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Drainage Linear Morphometric Aspect Analysis of Kumari and Kasai River Basin in Purulia District of West Bengal using Remote Sensing and GIS

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***Abstract*: The effectiveness of any water resource planning, conservation and management highly associated with Drainage Morphometric study. Analysis of Drainage Morphometry of a Watershed has immense significance in Water resource management. This analysis facilitates to the planner, researcher to conduct the study on a watershed and implement a proper plan. The present study has been conducted to analyze the drainage morphometry (Linear Aspect) of Kumari-Hanumata, Kumari-Chaka, Kasai- Patlol, Kasai- Kangsai Watersheds of Kimari and Kasai River Basin in Purulia district, West Bengal, India. In this study, linear morphometric parameters have been analyzed, using Remote Sensing and GIS. The study has been investigated the Linear parameters of Drainage Morphometric analysis include stream number, stream length, mean stream length, stream length ratio, bifurcation ratio, etc., of four watersheds. The result of the present GIS based Drainage Morphometric analysis study has revealed that the all studied watersheds are the 6th order drainage watersheds. The stream number and stream length have been decreasing with increasing stream order except in Kasai- Patlol watershed. The mean bifurcation ratio of the watershed indicates that the watershed is largely controlled by the structure and there is the strong structural control on the drainage pattern. The analysis has been demonstrated the characteristics and relationship of drainage Morphometric with watershed geometry of the Kumari and Kasai river basins.**

***Keywords*: Morphometric analysis, Bifurcation ratio and Stream Length**

1. Introduction

Morphometry is the measurement and mathematical analysis of the configuration of the earth surface, shape and dimension of land forms. The analysis of drainage basin is highly important in any hydrological investigation like, identify groundwater potential zone, groundwater management, pedology, watershed prioritization, drainage basin evaluation etc. Remote Sensing has the ability of obtain the study and view of the larger area and analyze drainage morphometry easily. Many researchers have attempted studies on morphometric analysis using advance tool Remote Sensing and GIS. In this study, Drainage morphometry analysis of Kumari and Kasai River Basin in Purulia District, West Bengal has been done using Remote Sensing and GIS for water resource management.

2. Study area and relevant data

A. Description of the Study Area

Kumari and Kasai River basin is located in the South- East Part of the Purulia District, West Bengal. It is surrounded by Dwarakeshwar and Subarnarekha River Basins. Location map of the study area has been shown in Fig. 1.

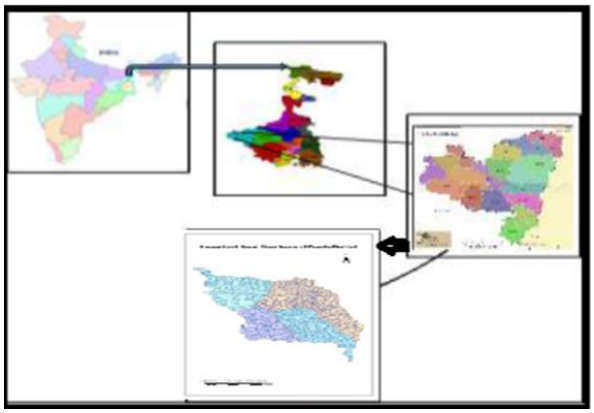

Fig. 1. Study area

B. Relevant Data

In this study, Remote Sensing (IRS-P6,LISS III) and Ancillary data have been used to prepare necessary maps which are associated with this study. In this study, Survey of India Topo Sheet Maps No. 73E, 73I and 73 J (Scale 1: 2,50,000) data, and District planning Map has been used. IRS-P6, LISS-III Imageries of National Remote Sensing Centre (NRSC), Indian Space Research Organization, Government and SRTM DEM data (90-meter Resolution) have been collected. The work has been carried out by the help of GIS software, Erdas Imagine 9.2 and ArcGIS10.

