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DRAINAGE MORPHOMETRY OF THE CHARGARH RIVER BASIN IN TALUKA MORSHI AND CHANDUR BAZAR, LOCATED IN AMRAVATI DISTRICT, MAHARASHTRA, CONDUCTED THROUGH REMOTE SENSING AND GIS

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ABSTRACT:

A valuable tool for delineating groundwater potential and drainage patterns involves utilizing GIS to identify morphological features and analyze basin properties. In this research, the Chargarh River Basin, a tributary of the Wardha River, was chosen for detailed morphometric analysis. Various morphometric parameters such as stream order, length, bifurcation ratio, drainage density, stream frequency, form factor, and circulatory ratio were computed. The basin's drainage area covers 548 km^2, displaying a sub-dendritic to dendritic drainage pattern. Physiographic and lithological conditions primarily govern the stream order, categorizing the study area as a six-order basin. The low bifurcation ratio suggests minimal influence from geological structures on drainage patterns. Stream frequency indicates low relief, while the elongation ratio (0.33) signifies an elongated basin shape. A drainage density of 2.27 implies limited surface runoff and uniform rock type. The low bifurcation ratio suggests minimal influence from geological structures on drainage patterns. Stream frequency indicates low relief, while the elongation ratio (0.33) signifies an elongated basin shape. A drainage density of 2.27 implies limited surface runoff and uniform rock type.

KEYWORDS:

MORPHOMETRIC ANALYSIS, CHARGARH RIVER, GEOMORPHOLOGY, DRAINAGE BASIN, REMOTE SENSING, GIS.

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1. INTRODUCTION

All living things depend on water, which also acts as the basis for all human undertakings. The acute water shortage has been getting worse year after year, but water pollution has also been getting worse due to unexpectedly rapid population expansion, more irrigation, frequent droughts, and accelerated urbanization and industry. The supply of surface water is not assured all year round, especially during the summer months when insufficient rainfall prevents surface water resources from meeting demand and causes groundwater to become scarce. The morphometric characteristics of a river basin reveal its hydrological behavior and are useful in determining the hydrologic response of the basin. The drainage system is more understandable with the use of a quantitative morphometric study.

STUDY AREA

The study area is located in the northeastern section of the Amravati district and encompasses the Chandur Bazar and Morshi region. It is mapped on a 1:50,000 scale and includes the toposheet numbers 55 G/14, 55 G/15, 55 G/16, 55 K/3, and 55 K/4. Situated between latitudes $21^0$7'0"N and $21^0$31'30"E and longitudes $77^0$47'0"E to 78^0 50' 0"E.

The Wardha River originates in Multai, Madhya Pradesh, and receives several small tributaries that flow directly with the district. The Chargarh River is one of the major tributaries that join the Wardha, covering an area of 548 km^2. It passes through the Taluka of Morshi and Chandur Bazar; the majority of the study area is made up of the Deccan trap (CGWB, 2017). During the rainy season, there is moderate rainfall, while the winters are brief and chilly. The lithology of the area is composed of hard rock. The river passes through communities with a low population density and agricultural area along its course. Some of the villages are deserted because of the uneven exposure of the rock, extensive use of the water in agriculture and drinking. The watershed is drained by 1st to 6th order streams.

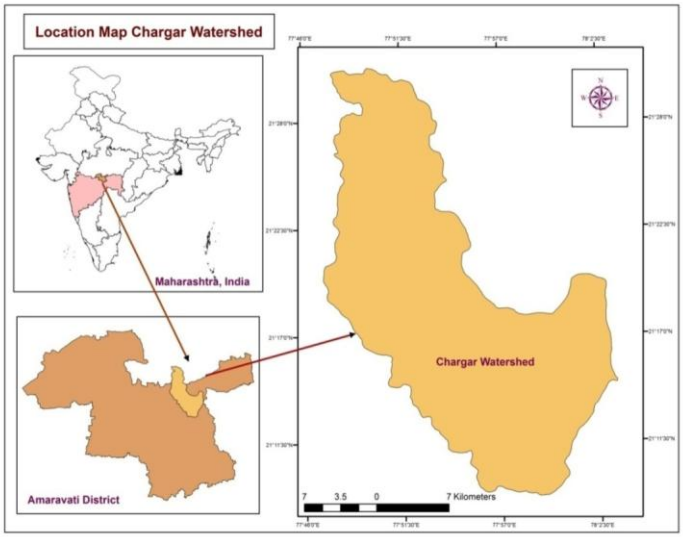

FIG.1: LOCATION MAP OF THE STUDY AREA.

