Journal of East-West Thought
ISSN: ***2168-2259 (online)***
(*https://jetjournal.us/*)
Volume 15, Issue 1, Jan-March – 2025 Special Issue 2

Impact Factor: 7.665, Peer Reviewed and UGC CARE I

QUANTITATIVE ANALYSIS OF THE DRAINAGE AND MORPHOMETRIC CHARACTERISTICS OF THE ARUNAVATI RIVER BASIN, USING GEOSPATIAL APPROACH

Dr. Bhagwan N. Girase, Department of Geography, G.V.S Arts College Bamkheda Tal. Shahada, Dist. Nandurbar

Dr. Rupesh R. Deore, Department of Geography, N.T.V.S'S G. T. Patil Arts, Commerce & Science College, Nandubar Dist. Nandurbar

ABSTRACT

This study deals that morphometric evaluation is feasible method of characterization of hydrological response behavior of the any river basin. In this study, Arunavati basin a tributary of the Tapi river has been selected for the detailed morphometric evaluation. The Arunavati basin is approximate 778 km2 and shows sub-dendritic to dendritic drainage pattern. The measurement and analysis for Arunavati basin and its five major sub-watershed are carried on GIS platform to describe the topography and drainage characteristics.Morphometry may be defined as the measurement and mathematical analysisof the configuration of the earth's surface, shape and dimensions of its landform.Morphometry has been used primarily to facilitate description of specific relieffeature-erosion surface, slopes, valley and that of the character of relief as-a-whole(Clarke 1970). The valley formation is essentially a function of the concentrated flowof water which occupies only a small portion of the larger trough. The valley formsare directly or indirectly controlled by various activities of stream at the base oftrough. The stream lowering its bed forms base level for valley varies according to thework of erosion carried out by the stream.

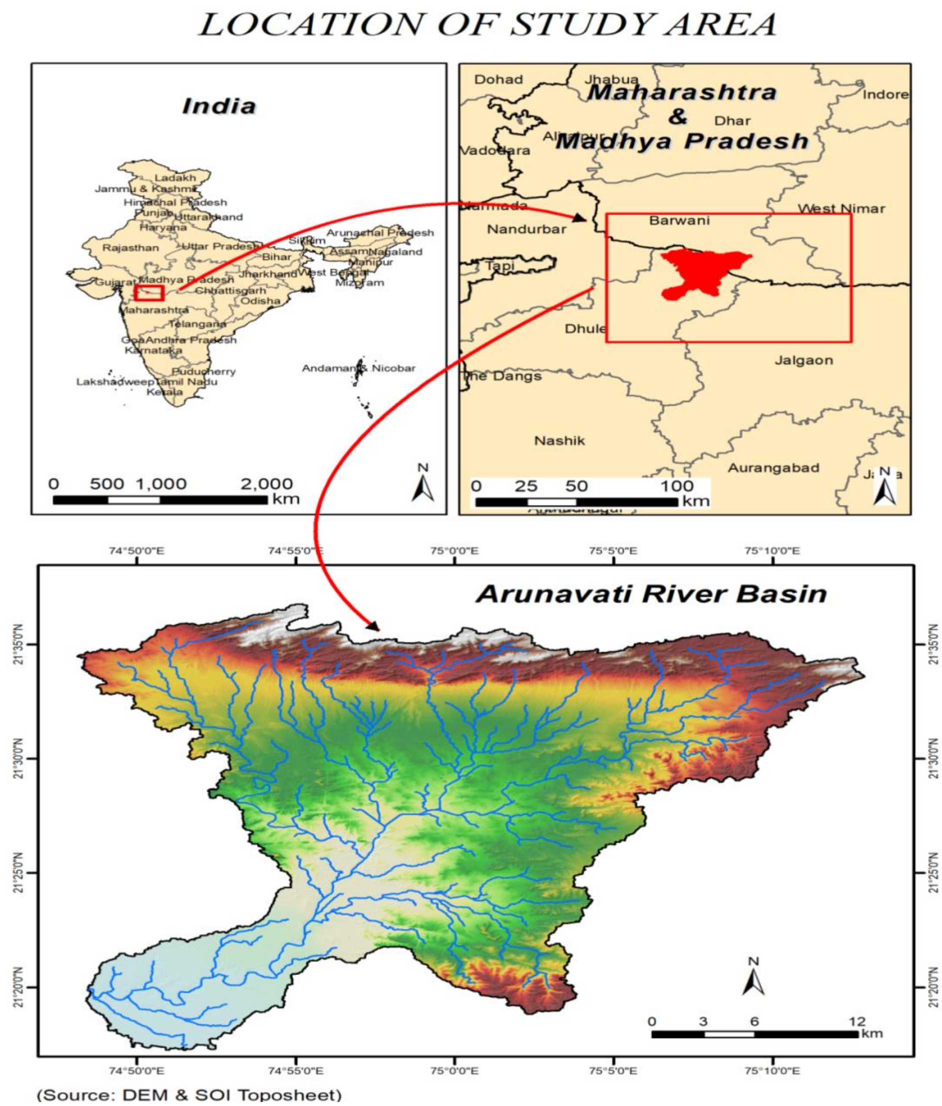
Keywords: Morphometric Analysis, Drainage Network Analysis,Geographic Information System, Arunavati Basin

