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MORPHOMETRIC ANALYSIS OF GP2 SUB - WATERSHED USING REMOTE SENSING AND GIS TECHNIQUES IN BULDHANA DISTRICT OF MAHARASHTRA INDIA

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Abstract: In this study, an attempt has been made to understand the morphometric Analysis of GP2 Sub - watershed using remote sensing and GIS techniques in Buldhana District of Maharashtra, India. The morphometric analysis contains the linear aspects, areal aspects and relief aspects of a drainage basin through which overall perception about the physiographic, geology, recent diastrophisms, nature of rock material etc. can develop. In the current paper, an attempt has been complete to study the detail Morphometric features of the GP2 sub watershed. The drainage map of the area was prepared from the Survey of India (SOI) topo sheets using ARC GIS 10.2 software. The morphometric parameters viz; stream order; stream length, bifurcation ratio, drainage density etc. were measured. These studies are very beneficial for development of rainwater harvesting and watershed management.

Key Words: Morphometric analysis, GIS, R.S, Drainage network

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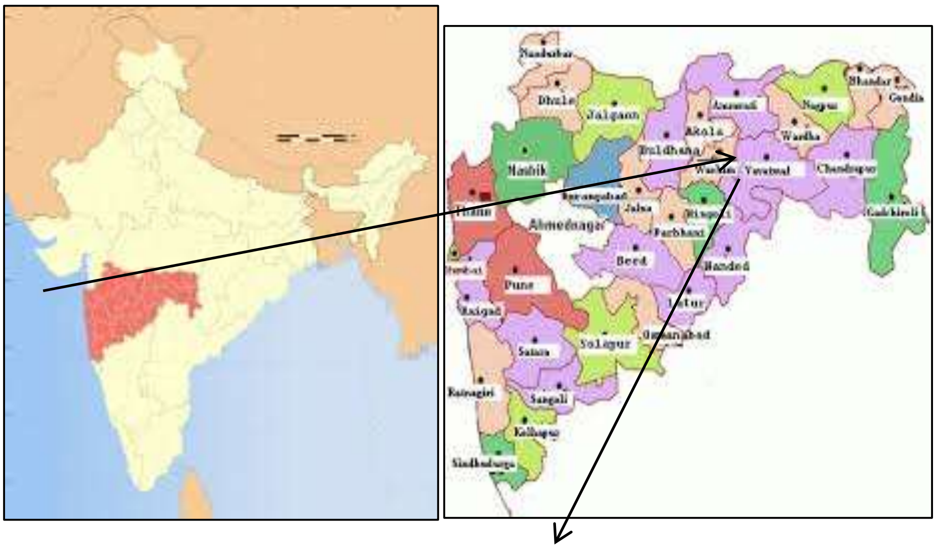
INTRODUCTION

Watershed is a natural hydrologic unit, considered as the most appropriate basis for sustainable integratedmanagement of the land and water resources. Judicious management and conservation of soil and water resourceson watershed basis is perquisite for sustaining the productivity. Characterization and prioritization of watershedsare essential steps in the integrated management of land resources. Remote sensing using aerial and space borne sensors can be effectively used forwatershed characterization and assessing watershed priority, evaluating problems, potentials, managementrequirements and periodic monitoring. 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.



