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MORPHOMETRIC ANALYSIS OF PEDDAVAGU DRAINAGE, CHITTOOR DISTRICT, ANDHRA PRADESH, INDIA

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Abstract

The morphometric analysis gives an insight about the linear, aerial and relief parameters of the streams in any area. These parameters provide information on topography, structural controls and geomorphological condition of an area. This analysis certainly helps the administrators in prioritising the watersheds. In the study area, the watershed boundaries are delineated after delineation of the streams using Survey of India Toposheets on 1:50000 scale. The order of streams varies from first order to fifth order with variable stream lengths.The stream orders and stream numbers are inversely related. Based on the streams, it is noted that the drainage pattern is dendritric. The drainage intensity is 1.26 indicates that there is little influence of geological structures and lithology on the streams

Keywords: *Morphometric analysis, watershed, Drainage, Peddavagu, Chittoor*

Introduction: Quantitative Morphometric analysis of any area is important for the assessment of groundwater potential and management. In the present study, linear, areal and relief parameters of the basin were evaluated. These parameters are evaluated through the measurement and calculation in GIS software. The drainage characteristics of the adjacent basins of the study area were calculated by few researchers (Rao.et al. 1995; Venkata et al., 2011).

Study area: The study area lies between $78^{0}41^{1}34^{11}$ to $78^{0}57^{1}39^{11}$E longitudes and $13^{0}19^{1}12^{11}$ to $13^{0}34^{1}37^{11}$N latitudes in the survey of India toposheets 57K11,57K14 and 57k15 with an extent of 417.39 sq.km. The area is well connected with major roads and other roads. The rocks present in the study area belongs to unclassified crystalline i.e. granites and granites gneisses. The Peddavagu flows from north to south in the study area.

Methodology: The survey of India toposheets 57K11, 57K14 and 57k15 on 1:50000 scalewere used in the present study. These toposheets were geo-referenced and projectedin order to carry out morphometric analysis. The study area boundary was delineated along withstreams, tanks and river features in ArcGIS. The attributes were assigned to create digital database to drainage thematic layer consisting of all line (streams) features and polygon features (Tanks, River) present in the study area. This digital database is further used to calculate various parameters i.e. linear, areal and relief parameters of the drainage features.