1. INTRODUCTION

A drainage basin is well defined portion of the earth's surface within aphysical boundary defined by topographic slopes that diverts all runoff to the samedischarge outlet. The drainage basin can be thought of as a system that convertsrainfall into runoff. Certain characteristic of a drainage basin reflect hydrologicbehavior and are therefore useful when quantified in evaluating the hydrologicresponse of the basin (Singh,1994). It also plays a vital role on the hydrogeomorphicperformance and hydrologic behavior of a basin. Horton (1932, 1945) pioneered thehydromorphometric analysis of drainage basin and provided a rational and systematicbase, rather a framework of outline of geomorphological characteristics to relate themto various hydrological properties of drainage basin.

Journal of East-West Thought
ISSN: *2168-2259 (online)*
(*https://jetjournal.us/*)
Volume 15, Issue 1, Jan-March – 2025 Special Issue 2
Impact Factor: 7.665, Peer Reviewed and UGC CARE I

1.1 STUDY AREA:



Map1.1Location Ofthe Study Area

The Arunavati River is a right bank tributary to the river Tapi. The study area spreads over an area of North west corner of Maharashtra and covered between the 21°18' N to 21°37'N latitude and 74°49'E to 75°13'E longitude.Arunavati river basincovers an area of 738 sq.km. and lies in Madhya Pradesh and Maharashtra. Thesurvey of India toposheet no. 46 0/2, 46 0/3, 46 k/14, 46 k/15 are used for present study. Itflows in a South-Westerly direction over a length of 69.5 kms, joins the Tapi river atVanaval Village. The north and north east part of the study area is occupied by the hilltrack. While the southern part of the study area is plain. The highest point of the hillranges in near Jhirpan Village at 650 mts. altitude towards north eastern part of

Journal of East-West Thought
ISSN: *2168-2259 (online)*
(*https://jetjournal.us/*)
Volume 15, Issue 1, Jan-March – 2025 Special Issue 2
Impact Factor: 7.665, Peer Reviewed and UGC CARE I

basin.The study area experiencestropical climate with very hot summer and cold winterconditions. The maximum temperature is recorded at 45 o C andminimum temperature about 27 o C. In winter season, the minimumtemperature varies from 3 to 8o C. The area receives ~90%of the total annual rainfall . 800-900mm averageannual rainfall from southwest monsoon from June toSeptember.Arunavati enters in Dhule district and flows in ageneral south westerly direction. Further making its way through the outer ranges ofthe Satpuda and after passing by Shirpur it joins the Tapi.The northern parts of the River dis being hilly terrain are drought prone and faces the problem of acute water scarcity.

2. OBJECTIVES

1. To understand the environmental circumstances of Arunavati basin.
2. To study the morphometric characteristics of the study area.