METHODOLOGY

Using the Hydrology tool in Arc GIS 10, the Geological Survey of India toposheet is used to create base maps, identify sample regions, and to generate slope and lineation maps. We have calculated the morphometric characteristics of the Chargarh river basin and its tributaries using Arc GIS 10. The analyses of the asymmetry factor, elongation ratio, ruggedness number, basin relief, basin elongation ratio, drainage density analysis, and drainage pattern analysis that have been carried out for each drainage basin using remote sensing and GIS techniques make up the morphotectonic indices of the Chargarh river basin.

GEOMORPHOLOGY

The science of earth formations known as geomorphology is crucial to the assessment and categorization of land forms. The research area's geomorphological investigations were conducted using in-depth remote sensing analysis. Physiographically, the basin is characterized by residual hills that frequently display butte features, alluvial plains and a plateau that is worn and moderately or slightly dissected (see fig. 2).

DRAINAGE SYSTEM

Drainage system, also called as river system, is the patterns formed by the streams, rivers and lakes in a particular drainage basin. They are governed by the topography of the land, whether a particular region is dominated by hard or soft rocks, and the gradient of the land. The Chargarh river basin shows dendritic, sub-dendritic and sub-parallel drainage patterns (see fig. 3).

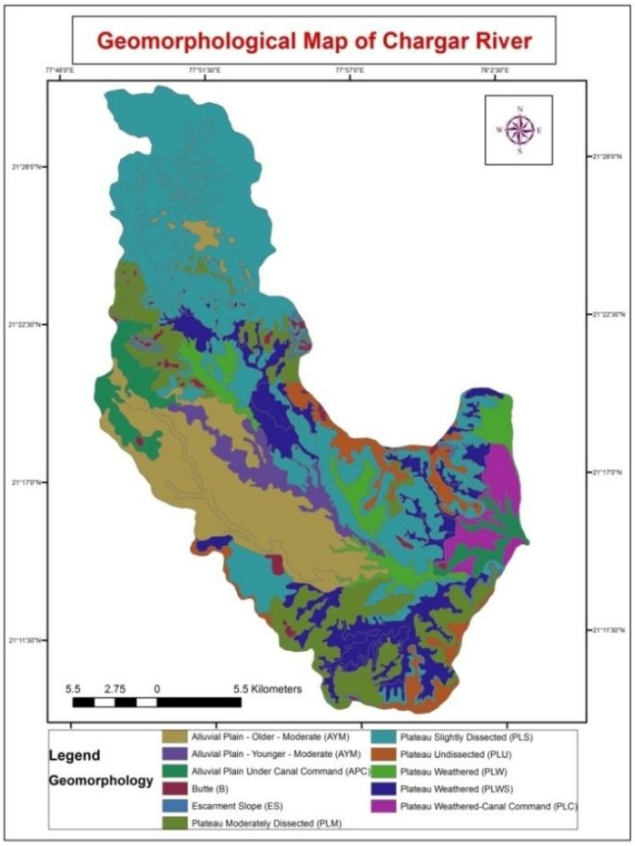

FIG. 2: GEOMORPHOLOGICAL MAP OF CHARGARH RIVER.

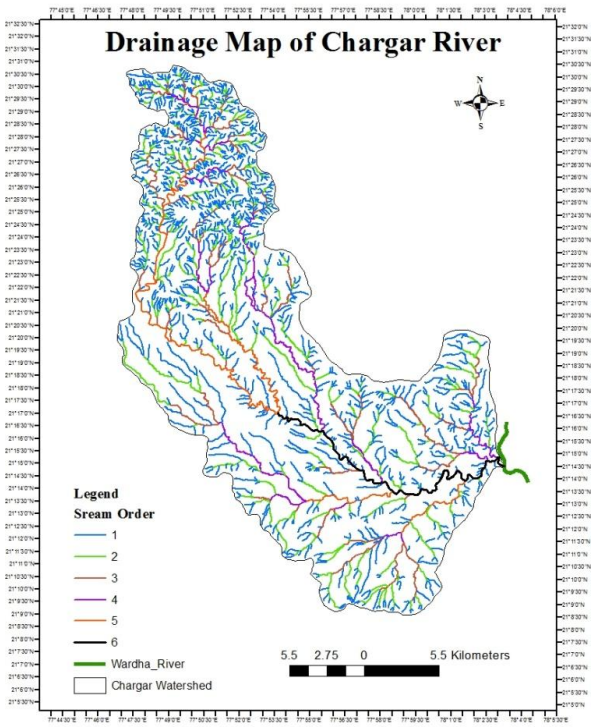

FIG.3: DRAINAGE MAP OF CHARGARH RIVER.

