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GEOGRAPHICAL INFORMATION SYSTEM – BASED MORPHOMETRIC ANALYSIS OF ASIRGARH AREA, BURHANPUR DISTRICT, M.P., INDIA

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Abstract: Detailed morphometric analysis of the Asirgarh area in Burhanpur district has been attempted to demarcate the various groundwater potential zones and understanding the landform processes, soil physical properties and erosion characteristics, etc. Morphometric analysis is defined as the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of its landforms (Clarke, 1966). This analysis can be achieved through dimension of linear, aerial and relief aspects of the basin (Nag and Chakra borty, 2003). For the Morphometric analysis Geographic information system techniques has been used and as per the law of Horton (1945) and stream ordering is Strahler (1964) stream order method used for stream ordering. The drainage density (D) of study area is 1.9674 km indicating low to moderate drainage density. In this study an attempt has been made to identify with the morpho-tectonic analysis of the Asirgarh area by utilizing the remote sensing and GIS techniques for delineating groundwater potential zones for the sustainable improvement of the section. The dendritic drainage pattern shows Vth stream order in the study area. The bifurcation ratio reflecting geotectonic characteristics of the Asirgarh area was estimated 5.02.

Keywords: Morphometric Parameters, Location Map, GIS, Spatial data

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INTRODUCTION

Accurate development and managing of presented natural resources is basic for improvement and economic development in farming which are in hilly region. Water, which is expensive natural resource, very important for supporting all life on the earth is becoming insufficient due to various reasons including decrease in permeation rates, overflow, wasteful use, overexploitation of the surface water resources etc; therefore change in land use patterns and degradation of land cover. Morphometric characterization is considered to be the most appropriate method for the proper development and managing of watershed, for the reason that it enables us to identify with the relationship among different aspects of the drainage pattern of the basin, and also to make a comparative evaluation of different drainage basins, developed in various geologic and climatic regimes. The morphometric studies have been carried out in different Indian watersheds and consequently used for water resources improvement and organization projects (Chalam *et al.,* 1996; Chaudhary *et al.,* 1998; Kumar *et al.,* 2001; Ali & Singh *et al.,* 2002;).

STUDY AREA:

asirgarh area is situated at north eastern part of Burhanpur District. It is located about 20 km North West of the town of Burhanpur in Madhya Pradesh. The study area lies between latitude 21^0 11'- 21^0 52' N and longitude 75°55' – 76°30' E located in toposheet no 55C/1 to C/8. The study area forming about 460m thick sequence of lava flows covering of an area of 4000 sq km in Burhanpur District of Madhya Pradesh. The study area covers by the drainages of Tapi River and ChhotaTawa River. The study area situated in the valley of Narmada and Tapi River amidst the satpura ranges, on the flat ground along the North bank of Tapi River. The Tapi River flows through the north east to south west. The Tapi River is one of the three peninsular itiniery. The ChhotaTawa River is the Narmadas longest tributary at 172 km. It raises in the Satpura ranges at Betul and flowing North and West join the Narmada at the village of Bandra Bhan in Hoshungabad District.

Table 1: Geological succession of the study area

AGE	Formation	Lithology
Quaternary	Alluvium	**Yellow color clay, With sand bed and Silt with course sand, Gravel and Boulder**
----------Angular Unconformity----------		

Upper Cretaceous to Lower Eocene	Deccan trap (Malwa group)	Inore Formation Kankaria-Pirukheri Formation Kallisindh Formation
----------Unconformity----------		
Lower Triassic to Cretaceous	Gondwana super group	Sandstone