3. METHODOLOGY

The methodology adopted for the present study is shown in Fig. 1. The base map of Arunavati River was prepared using a shape file of the Maharashtra for village level on a 1:50,00Arunavati River basin is a seventh order tributary of Tapi. The Arunavatidrainage basin parameters have been measured and computed from survey of Indiatopographical maps on 1:50000 scale (460/2, 460/3, 46k/14, 46k/15) to bring out thedetailed picture of morphometric characteristics of the study area. The entirecatchment area has been drawn from the topographical maps with all perennial andnon-perennial streams. The water divides of Sub-basins, main stream basin, spotheights and major contour lines are takes in to considerably for demarcation of waterdivide.The morphometric parameters like stream order, stream number, length area,basin perimeter, length of main river, source height confluence height, and lowestpoint of the basin and drainage orientation has been worked out. The computedparameters also include bifurcation ratio, mean length ratio, sinuosity index, formfactor, circularity ratio, elongation ratio, constant of channel maintenance, streamfrequency, drainage density, texture, valley sides, slopes and raggedness number scale.

DRAINAGE COMPOSITION

According to Horton's law of drainage composition the number, length andarea are selected to order in geometric proportion, with number having inversegeomorphic relation. The order and number of streams in the basin is given in the following table (Table 1.1).

Journal of East-West Thought
ISSN: *2168-2259 (online)*
(https://jetjournal.us/)
Volume 15, Issue 1, Jan-March – 2025 Special Issue 2
Impact Factor: 7.665, Peer Reviewed and UGC CARE I

Table No.1.1 Arunavati basin Order wise Stream Number

Sr. No.	Sub-basin	I	II	III	IV	V	VI	VII	Total
1	AmbadNala	470	111	26	5	1	-	-	613
2	ChondiNala	299	73	18	3	1	-	-	394
3	ChulNala	259	67	16	5	2	1	-	350
4	KunjalNala	162	38	10	3	1	-	-	214
5	AsrapaniNala	132	31	9	1	-	-	-	173
6	KhambaleNala	135	36	7	2	1	-	-	181
7	JhibaviNala	463	103	21	5	2	1	-	595
8	ArunavatiBasin	-	-	-	-	-	-	1	1
Total(MainRiver)		1920	459	107	24	8	2	1	2521
Arunavati basin Stream order and Stream Number									
Stream Order(u)		**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**Total**
Number of Stream(N_u)		1920	459	107	24	8	2	1	2521

(Source: Computed by Researcher)

Aspect of the basin

Drainage Pattern: It is a type of drainage pattern which develops as an entirely random networkbecause of the absence of structural controls. Thus, a dendritic pattern is acharacteristic of terrain which is of uniform lithology and where faulting and jointingare significant, e.g., massive crest line rock or thick clay plains. Because of itsbranching nature, the stream network has been termed dendritic from the Greek term Dendron (meaning 'tree'). The streams in this pattern follow the regional slope and 40 therefore such streams were called as insequent by Davis. In this pattern, thetributaries do not meet the main stream at right angle (Majid Husain 2009). TheArunavati basins pattern is a dendritic and its sub-basin drainage pattern is alsodendritic (Fig.No.3.2).

Journal of East-West Thought
ISSN: *2168-2259 (online)*
(https://jetjournal.us/)
Volume 15, Issue 1, Jan-March – 2025 Special Issue 2
Impact Factor: 7.665, Peer Reviewed and UGC CARE I

LINEAR ASPECTS:

Linear aspects of the basin are related to the channel patterns of the drainagenetwork where in the topological characteristics of the stream segments in terms ofopen links of the network system (streams) are analysed. Thus, the linear aspectincludes the discussion and analysis of stream order (u), stream number (Nu),bifurcation ratio (Rb),stream lengths (Lu),length ratio (RL), basin length (L), basinshapes and circularity ratio and sinuosity index.