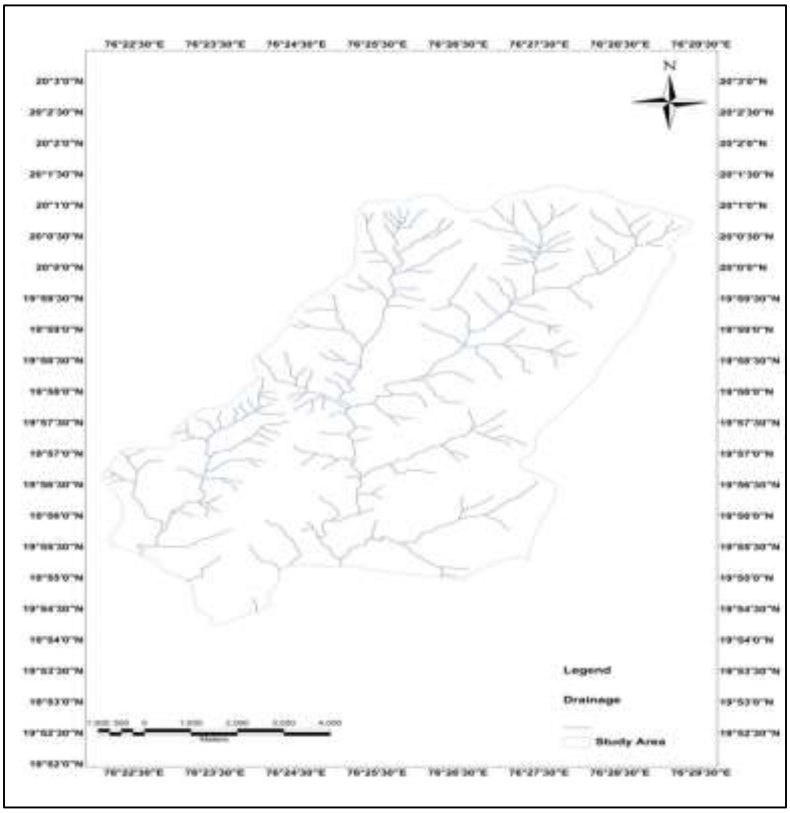


Fig.1 Location map of Study Area

Study area

The study area GP2 is situated in Buldhana Districts of Maharashtra which is located between 19°52’30” to 76°22′30″ latitude and 19°52’00’’ to 76°29’30’’ longitude. The study area is covered by Survey of India (SOI) toposheet 55D/12 and 55D/8 on 1:50,000 scale. The maps were georeferenced and digitized using the Arc GIS 10.2 GIS software’s and 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. The drainage basin characteristics help in deciphering and understanding the interrelated relief and slope properties. The previously mentioned TIN model is used to understand the detail nature of study area.

Methodology

The quantitative analysis of the morphometric characteristics 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. Digitizing stream network and assigning the stream order from a published topographic map for a large area is a tedious task. The stream network of the study area is extracted from a series of geoprocessing tools (Fig.2). The output of this technique will create a stream network grid with stream classification based on Strahler (1964). Strahler’s system of classification designates a segment with no tributaries as a first-order stream. Where two first-order stream segments join, they form a second-order stream segment and so on. The highest stream order in the study area was computed as fifth.To evaluate the basin morphometry, various parameters like stream number, stream order, stream length, stream length ratio, bifurcation ratio have been analyzed using the standard mathematical formulae.

Result and discussion:

The morphometric analysis provides as quantitative description of the basin (Pamela Deb 2012). The stream orders are calculated as per the law of Strahlers (1964). In this analysis it is observed that higher 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 attitude 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 Tapi micro 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

