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MORPHOMETRIC ANALYSIS OF TAPI MICRO - WATERSHED USING REMOTE SENSING AND GIS TECHNIQUE IN BURHANPUR DISTRICT OF M.P. INDIA

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Abstract: Morphometric analysis of any drainage basin is providing us quantitative description of basin and understanding hydrological behavior of the basin. The morphometric analysis includes the linear aspects, areal aspects and relief aspects of a drainage basin through which a general perception about the physiographic, geology, recent diastrophisms, nature of rock material etc. can develop. Proper planning and management of available natural resource is necessary for progress and economic development in agriculture which are main stay of people leaving in the hilly region. Physical characteristics of drainage basin provides some pre-information mainly runoff, stages of its development and soil loss productivity characteristics. The study area in this paper is tributaries of Tapi river is a part of Deccan Traps and dissected topography are seen most part of the area. Tapi River and its tributaries created such topography in this area. The qualitative analysis of the morphometric characteristics of the basin have been done and computed using GIS software. The drainage type of the study area is dendritic which indicates the area consists of homogeneous rock material which is structurally undisturbed. The basin is passing through an early mature stage to old stage of the fluvial geomorphic cycle. The morphometric parameters viz; stream order, stream length, bifurcation ratio, drainage density, drainage frequency, drainage texture, form factor, circulatory ratio, elongation ratio and compactness ratio, etc. were measured.

Keywords: Morphometric analysis, GIS, R.S, Drainage network

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INTRODUCTION

Studies on drainage basin morphometry have been carried out in many parts of the world. The basins in their areas of studies have been classified as the case may be and drainage basin morphometry related to the processes that are prevalent in such areas (EZE B.E. &Efiong J.). The drainage basin, alternatively described a catchment area, is in geomorphology and hydrology a region drained by particular stream or by a river system (Farbridge, 1968). Drainage basin is considered as an open system as these receive the input or energy from the climate over the basin and lose output through the water and sediment lost by the basin. The basin is the collecting ground and stoppage container for precipitation, the system of routes by which water and sediment are transported to the ocean andthe expression of the underlying geologic structure, while its surface is zone of interaction between atmosphere, biosphere, lithosphere (Seby, 1985).

Watershed is also classified based on the area that a watershed contains. On the basis of area, watersheds can be classified as: micro watershed (0 to 10 ha), small watershed (10 to 40 ha), mini watershed (40 to 200 ha), sub watershed (200 to 400 ha), macro watershed (400 to 1000 ha), river basin (above 1000 ha). One of the major concerns of the present time is the management and protection of the watershed area. Morphometric analysis of watershed requires measurement of linear features, gradient of channel network and contributing ground slopes of drainage basin. Morphometric analysis of a watershed provides a quantitative description of the drainage system, which is an important aspect of the characterization of watersheds (Strahler, 1964). The morphometric characteristics of various basins have been studied by various scientists using conventional methods (Horten,1945;Smith,1950; Strahler, 1964). The morphometric parameters have been used various studies like geomorphology, hydrology, plate tectonics, watershed management studies have a special importance in the field of research, due to the increasing demand of water.