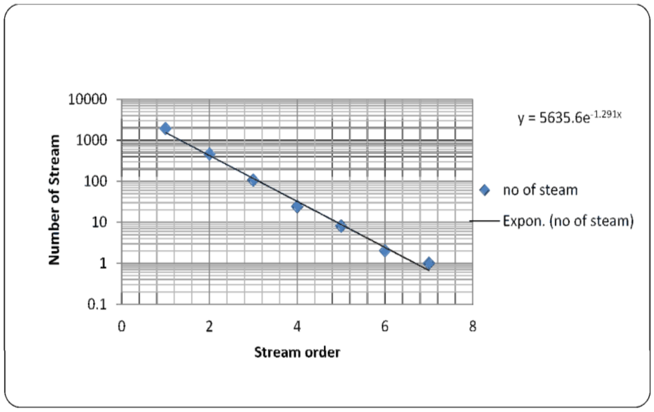
A. Stream order and Stream number:

Stream Order (Nu) –The stream ordering map (Table 1.1) shows that the Karha river basin is a seventh order stream. The maximum frequency is found in first order And Second Ordered streams and its decreases from higher order to lower order stream.

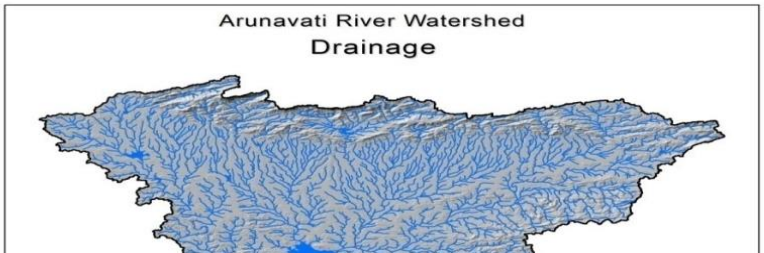
"Stream order is a measure of the position of stream in the hierarchy ofdistributaries" (Leopold, 1964). This offers "a quantitative basis for comparison of thedegree of development in the drainage nets of comparable size". (Horton,1945). Thenetwork of the channels of the Arunavati basin in Badavani district of MadhyaPradesh and some parts of Dhule District in Maharashtra has been traced from the 1: 50,000 scale of topographical sheets. It is divided in to hierarchical orders of different magnitudes.according to Strahler (1957) system of stream ordering.

The Arunavati basin is 7th order stream covers an area of 738 Sq.km. (Table No.1.1, Fig.No.1.2). The drainage pattern of Arunavati basin is a rectangular. Entire Arunavatibasin is further divided into seven major sub-basin namely:

1) Ambad nala, 2) Chondi nala,3) Chul nadi 4) Kunjal nala,5) Asrapani nala, 6) Khambale nala7)Jhirbavinal



FigNo.1.2: Arunavati basin Stream order and Stream number

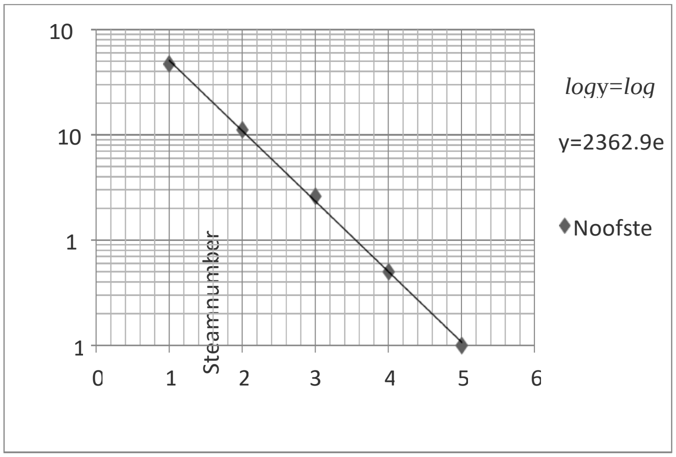


Journal of East-West Thought
ISSN: *2168-2259 (online)*
(https://jetjournal.us/)
Volume 15, Issue 1, Jan-March – 2025 Special Issue 2
Impact Factor: 7.665, Peer Reviewed and UGC CARE I

