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Research Article

MORPHOMETRIC ANALYSIS OF DRAINAGE BASIN USING GIS TECHNIQUES A CASE STUDY OF AMARAVATHI RIVER BASIN, TAMILNADU

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ABSTRACT

The study of morphometric analysis of Amaravathi River drainage basin has been conducted based on the secondary source, the SRTM data has been downloaded from GLCF website. The downloaded data has been analyzed using ArcGIS software, the study Linear, Relief and Arial aspects of drainage basin retrieved that, total numbers of streams are 16369, in that 12695 are first orders, 2871 are second orders, 626 are third orders, 142 are fourth order, 27 are fifth orders, 7 are sixth orders, 1 is seventh order streams. The tributaries branch irregular in all directions and join the main stream at all angles. The dendritic and sub-dendritic drainage which reflects the homogeneous character of the subsurface materials in the Amaravathi River Basin, Tamil Nadu. The length of stream segments is maximum for first order stream and decreases as the stream order increases. The linear aspects considered for the study include stream order, stream number, stream length, bifurcation ratio and length ratio. The areal aspects include basin area, form factor, circulatory ratio, elongation ratio, drainage density, stream frequency, length of overland flow and the relief aspects considered for the present study are basin relief and ruggedness number. The study of the drainage map reveals that the amaravathi River Basin is consequent in nature, whose course is due to the slope of the land surface. Tributaries joining the main stream, whose direction of flow is controlled by structural features, are called subsequent streams. Most of the lower order streams are found to be in sequent in nature joining the higher order main stream. The tributaries branch irregular in all directions and join the main stream at all angles. The dendritic and sub-dendritic drainage which reflects the homogeneous character of the subsurface materials in the Amaravathi River Basin, Tamil Nadu

INTRODUCTION

Study Area

Amaravathi River is one among the major tributaries of the Cauvery River Basin system in South India peninsula. It originates from Anaimalai hills at an altitude of 1827m (AMSL) which drains from south to the north, north eastern parts and confluences with the main river Cauvery at Thirumukkudalur, which is situated around 10km east of Karur city in Tamil Nadu State. This basin is located between latitudes 10º 8′ 51"N to 11º 1′ 44" N and longitudes 77º 5′ 32" E to 78º 3′ 25" E. The entire Amaravathi River Basin covers an area of about 8554sq.km. Out of this, the hilly and forest region covers an area of about1109 sq.kms. This hilly and forest regions were not accessible. Hence, we will take in account my study area is about 7445 sq.km (Fig. 1). The Amaravathi River Basin is enclosed by Coimbatore uplands on the west and by the Anaimalais, Palani and Sirumalai hills on the south and southeastern parts. Further on the east, the plain slopes gently towards the Cauvery and is flanked by Aiyalur Reserve Forest and Kadavur hills. The physiography in the study area is broadly classified into three horizons such as highly elevated hills (Western Ghats), hills and adjoining area and gently sloping plain region. The northern part of the basin has an undulating plain with an average elevation of 300m forming an effective topographic barrier between Noyal and other sub-basin of the Cauvery River. Similarly, the headwaters of this basin are separated from those of Vaigai River, existing in the south by the Anaimalais and Kodaikanal-Palani hills.

MATERIALS AND METHODS

The study area is covered within Survey of India (SOI) topographic sheets Nos 58E/8, 58E/12, 58F/1-58F/3, 58F/5 - 58F/16, 58J/1 - 58J/4 and 58I/4 in the scale of 1:50,000.

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Topographical maps were rectified/ referenced geographically and mosaiced and entire study area was delineated in GIS environment with the help of Arc-GIS 10.0 software assigning Universal Transverse Mercator (UTM), World Geodetic System (WGS dating from 1984 and last revised in 2004) and 43N Zone Projection System. Since, morphometric analysis of a drainage basin requires the delineation of all the existing streams, digitization of the drainage basin was carried out for morphometric analysis in GIS environment using Arc GIS 10.0 software. The attributes were assigned to create the digital data base for drainage layer of the basin.