3. Methodology

Survey of India (SOI) Topo sheets of 73E, 73I and 73 J with

1: 2,50000 scale have been used as the reference map. In this study, SOI Topo sheets on 1: 2,50000 scale and collected IRS-P6, LISS-III Imageries from National Remote Sensing Centre (NRSC), Indian Space Research Organization (ISRO), Government have been utilized for digitization and upgradation of drainage networks of all existing orders by following Strahler stream ordering technique, after geometric correction to global coordinate system using ERDAS Image Processing 9.2 software and ARCGIS 10 software. Watershed boundaries of Purulia district, West Bengal has been delineated using Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) data by assigning Pour Points using Geographical Information System (GIS) software after detail study of the topographical map to obtain the correct result. Various morphometric parameter analysis including linear aspects of the drainage network such as stream order, bifurcation ratio, stream length of the basin, etc. have been computed using ArcGIS software and Excel file. The morphometric parameters for the delineated watershed area were calculated in GIS environment based on the formula suggested by Strahler, Horton, Schumm , Miller etc.

4. Results and discussion

A. *Linear aspects of the channel*

1) *Stream order and stream number*

Stream Ordering is an initial step in the analysis of drainage basin. It is not only the index; it is an approximate index of the amount of stream flow. The concept of Stream order was first founded by Horton (1945), but it has modified by Strahler (1952). In the present study, the stream ordering of Kumari Hanumata watershed has been done based on the proposed Hierarchical Rank method of Strahler (1964) using SOI Topo sheet and Satellite Image in ArcGIS 9.2 software. In this study, it is observed that the maximum stream frequency shown in first order stream. Stream frequency has been decreased as the stream order increase. The stream order of the basin varies from 1st order to 6th order. The change in the stream order indicates that the streams are flowing from high altitude.

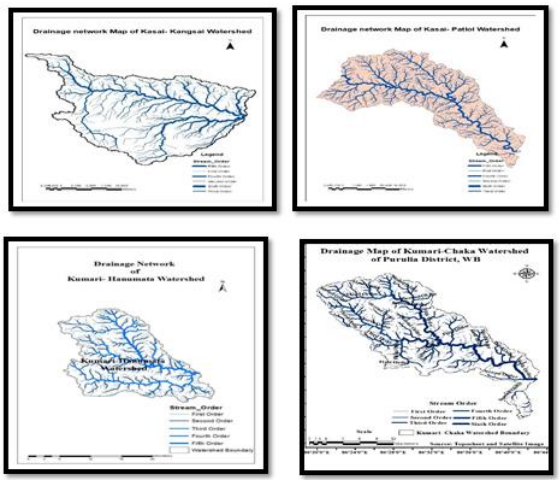

Fig. 2. Stream order maps

2) *Stream length*

Stream length is a most significant parameter of Morphometric analysis of Watershed. The length of the computed streams of the different order from SOI Topo sheet and satellite Image has been calculated with the help of ArcGIS 9.2 software based on the proposed theory of Horton (1945). The stream length has been decreased with increasing stream order which indicates that geometrical similarity is preserved generally in the watershed of increasing order. The value of the stream length of different stream order of Kumari and Kasai River Basin has been shown below. Total Stream Length of Kumari – hanumata, Kumari0 Chaja, Kasai- Patlol, and Kasai-Kangsai is -741.29Km, 789.18 km, 1249.10 km, 758.55 km.

Table 1
Linear aspect of Kumari and Kasai river basin

Watersheds	Stream Number (Nu)						Total Order Number (N)	Stream Length (Lu) (in Km)						Stream Length (in Km)
							$\sum N_u$							$\sum L_u$
	First Order	Second Order	Third Order	Fourth Order	Fifth Order	Sixth Order		First Order	Second Order	Third Order	Fourth Order	Fifth Order	Sixth Order	
Kumari-Hanumata	479	139	30	6	2	1	657	329.9370	186.0678	98.5271	47.6631	52.3033	26.7937	741.2920
Kumari-Chaka	493	145	30	5	2	1	676	370.0604	199.6145	105.0891	46.4727	39.5554	28.3898	789.1818
Kasai- Patlol	903	248	55	10	2	1	1219	641.1030	295.4698	165.7308	61.3655	12.4094	73.0220	1249.1005
Kasai-Kangsai	417	130	31	7	2	1	588	368.2512	180.0316	136.0075	51.2752	23.8660	0.1192	758.5507