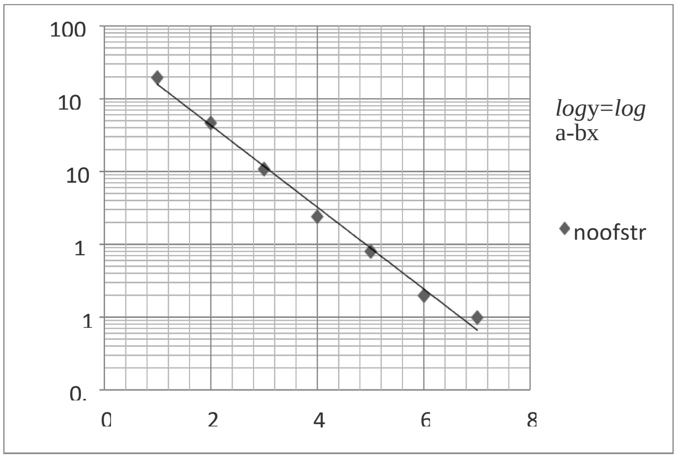
FigNo.1.3: Arunavati Basin Drainage

Relationship of Stream order to Stream number:

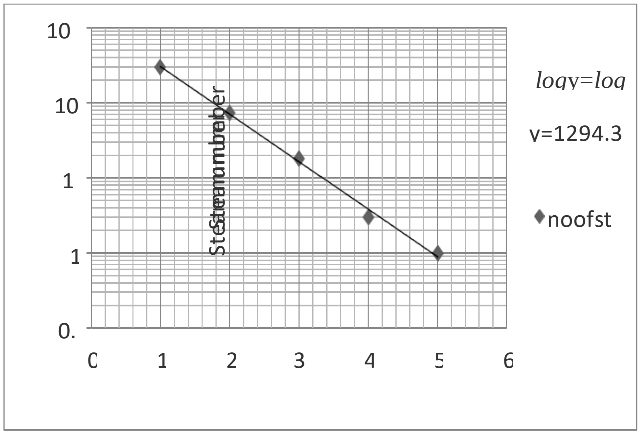
1. ArunavatiBasin



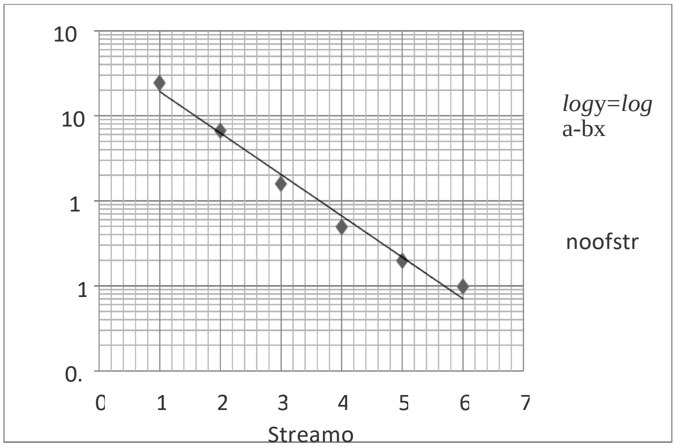
2. Ambad Nala



3.ChondiNala

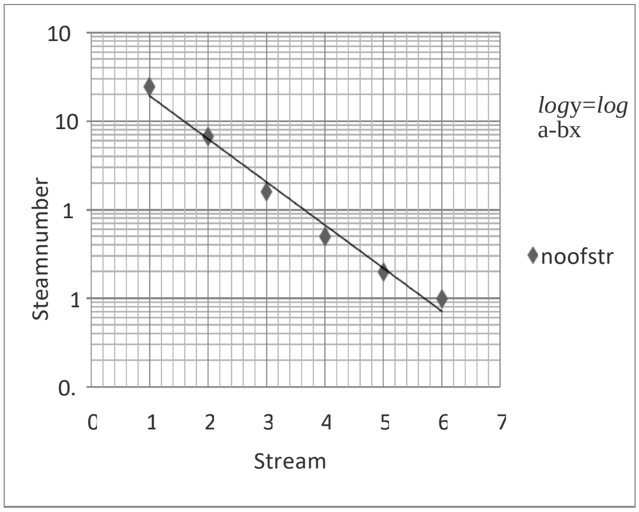


4. Chul Nadi

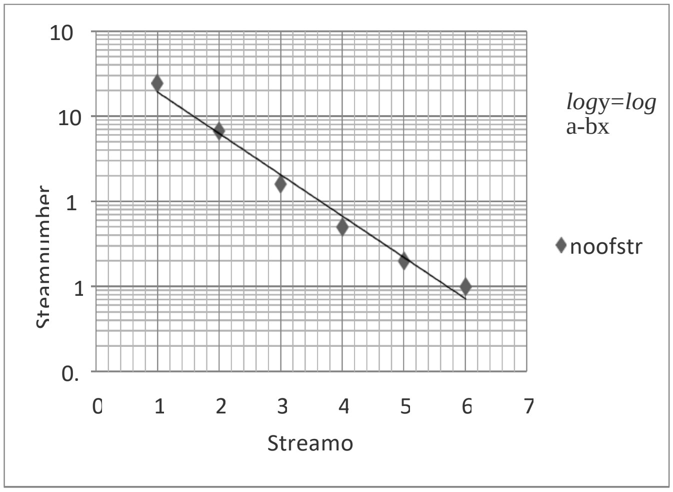


Journal of East-West Thought
ISSN: *2168-2259 (online)*
(https://jetjournal.us/)
Volume 15, Issue 1, Jan-March – 2025 Special Issue 2
Impact Factor: 7.665, Peer Reviewed and UGC CARE I

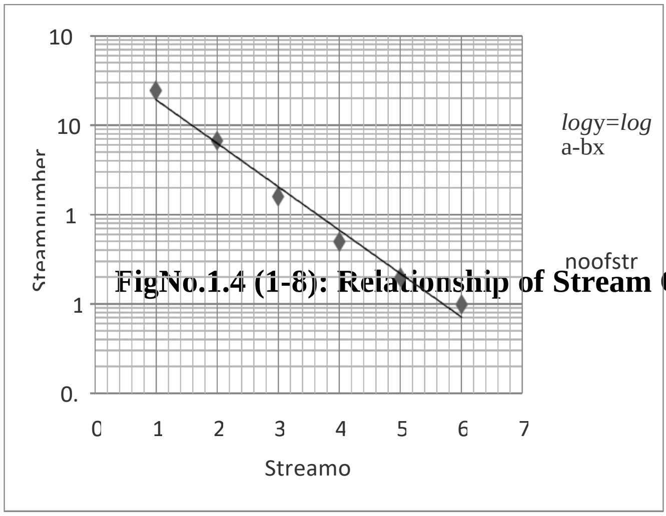
5. Kunjal Nala



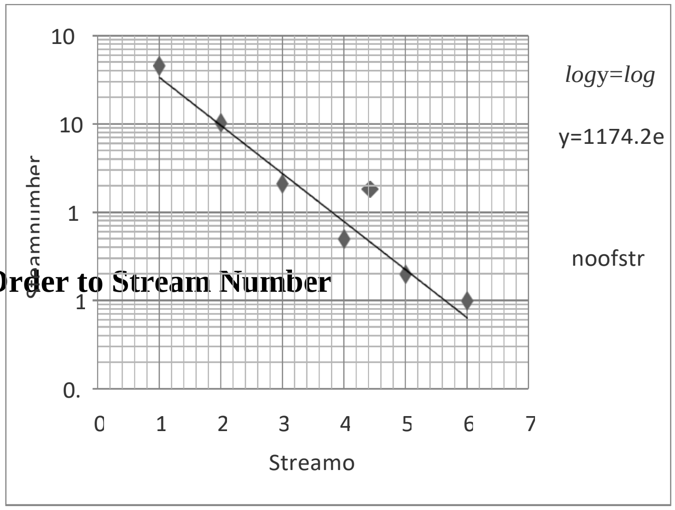
6. AsrapaniNal



7. **KhambaleNala**



8. JhirbaviNala



FigNo.1.4 (1-8): Relationship of Stream Order to Stream Number

Journal of East-West Thought
ISSN: *2168-2259 (online)*
(*https://jetjournal.us/*)
Volume 15, Issue 1, Jan-March – 2025 Special Issue 2

Impact Factor: 7.665, Peer Reviewed and UGC CARE I

Stream Number - The Auranvati basin contains total of 2521 streams in which first order streams are 1920followed by second (459), third (107), fourth (24), fifth (8), sixth (2), and seventh (1) order streams (Table 2). A strong negative correlation was observed between stream order and the number of streams

The total numbers of streams in Arunavati basin are 2521. The total number of streams found in a drainage basin as a whole is important no doubt, but of greater importance is their number per unit area and their frequency of occurrence in different parts of the drainage basin.

