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MORPHOMETRIC ANALYSIS OF CHULHER NALA, LAKHANPUR TEHSIL, VILLAGE –KUNWARPUR, SARGUJA DISTRICT- A MANNUAL APPROACH

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Abstract

Morphometric analysis of drainage basin has been done by manually. The drainage basin analysis is important in any hydrological investigation like assessment of groundwater potential and groundwater management. Various important hydrologic phenomena can be correlated with the physiographic characteristics of drainage basins such as size, shape, slope of drainage area, drainage density, size and length of the tributaries etc. These data can be used in conjunction with conventional data for delineation of ridgelines, characterization, priority evaluation, problem identification, assessment of potentials and management needs, identification of erosion prone areas, evolving water conservation strategies, selection of sites for check dams and reservoirs etc.

Keywords: *Stream Order, Relief Aspects, Form factor.*

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1. INTRODUCTION

Morphometric analysis of drainage basin has been done by mannualy. The drainage basin analysis is important in any hydrological investigation like assessment of groundwater potential and groundwater management. Various important hydrologic phenomena can be correlated with the physiographic characteristics of drainage basins such as size, shape, slope of drainage area, drainage density, size and length of the tributaries etc. (Rastogi et al.,1976). These data can be used in conjunction with conventional data for delineation of ridgelines, characterization, priority evaluation, problem identification, assessment of potentials and management needs, identification of erosion prone areas, evolving water conservation strategies, selection of sites for check dams and reservoirs etc. (Dutta et al.,2002). The present approach describes the drainage characteristics of Chulher nala of Kunwarpur in Sarguja District obtained through morphometric analysis.

2. LITERATURE REVIEW

Ramu, B.Mahalingam and P.Jayashree, (2013) have conducted morphometric analysis of Tungabhadra drainage basin based on secondary source data.

Rao, L.A.K et al., (2009) demonstrated the dynamic equilibrium that has been achieved due to interaction between matter and energy to understand the prevailing geo-hydrological characteristics of the drainage basins.

R.K. Somashekar and P.Ravikumar.,(2011) carried out quantitative morphometric analysis for Hesaraghatta watershed, and the four sub watersheds, Banglore independently by estimating their various aerial, linear, relief aspects.

SangitaMishra.S and Nagarajan.R., (2010) have carried out study in Odisha, area recurring drought coupled with increase in ground water exploitation results in decline in the groundwater level. The compound parameter value is calculated and the sub- watershed with the lowest compound parameter is given the highest priority.

M.L. Waikar and Ajay Chavadekar., (2014) carried out Investigations on spatial and temporal land use/land cover (LULC) changes at regional scales

3. STUDY AREA

The study area is located in the Sarguja District of Chhattisgarh. It has been natural boundaries of the Chulher nala with a stretch of 103.65 km. The climate of the district is Semi-arid, Humid and Subtropical. The average annual rainfall in the Sarguja District is about 1526.9 mm and temperature goes up to 39.4°C in summer season and comes down to 8.5°C in winter season. The Chulher nala is geographically located between 83° 23′ 0'', 23°7''30' E longitudes, and 22°52′30'', 23°0'0′′ N latitudes. In the Survey of India toposheet, it forms part of 64 N/1 (F44L1) on 1:50000 scale.

4. METHODOLOGY

In the study of morphometric analysis of basin is based on the manually and graphically with respect to Survey of India (SOI) topographical maps at 1:50000. The drainage basin is carried out by Threading method. For stream ordering, Horton's law is followed by designating an un-branched stream as first order stream, when two first order streams join it is designated as second order. Two second order steams join together to form third order and so on. The number of streams of each order are counted and recorded. Morphometric parameters under linear and shape are computed using standard methods and formulae (Horton 1932, 1945; Smith 1954; Strahler 1964). The fundamental parameter namely; stream length, area, perimeter, number of streams and basin length are derived from drainage layer. The values of morphometric parameters namely; stream length, bifurcation ratio, drainage density, stream frequency, form factor, texture ratio, elongation ratio, circularity ratio and compactness constant are calculated based on the formulae suggested by Horton (1945), Miller (1953), Schumn (1956), Strahler (1964), Nookaratm (2005).

5. MORPHOMETRIC ANALYSIS OF BASIN

The following paragraphs describe the physical meaning of various morphometric parameters. Further values of these parameters are obtained as per methods proposed by various researchers for the study area and indicated in respective descriptions.

LINEAR ASPECTS

The linear aspects of morphometric analysis of basin include stream order, stream length, mean stream length, stream length ratio and bifurcation ratio.

STREAM ORDER (U)

There are four different system of ordering streams that are available [Gravelius(1914), Horton (1945), Strahler (1952) and Schideggar (1970)]. Strahler system, which is a slightly modified of Hortons system, has been followed because of its simplicity, where the smallest, unbranched fingertip streams are designated as 1st order, the confluence of two 1st order channels give a channels segments of 2nd order, two 2nd order streams join to form a segment of 3rd order and so on. When two channel of different order join then the higher order is maintained. The trunk stream is the stream segment of highest order. It is found that Chulher Nala tributaries are of 4th order. In all 235 streams were identified of which 128 are first order, 53 are second order, 32 are third order, and 22 in fourth order. The properties of the stream networks are very important to study basin characteristics (Strahler, 2002).