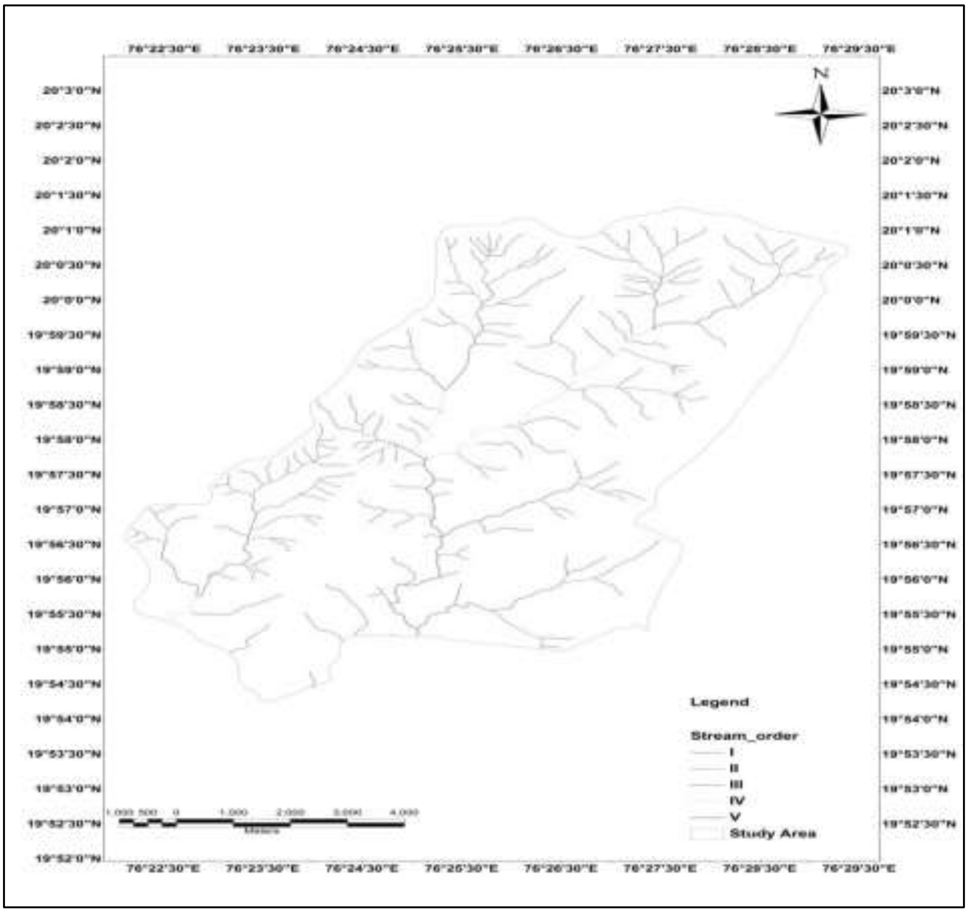


Fig.2 Stream order map of study area

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	149	---	---	---	
II	38	3.92	187	733.04	
III	9	4.22	47	198.34	**3.91**
IV	3	3	12	36	
IV	1	3	4	12	
Total	200	14.14	250	979.38	
Mean		**3.53**			

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 **3.91** 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	90.42	0.60	---	---	---	
II	27.21	0.71	1.18	117.63	138.80	
III	20.56	2.28	3.21	47.77	153.34	**1.59**
IV	9.39	3.13	1.37	29.95	41.03	

V	6.06	6.06	0.61	21.51	13.12
Total	153.64	12.78	7.55	216.86	346.29
Mean			**1.88**		

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.