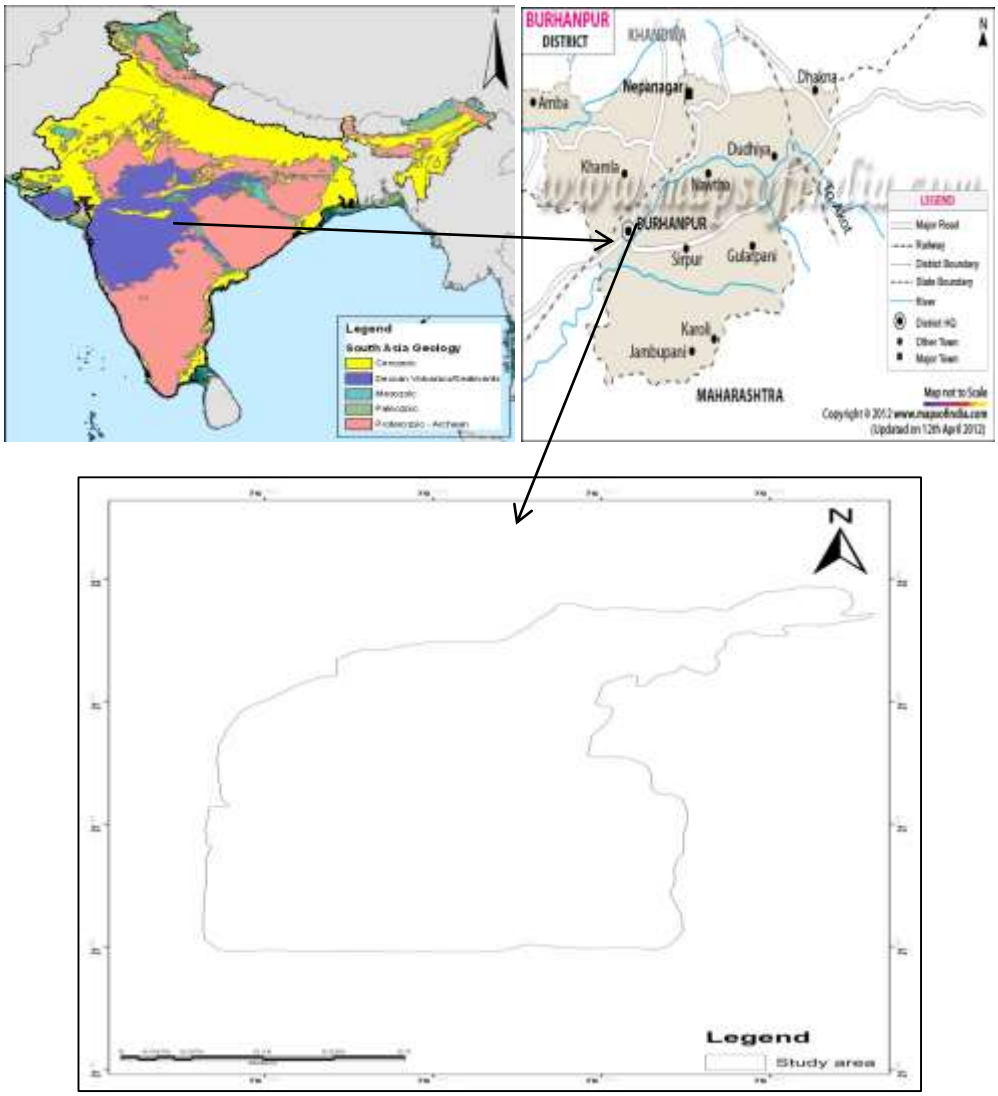

Fig. 1 Location map of study area

METHOD OF INVESTIGATION:

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 eight toposheets are used in carried out to study which are 55C/1 to 55C/11. Other collateral data like existing maps and reports were also used for additional information for morphometric analysis. The morphometric analysis of the around Asirgarh volcanic on published topographical maps on a 1:50,000 scale. 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. The Morphometric analysis of drainage basin is analyzed as per the law of Horton (1945) and stream ordering is Strahler (1964) and other analysis drawn by computer software. The flowchart of morphometric methodology given in figure:

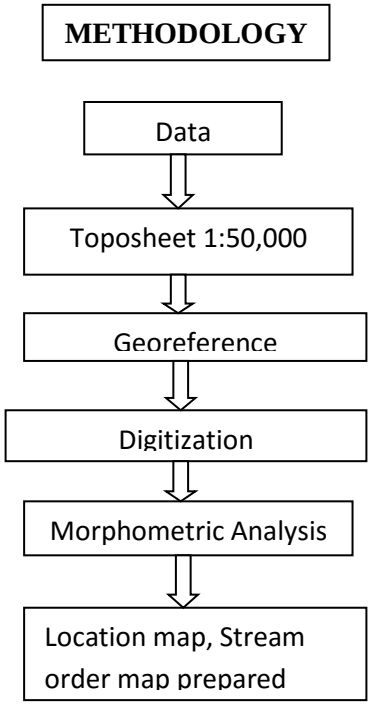

Fig.: - Flow chart showing the broad methodology of Morphometric analysis

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 4. 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.