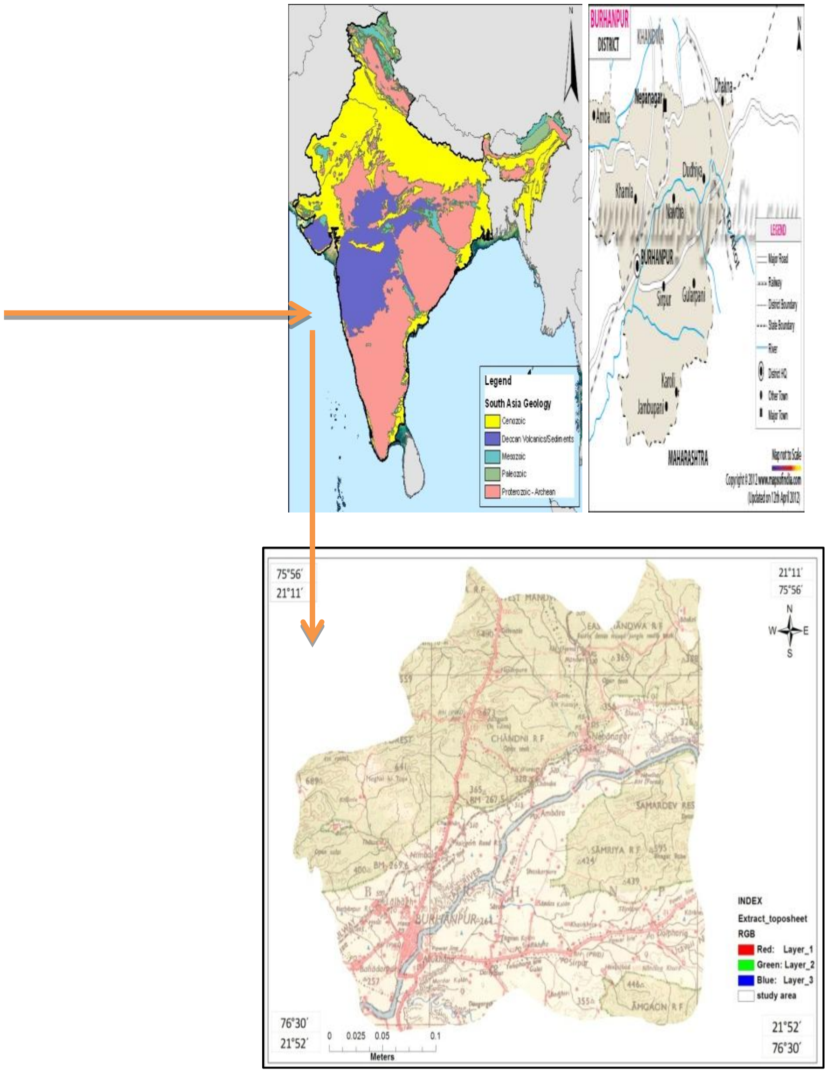

Fig.1 Location map of Study Area

Study area

The Tapi River is one of the three peninsular rivers in India that flow in an eastto west itinerary. The river originates in the eastern portion of the Satpura Mountain ranges in south Madhya Pradesh. The geographical features of the Tapi River are somewhat similar to the geography of Indian peninsula. The source of Tapi River is located in the Betual district. The location is also known as Multai. The tributaries of Tapi River are. The some tributaries of TapiRiver around Asirgarhbelong to latitude and longitude in the survey of India toposheet numbers 55C/3, 55C/4, 55C/7, 55C/10, 55C/11, on a scale of 1:50,000.

The study area has a subtropical climate like most it has a hot dry summer (April-June) followed by monsoon rains (July-September) and a cool and relatively dry winter. Geologically, the study area rocks ranging in age from Archean to Phanerozoic. In this area Laterites and Basalt are the main rock types found. The study area is a part of Deccan. The Deccan Traps are a large igneous provinces located on the Deccan plateau and one of the largest volcanic feature of the earth. The Deccan trap formed between 60 and 68 million periods.

Structurally the area shows the major fault (SON NARMADA FAULT), Plateau (DECCAN), Fold (Satpura hill ranges) etc. Therefore seismicity in this area is characterized by deep intraplate earthquakes are followed by aftershock sequences. Hydrologically, in the study area groundwater occurs under phreatic (unconfined) condition in Laterites and Basalt below Laterites occur under semi confined to confined condition. The groundwater is exploited by either dug well or bore well in the study area.

METHODOLOGY & MATERIAL USED

Material used

The data used in morphometric analysis are the topographical data and other collateral data. Geological Survey of India toposheet on the scale of 1:50,000. There are five toposheets are used in carried outto study which are 55C/3, 55C/4, 55C/7, 55C/10, 55C/11. Other collateral data like existing maps and reports were also used for additional information for morphometric analysis. The data used in morpho tectonic analysis. There are eight toposheets were used to carry out the study which are 55C/3, 55C/4, 55C/7, 55C/10, 55C/11.Other collateral data like existing maps and reports were also used to additional information on the morpho tectonic and for preparing base maps.

