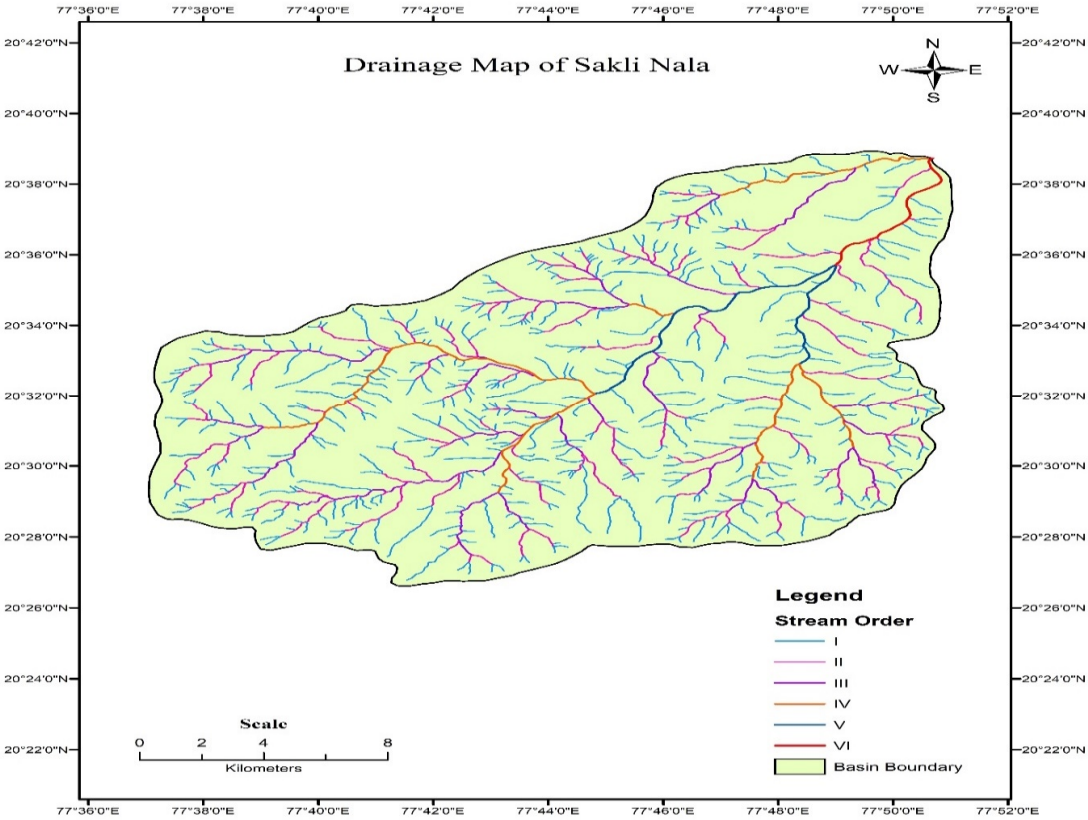

Fig. 2. Drainage Map of Sakali Nadi Basin

12. Drainage Texture (RT)

Drainage texture is an aggregate of product of drainage density and stream frequency. The drainage texture depends upon several natural aspects or strands such as climate, vegetation type and density, rock and soil type infiltration capacity, relief, and stage of development. The drainage texture for the Sakali Nala is found to 7.75. Low drainage density leads to coarse drainage texture while high drainage density influences fine drainage texture which is dependant of infiltration capacity of mantle rock or bed rock. The result indicates that area has fine drainage texture.

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :6.514(2020); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:10, ISSUE:1(1), January :2021
Online Copy Available: www.ijmer.in

13. Stream Frequency (FS)

Stream frequency is sum of all stream segment of all orders per unit area (Horton, 1932). Basically, it depends upon the basin lithology and indicates distinctly texture of the drainage network. It is an indicator of various stages of landscape evolution. The main characters that influence the stream frequency are structural geology, infiltration capacity, vegetation cover, relief nature, and annual amount of rainfall and permeability of the area. The stream frequency is calculated as 1.77 and the low value of stream frequency exhibits presence of a permeable subsurface material.