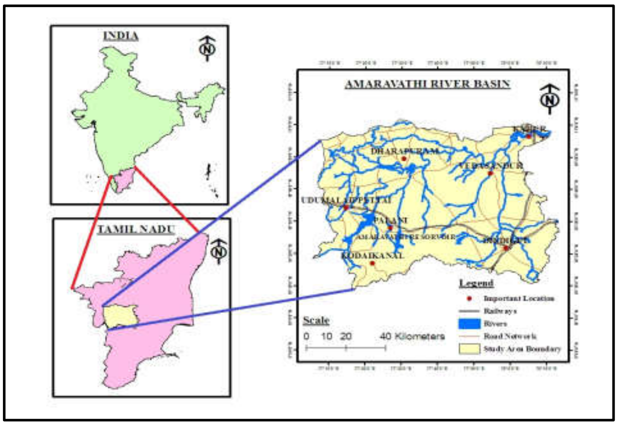

Fig 1 Location of Study area map

ratio, basin length, drainage density, stream frequency, elongation ratio, circularity ratio, form factor, basin relief, relief ratio, channel gradient using mathematical formulae as given in Table 1 and the results are summarized in Tables 2-4. The properties of the stream networks are highly important to study the landform making processes. Morphometric parameters such as basin relief, basin shape and stream length also influence basin discharge pattern strongly through their varying effects on lag time. The natural runoff is one of the most potent geomorphic agencies in shaping the landscape of an area. The land area that contributes water to the main stream through smaller ones forms its catchment area or the drainage basin. The arrangement of streams in a drainage system constitutes the drainage pattern, that in turn reflects mainly structural/ or lithologic controls of the underlying rocks. The drainage pattern of Amaravathi River basin is dendritic to sub-dendritic in nature.

Linear Aspects

Linear aspects of the basin are related to the channel patterns of the drainage network wherein the topological characteristics of the stream segment in terms of open links of the network, which consists of all of the segment of stream of a particular river, is reduced to the level of graphs, where stream junctions act as points (nodes) and streams, which connect the points (junctions) become links or lines where in the numbers in all

Table 1 Methods of Calculating Morphometric parameters of Drainage basin

	Morphometric Parameters	Methods	References
	Stream order (U)	Hierarchical order	Strahler, 1964
	Stream length (Lu)	Length of the stream	Horton, 1945
	Mean stream length (Lsm)	Lsm = Lu/Nu where, Lu=Stream length of order ‘U’, Nu=Total number of stream segments of order ‘U’	Horton, 1945
	Stream length ratio (RL)	RL=Lu/Lu-1; where Lu=Total stream length of order ‘U’, Lu- 1=Stream length of next lower order.	Horton, 1945
LINEAR	Bifurcation ratio (Rb)	Rb = Nu/ Nu+1; where, Nu=Total number of stream segment of order‘u’; Nu+1=Number of segment of next higher order	Schumn,1956
	Basin relief (Bh)	Vertical distance between the lowest and highest points of watershed.	Schumn, 1956
RELIEF	Relief ratio (Rh)	Rh=Bh/Lb; Where, Bh=Basin relief;Lb=Basin length	Schumn, 1956
	Drainage density (Dd)	Dd = L/A where, L=Total length of streams;A=Area of watershed	Horton, 1945
	Stream frequency (Fs)	Fs = N/A where, N=Total number of streams; A=Area of watershed	Horton, 1945
	Texture ratio (T)	T = N1/P where,N1=Total number of first order streams; P=Perimeter of watershed	Horton, 1945
	Form factor (Rf)	Rf=A/(Lb) 2;where, A=Area of watershed, Lb=Basin length	Horton, 1932
	Circulatory ratio (Rc)	Rc=4πA/P2 ;where, A=Area of watershed, π=3.14, P=Perimeter of watershed	Miller, 1953
ARIAL	Elongation ratio (Re)	Re=2√(A/π)/Lb ;where, A=Area of watershed, π=3.14, Lb=Basin length	Schumn,1956

RESULTS AND DISCUSSION

The study of basin morphometry relates basin and stream network geometries to the transmission of water and sediment through the basin. Systematic description of the geometry of a drainage basin and its stream channel requires measurement of linear, areal and relief (gradient) aspects of the channel network and contributing ground slopes. In the present study, the morphometric analysis has been carried out about parameters as stream order, stream length, bifurcation ratio, stream length segments are counted, their hierarchical orders are determined, the length of all stream segments are measured and their different interrelationship are studied. The nature of flow paths in terms of sinuosity is equally important in the study of linear aspects of the drainage basins. Thus, the linear aspect includes the discussion and analysis of Stream order (μ), Stream number (nμ), Bifurcation ratio (Rb), Stream lengths (Lμ) and Length ratio (RL).

