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Morphometric Analysis of Gandheswari River Basin Area in Bankura District, Westbengal, India, Using GIS Techniques

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ABSTRACT

Morphometry is the measurement of geometry of drainage basin or of a part of it. Significant numerical values for the linear, areal and relief features of the area can be concerned obtained from such measurements. Morphometric analysis plays a vital role to know about hydrological balance of drainage basin. It also provides basic knowledge about climate, bed rock, geological features, runoff, and hydrodynamics of river. Morphometric analysis is a quantitative evolution of drainage system. Gandheswari river is a significant tributary of the river Dwarakeswar. Catchment area of Gandheswari river is highly correlate with morpho tectonics activity. This study we have mainly used quantitative analysis based on secondary data source. Various Governmental reports , journals, newspaper reports, SRTM DEM, Toposheet and Google Earth images has been used for secondary data source generation. Statistical and GIS software has been used for tabulation, computational and map generation. Present study is suggested that the selected river is progressing to reach its maturity level. These studies are very useful for watershed management and maintaining the river health.

1. Introduction

The term of 'Geomophology' stems greek word Geo means Earth, Morphe means Form and logos means discourse, so 'Geomorphology' may be defined as the scientific study of surface features of earth surface involving interpretative description of landforms their origin and development and nature and mechanism of geomorphological process which evolve the landforms. Whereas, the term Morphology is a science and measurement of forms or structures which is quantitative determination of landform .The term Morphometry literally means measurement of forms introducing quantitative description for landform. The most dominant geomorphic systems of earth's surface are rivers and fluvial processes which lead to morphometric changes in drainage basin or the watershed. In present era river is a most significant exogenous force. Most of the civilizations were established on the bank of the river. Bankura district is an extended part of Chottonagpur plateau, which is characterized by numerous fluvial systems**.** The morphometric examination of the basin is achieved through computation linear, aerial relief and gradient of channel network and contributing ground slope basin.

2. Study area

Gandheswari river, a tributary of Darakeswar, is a major river in Bankura District. Geomorphologically, the landscape of Bankura may be described as a connecting link between the plains of Bengal and the Chhotanagpur plateau. Gandheswari River flows North- Western part of the district through four blocks viz. Bankura, Saltora, Chatna, and Gangajalghati. It has originated at Saltora (BM-162m.) and flows towards South-East and meets with river Darakeswar near Bankura town (BM-76m.). Maximum and minimum elevation of the river basin is 440 meter and 76 meter. The total length of Gandheswari River is 49 km and is a 5th order stream. The latitudinal extension of the river basin is $23^0 13'28''$N to $23^0 30'25''$N and the longitudinal extension is $86^0 53'13''$E to $87^0 07'30''$E.

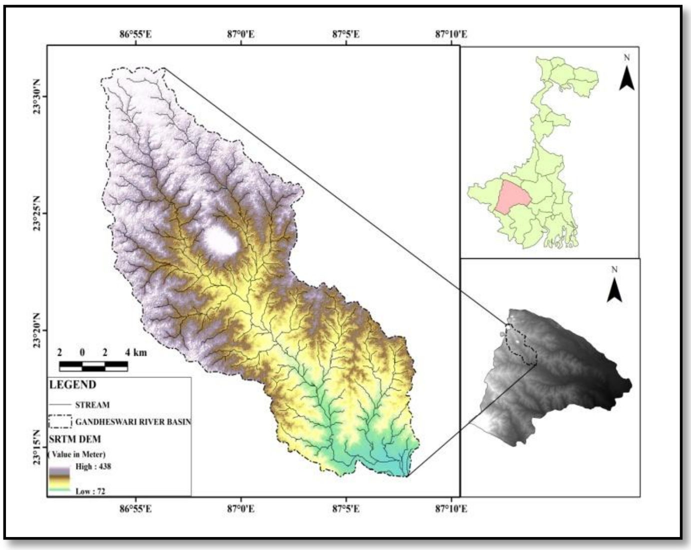

Fig. 1: Location Map of Study Area

3. Material & Method

In the present study field observation and data collection is done and measurement also taken of various geomorphic features. The sample collected from the field is properly analyzed in the laboratory, and finally the mapping was done by various softwares like, Arcgis 10.2 and Qgis 2.14. Toposheet No.- are 73 I/14, 73 I/15 , 73 M/3 , 73 M/4 . Explanation of past, present and future of any geomorphological event require a particular method and approach for analysis.