According to Strahler (1957)system Of stream ordering the Arunavat The total numbers of streams in Arunavati basin are 2521. The total number ofstreams found in a drainage basin as a whole is important no doubt, but of greaterimportance is their number per unit area and their frequency of occurrence in differentparts of the drainage basin.According to Strahler (1957) system of stream ordering the Arunavati basin isa seventh ordered stream. The drainage pattern of the Arunavati is dendritic. Thedendritic pattern means the development of drainage system is developed on thehomogeneous structure. The drainage pattern developed over Deccan trap is generallydendritic in nature and that type of similarities is observed in Arunavati basin. The drainage map of the Arunavati basin shows the network of streams of different orders and lengths (Fig No.1.3). The entire Arunavati basin is composed of2521 streams in which 94.30 % streams are of first and second order. The higherorder stream successively reduces till the seventh order. It has been observed that thetotal length of the entire network is 1244.5 +69.5 = 1314 kms of which the first andsecond order streams contributes for 80% of the length.The regression coefficients have been calculated for each drainage model withthe help of the following regression formula as suggested by Strahler (Prasad, 1987).

$$\log y = \log a - b X$$

Where, y = number of streams segments (Nu), X= stream order (u), a = constant, b = regression coefficient.

Steam number Stream order no of stream 46 On the basis of the regression lines of negative exponential function modelplotted against stream orders and number of stream segments (Fig.No.1.4. (1-8))explained that the above model holds good in the case of four 5th order basins (Ambadnala, Chondi nala, Kunjal nala and Khambale nala) and Chul nadi and Jhirbavi nala6th order basins. These 5th order basins were points fluctuate much from theregression lines due to the varying surfaces i.e. hilly terrain in the upper reaches andflat and rolling surfaces in the lower reaches of the drainage basins.On the basis of the above discussion it is concluded that the lower the order,the larger the number of stream segments in all the 8 drainage basins are perfect asregards the Hortonian law. It is also apparent that the youngest basins of lower orderusually conform closure to the regression lines than that of the basins higher order ofthe older age.

Bifurcation Ratio (Rb):

Horton (1945) and Strahler (1952) had defined bifurcation ratio as number ofstreams

Journal of East-West Thought
ISSN: 2168-2259 (online)
(https://jetjournal.us/)
Volume 15, Issue 1, Jan-March – 2025 Special Issue 2
Impact Factor: 7.665, Peer Reviewed and UGC CARE I

of one order to the number of the next higher order.Bifurcation ratio (Rb) dimensionless property of the drainage basin is supposed to be controlled by thedrainage density, stream confluence angle, lithology, basin shape, basin area etc. Thestudies of bifurcation ratio of different region of the world by differentgeomorphologist.Horton (1945) has also explained the erosional development of stream andtheir drainage basin. The bifurcation ratio ranges between 3 and 5 under normalenvironmental circumstances. The extreme value clearly indicates abnormalenvironmental circumstances. The abnormal values are frequently associated witheither rejuvenation or strong structural control over the drainage basin development.Besides this the bifurcation ratio also affects on the hydrological conditions ofdrainage basin especially the flood discharge conditions. The elongated basin withhigh value of bifurcation ratio yields a low but extended peak flows, which in turncontributes more infiltration of water along the streams, means it will be helpful forincrease in the ground water resources while basin with near circular shape with lowbifurcation ratio produces a sharp peak flows giving very less time for infiltration ofwater in the soil layers along the stream. (Magar, 2007).Table No. 3.4 and 3.5 indicates the bifurcation ratio of Arunavati basin and itstributaries. It ranges between 2 and 4.45 with average value of 3.65. It indicates thatin this region there are normal environmental circumstances for development ofdrainage development.Two bifurcation ratio for the seventh order stream indicates flat a rollingtopography, 3 to 4 bifurcation ratios of 4th and 5th order stream indicates mountainoushilly dissected basin whereas 4.18, 4.28, 4.45 bifurcation ratios of second, third andfourth ordered basins indicates that these streams are developed over hilly and highly dissected regions.