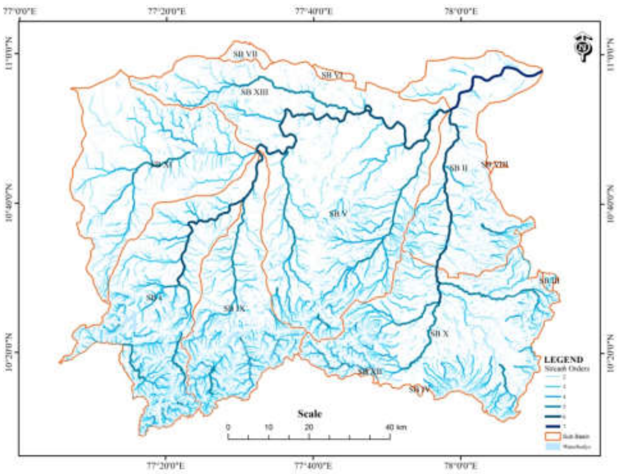

Fig 2 Drainage Order and Sub-basin of the Amaravathi River BasinTamil Nadu

The order does not increase if a lower order stream segment meets a stream segment of high order. The geometric relation between the logarithm of average number of streams (Nu) and stream orders (U) is illustrated in Fig.(3.7). This shows an inverse linear relationship because the number of streams (Nu) decreases as the stream order (U) increases. Fig (3.8) shows the Horton's law of stream number versus Stream order.

Stream Length (Lu)

The stream length (Lu) has been computed based on the law proposed by Horton (1945). Stream length is one of the most significant hydrological features of the basin as it reveals surface runoff characteristics. The stream of relatively smaller length is characteristics of areas with larger slopes and fiber textures. Longer lengths of streams are generally indicative of flatter gradient. Generally, the total length of stream segments is maximum in first order stream and decreases as stream order increases.

Table 2 Result of Linear Aspect of Amaravathi River Basin, Tamil Nadu

Sub Basin Name	Sub Basin	Area km2	Length km	Perimeter km	Stream Order	Stream Length km	Bifurcation ratio	Stream Length
Amaravathi	B I	1153	93	237	4199	2854	5.526	7.458
Kodavanar	B II	1048	84	207	1193	1189	3.721	7.941
Koraiyar	B III	12	6	15	38	26	2.422	2.251
Lower Vaigai	B IV	4	1.44	9	9	6	0.700	0.566
Nanganji	B V	1751	125	225	2521	2444	4.570	9.687
Noyil Lower	B VI	20	8.47	24	13	8	1.100	0.476
Noyil Upper	B VII	45	11.41	35	14	15	1.466	0.866
Pungar	B VIII	6	2.81	15	3	2	0.000	0.704
Shanmukha	B IX	887	72.31	178	3275	2223	4.073	4.624
Uppar Kodavanar	B X	1517	52.1	225	3655	2825	4.940	6.336
Uppar Odai	B XI	1252	62.29	185	817	1165	4.280	6.660
Varaha	B XII	6	5.7	15	26	21	1.800	1.403
Vattamalai	B XIII	853	64.92	229	619	667	3.946	10.404