Field Observation: Field observation includes qualitative as well as quantitative methods of data acquisition Data obtained from extensive field observation in the form of numerical and informative form. For this research work several time I visited the study area to derive the quantitative and quantitative data.

Laboratory observation: Laboratory observations include experimental and laboratory based work, which help to conceptualize the process, generation of data and mapping of data which are constructed from the field. MS WORD 2016, MS EXCEL 2016, ARCGIS, QGIS, GOOGLE EARTH is the main software's that have been used in this purpose.

Office observation: Official observation includes different sources of data in the form of qualitative and quantitative format. The different data sources and their tabular data format are given below, which have been use to analysis the research work.

DATA SOURCE	TYPES OF DATA	DATE	SCALE
Survey of India	Toposheet 73 I/14, 73 I/15 , 73 M/3 , 73 M/4	1975	R.F = 1 :50,000
Open DEM	SRTM DEM	2015	30 X 30 Spatial Resolution

Table No. 1: Data Source of Study

Theoretical Work:

This is a very important step, because all of the previous work depend its efficiency for result output. In this step involves data processing, analysis and interpretation of the entire work

4. Result and Discussion

4.1. Basin Geometry

Basin Area (A) and Basin Perimeter (P)

Basin area, basin perimeter and channel length are significant morphometric variables which determine the shape, size and genetic aspect of relief, drainage network and characteristics of drainage basin. The drainage area is probably the single most important watershed characteristic to hydrological design and reflects the volume of water that can be generated from rainfall. In the present study shows that the area of the basin is 364.9 sq.km and perimeter of the river is 101.54 km.

Basin Length (Lb)

Generally the basin length can be measure of main axis of flow on which the basin is divided. In that case the total length of Gandheswari river basin is 39.4 km.

Form factor (Rf)

According to Horton (Horton, 1932) form factor is the ratio of the area of the basin to square of the basin length. In the present study indicates the basin is elongated and will have a flatter peak of flow for a longer duration and is easier to manage the floods than the circular form of a basin.

Shape factor (Sf)

The shape factor can be defined as the ratio of the square of the basin length to area of the basin (Horton, 1932) and is inverse proportion with form factor. Shape factor of the river indicates the elongated shape of the basin.

Circulatory Factor (Rc)

Circulatory ratio is the total drainage basin area divided by the area of a circle having the same perimeter as the basin (Summerfield, 1991). It has highlighted the elongation shape of basin.

Elongation Ratio (Re)

Elongation ratio is defined as the ratio of diameter of a circle of the same area as the basin to the maximum basin length (Schumm, 1956). In the present study, this value is hence the basin is elongated shape (Strahler)