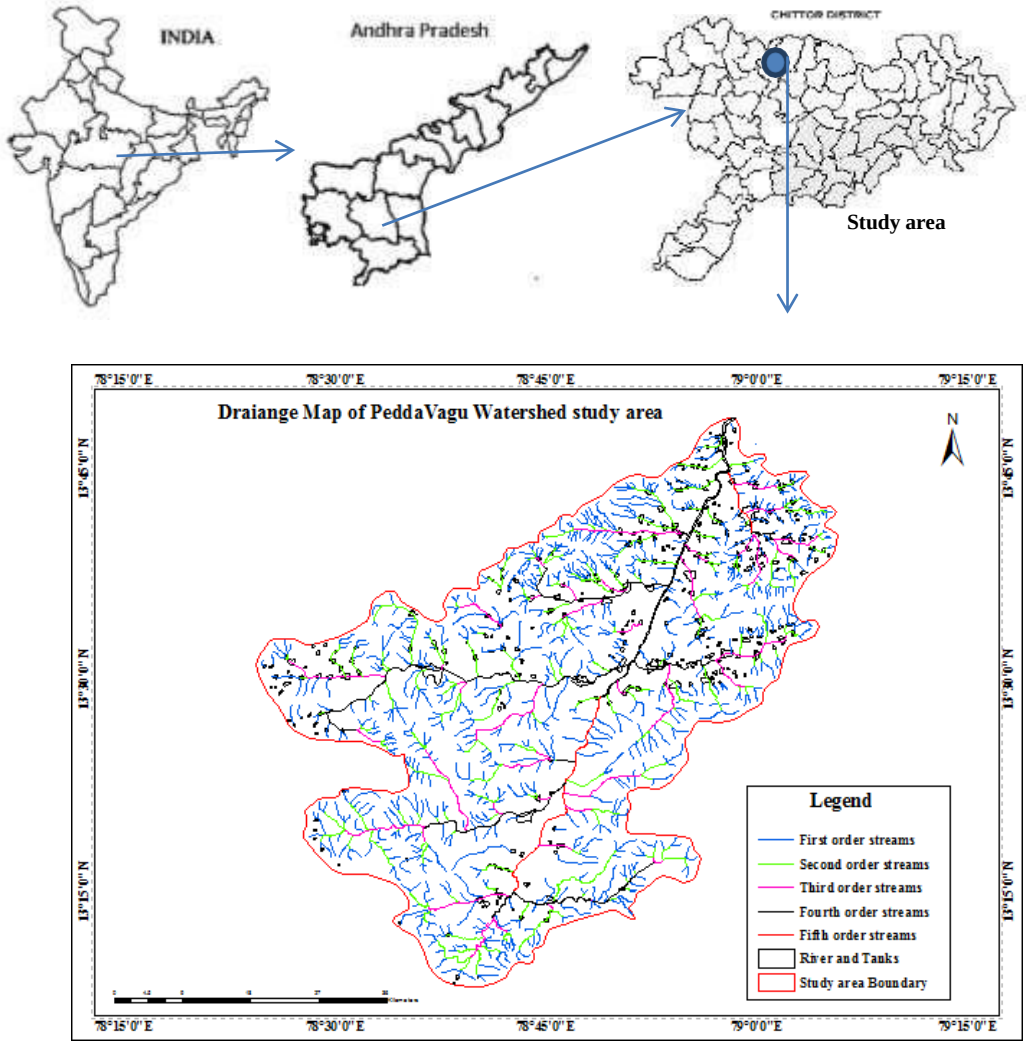

Fig. 1.1 Location map of the Study Area

Results and Discussion

The total drainage of the study area falls in a watershed with code 4C3B5 (4- region i.e. Bay of Bengal, C-Basin i.e. Penna river basin, 3-catchment, B-sub catchment and 5 watershed)as per watershed atlas of India. The drainage pattern of the study area belongs to dendritic type.

Linear parameters

Linear parameters of the drainage network are stream order, stream length, bifurcation ratio, basin length andoverland flow.

Stream order (u)

Stream ordering is the process of assigning the number i.e. first, second and third order and so on as per the strahler (1957). The order of streams and total number of streams under a particular order gives an idea of scale of basin. The un-branched stream is designated as first order streams and when two first order streams confluence resulting stream is designated as second order stream and so on (Waugh and David, 1995). The 5^{th} order streams are the highest order of streams in the study area.

Stream number (Nu)

It is the total number of streams of one stream order. There is an inverse relationship between stream orders and total stream numbers. The total number of streams are 1069 out of which 774 are of 1^{st} order, 212 are of 2^{nd} order, 67 are of 3^{rd} order, 13 are of 4^{th} order and number of streams of each stream orders i.e. first order to 5^{th} order are 774,212,67,133 are of 5^{th} order.

Stream length (Lu)

There is an inverse relationship between stream orders and its lengths. Total length of a particular order of streams decreases from lower order to higher order streams. The total length (km) of each orders from 1^{st} to 5^{th} order is 514.44, 18023, 92.98, 56.12, and 15.42.

Stream length ratio(R_L)

It is the ratio of the mean length of streams of one order to that of next lower order (Horton, 1945). The variation of length ratios is due to the difference in slope and topographic conditions (Sreedevi, 2005). The stream length ratios of each orders from 1^{st} to 5^{th} orders are 0.66, 0.85, 1.39, 4.32, and 5.14.

Bifurcation ratio(R_b)

It is the ratio of number of streams of lower order (u) to the number of streams of next higher order (u+1). As per Chow (1965) there is no influence of geological structures on drainage pattern when the bifurcation ratio is between 3 to 5. The mean bifurcation ratio of the study area is 4.076.