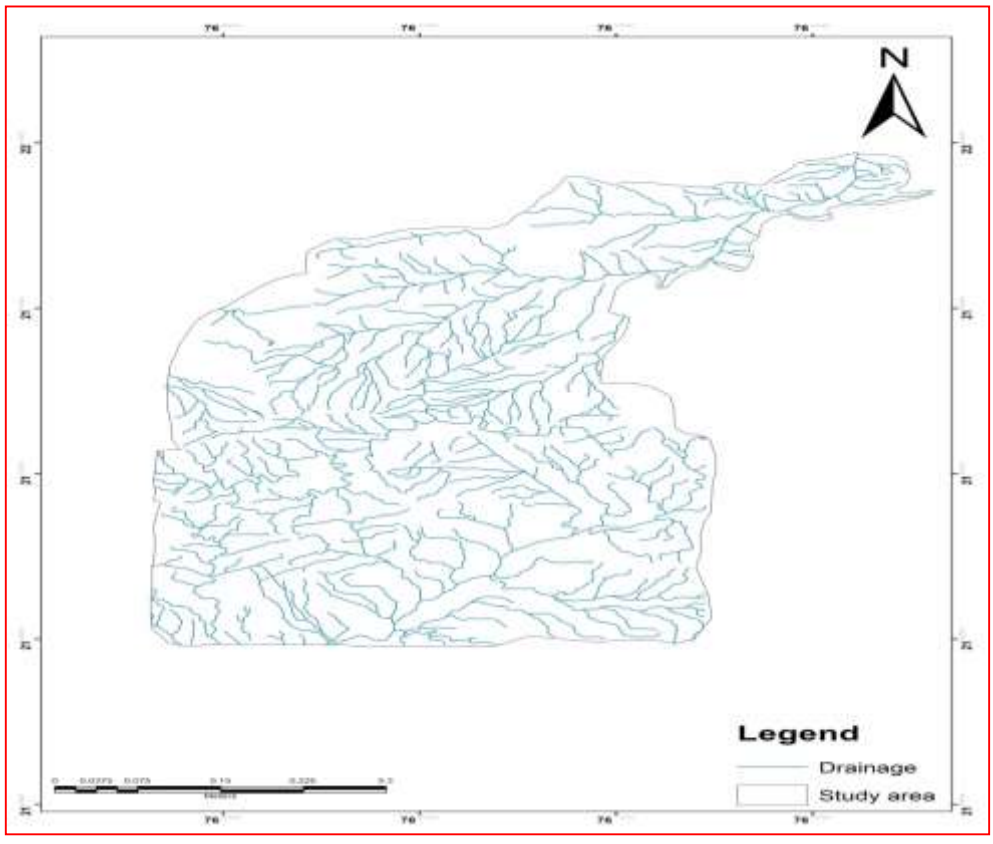

Fig 2: DRAINGE MAP

Table 2: 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	327	---	---	---	
II	80	4.08	407	1660.56	
III	20	4	100	400	**4.13**
IV	4	5	24	120	
V	1	7	5	35	
Total	432	20.08	536	2215.56	
Mean		**5.02***			

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.

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 2. 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 2.

Stream Length (Lu)

The total stream lengths of the Asirgarh area have various orders, which have computed with the help of SOI topographical sheets and Arc GIS 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 2