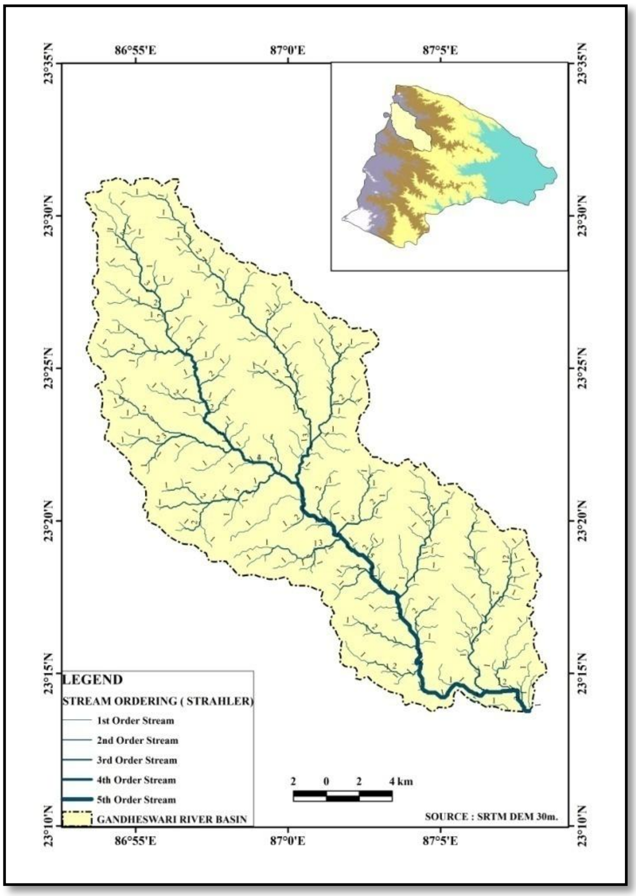

Fig. 2: Stream Ordering of Gandheswari River Basin

Texture Ratio (T)

Schumm (Schumm, 1956) defined, texture ratio is an important factor in the drainage morphometric analysis which is depending on the underlying lithology, infiltration capacity and relief aspect of the terrain. The texture ratio can be defined as the ratio of total number of streams of first order to the perimeter of the basin.

Drainage texture (Dt)

An important geomorphic concept is drainage texture by which we mean the relative spacing of drainage lines (Smith, 1939) while Horton (Horton, 1945) defined Drainage texture on the basis of stream frequency (number of stream per unit area).

Fitness ratio (F)

It is the ratio of main channel length to the length of the watershed perimeter is fitness ratio (Melton, 1957), which is a measure of topographic fitness.

Stream Length Ratio (Lur)

Miller (1964) defined stream length ratio as 'average ratio of average length of streams of a given order to average length of streams of next lower order'.

Table No. 2 - Stream Length Calculation

Stream Order	Count	Total Length
1	94	127
2	32	62
3	6	31
4	2	4.
5	1	28

Source- Authors Calculation

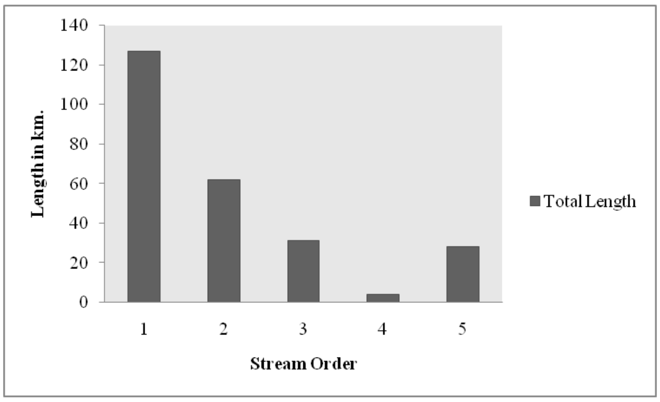

Fig. 3: Stream length of Gandheswari river basin

Drainage Network

Stream Ordering (Su) and Number of Stream (Nu) Stream order expresses the hierarchical arrangement between streams. It is a fundamental property of stream networks since it is related to the relative discharge of a channel segment (Summerfield, 1991). Gandgeswari river basin is a 5th order stream. From the authors calculation table total number of stream of the river basin is 135

Stream Length (Lu) and Main Channel Length (L) Leopold et al., (1964) defined stream length as 'the distance along a stream channel'. The calculated total stream length of the river basin is 251.77 km (from authors calculation table) and the main channel length of the river basin is 49 km.

Areal Attributes of Gandeshwari River:

The main drainage pattern of this river is dendritic or sub dendrictic . This drainage pattern indicates that surface layer of basin is homogeneous in nature and it maintains uniformity in erosion and weathering processes.

The dendritic and sub dendritic pattern of Gandeshwari rivulet signifies the following geomorphic facts:

Uniform sub surface and Sub surface layer (rocks and mineral composition)

Uniform rate of erosion (obviously by uniform erosion agents)

The principal gradient is toward the main surface runoff

The surface runoff is mainly subsequent and consequent types

Uniformity in surface elevation.