14. Elongation Ratio (RE)

Elongation ratio is the ratio of a diameter of a circle having the same area as of the basin and maximum basin length. The value of elongation ratio varies from "0" which indicates elongated shape to unity i.e., 1, which shows circular shape of a drainage basin. As elongation ratio is index of the overall shape of river basin and it depends on various geological as well as climatic factors. These values can be grouped into 3 categories, viz. circular (>0.9), oval (0.9 to 0.8) and less elongated (<0.7). The value of elongation ratio for the present study area is found to be 0.75 which corresponds to oval to les elongated shape.

15. Circularity Ratio (RC)

Circularity ratio is the ratio of an area of basin to an area of circle having same circumference as the perimeter of basin. According to Miller (1953), it is a ratio that exhibits stages of drainage and its development due to variation in the slope and relief pattern of the basin. It is used as quantitative measure for the shape of the basin. Low, medium, and high value of circularity ratio manifests the young, mature and old stages of the life cycle of tributary drainage basin. The value of circulatory ratio for the present study is 0.66 indicating the mature stage of drainage system.

16. Length of Overland Flow (LG)

Length of overland flow is the length of flow of water over the ground before it merges in definite stream channel. Horton (1945) expressed it as half of the reciprocal of drainage density. The length of overland flow for present study calculated as 0.29.

17. Form factor (RF)

According Horton (1945) form factor is a numerical index commonly used to represent different shapes of basin. It can be defined as the ratio of the basin area and square of basin length. The value of form factor usually ranges between 0.1 to 0.8. In the study area, form factor comes to be 0.44 which indicates that basin elongated.

18. Constant of Channel Maintenance (CM)

According to Schumm (1956) the inverse of drainage density is termed as Constant of Channel Maintenance. In present study, it is calculated as 0.58 Km^2. The higher values of constant of channel maintenance indicates strong control of lithology having high permeability in the area.

19. Relief Ratio (RH)

The ratio between to the maximum relief of the basin to the horizontal distance along the largest dimension of the basin parallel to the principal drainage line is termed as relief ratio by Schumm (1956). It measures the overall steepness of the drainage basin. Relief ratio is an indication of the intensity of erosional process operating on slope of the basin. The relief ratio for the study area is computed as 2.01. Relief ratio is inversely proportional to the drainage area and the size of given drainage.

20. Ruggedness Number (RN)

Ruggedness number is defined as the product of basin relief and drainage density. It is a dimensional number and useful to combine steepness of slope with its length (Strahler,1968). The ruggedness number is calculated as 0.07.

Table 1: Result of Morphometric parameters for Sakali Nala Basin.

Aspect	Sr. No.	Parameter	Formula	Result
LINEAR	1	Stream Order (U)		VI
	2	Total Number of stream (Nu)	*(Nu)*	650
	3	Total length of the stream	*Lu*	632.20 Km
	4	Mean stream Length (Lsm)	*Lsm=Lu/Nu*	0.38 to 0.55
	5	Bifurcation Ratio (Rb)	*Rb=Nu/Nu+1*	0.38 to 1.17
	6	Stream Length Ratio (Ri)	*Ri=Lmu/(Lmu-1)*	0.85 to 1.74
	7	Mean Bifurcation Ratio (Rbm)	*Rb=Nu/Nu+1*	0.68
AERAL	8	Area of the basin (A)		368.5Km^2
	9	Basin length (Lb)		28.82 Km
	10	Basin Perimeter (P)		83.92
	11	Perimeter (square)		7042.25
	12	Drainage intensity (Di)	Di = Fs/Dd	1.03
	13	Drainage texture (Rt)	Rt=Nu/P	1.75

	14	Drainage Density (Dd)	Dd=Lu/A	1.72
	15	Stream frequency (Fs)	Fu=Nu/A	1.77
	16	Circulatory Ratio	Rc = 4pi*A/P2	0.66
	17	Elongation Ratio (Re)	Re=2/Lb*(A/3.14)^0.5	0.75
	18	Length of overland flow (Lg)	Lg= 1/Dd*2	0.29
	19	Constant channel maintenance	Cm=1/Dd	0.58
	20	Form factor	Rf=A/Lb^2	0.44
RELIEF	21	Height of Basin mouth (z)	*z*	249 M
	22	Height of the Highest point on the basin (Z)	*Z*	307M
	23	Basin Relief (H)	*H=Z-z*	58
	24	Relief ratio (Rh)	*Rh=H/Lb*	2.01
	25	Ruggedness number (Rn)	Rn = H*Dd/1000	0.07