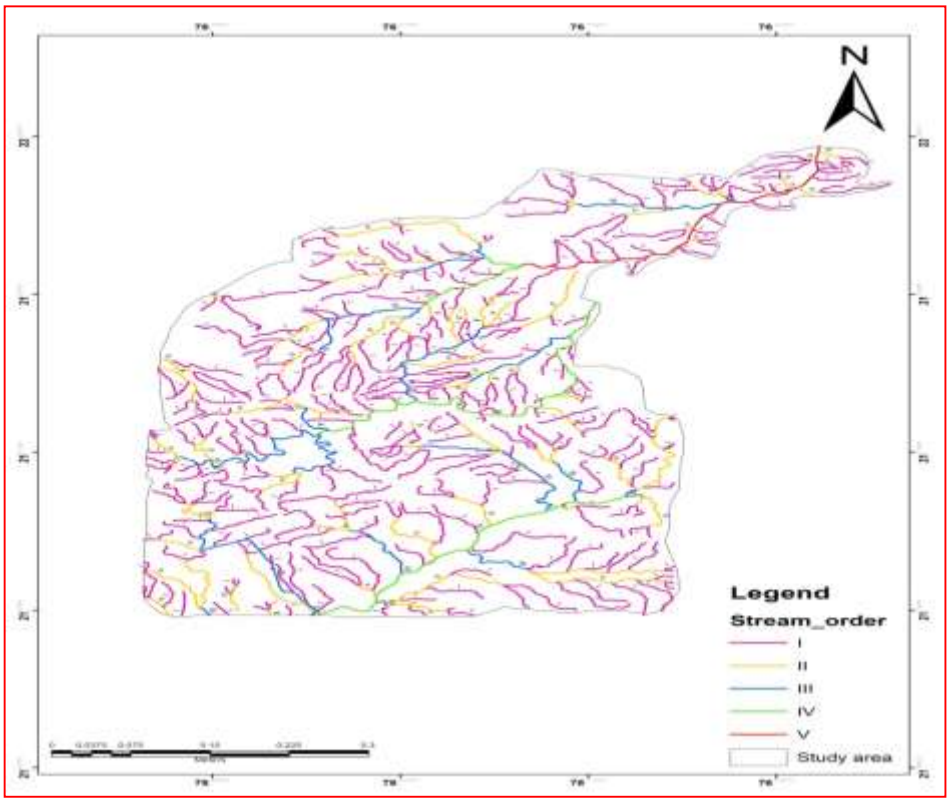

Fig.3 Stream order map of study area

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). The changes of stream length ratio from one order to another order indicating that 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 2. 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 4 to 7. 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 **4.13** 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 3: stream length and stream length ratio in Asirgarh area.

S_u	L_u	L_u/S_u	Lur	L_{ur-r}	$L_{ur}*L_{ur-r}$	L_{uwm}
I	0.0125	3.82	---	---	---	
II	0.0038	0.0000475	1.24	0.0163	0.020	
III	0.0020	0.0001	2.10	0.0058	0.012	**1.55**
IV	0.0010	0.00025	2.5	0.003	0.0075	
V	0.0004	0.0004	1.6	0.0014	0.0018	
Total	0.0188	3.82	7.44	0.0265	0.0413	
Mean			**1.86**			

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.

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 **0.000403**Kms.

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 it is 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 Asirgarh area is in accordance with the definition of Schumm (1956) that is **13.24** Kms.

Basin Area (A)

The area of the Asirgarh is another important parameter like the length of the stream drainage. Schumm (1956) established an interesting relation between the total Asirgarh 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 **3.074**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 **2.057** Kms.

Table 4: Morphometric Analysis of Asirgarh area:

S. N	Morphometric Parameter	Formula	Reference	Results
A	**Drainage Network**			
1	Stream Order (S_u)	Hierarchical Rank	Strahler (1952)	**1 To 5**
2	1st Order Stream (S_{uf})	Suf = N1	Strahler (1952)	**327**
3	Stream Number (N_u)	Nu = N_1+N_2+ …N_n	Horton (1945)	**432**

4	Stream Length (L_u) m	Lu = L_1+L_2 … L_n	Strahler (1964)	**19.89**
5	Stream Length Ratio (L_{ur})	see Table 2.3	Strahler (1964)	**7.44**
6	Mean Stream Length Ratio (L_{urm})	see Table 2.3	Horton (1945)	**1.86**
7	Weighted Mean Stream Length Ratio (L_{uwm})	see Table 2.3	Horton (1945)	**1.55**
8	Bifurcation Ratio (R_b)	see Table2.2	Strahler (1964)	**20.08**
9	Mean Bifurcation Ratio (R_{bm})	see Table 2.2	Strahler (1964)	**5.02**
10	Weighted Mean Bifurcation Ratio (R_b)	see Table 2.2	Strahler (1953)	**4.13**
11	Main Channel Length (C_1) Km.	GIS Software Analysis		**0.000403**
12	Valley Length (VI) Kms	GIS Software Analysis		**13.24**
13	Basin Length (L_b) Kms	GIS Software Analysis	Schumm(1956)	**13.24**
14	Basin Perimeter (P)Kms	GIS Software Analysis	Schumm(1956)	**2.057**
15	**Basin Area (A) Sq Kms**			**3.074**

CONCLUSION

The present study using GIS techniques for the Morphometric analysis made the task easier of the computation of morphometric and morpho-tectonic parameters and their analysis. GIS techniques characterized by 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 parameters such as drainage density, stream frequency and bifurcation ratio are important for the integrated decision making process in flood management, soil erosion assessment and water resource management. The value of stream frequency indicate that the watershed show positive correlation with increasing stream population with respect to increasing drainage density. The results of this study will certainly help in understanding groundwater regime of the region by locating groundwater potential zones in the region where

the hydrogeological conditions are unpredictable. Based on this study, various groundwater potential zones can be identified for the sustainable development of the region.

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