Table 3 Areal Aspects of Amaravathi River Basin, Tamil Nadu

Subbasin Name	Sub Basin	Stream Frequency	Drainage Density Km^{-1}	Drainage Texture Km^{-1}	Elongation Ratio	Ciruculatory Ratio	Form Factor
Amaravathi	B I	3.642	2.475	17.682	0.410	1.01	0.36
Kodavanar	B II	1.138	1.134	5.774	0.430	1.1	0.38
Koraiyar	B III	3.142	2.144	2.601	0.650	1.63	0.57
Lower Vaigai	B IV	2.151	1.486	1.006	1.560	1.57	1.38
Nanganji	B V	1.439	1.396	11.221	0.37	1.31	0.33
Noyil Lower	B VI	0.652	0.394	0.532	0.59	1.31	0.52
Noyil Upper	B VII	0.314	0.333	0.400	0.66	1.35	0.58
Pungar	B VIII	0.494	0.348	0.201	0.98	1.15	0.86
Shanmukha	B IX	3.694	2.508	18.393	0.46	1.18	0.41
Uppar Kodavanar	B X	2.409	1.863	16.212	0.84	1.22	0.74
Uppar Odai	B XI	0.652	0.930	4.419	0.64	1.35	0.56
Varaha	B XII	4.622	3.696	1.759	0.48	1.15	0.42
Vattamalai	B XIII	0.726	0.782	2.706	0.5	0.9	0.44

Stream Order (U)

The designation of stream orders is the first step in drainage basin analysis based on a hierarchic ranking of streams. In the present study, ranking of streams has been carried out basin on the method proposed by Strahler (1964).According to him "each finger-tip channel is designated as segment of 1st order. At the junction of any two 1st order segments, a channel of 2nd order is produced and extends down to the point, where it joins another 2nd order segments where upon a segment of 3rd results and so forth". These streams may have additional stream segments of lower orders than their own order and thus these do not affect the classification. It may be mentioned that the hierarchical order increases only when two stream segments of equal meet and form a junction.

The number of streams are of various orders in a watershed are counted and their lengths from month to drainage divide are measured with the help of GIS software. The logarithm of stream length (ordinate) as a function of stream order (abscissa) yields a set of points lying essentially along a straight line fit following Horton's (1945) law of stream length. The straight line fit indicates that the ratio between Lu and U is constant throughout the successive order of a basin and suggests that geometrical similarity is preserved in basins of increasing order. It also indicates that all the sub-watersheds homogeneous rock material is subjected to weathering-erosion characteristics of the watershed.

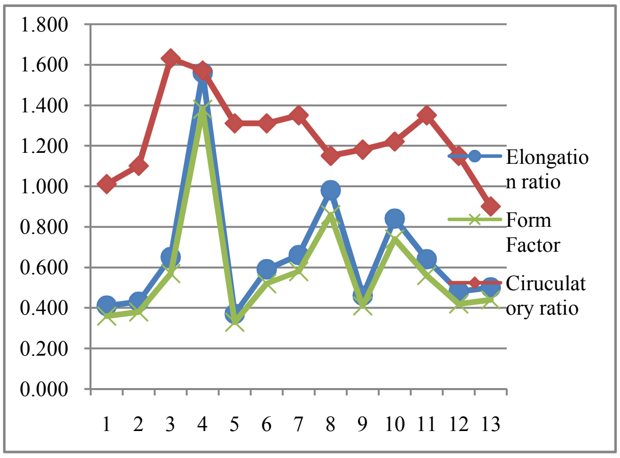

Fig 3 Areal Parameter of the Amaravathi River BasinTamil Nadu Circulatory Ratio (Rc)

Bifurcationratio (Rb)

Bifurcation ratio (Rb) may be defined as the ratio of the number of stream segments of given order to the number of segments of the next higher order (Schumn, 1956). Horton (1945) considered the bifurcation ratio as an index of relief and dissections (Table II). Strahler (1957) demonstrated that the bifurcation ratio shows a small range of variation for different environmental Conditions, except where the geology dominates. It is observed that Rb is not the same from one order to its next order. Higher value of bifurcation ratio for a sub-watershed indicates high runoff, low recharge and mature topography. A high bifurcation ratio is expected in the region of steeply dipping rock strata, where narrow valley is confined between the ridges.