Conclusion

The morphometric analysis of Drainage basin gives the quantitative information on landform. In simple words, the quantitative evaluation of morphometric parameters is essential tool in river basin analysis for water resource and natural resource management. The morphometric assessment of drainage system is very important to any hydrological studies. Therefore, various hydrological phenomena of drainage basin can be in relevance to size, shape of drainage basin. The detailed study of morphometry of basin reveals drainage pattern which in turn revels the lithological character. The present study pertains to the morphometric analysis of Sakali Nala basin using GIS. The GIS platform facilitates the analysis of various morphometric parameters. The sakali nala basin is well drained with stream order varying from I to VI. The present study has area of about 368.05 Km^2 with total length of basin is 28.82 Km. The total number of streams in the basin is 650. The basin under study exhibits dendritic drainage pattern with bifurcation ratio ranging between 0.38 to 1.17. The drainage density is calculated as 1.72. If the drainage density is high, then the runoff is rapid and vice-versa. The morphometric analysis always helps in the water resource management of the region.

References

1. Chorely, R. J. (1957). Illustrating laws of morphometry. Geol. Mag., V.94, pp. 140- 150.
2. Clarke, J.J. (1966). Morphometry from map. Essays in geomorphology, Elsevier, New York, pp. 235-274.
3. Horton, R. E. (1932). Drainage basin characteristics. Transactions. Amer. Geophy. Union,V. 13, pp. 350-361.
4. Horton, R. E. (1945). Erosional development of stream and their drainage basin: hydrological approach to quantitative morphology. Bull. Geol. Soc. of Amer., V. 5, pp. 275-370.
5. Schumm, S. A. (1956). Evolution of drainage system and slopes in badlands at Perth Amoby, New Jersey. Bull. Geol. Soc. Amer. V.67, pp. 597-646.
6. Strahler, A. N. (1957), Quantitative analysis of watershed geomorphology, Transections Amer. Geophy. Union V. 38, pp. 912-920.
7. Strahler, A. N. (1964). Quantitative geomorphology of drainage basin and channel network. Handbook of Appl. Hydro., pp. 39-76.
8. Smith, K. G. (1950). Standards for grading textures of erosional topography. Amer. Jor. Sci., V.248, pp. 655-668.
9. Miller, V. C. (1953). A quantitative geomorphic study of drainage basin characteristics in the Clinch Mountain Area, New York, Dept. of Geology, ONR, Columbia Univ., Virginia and Tennessee, Project, NR, Technical Report 3, pp. 489-402.
10. Singh, S. (1998). "Physical Geography", Prayag Pustak Bhawan, Allahabad, India, p 613.
11. Pareta, K. and Pareta, U. (2011). Quantitative Morphometric analysis of a watershed of Yamuana basin, India using ASTER (DEM) data and GIS. Int. Jour. Geomat. Geosci., Vol. 2(1) pp. 248-269.
12. Murkute, Y.A. and Joshi, S. P. (2011). Morphometric study of Panchdhara watershed, Seloo Taluka, Wardha District, Maharashtra. Gond. Geol. Magz., v. 26(2), pp. 163-168.
13. Pophare, A. M. and Balpande, U.S. (2014). Morphometric analysis of Suketi River basin, Himachal Himalaya, India, Jour. Earth Sys. Sci. V.123(7), pp. 1501-1515.
14. Khadri S.F.R. and Kulkarni S.V. (2000). Geomorphological Characteristics of Mukatagiri region, Betul (M.P.) and Amravati (M.S.) district with emphasis on Water Resource Management, Gond. Geol. Magazine., V. 15(2), pp. 47-57.
15. Kulkarni Mangesh D. (2015). The Basic Concept to study Morphometric study of Drainage Basin: A Review, International Jour. of Sci. and Research, Vol.4, Issue 7, pp. 2277-2280.
16. Obi Reddy, G.E., Maji, A.K., Gajbhiye, K.S. (2002). GIS for morphometric analysis of drainage basin, GIS India, V.11(4) pp. 9-14.
17. Kale H.S. and Deshmukh S.B. (2020). Morphometric Analysis of WGKD sub-watershed using Remote Sensing and GIS Techniques, Journal of Geosci. Research, Vol.5, No. 1, pp. 35-42.