STREAM LENGTH (Lu)

The stream length (Lu) has been computed based on the law proposed by Horton. 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 finer 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. The numbers of streams are of various orders in a watershed are counted and their lengths from mouth to drainage divide are measured with the help of Threading method of Toposheet number 64N/1. The length of first order stream is 66 Km, second order stream is 17.3 Km, third order stream is 13.925 Km, and fourth order stream is 6.425 Km.

MEAN STREAM LENGTH (Lsm)

The mean stream length is a characteristic property related to the drainage network and its associated surfaces. The mean stream length (Lsm) has been calculated by dividing the total stream length of order by the number of stream. The mean stream length of study area is 0.52 for first order, 0.33 for second order, 0.44 for third order, 0.30 for fourth order.

STREAM LENGTH RATIO (RL)

The stream length ratio can be defined as the ratio of the mean stream length of a given order to the mean stream length of next lower order and has an important relationship with surface flow and discharge (Horton, 1945). The RL values between streams of different order in the basin reveal that there are variations in slope and topography.

BIFURCATION RATIO (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. Strahler (1957) demonstrated that the bifurcation ratio shows a small range of variation for different regions or different environmental conditions, except where the geology dominates. It is observed that Rb is not the same from one order to its next order. In the study area mean Rb varies from 1.5 to 2.5 the mean Rb of the entire basin is 1.8. Usually these values are common in the areas where geologic structures do not exercise a dominant influence on the drainage pattern.

RELIEF ASPECTS

The relief aspects determined include relief ratio, relative relief and ruggedness number.

RELIEF RATIO (Rh)

The relief ratio (Rh) is ratio of maximum relief to horizontal distance along the longest dimension of the basin parallel to the principal drainage line (Schumm, 1956). The Rh normally increases with decreasing drainage area and size of watersheds of a given drainage basin. Relief ratio measures the overall steepness of a drainage basin and is an indicator of the intensity of erosion process operating on slope of the basin (Schumm, 1956). The value of Rh in basin is 3.6 km.

RELATIVE RELIEF (Rbh)

This term was given by Melton (1957). Study area it is obtained by visual analysis of the elevation from Toposheet. The elevation of the study area varies from 580m to 780m.

RUGGEDNESS NUMBER (RN)

It is the product of maximum basin relief (H) and drainage density (Dd), where both parameters are in the same unit. An extreme high value of ruggedness number occurs when both variables are large and slope is steep. The value of ruggedness number in the drainage basin is 43.677. (Schumm, 1956).

AERIAL ASPECTS

It deals with the total area projected upon a horizontal plane contributing overland flow to the channel segment of the given order and includes all tributaries of lower order. It comprises of drainage density, drainage texture, stream frequency, form factor, circularity ratio, elongation ratio and length of overland flow.

DRAINAGE DENSITY

Horton (1932), introduced the drainage density (Dd) is an important indicator of the linear scale of land form elements in stream eroded topography. It is the ratio of total channel segment length cumulated for all order within a basin to the basin area, which is expressed in terms of Km/Km2.The drainage density, indicates the closeness of spacing of channels, thus providing a quantitative measure of the average length of stream channel for the whole basin. It has been observed from drainage density measurement made over a wide range of geologic and climatic type that a low drainage density is more likely to occur in region and highly resistant of highly permeable subsoil material under dense vegetative cover and where relief is low. High drainage density is the resultant of weak or impermeable subsurface material, sparse vegetation and mountainous relief. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture (Straher 1964). The drainage density (Dd) of study area is 0.69 Km/km2.

STREAM FREQUENCY (FS)

Stream frequency (Fs) is expressed as the total number of stream segments of all orders per unit area. It exhibits positive correlation with drainage density in the watershed indicating an increase in stream population with respect to increase in drainage density. The Fs for the basin is 1.49 km2 . (Horton, 1932).

TEXTURE RATIO (T)

Drainage texture ratio (T) is the total number of stream segments of all orders per perimeter of that area (Horton, 1945). It depends upon a number of natural factors such as climate, rainfall, vegetation, rock and soil type, infiltration capacity, relief and stage of development. In our study the texture ratio of the basin is 4.66 Km and categorized as moderate in the nature.

FORM FACTOR (Ff)

Form factor (Ff) is defined as the ratio of the basin area to the square of the basin length. This factor indicates the flow intensity of a basin of a defined area (Horton, 1945). The form factor value should be always less than 0.784 (the value corresponding to a perfectly circular basin). The Ff value for study area is 0.51.

CIRCULATORY RATIO (Rc)

Circularity Ratio is the ratio of the area of a basin to the area of circle having the same circumference as the perimeter of the basin (Miller, 1953). It is influenced by the length and frequency of streams, geological structures, land use/ land cover, climate and slope of the basin. The Rc value of basin is 2.63. The high value of circularity ratio shows the late maturity stage of topography.