RESULT AND DISCUSSION

TABLE 1: FORMULAE ADOPTED FOR COMPUTATION OF MORPHOMETRIC PARAMETERS.

Sr. No	Morphometric Parameters	Formula/Definition	Reference
1	Stream order (U)	Hierarchical order	Strahler (1964)
2	Stream Length (L_u)	Length of the Stream	Horton (1945)
3	Mean Stream Length	$RL=L_u/L_u-1$ Where, R_L=Stream Length ratio, L_u=Total stream length of the order 'u'; L_u-1=The total stream length of its next order.	Schumn (1956)
4	Bifurcation ratio (R_b)	$R_b=N_u/N_u+1$ Where, N_u= Number of stream segments present in the given order, N_u+1= Number of segments of the next higher order.	Schumn (1956)
5	Mean Bifurcation ratio	R_{bm}=Average of Bifurcation ratios of all orders.	Strahler (1957)
6	Drainage Density (D_d)	$D_d = L_u/A$ Where, Dd= Drainage Density, Lu= Total stream length of all orders, A= Area of the basin (km^2).	Horton (1945)
7	Stream Frequency(F_s)	$Fs= N_u/A$ Where, F_s= Stream Frequency, N_u=Total no.of streams of all orders, A= Area of the basin(km^2).	Horton (1932)
8	Drainage Intensity (D_i)	$D_i=$ Dd/Fs Where, D_d= Drainage Density, Fs= Stream Frequency.	Horton (1945)
10	Circulatory Ratio (R_c)	$Rc=4*Pi*A/P^2$ Where, Rc=Circulatory ratio, Pi=Pi value i.e., 3.14, A= Area of the basin (km2), P^2=Square of the perimeter (km).	Horton (1945)
11	Texture Ratio (T)	T=N1/P Where, N1= Total number of first order stream, P=Perimeter of basin.	Horton (1945)
12	Form Factor (R_f)	$Rf= A/Lb^2$ Where, Rf=Form Factor, A=Area of the basin (km^2), Lb^2= Square of Basin length.	Horton (1945)
13	Constant channel maintenance (C)	C=1/Dd Where, Dd= Drainage density.	
14	Elongation ratio (R_e)	$R_e=2\sqrt{(A/\pi)}/Lb$ Where, R_e=Elongation ratio, A=Area of basin (km^2), Pi='Pi' value i.e., 3.14, Lb= Basin length.	Schumn(1956)
15	Length of overland flow (L_g)	$L_g=1/D*2$, Where, L_g=Length of overland flow, D= Drainage Density	Horton (1945)
16	Basin relief (B_h)	Vertical distance between the lowest and highest points of basin.	Schumn (1956)
17	Relief ratio (R_h)	$R_h=$ Bh/Lb Where, Bh= Basin relief, Lb= Basin length.	Schumn (1956)

18	Ruggedness number (R_n)	$R_n = B_h * D_d$ Where, B_h= Basin relief, L_b= Basin length	Schumn (1956)
19	Perimeter (P)	Calculated	Schumm (1956)
20	Basin Area (A) $(Km)^2$	Calculated	Schumm (1956)
21	Basin Length (Lb) (Km)	Calculated	Schumm (1956)

LINEAR ASPECTS

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 (H), stream number (N), bifurcation ratio (Rb), stream lengths (Lu), Stream Length ratio (RL), Length of overland flow (Lg) Sinuosity indices etc.

STREAM ORDER (U)

Stream order found that Chargarh river tributaries are the 6 order in all streams 1416 where identify of which 1086 are first order, 250 second order, 59 are third order,16 are fourth and 4 are five order and stream order 6 is 1. The drainage pattern of stream network from the basin have been observed as Mainly of dendritic type which Indicates the homogeneity in texture and lack of structural control.

STREAM LENGTH (LU)

The length of first order 682.88 Km, second stream order 258.06 km, third order 130.03 km, fourth order stream 78.79 km, fifth order stream 70.23 km and six order 26.12 km. The change may indicate flowing of stream from higher altitude, lithological variation and moderately steep slope.

MEAN STREAM LENGTH

The mean stream length is a characteristic property related to the drainage network and it is associated surface (Strahler, 1964). The mean stream length (Lsm) has been calculated Bh dividing the total stream length of order by the number of stream. The mean stream length (Lcm) of study area is 0.629 for first order, 1.032 for second order, 2.204 for fifth order, 26.118 for six order. The mean stream length of stream increases with increases of the order.