Methodology

The morphometric analysis of the tributaries of Tapi river basins around Asirgarh volcanic on published topographical maps on a 1:50,000 scale. The quantitative analysis of the morphometriccharacteristics of the basin include stream order, stream length, etc. which determines drainage characteristics, topography of the area, geomorphic stage of development of the area and hydrological investigation.

The morphometric analysis of drainage basinis analyze as per the law of Horton (1945) and stream ordering is Strahler (1964) and other analysis drawn by computer software. The flowchart of morph tectonic methodology given in figure:

RESULT AND DISCUSSION:

The morphometric analysis provides as quantitative description of the basin (Pamela Deb 2012). The morphometric analysis defined as the measurements and mathematical analysis of the configuration of the earth surface, shape and dimension of its landforms (Agrawal, 1998; Obi Reddy et al, 2002).The analysis of various morphometric parameter of basins are given in this paper, which are calculated as per the mathematical expression as detailed in table.

The stream orders are calculated as per the law of Strahlers (1964). In this analysis it is observed that higer no. of streams belonging to lower order and goes on decreasing with higher order. It is observed that more the no of streams in an area, more the soil erosion and poor soil development and vice versa. In the stream length , there are first order has higher stream length and seventh order has lower stream length from this lower order indicated that the area is high attitudal zones which are characterized by steep slope and low ground water potential and vice versa.

Drainage Network

Stream Order (Su)

Stream ordering is the first step of quantitative analysis of the watershed. The stream ordering systems has first advocated by Horton (1945), but Strahler (1952) has proposed this ordering system with some modifications. Author has been carried out the stream ordering based on the method proposed by Strahler, Table 1. It has observed that the maximum frequency is in the case of first order streams. It has also noticed that there is a decrease in stream frequency as the stream order increases.

Stream Number (Nu)

The total of order wise stream segments is known as stream number. Horton (1945) states that the numbers of stream segments of each order form an inverse geometric sequence with order number, Table 1.

Stream Length (Lu)

The total stream lengths of the Tapimicro watershed have various orders, which have computed with the help of SOI topographical sheets and ArcGIS software. Horton's law of stream lengths supports the theory that geometrical similarity is preserved generally in watershed of increasing order (Strahler, 1964). Author has been computed the stream length based on the low proposed by Horton (1945), Table 1

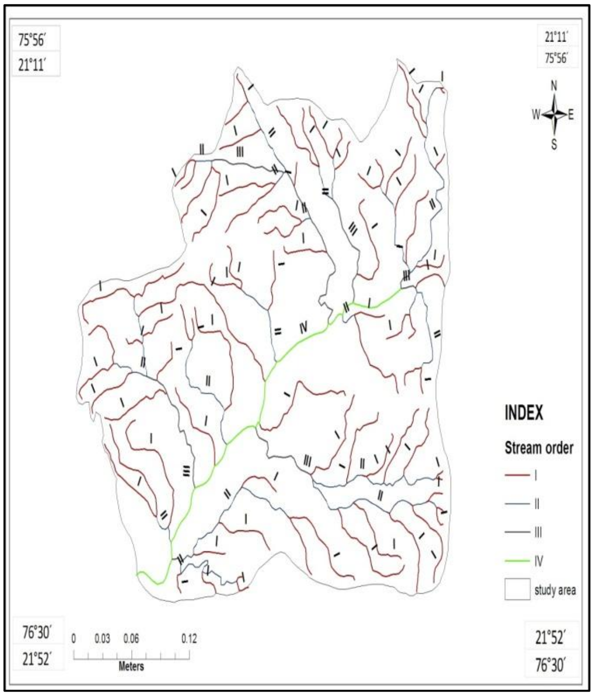

Fig.2 Stream order map of study area

Table 1: Stream Order, Streams Number, and Bifurcation Ratios of study area

S_u	N_u	R_b	N_{u-r}	R_b*N_{u-r}	R_{bwm}
I	82	---	---	---	
II	21	3.90	103	407.1	
III	7	3.00	28	84	**0.41**
IV	1	7.00	8	56	
Total	183	13.90	139	57.1	
Mean		**4.63***			

S_u: Stream order, N_u: Number of streams, R_b: Bifurcation ratios, R_{bm}: Mean bifurcation ratio*, N_{u-r}: Number of stream used in the ratio, R_{bwm}: Weighted mean bifurcation ratios

Mean Stream Length (Lum)

Mean Stream length is a dimensional property revealing the characteristic size of components of a drainage network and its contributing watershed surfaces (Strahler, 1964). It is obtained by dividing the total length of stream of an order by total number of segments in the order.