3) *Mean stream length*

Mean Stream length is a dimensional property revealing the characteristic size of components of a drainage network and its Contributing watershed surfaces (Strahler, 1964). Mean stream length of a given order is higher than the lower order and less that its next higher order. In this study, the trend followed properly in Kumari-Hanumata, Kumari- Chaka, and Kumai-Patlol watesheds that indicated that the watershed controlled by lithology and structure. But, the trend followed properly in Kasai- Kangsai Watershed. Mean stream length of the different order has been shown in Table 2.

Table 2
Linear aspect of Kumari and Kasai river basin

watersheds	Mean Stream Length (Lsm)						Total Mean Stream Length	Stream Length Ratio				
	$Lsm = L_u/N_u$						$\sum L_u/N_u$	$R_L = L_u/L_u - 1$				
	First Order	Second Order	Third Order	Fourth Order	Fifth Order	Sixth Order		II/I	III/II	IV/III	V/IV	VI/V
Kumari-Hanumata	0.6888	1.3386	3.2842	7.9438	26.1517	26.7937	66.2009	0.5639	0.5295	0.4838	1.0974	0.5123
Kumari-Chaka	0.7506	1.3767	3.5030	9.2945	19.7777	28.3898	63.0923	0.5394	0.5265	0.4422	0.8512	0.7177
Kasai- Patlol	0.7100	1.1914	3.0133	6.1366	6.2047	73.0220	90.2779	0.4609	0.5609	0.3703	0.2022	5.8844
Kasai-Kangsai	0.8831	1.3849	4.3551	7.3250	11.9330	0.1192	26.0003	0.4889	0.7499	0.3798	0.4654	0.0050

4) *Stream length ratio*

Stream Length Ratio is the ratio of the Mean stream length of any order to the mean stream length of next lower order. Horton (1945) 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.

5) *Bifurcation ratio (Rb)*

Bifurcation ratio is related to the branching pattern of a drainage network. The bifurcation ratio is the ratio of the number of the stream segments of given order to the number of

streams in the next higher order. 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. In this study, it is observed that Bifurcation Ratio is not same from one order to its next order, it reveals that these irregularities depend on the geological and lithological development of the watershed. 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 affected by structural disturbances.

Table 3
Linear aspect of Kumari and Kasai river basin

watersheds	Bifurcation Ratio (Rb)					Total Bifurcation Ratio	Mean bifurcation ratio (Rbm)
	$R_b = N_u/N_u + 1$					$\sum R_b$	$\frac{\sum R_b}{\text{Number of Rb}}$
	I/II	II/III	III/IV	IV/V	V/VI		
Kumari-Hanumata	3.4460	4.6333	5.0000	3.0000	2.0000	18.0794	3.615875
Kumari-Chaka	3.4000	4.8333	6.0000	2.5000	2.0000	18.7333	3.746667
Kasai- Patiol	3.6411	4.5091	5.5000	5.0000	2.0000	20.6502	4.130044
Kasai-Kangsai	3.2077	4.1935	4.4286	3.5000	2.0000	17.3298	3.465962

5. Conclusion

Morphometric analysis of River Basin is one of the most important aspects and study for watershed management. Dendritic Drainage pattern are found in both Kumari-chaka and Kumari-hanumata watersheds of Kumari River Basin. Calculation of bifurcation ratio is a good indicator of the structural development of drainage pattern. The higher value of bifurcation ratio of the study area indicates the structural disturbances to the drainage basin. The bifurcation ratio of the study area between 2 to 5 which indicates that the drainage network of the study area is well developed. The present study demonstrates the utility of Remote Sensing and GIS techniques in morphometric analysis and the significance of morphometric analysis in the geomorphological study

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