Bifurcation ratio (Rb) which is related to the branching pattern of the drainage network, is defined as a ratio of the number of streams of a given order ((Nu) to the number of streams of the next higher order (Nu+1) and is expressed in terms of the following equation

Rb= Nu/ Nu+1

[Where, Nu= number of streams of a given order

Nu+1= number of streams of the next higher order]

Mean bifurcation ratio varies from 2.0 for flat or rolling basins to 3.0-4.0 for mountainous, hilly dissected basins (Horton, 1945). Bifurcation ratio of Gandheswari river basin has been calculated as 2.654. Thus the results suggest that the basin is situated in a dissected or hilly tract.

Table No. 3 - Stream Order, Number, Bifurcation Ratio

Su	Nu	Rb
1^{st} order stream	94	
Number of 2^{nd} order stream	32	2.94
Number of 3^{rd} order stream	6	5.33
Number of 4^{th} order stream	2	3
Number of 5^{th} order stream	1	2
Total	135	13.7
Mean		2.654

Source- Authors calculation

Drainage Texture Analysis

Stream Frequency (F) Stream Frequency defined as the Number of stream segments of all orders per unit area (Summerfield, 1991).

Drainage Density (Dd) Drainage density is defined as the mean length of stream channel per unit area. The drainage density (Horton, 1932, 1945) is the average length of stream channel per unit areas: D=Σ1/A, Where D is the drainage density per unit area Σ1 is the summation of the length of channels within the area A.

Drainage Intensity It is the ratio of the stream frequency to the drainage density (Faniran, 1968).

Constant of Channel Maintenance Strahler (1952) stated that 'the constant of channel maintenance indicates the relative size of landform units in a drainage basin and has a specific genetic connotation'.

Infiltration Number

The infiltration number of a watershed is defined as the product of drainage density and stream frequency and given an idea about the infiltration characteristics of the watershed. The higher the infiltration number, the lower will be the infiltration and the higher ran-off (Pareta & Pareta, 2011).

Length of Overland Flow (Lo) The distance covered from the water divide to the nearest channel represents the length of overland flow, an important variable on which runoff and flood processes depend (On the other hand, according to Leopold et al., (1964), length of overland flow is 'mean distance from channels up maximum valley-side slope to drainage divide'.

Table No. 4 - Drainage Texture Analysis

SL.NO	PARAMETERS	FORMULA	FIRST USED BY
1	Stream Frequency (F)	F=Nu/A	Horton (1945
2	Drainage density (Dd)	Dd= Lu/A	Strahler (1964)
3	Maintenance (C)	C=1/Dd	Schumm

			1956)
4	Drainage intensity (Di)	Di= F/Dd	Faniran (1958)
5	Infiltration Number (If)	If= F × Dd	Faniran (1958)
6	Length of overland flow (Lo)	Lo= 1/Dd×2	Horton (1945

5. Relief Parameter

Absolute Relief (Ra) It is actual height of a place with respect to mean sea level. Absolute relief of the river basin has

Relative Relief (Rr) Relative Relief is defined as the differences in height the highest and the lowest points in a unit area. It is an important morphometric parameter which is used for the overall assessment of morphological characteristics of terrain. The relative relief of the basin is 366 m. Because of its close association with slope, the relative relief is more expressive and useful in different fields including relief dissection and surface ruggedness. When the amplitude of regional relief is greater, the surface roughness will be seen to vary significantly from unit to unit under the over thrusting natural set of hydromorphic condition. Thus the more is the local relative relief, the more is the roughness and there manifold decrease is the effective value of terrain for arable farming (Singh & Dhillion, 1984).

Dissection Index (Di) The concept of relative is not entirely satisfactory as a criterion of the nature of relief. Dissection index indicates the intensity of effectiveness of relief intensity in achieving an apparent usability of an area unit. The dissection index gives clue to the development of land forms under the purview of fluvial geomorphic cycle of erosion" (Prasad, 1985). The dissection value of the river basin indicates the basin situated in a hilly tract. Susunia hill (Height 440m.) is the highest elevation zone of the basin and except this hill other region is more or less little undulating surface.