Stream Length Ratio (Lurm)

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), which tends to be constant throughout the successive orders of a basin. His law of stream lengths refers that the mean stream lengths of stream segments of each of the successive orders of a watershed tend to approximate a direct geometric sequence in which the first term (stream length) is the average length of segments of the first order (Table 2). Changes of stream length ratio from one order to another order indicating their late youth stage of geomorphic development.

Bifurcation Ratio (Rb)

The bifurcation ratio is the ratio of the number of the stream segments of given order 'Nu' to the number of streams in the next higher order (Nu+1), Table 1. Horton (1945) considered the bifurcation ratio as index of relief and dissertation. Strahler (1957) demonstrated that bifurcation shows a small range of variation for different regions or for different environment except where the powerful geological control dominates. It is observed from the Rb is not same from one order to its next order these irregularities are dependent upon the geological and lithological development of the drainage basin (Strahler 1964). The bifurcation ratio is dimensionless property and generally ranges from 3.35 to 4.0. The lower values of Rb are characteristics of the watersheds, which have suffered less structural disturbances (Strahler 1964) and the drainage pattern has not been distorted because of the structural disturbances (Nag 2005). In the present study, the higher values of Rb indicates strong structural control on the drainage pattern, while the lower values indicative of watershed that are not affect by structural disturbances.

Weighted Mean Bifurcation Ratio (Rbwm)

To arrive at a more representative bifurcation number used a weighted mean bifurcation ratio obtained by multiplying the bifurcation ratio for each successive pair of orders by the total numbers of streams involved in the ratio and taking the mean of the sum of these values. Schumm (1956, pp 603) has used this method to determine the mean bifurcation ratio of the value of **1.73** of the drainage of Perth Amboy, N.J. The values of the weighted mean bifurcation ratio this determined are very close to each other.

Table 2: stream length and stream length ratio in study area.

S_u	L_u	L_u/S_u	Lur	L_{ur-r}	$L_{ur}*L_{ur-r}$	L_{uwm}
I	3.72	0.045	---	---	---	
II	1.28	0.060	1.33	5.0	6.65	
III	0.52	0.074	1.23	1.8	2.21	**1.73**
IV	0.37	0.37	5.00	0.89	4.45	
Total	5.89	37.179	7.56	7.69	13.31	
Mean			2.52			

S_u: Stream order, L_u: Stream length, L_{ur}: Stream length ratio, L_{urm}: Mean stream length ratio*, L_{ur-r}: Stream length used in the ratio, L_{uwm}: Weighted mean stream length ratio.

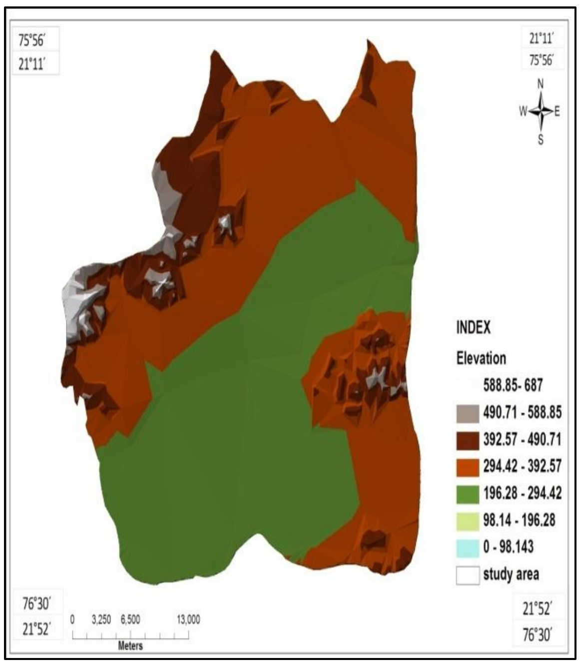

Fig.3 Triangular Irregular Network (TIN) Map

Length of Main Channel (Cl)

This is the length along the longest watercourse from the outflow point of designated sun watershed to the upper limit to the watershed boundary. Author has computed the main channel length by using ArcGIS-10 software, which is **0.00054**Kms.