CONCLUSION

The current study provides the precise data for topography, drainage system, stream length, water division, geomorphologic setup, and other factors crucial for the classification and management of watersheds. The morphometric analysis of Arunavati basin using Geographic Information System is a tool that helps the researchers to analyses the drainage basins easily and accurately in short time duration. GIS facilitates analysis of various morphometric parameters and acts as an effective tool in establishing relationship between drainage morphometry and properties of landforms. Geomorphological study of an area is the systematic study of present day landforms, related to their origin, nature, development, geologic changes recorded by the surface features and their relationship to flood hazard. Some morphometric elements (measurement of landforms) provide valuable information for vulnerability to flood. The morphometric parameters evaluated using GIS helped to understand various terrain parameters such as nature of the bedrock, infiltration capacity, runoff, etc. Similar studies in conjunction with high resolution satellite data help in better understanding the landforms and their processes and drainage pattern demarcations for basin area planning and management (M. Bagyaraj and B. Gurugnanam, 2011). The analysis of linear aspects of drainage basin result shows that the basin has a dendritic pattern with third order.

Acknowledgement :

This study was partially supported by the research grant received by first author for the project entitled "Quality Assessment and Demarcation of Groundwater Potential Zone of Arunavati River Basin, Using Remote Sensing and GIS Techniques" under the Vice Chancellor Research Motivation Scheme grants program implemented by Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgoan

REFERENCES

1. Ahmed, S.A., Chandreshekarappa, K.N., Raj, S.K., Nischitha, V. and Kavitha, G. (2010). "Evaluation of morphometric parameters Derived from ASTER and SRTM DEM – A study on Bandihole Subwatershed Basin in Karnataka".
2. Bajirao, T.S.; Kumar, P.; Kumar, A. Application of Remote Sensing and GIS for Morphometric Analysis of Watershed: A Review. Int. J. Chem. Stud. **2019**, 7, 709–713. [**Google Scholar**]
3. Clark (1966). "Morphometry from Map, Essay in geomorphology", Elsevier publ. co. New York, pp. 235-274.
4. Patel, D.P.; Dholakia, M.; Naresh, N.; Srivastava, P.K. Water Harvesting Structure Positioning by Using Geo-Visualization Concept and Prioritization of Mini-Watersheds through Morphometric Analysis in The Lower Tapi Basin. J. Indian Soc. Remote Sens. **2012**, 40, 299–312. [**Google Scholar**] [**CrossRef**]
5. Patel, J. (2020). Delineation of groundwater potential zones in Rajkot tehsil, Gujarat, using remote sensing and GIS techniques. International Journal of Environment and Geoinformatics (IJEGEO), 8(3), 276-282. .doi. 10.30897/ijegeo. 718029
6. Girase B. N. (2013) Geomorphic Analysis Of Arunavati River A Thesis Submitted to North Maharashtra University, Jalgaon For the Degree of Doctor of Philosophy in Geography Under the Faculty of Science KBCNMU Jalgaon
7. Mani, A.; Kumar, D. Morphometric Analysis of Manali Watershed of Beas River Basin for Watershed Management. VayuMandal **2020**, 46, 21–29. [**Google Scholar**]
8. Magesh, N.; Chandrasekar, N.; Soundranayagam, J. Morphometric Evaluation of Papanasam and Manimuthar Watersheds, Parts of Western Ghats, Tirunelveli District, Tamil Nadu, India: A GIS Approach. Environ. Earth Sci. **2011**, 64, 373–381. [**Google Scholar**] [**CrossRef**]
9. Chorely, R.J. (1957). "Illustrating the laws of morphometry", Geological Magazine, Vol.94, pp.140-150.
10. Faniran (1968). "The index of drainage intensity - A provisional new drainage factor", Australian Journal of Science, Vol.31, pp.328-330.
11. Hack, J.T. (1957). "Studies of longitudinal profiles in Virginia and Maryland", U.S. Geological Survey Professional Paper, Vol.294 (B), pp.45-97.