ELONGATION RATIO (RE)

Schumm (1956) defined elongation ratio as the ratio of diameter of a circle of the same area as the drainage basin and the maximum length of the basin. Values of Re generally vary from 0.6 to 1.0 over a wide variety of climatic and geologic types. Re values close to unity correspond typically to regions of low relief, whereas values in the range 0.6–0.8 are usually associated with high relief and steep ground slope (Strahler 1964). These values can be grouped into three categories namely (a) circular (>0.9), (b) oval (0.9-0.8), (c) less elongated (<0.7). The Re values in the study area is 0.69.

LENGTH OF OVERLAND FLOW (Lg)

The Length of Overland Flow (Lg) 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 basins. The length of overland flow is approximately equal to the half of the reciprocal of drainage density. This factor is related inversely to the average slope of the channel and is quiet synonymous with the length of sheet flow to a large degree. The Lg value of study area is 0.72

Table .1 Method of Calculating Morphometric Parameters of Drainage Basin

	Morphometric Parameters	Formula/Defination	References
	Stream order (U)	Hierarchical order	Strahler,1964
	Stream Length (LU)	Length of the stream	Hortan, 1945
LIN-EAR	Mean stream length (Lsm)	Lsm=Lu/Nu; Where, Lu=Mean stream length of a given order (km), Nu=Number of stream egment.	Hortan, 1945
	Stream length ratio (RL)	RL= Lu / Lu-1 Where, Lu= Total stream length of order (u), Lu-1=The total stream length of its next lower order.	Hortan, 1945
	Bifurcation Ratio (Rb)	Rb = Nu / Nu+1 Where, Nu=Number of stream segments present in the given order Nu+1= Number of segments of the next higher order	Schumn,1956
RE-LIEF	Basin relief (Bh)	Vertical distance between the lowest and highest points of basin.	Schumn, 1956
	Relief Ratio (Rh)	Rh = Bh / Lb Where, Bh=Basin relief, Lb=Basin length	Schumn,1956
	Ruggedness Number (Rn)		Schumn, 1956
AER-IAL	Drainage density (Dd)	Dd=L/A Where, L=Total length of stream, A= Area of basin.	Hortan, 1945
	Stream frequency (Fs)	Fs=N/A Where, L=Total number of stream, A=Area of basin	Hortan, 1945
	Texture ratio (T)	T=N1/P Where, N1=Total number of first order stream, P=Perimeter of basin.	Hortan, 1945
	Form factor (Rf)	Rf=A/(Lb)2 Where, A=Area of basin, Lb=Basin length	Hortan, 1945
	Circulatory ratio (Rc)	Rc=4πA/P2Where A= Area of ba-sin,π=3.14, P= Perimeter of basin.	Miller, 1953
	Elongation ratio (Re)	Re=√(Au/π)/ Lb Where, A=Area of basin, π=3.14, Lb=Basin length	Schumn, 1956
	Length of overland flow (Lg)	Lg=1/2Dd Where, Drainage density	Hortan, 1945
	Constant channel maintenance(C)	Lof=1/Dd Where, Dd= Drainage density	Hortan, 1945

Table.2 Result of morphometric analysis

Stream order	Number of stream Nu	Total length of stream Lu (km)
1	128	66
2	53	17.3
3	32	13.925
4	22	6.425
Total	235	103.65

Table.3 Result of morphometric analysis

Stream order	Number of stream Nu	Bifurcation ratio	Total length of stream Lu (km)	Log Nu	Log Lu	Mean bifurcation
1	128	2.41	66	2.107	1.819	
2	53	1.65	17.3	1.724	1.238	1.8
3	32	1.45	13.925	1.505	1.143	
4	22	-	6.425	1.342	0.807	

CONSTANT CHANNEL MAINTENANCE (C)

Schumm (1956) used the inverse of drainage density as a property termed constant of stream maintenance C. This constant, in units of square feet per foot, has the dimension of length and therefore increases in magnitude as the scale of the land-form unit increases. Specifically, the constant C provides information of the number of square feet of watershed surface required to sustain one linear foot of stream. The value C of basin is 1.45 km. It means that on an average 1.45 sq. feet surface is needed in basin for creation of one linear foot of the stream channel

6. CONCLUSION

Table.4 Result of morphometric analysis

Serial number	Parameter	Value
1	Basin area	157.6(km2)
2	Perimeter	27.45 (km2)
3	Stream order	4
4	Drainage density (Dd)	0.69 (km/km2)
5	Stream frequency (Fs)	1.49(km2)
6	Relief ratio (Rh)	3.6km
7	Texture ratio (T)	4.66 Km
8	Basin length (Lb)	17.55km
9	Basin relief (Bh)	16.3m
10	Ruggedness number (Rn)	44
11	Mean bifurcation ratio (Rb)	1.8
12	Form factor (Rf)	0.51
13	Circulatory ratio (Rc)	2.63
14	Elongation ratio (Re)	1.69

15	Length of overland flow (Lg)	0.72km
16	Constant channel maintanance	1.45km

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