Basin Geometry

Length of the Basin (Lb)

Several people defined basin length in different ways, such as Schumm (1956) defined the basin length as the longest dimension of the basin parallel to the principal drainage line. defined the basin length as the longest in the basin in which are end being the mouth. Gardiner (1975) defined the basin length as the length of the line from a basin mouth to a point on the perimeter equidistant from the basin mouth in either direction around the perimeter. The length of the Tapimicro watershed in accordance with the definition of Schumm (1956) that is **3.73** Kms.

Table 3: Morphometric Analysis of Tapi micro-watershed Comparative Characteristics

S. N	Morphometric Parameter	Formula	Reference	Results
A	**Drainage Network**			
1	Stream Order (S_u)	Hierarchical Rank	Strahler (1952)	**1 to 4**
2	1st Order Stream (S_{uf})	Suf = N1	Strahler (1952)	**82.00**
3	Stream Number (N_u)	Nu = $N_1+N_2+ \ldots N_n$	Horton (1945)	**111.00**
4	Stream Length (L_u) Kms	Lu = $L_1+L_2 \ldots L_n$	Strahler (1964)	**5.89**
5	Stream Length Ratio (L_{ur})	see Table 2.3	Strahler (1964)	**7.56**
6	Mean Stream Length Ratio (L_{urm})	see Table 2.3	Horton (1945)	**2.52**
7	Weighted Mean Stream Length Ratio (L_{uwm})	see Table 2.3	Horton (1945)	**1.73**
8	Bifurcation Ratio (R_b)	see Table2.2	Strahler (1964)	**4.63-13.90**
9	Mean Bifurcation Ratio (R_{bm})	see Table 2.2	Strahler (1964)	**4.63**
10	Weighted Mean Bifurcation Ratio (R_b)	see Table 2.2	Strahler (1953)	**0.41**
11	Main Channel Length (C_1) Km.	GIS Software Analysis		**0.00054**
12	Valley Length (Vl) Kms	GIS Software Analysis		**3.73**
13	Basin Length (L_b) Kms	GIS Software Analysis	Schumm(1956)	**3.73**
14	Basin Perimeter (P)Kms	GIS Software Analysis	Schumm(1956)	**8.412**
15	**Basin Area (A) SqKms**			**9.719**

Basin Area (A)

The area of the Tapi micro watershed is another important parameter like the length of the stream drainage. Schumm (1956) established an interesting relation between the total Tapi micro watershed areas and the total stream lengths, which are supported by the contributing areas. The author has computed the basin area by using ArcGIS-10 software, which is **9.719**Sq. Kms.

Basin Perimeter (P)

Basin perimeter is the outer boundary of the watershed that enclosed its area. It is measured along the divides between watersheds and may be used as an indicator of watershed size and shape. The author has computed the basin perimeter by using ArcGIS-10 software, which is **8.412** Kms.

CONCLUSION

The study reveals that remotely sensed data and GIS based approach in evaluation of drainage morphometric parameters and their influence on landforms, soils and eroded land characteristics at river basin level is more appropriate than the conventional methods. GIS techniques characterized by high accuracy of mapping and measurement prove to be a competent tool in morphometric analysis. GIS techniques characterized by very high accuracy of mapping and measurement prove to be a competent tool in morphometric analysis.

The morphometric analyses were carried out through measurement of linear, areal and relief aspects of the watershed with more than 15 morphometric parameters. The morphometric analysis of the drainage network of the watershed show dendritic and radial patterns with moderate drainage texture. The morphometric analysis of the drainage network of the watershed show dendritic and with coarse drainage texture. The variation in stream length ratio due to change in slope and topography. The bifurcation ratio in the watershed indicates normal watershed category and the presence of moderate drainage density suggesting that it has moderate permeable sub-soil, and coarse drainage texture. The value of stream frequency indicate that the watershed show positive correlation with increasing stream population with respect to increasing drainage density. Hence, from the study it can be concluded that GIS techniques, prove to be a competent tool in morphometric analysis.

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