Table: 1 Morphometric analysis results of Peddavagu watershed

Stream orders (u)	**No.of streams(N_u)**	**Stream length (L_u) (km)**	**Bifurcation ratio (R_b)**	**Mean stream length (L_{um})**	**Stream Length ratio (R_L)**
1st	774	514.44			
2nd	212	180.23	3.65		0.35
3rd	67	92.98	3.16		0.51
4th	13	56.12	5.15		0.60
5th	3	15.42	4.33		0.27
Total	**1069**	**859.19**	**16.30**		**1.74**
		Mean	**4.076**	**0.789**	**0.436**

Areal parameters

The areal parameters indicate the shape of a watershed. The watershed may be near circular, slightly elongated or highly elongated. The areal parameters calculated for the study area watershed are Elongation ratio, Form factor, Circularity ratio, Drainage density, Stream frequency, Drainage texture.

Elongation ratio (R_e)

It is the ratio between the diameter of the circle of the same area as the drainage basin and the maximum length of the basin (Schumm, 1956). If the value is between 0.6-0.8 then then the area is associated with high relief and steep ground slope (Strahler, 1956).The elongation ratio of the study area is 0.75 which indicates high relief and steep slope.

Form factor (R_f)

It is the ratio of basin area to square of basin length (Horton, 1932). This parameter indicates the flow intensity of a basin for a defined area (Prafullsinghet.al. 2014).Smaller the value of the form factor, the more elongated will be the basin (Gupta, 1999). The form factor of the study area is 0.446 which indicates that the basin has flatter peak of flow for longer duration.

Circularity ratio (R_c)

Circularity ratio is the ratio of the watershed area to the area of the circle having same perimeter of the watershed (Miller, 1953). The ratio is equal to unity when the basin shape is a perfect circle, decreasing to 0.785 in case of square shape and continues to decrease to the extent to which the basin becomes elongated (Zavoianu, 1985). The study area has 0.446 with circularity ratio which indicates elongated and highly permeable homogenous geological materials.

Drainage density (D_d)

It is the ratio of the total length of streams of all orders per drainage areaand it indicates the closeness of spacing of channels (Horton, 1932). The low drainage density generally results in the areas of highly resistant or permeable subsurface material with low relief and coarse drainage texture (Strahler, 1964). The present study area has 2.02 value which is low and it indicates coarse drainage density.

Stream frequency (F_s)

Stream frequency is a ratio between the total number of channels cumulated for all orders to the basin area (Horton, 1945).It is directly related to the lithological characteristics of the basin (venkataet.al. 2011). The value for this parameter is 2.56 for the study areathat indicates moderatetexture of streams.

Drainage texture (D_t)

It is the ratio of total no. of streams to the perimeter of the basin (Smith, 1950). It is also depended on the lithology, infiltration capacity and relief of the basin (Sanjeevkumar and chowdary, 2016). The value for drainage texture is 9.02 and considered as very fine texture as per Smith (1950) classification.

Constant of channel maintenance (C_m)

The reciprocal of drainage density is constant of channel maintenance (Schumm, 1956). The value for this parameter is 0.49 which indicates that on the average 0.49 km^2 of surface area required to maintain each kilometre of channel length. Hence, it is noted that the rocks are little permeable and moderate slope.

Length of overland flow (L_g)

The average length of overland flow is approximately equal to half the average distance between the channels (Horton, 1945). The length of overland flow of the study area is 1.01which indicates that the rainwater must flow over this distance before getting concentrated in stream channel.

Leminscate's value (L_k)

As per Chorley et al. (1957) the value of 1 indicates that the basin is circular, and when its value increases, the basin is assumed as elongated. The study area has 3.29 leminscate's value and indicates that the basin is elongated.

Shape factor (S_f)

It is ratio of the square of basin length to the basin area (Venkataet.al. 2011).The basin shape factor is 2.24 which indicates elongated shape of the basin. The runoff discharge is not efficient in elongated basin.

Compactness coefficient (C_c)

It is the ratio of perimeter of watershed to circumference of circular area which equals the area of the watershed (Gravelius,1914). The study area has 1.637 as compactness coefficient.