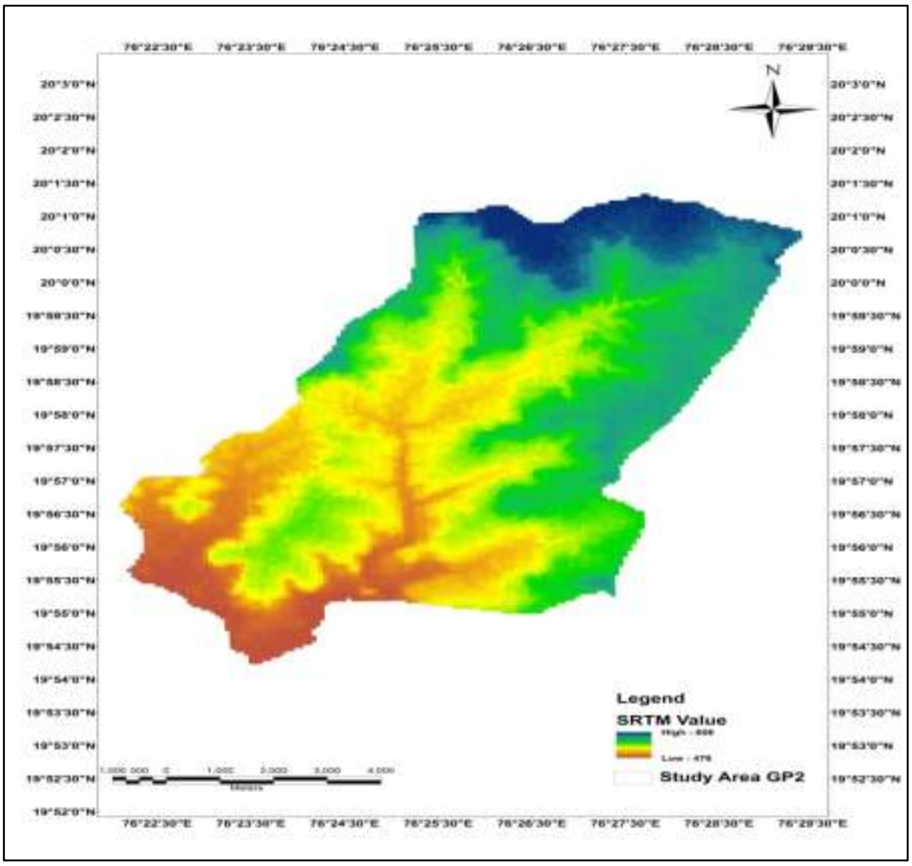


Fig. 3 SRTM map of study area

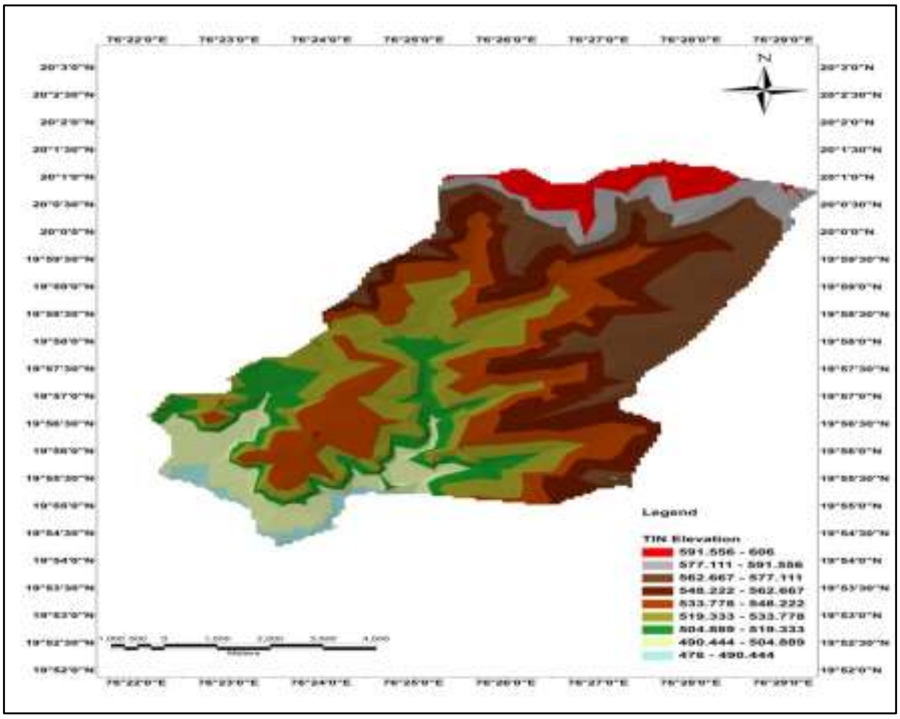


Fig. 4 Triangular Irregular Network (TIN) Map

CONCLUSIONS

The relationship between geological setup and drainage pattern is analyzed using a triangulated irregular network (TIN). Regional and local trends of geological setup are reflected in the variable orientation of channels of different rank in the catchment. The study reveals that remotely sensed data (ASTER-DEM) and GIS based approach in evaluation of drainage morphometric parameters and their influence on landforms, soils and eroded land characteristics at GP-2 area level is more appropriate than the conventional methods. 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. Hence, from the study it can be concluded that GIS techniques, prove to be a competent tool in morphometric analysis.

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