Table 4 Relief Aspects of Amaravathi River Basin, Tamil Nadu

Sub Basin Name	Sub Basin	Elevation of Highest Point on Basin Perimeter	Elevation of lowest point at the mouth	Maximum Basin Relief (H)	Maximum Basin Length (Lb)	Relief Ratio (Rh)
Amaravathi	SB I	2528	294	2234	93	0.024
Kodavanar	SB II	1016	131	885	84	0.011
Koraiyar	SB III	651	298	353	6	0.059
Lower Vaigai	SB IV	326	270	56	1.44	0.039
Nanganji	SB V	1549	185	1346	125	0.011
Noyil Lower	SB VI	289	229	60	8.47	0.007
Noyil Upper	SB VII	76	286	73	11.41	0.006
Pungar	SB VIII	230	194	37	2.81	0.013
Shanmukha	SB IX	2489	284	2205	72.31	0.030
Uppar Kodavanar	SB X	1883	249	1634	52.1	0.031
Uppar Odai	SB XI	1263	271	992	62.29	0.016
Varaha	SB XII	1295	315	980	5.7	0.172
Vattamalai	SB XIII	426	152	274	64.92	0.004

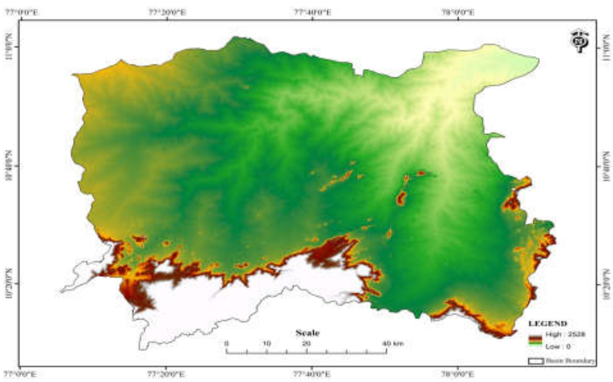

Fig 4 Shuttle Radar Topography Mission (SRTM) of Amaravathi River Basin,Tamil Nadu

Stream Length Ratio (Rl)

The length ratio RL (which is ratio of mean length Lu of segments of order u to mean length of segments of the next lower order Lu/Lu-1 tends to be constant through the successive order of watersheds.

The RL values are presented in Table 2. The stream length ratio is between the streams of different orders of the study area shows a change in each sub-basin. The change might be attributed to variation in slope and topography, indicating the late youth stage of geomorphic development in the streams of the study area (Singh and Singh, 1997 and Vittala *et.al.,* 2004).

Areal Aspects

The parameters which are governed by the area of the drainage basin are classed as area aspects of the basin. The areal aspect of the drainage basin include the study of basin perimeter, geometry of closed links i.e. Stream frequency (Fs), Drainage density (Dd), Drainage texture (Rt), Texture ratio (T), Form factor (Rf), Circulatory ratio (Rc), Elongation ratio(Re).

Drainage Texture (Rt)

There are different natural factors on which drainage texture depends like climate, rainfall, vegetation, rock and soil type, infiltration capacity, relief and stage of basin development (Smith, 1950). Generally soft and weak rocks unprotected by vegetation cover produce a fine texture, whereas, massive and resistant rocks produce coarse texture. Horton recognized infiltration capacity as the single important factor, which influence the drainage texture. The drainage texture of region is directly related to Dd and Fs of that region and is expressed as the product of them (Smith, 1950). The drainage texture of the sub basins ranges from 0.20 km^{-1} (SB-VIII) to 18.39km^{-1}(SB-IX).

Stream Frequency (Fs)

Stream Frequency is the number of streams segment per unity area and relates to the importance so ground water recharge characteristics in a river basin, It is obtained by dividing the total number of stream to the total drainage basin area. The lowest and the highest values of stream frequency are 0.314

km^{-2} (SB-VII) and 4.622 km^{-2} (SB-XII) Table 3.2. High Fs indicate the high relief and high infiltration capacity of the bed rocks pointing towards the increase in stream population respectively to high in nature, which indicate erodiability of the rock surface as moderate to high in nature and infiltration capacity and relief aspect of the terrain are also moderate to high.