Drainage Intensity (D_i)

According to Faniran (1968) the drainage intensity is the ratio between stream frequency and drainage density. The drainage intensity of the study area is 1.26. The low value indicates the stream frequency and drainage density have less influence of on the extent to which the surface has been lowered by agents of denudation. Hence, surface runoff is not quickly removed from the watershed, making it highly susceptible to flooding, gully erosion and landslides.

Infiltration number (I_{fn})

It is the product of drainage density and stream frequency (Faniran, 1968). Low infiltration number indicates high infiltration and low runoff, whereas high infiltration

number indicates low infiltration and high runoff. The infiltration number of the study area is 5.17 (<6:low, >10: high) which is low.

Relief parameters

Elevation value is considered to calculaterelief parameters of the basin.

Relief (R)

It is the elevation difference between the highest and lowest of the basin. This parameter indicates the denudational characteristics of the basin. The relief of the study area is 717m.

Relief ratio (R_h)

It is the ratio of maximum relief to horizontal distance along the longest dimension of the basin parallel to the principal drainage line. It gives the overall steepness of the drainage basin and also intensity of erosion process within the basin(Schumm, 1956). The value of relief ratio is 0.023

Gradient ratio (R_g)

It is an indication of river or stream slope from source to mouth. The gradient ratio of the study area is 0.020 which indicates a nearly level bed and hence only small sediments can move throughout the flow of water in the streams.

Ruggedness number (R_n)

It is the product of basin relief and drainage density. The ruggedness number of the basin is 604.98 which indicates the basin has steep slope.

Table. 1 Morphometric analysis results of Peddavagu watershed

Sl.No	Parameter	Value	Units
	Linear aspects		
1	Longest axis of the basin / Basin length (L_b)	**30.59**	**Km**
2	Total number of stream orders	**1069**	**----**
3	Total length of all stream orders	**843.79**	**Km**
4	Main Stream length (L_u)	**18.13**	**Km**
5	Maximum stream order	**5**	**----**
6	Bifurcation ratio (R_b)	**4.07**	**----**
	Areal aspects		
7	Total Area of the Basin (A)	**417.39**	**Km^2**
8	Basin Perimeter (P)	**118.5**	**Km**
9	Form factor (R_f)	**0.446**	**----**
10	Drainage density (D_d)	**2.02**	**Km/Km^2**
11	Elongation ratio (R_e)	**0.754**	**----**
12	Circularity ratio (R_c)	**0.373**	**----**
13	Compactness coefficient (C_c)	**1.637**	**----**
14	Stream frequency (F_s)	**2.561**	**Km^2**
15	Drainage texture (D_t)	**9.02**	**----**
16	Constant of channel maintenance (C_m)	**0.495**	**Km^2**
17	Length of overland flow (L_g)	**1.01**	**Km**

18	Leminscate's value (L_k)	**1.76**	**----**
19	Shape factor (S_f)	**2.24**	**----**
20	Drainage Intensity (D_i)	**1.26**	**----**
21	Infiltration number (I_{fn})	**5.17**	**----**
	Relief aspects		
22	Highest elevation of basin (H)	**1222**	**M**
23	Lowest elevation (elevation at mouth)of the basin (h)	**505**	**M**
24	Basin relief (R) = (H-h)	**717**	**M**
25	**Relief ratio of** the basin (R_h) = (R/L_b)	**0.023**	**----**
26	Elevation at source of stream (a)	**1120**	**M**
27	Elevation at mouth of stream (b)	**520**	**M**
28	Fall in Height of the stream(a-b)	**600**	**M**
29	Ruggedness number (R_n)	**2.93**	**----**
30	Gradient ratio (R_g)	**0.02**	**----**

Conclusion

The dendritic drainage pattern is noticed in the study area. 5th order stream is the highest order of the stream. There is no influence of geological structures on drainage pattern because of the mean bifurcation ratio 4.076 of the study area. The elongation ratio of the study area is 0.75 which indicates high relief and steep slope. The study area has 0.446 with circularity ratio which indicates elongated and highly permeable homogenous geological materials.The study area has 3.29 leminscate's value and indicates that the basin is elongated.The gradient ratio of the study area is 0.020 which indicates a nearly level bed and hence only small sediments can move throughout the flow of water in the streams.

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