BIFURCATION RATIO (RB)

Bifurcation ratio is a dimensionless property of the drainage basin is supposed to be controlled by drainage density, stream entrances angle, lithological characteristics, basin shapes, area etc. Bifurcation ratio of Chargarh River is shown in table 2.

MEAN BIFURCATION RATIO

Mean bifurcation ratio show trend in a region of uniform geological structure and lithology but they show variable trends over varying geological structure. Mean bifurcation ratio of study area is 4.0537 which showing the area is not significant structurally control.

TABLE 2: LINEAR ASPECTS OF CHARGARH RIVER.

Stream Order	Number of Stream(N_u)	Stream Length (L_u)	Stream Mean	Bifurcation ratio (R_b)	Mean bifurcation ratio
1	1086	682.88	0.629	4.344	4.0537
2	250	258.06	1.032	4.2372	
3	59	130.03	2.204	3.6875	
4	16	78.79	4.925	4	
5	4	70.23	17.59	4	
6	1	26.12	26.118	-	
Total	1416	1246.11			

AREAL ASPECTS

Area of a basin (A) and perimeter (P) are the important parameters in quantitative morphology. Area of basin (A) is 548 km^2 and perimeter is 137 km are the important parameter is quantitative morphology. The area of the basin is defined as the total area projected upon a horizontal plane contributed to simulate of all order of basin parameter is the length of boundary of the basin.

DRAINAGE DENSITY (DD)

While high density is the result of week or impermeable subsurface materials, spores, vegetation, and mountains really floor drainage density least two coarse texture while high density to find drainage texture, low density is more likely to occur in regions with highly resistant of highly permeable subsoil material under dense vegetative cover and where relief is low. The value of drainage density is 2.2739 which shows course and a poorly drained basin

with a slow hydrologic response.

STREAM FREQUENCY (FS)

Stream frequency or drainage frequency is the measure of number of stream per unit area (may be square meter, square kilometer and so on) for the competition of stream frequency the basin is depend on the nature and structure of rock vegetation cover nature and amount of rainfall and the soil permeability also it is ratio of total number of stream of any order and the area of the basin in which is lies. The value of stream frequency is 2.58 which show the low class means low relief.

DRAINAGE INTENSITY (DI)

Drainage intensity refers to the multiplication of drainage density with stream frequency the value of drainage intensity implies that drainage density and stream frequency have little effect on the existence of which the surface has been lowered by agents of denudation no value of drainage density stream frequency and stream intensity indicated that the surface runoff is not quickly remove from the watershed making it highly susceptible to floating gully erosion and landslide. Drainage intensity of study area is 0.8800.

CIRCULARITY RATIO (RC)

Miller (1953) define a dimensionless circularity ratio as the ratio of basin area to the area of circle having the same perimeter as the base in the circulatory ratio value of a machine is helpful to interpret shapes, discharge of runoff and permeability of the sub soil condition tone. The circularity ratio of the study area 0.3654 shows low Rc means no structural disturbances.

TEXTURE RATIO (T)

Texture is a ratio of total number of first order stream and perimeter of watershed the ratio depend on the underlined lithology infiltration capacity and relief. It is an important factor in the drainage morphometric analysis which is depending on the underlying lithology. The texture ratio of the Chargarh river basin is 7.9270.

FORM FACTOR RATIO (RF)

Quantitative expression of drainage basin outline from was made by Horton (1932) through a form factor ratio which is the dimensionless ratio of basin area to the square of basin length. The Rf value of the study area is 0.2717 also indicating elongated basin with lower peak flows of longer duration than the average.

CONSTANT CHANNEL MAINTENANCE (C)

The value of constant channel maintenance of basin is 0.4398. Surface is needed in a basin for creation of one linear foot of the stream channel. The constant channel maintenance is depends on not only the rock type and permeability, climate region, vegetation cover and relief but also the duration of erosion and climate history. The areas of close dissection exhibit it very low value.

ELONGATION RATIO (RE)

The elongation ratio of the study area is 0.3320. It is a very significant criterion of in basin shape determination value of near 1.0 are typically off region of very low relief.

THE LENGTH OF OVERLAND FLOW (LG)

The length of overland Flow is the length of water over the ground surface before it gets concentrated into definite stream channel (Horton, 1945). Lg is one of the most important independent variables affecting hydrologic and physiographic development of drainage basin. The length of overland flow of Chargarh river basin is 0.8795.

RELIEF ASPECT

Relief aspects of the drainage basins are related to the study of three dimensional features of the basins involving area, volume and altitude of vertical dimension of landforms wherein different morphometric methods are used to analyze terrain characteristics, which are the result of basin processes. The Relief aspects determined include relief ratio and ruggedness.