Drainage Density (Dd)

Drainage density, according to Horton (1932), is defined as the length of streams per unity area. It expresses the closeness of spacing of channel. Dd is affected by the factors that control the characteristic length of stream like resistance to weathering, permeability of rock formations, climate, vegetation etc. Langbein, (1947) suggested that the Dd value varies between 0.55 and 2.09 km/km^2 in humid regions. The lowest value of Dd is observed in the regions underlain by highly resistant permeable material with vegetative cover and low relief. The lowest and the highest values of drainage density are 0.333 km^{-1} and 3.696 km^{-1} for sub-basins VII and XII respectively Table 3.2. Sub-basin VII with low values of drainage density has a well-developed drainage network and is capable of producing torrential runoff resulting in intense flood. In general, it has been observed from drainage density measurements made over a wide range of geologic and climatic types that a low drainage density is more likely to occur in regions of highly permeable subsoil material under dense vegetative cover and in situations where relief is low. In contrast, high drainage density is developed in regions of weak or impermeable subsurface materials, sparse vegetation and mountainous relief (Nag and Chakraborty, 2003). Low drainage density value (0.333 km^{-1}) for sub-basin VII indicates that it has highly resistant and highly permeable subsoil material with dense vegetative cover and low relief.

Elongation Ratio (Re)

Schumm (1956) defined elongation ratio as the ratio of diameter of a circle of the same areas as the drainage basin and the maximum length of the basin. In a circular basin the run-off discharge is higher than that of an elongated basin (Singh and Singh, 1964). The value of Re generally varies from 0.6 (for elongated basin) to 1.0 (for circular basin) due to variation in climate and geology. The different Re values can be classified as circular (>0.9), Oval (0.8-0.9) and elongated (<0.7). The elongation ratio for various sub-basins ranges from 0.37 to 1.56 for the SB-V and SB-1V respectively. High values of elongation ratio (Re) indicate strong relief and steep ground slope.

It is measured by dividing the area of the basin by the area of a circle having the same circumference as the perimeter of the basin (Miller, 1953). This ratio is highly influenced by the length and frequency of the streams, geological structures, land use/land cover, climate, relief and slope of the basin. The low, medium and high value of Rc are indicatives of the youth, mature and old stage of the life cycle of the tributaries of a basin. Circulatory ratio value ranges from 0.9 (SB-XIII) to 1.63 (SB-III) Table 3.2. Sub-basins having circular to oval shape allows quick disposal of runoff and results in a high peaked and narrow hydrograph, while elongated shape of sub-watershed allows slow disposal of water, and results in a broad and low peaked hydrograph (Singh and Singh, 1997). Fig (3)

Form factor (Ff)

Form factor is measured is by dividing the basin area by the square the basin area by the square of basin length (Horton, 1932). The basin length (Lb) is measured by measuring the distance from the mouth to the farthest point of the basin. Form factor ranges from 0.33 (SB-V) to 1.38 (SB-IV). SB-VIII and SB-IV with form factors of 0.86 and 1.38 indicate the basin as semi-circular in nature, and have a high peak flow for shorter duration. Fig (3)

Relief Aspects

The relief aspects of the drainage basins are related to the study of three dimensional features of the basin involving area, volume and altitude of vertical dimensions of land forms wherein different morphometric methods are used to analysis the terrain characteristics, which are the result of basin process. Thus, this aspect includes the analysis of the relationships between area and altitude (hypsometric analysis), altitude and slope angle (clinographic analysis), average ground slope, relative relief, relief ratio, dissection index, profiles of terrains and the rivers. The stream elevation can be estimated from the contour crossings on the topographic sheets. The total drop in elevation from the source to the mouth can be found for the elevation from the source to the mouth for the tributaries and the horizontal distances can be measured along the channel using a map measures.

Relief (R)

The relief is defined as the differences in elevation between the highest and the lowest points on the valley floor of a basin. Basin relief is an important factor is understanding the denudational characteristics of the basin and plays a significant role in landforms development, drainage development, surface and sub-surface water flow, permeability and erosional properties of the terrain. The relief value ranges from 37m (SB VIII) to 2234m (SB I). The high relief value (2234m) of the basin indicates the gravity of water flow, low infiltration and high runoff conditions.