Ruggedness Number (Rn) Goudie (2004) described the ruggedness of terrain as property of the landscape which describes the complexity of the topography and the roughness of the terrain. More rugged landscapes tend to exhibit a greater amount of complexity, having rough and uneven surfaces. According to Leopold et al., (1964) Ruggedness number is 'basin relief multiplied by drainage density'. The ruggedness number in Gandheswari river basin indicates the basin is less soil erosion prone and has inherent structural complexity in association with relief and drainage density.

Relief ratio (Rh) Schumm (1956) stated the relief ratio may be defined as the ratio between the total relief of a basin and the longest dimension of the basin parallel to the main drainage line. The total relief is the differences of highest elevation and lowest elevation of valley floor in the basin.

Table No. 5 – Relief Parameter Analysis

SL.NO	PARAMETERS	FORMULA	FIRST USED BY
1	Total basin relief (H)	H=Z - z	Strahler (1952)
2	Relief Ratio (Rh)	Rh= H / Lb	Schumm (1956)
3	Absolute Ratio (Ra)	GIS software analysis	
4	Dissection Index (Di)	Di= H/Ra	Singh and Dubey

			(1994)
5	Ruggedness Number (Rn)	Rn=Dd×(H/1000)	Patton and Baker (1976)

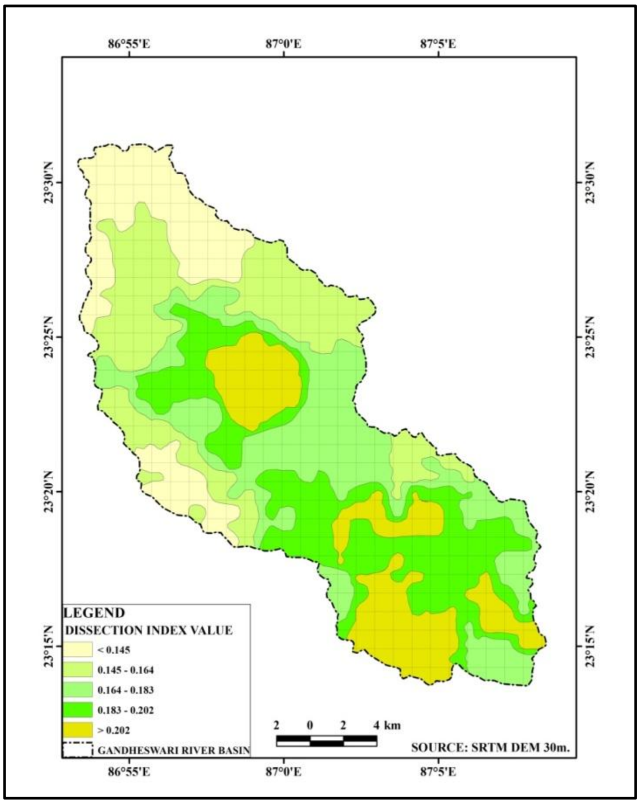

Fig. 4: Dissection map of the study area

6. Conclusion:

Prominently drainage basin morphometry is significant approach that reflects existing geomorphic process operating in fabric of a drainage basin. Drainage basin morphometry explicitly reveals quantitative information on landform. In simple words, the quantitative evaluation of morphometric parameters is essential tool in river basin analysis in terms of soil and water conservation and natural resource management. After using various hydrological and terrain tools in ArcGis we have concluded that dendritic drainage pattern, extreme lithology and highly slope topography have been seen due to its low level of maturity lateral movement have been found. It is a seasonal river so; there is not much water in summer time. But in rainy season heavy rain have been found on the upper catchment of basin that can occurs numerous flood every year and great damage in the lower catchment. So, we can use geospatial technology and take help of structural measures and non structural measures to create dams on the upper catchment .It will reduce the want of waters in dry areas and also provide fresh water for agricultural and industrial practices in Bankura district. Some of non – structural measures such as Floodplain zoning and its management, Flood forecasting, Flood vulnerability zoning, In this way we can provide a stable and beautiful watershed management. Moreover, the human intervention like excavation of alluvium along the tracks of river banks largely influence river morphology which in turn leads to fluctuation in flow velocity and sediment transport capacity of a river.

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