RELIEF RATIO (RH)

The value of Rh in basin is 0.0133 indicating lower relief and moderate slopes.

RUGGEDNESS NUMBER (RN)

The value of ruggedness number in present basin is 1.3643.

TERRAIN ANALYSIS

Various geomorphic features have been observed from sharp changes in tone which related to corresponding changes in topographic relief.

SLOPE MAP

An aspect slope map simultaneously shows the aspect (direction) and degree (steepness) of slope for a terrain. A high degree of slope is noticed in the western and north-western parts of the basin (In fig.4).

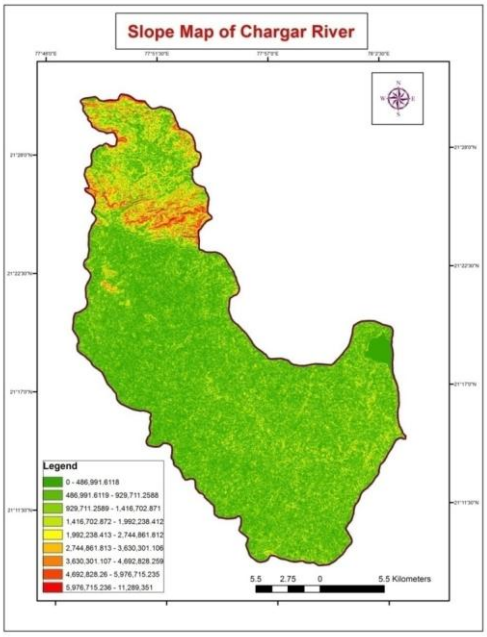

FIG. 4: SLOPE MAP OF CHARGARH RIVER.

CONTOUR MAP

In the dynamic mode, the approximate number of contours to be displayed is defined, and the function computes the appropriate contour interval while maintaining standardized intervals such as 1, 5, 10, 20and so on. Highest contour of Charger River basin is 900 and lowest contour indicates 300 (In fig.5).

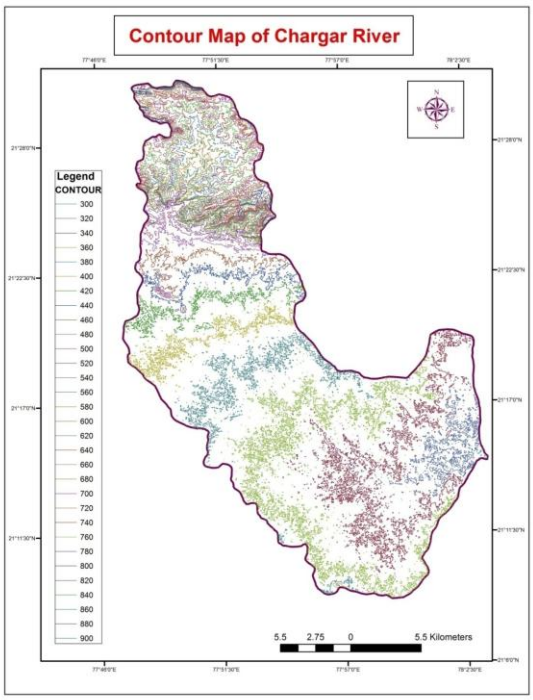

FIG. 5: COUNTOUR MAP OF CHARGARH RIVER.

CONCLUSION

- The detail morphometric of the study area is carried out from which we can conclude the following interpretation;
- In the area the stream length ratio is showing increasing trends from lower order to higher order indicate their mature geomorphic stage. The drainage pattern of stream network from the basin have been observed as mainly of dendritic type which Indicates the homogeneity in texture and lack of structural control.
- Bifurcation ratio of study area is low class means the drainage patterns is not affected by the geologic structure. Mean bifurcation ratio of study area is 4.0537 which is indicate mountain hilly dissected basin.
- The value of drainage density shows course and a poorly drained basin with a slow hydrologic response. Surface runoff is not rapidly removed from the watershed making it highly susceptible to flooding and has a permeable subsoil material, dense vegetation and low relief.
- The value of stream frequency is showing the low class means low relief.
- The form factor ratio (Rf) value of the study area is 0.27 also indicating elongated basin with lower peak flows of longer duration than the average. An elongated watershed means it has low peak flows for longer duration.
- The length of overland flow of Chargarh River is 0.8797 shows high value means gentle slope and long flow path, more infiltration and reduced runoff.
- The circularity ratio of the study area 0.3654 shows low Rc means no structural disturbances.
- Terrain analysis shows a high degree of slope is noticed in the western and north-western parts of the basin.

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