Relief Ratio (Rh)

Relief ratio is defined as the ratio of total relief and the basin length, the basin length is the longest distance watershed. It measures the overall steepness of a drainage basin and is an indicator of the intensity of erosion processes operating on the slopes of the basin. Relief aspect of the watersheds plays an important role in drainage development, surface and sub-surface water flow, permeability and landform development and associated features of the terrain. Difference in the elevation between the highest point of a watershed and the lowest point on the valley floor is known as the total relief of the river basin. The relief ratio may be defined as the ratio between the total relief of a basin and the longest dimension of the basin parallel to the main drainage line Schumm (1956). The possibility of a close correlation between relief ratio and hydrologic characteristics of a basin suggested by Schumm who found that sediments loose per unit area is closely correlated with relief ratios. In the study area, the value of relief ratio ranges from 0.004 (SB XIII) to 0.172 (SB XII) with an average relief ratio of 0.033. It has been observed that areas with low to moderate relief and slope are characterized by moderate value of relief ratios. Low value of relief ratios are mainly due to the resistant basement rocks of the basin and low degree of slope.

CONCLUSIONS

The drainage density of the mountainous and hilly terrain is high and the southwestern, southern and southeastern parts. A detailed quantative morphometric analysis has been brought out to know the basin morphology. The Amaravathi River Basin is divided into 13 sub basins of sixth order streams with total sub basin area of 8554 sq.kms. Stream orders were designated based on Strahler's concept (1952).The dimensional and non-dimensional paramaters have been studied in this chapter. The dendritic drainage pattern is almost common in the River Basin. The bifurcation ratio of the sub basins ranges from0.700-5.526 reflects the geologic and tectonic characteristics of the watershed area. Higher value of bifurcation ratio for a sub-watershed indicates the high runoff, low recharge and nature of topography. The stream frequency of the sub-basins varies from 0.314 to 4.622. The drainage density of the sub basins varies from 0.333 to 2.508 $km^{-}1$. The elongation ratio values varies from 0.37 to 1.56 for the SB-V and SB-IV respectively. The circulatory ratio value ranges from 0.9 (SB-XIII) to 1.63 (SB-III).

Reference

Harinath.V, and Raghu. V., (2013) Morphometric Analysis using Arc GIS Techinques. A case study of Dharurvagu, South Eastern part of Kurnool District, Andhra Pradesh, India, *International Journal of science and Research*, vol 2, pp 182-187.

Horton, R.E "Drainage basin characteristics". *Am. Geophys. Union,* 13: 350 – 360, 1932.

Nag SK, Chakraborty S (2003) Influence of rock types and structures in the development of drainage network in hard rock area. *J Indian Soc Remote Sens* 31(1):25–35

Nautiyal MD (1994) Morphometric analysis of a drainage basin, district Dehradun, Uttar Pradesh. *J Indian Soc Remote Sens* 22(4):251–261

Obi Reddy GE, Maji AK, Gajbhiye KS (2002) GIS for morphometric analysis of drainage basins. GIS lndia 4(11):9–14

R.K. Somashekar,P.Ravikumar.,(2011) "Runoff Estimation and Morphometric Analysis for Hesaraghatta Watershed", a remote sensing and GIS approach. *Jour. Indian Soc. Remote Sensing,* v.39 (1), 95-106.

Ramu, B.Mahalingam, P.Jayashree,(2013) "Morphometric analysis of Tungabhadra drainage basin in Karnataka using GIS" *journal of engineering, computers & applied science,* vol 2,no.7,.

Rao NK, Swarna LP, Kumar AP, Krishna HM (2010) Morphometric analysis of Gostani River Basin in Andhra Pradesh State, Indian using spatial information technology. *Int J Geomat Geoscience.*

Srinivasa Vittala, S., Govindaiah., and Home Gowda. H., (2004) Morphometric Analysis of sub-watersheds in the Pavagada Area of Surkur District, South India using Remote sensing and GIS Techniques. *Indian Soc. Remote sensing,* V.32(4).pp.351-362.

Schumm, S.A. Evolution of drainage system and slope in badlands of Perth Amboy, New Jersey. *Bull.Geol.Soc.Am.* 67: 597-46. (1956).

Strahler, A. N. "Quantitative slope analysis, *Bull.Geol. Societ. Am*. 67: 571-596, 1956

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