Morphometric Analysis of Surma River in Sylhet District, Bangladesh Using Remote Sensing and GIS

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Abstract

In This study, an attempt is made to study the morphometric characteristics of Surma River of Sylhet district, Bangladesh which covers an area of 230 km^2 by using geo-informatics techniques and satellite DEM data at 30m spatial resolution. Shuttle Radar Topographical Mission (SRTM) data was used to prepare the digital elevation model using GIS for a thorough analysis. Morphometric analysis is carried out for watershed boundary, flow accumulation, stream number, stream ordering and stream length. The bifurcation ratio for the river basins and the weighted stream length ratio demonstrate that geological structures may not have much impact on the drainage pattern. The stream length of 459.58 km has found for 72 streams under the stream order I to III. Based on the results obtained from all morphometric studies, the study area can be categorized as a morpho-tectonic zone. This research will help in understanding the nature and mechanism of land types, soil degradation, drainage control, and land potential situations for successful planning and management of reservoir catchment.

Keywords: *Morphometric Analysis; Surma River; Remote Sensing; GIS; Drainage Basin*

1. Introduction

Morphometric analysis of the river basin is a quantitative representation of the basin. In recent years Morphometric analysis using remote sensing technique has emerged as a powerful tool. The use of quantitative morphometric analysis to impose characteristics offers knowledge on the geologic features of rocks and the hydrological characteristics of the drainage basin. A proper drainage map will give a clearer estimate of basin yield and rock permeability index (Umakant et Al., 2017). The morphometric analysis provides information about the useful variables of the drainage basins and depicts the role of basin dynamics (Prakash et al., 2018).

A Watershed can be defined as a natural hydrological entity, or a catchment that enables surface runoff to identify drain, channel, stream, or river at any point (Khadri & Moharir, 2013). Watershed can be categorized into micro watershed (5-10 sq. km), mini watershed (10-30 sq. km), and sub-watershed (30-50 sq. km) based on the area it covers (NRSA, 1995). In order to assess the morphometric effects in a river that largely dominates the basin capacity and other crucial aspects of the basin, watershed characteristics should be derived and made available with the help of digital topographic maps and techniques. GIS has appeared as a formidable tool in shaping the watershed delineation for its efficiency to accumulate spatial data from diverse resources (Moharir et al., 2017).

It is imperative to comprehend the nature of the alluvial river, which has the tendency to change its course and shape from time to time for the change in its bed and banks (Rahman et al., 2018). River morphometry has been studied by many researchers both in traditional methods and remote sensing and GIS methods as well. The objectives of this study are to demonstrate the morphological features of the Surma River and interlink them with several variables by using GIS-based techniques.

2. Study Area

The Surma is a meandering and dynamic river and considered a populous river basin covered the eastern part of Bangladesh. It originates when the Barak River from northeast India splits into the Surma and the Kushiyara River in Amalshid at the Bangladesh border. It has crossed 215 km from Amalshid to Sunamganj district inside Bangladesh (Biswas, 2010). The inflow from Barak River to Surma River is less than Kushiara, because the Surma Riverbed at Amalshid is higher than Kushiara. The depth of the Surma Riverbed is decreasing at a large scale as it receives only 20 percent water flow from Barak River. The average depth of the Surma River in Sylhet District has been measured in 2015 as 11.58 m which was 13.86 m in 1993 (Rahman et Al., 2018). Its depths decrease as it moves downstream from Amalshid to Sunamganj. It has a mean slope of 50 mm/km and the width is approximately 150 m at bank full stage (Sarkar, 2005). The mean discharge in this river during monsoon (May-October) is around 30,000 cusecs (Banglapedia). In this study, the Surma River and its network in Sylhet district has been considered which covers a total catchment area of 230 sq. km.

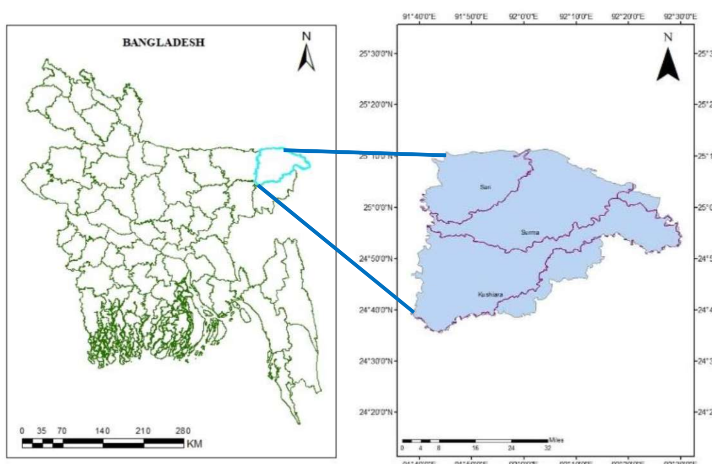


Figure 1. Maps of Study Area

3. Methodology

The morphometric properties of a drainage basin require the delineation of all current streams. The historical data and documentary information on river channel evolution used in the analysis are collected from Satellite images. This study is dependent on secondary data downloaded from USGS website as zip format. The detail of the river morphometric characteristics is found form the satellite images of Sylhet district.

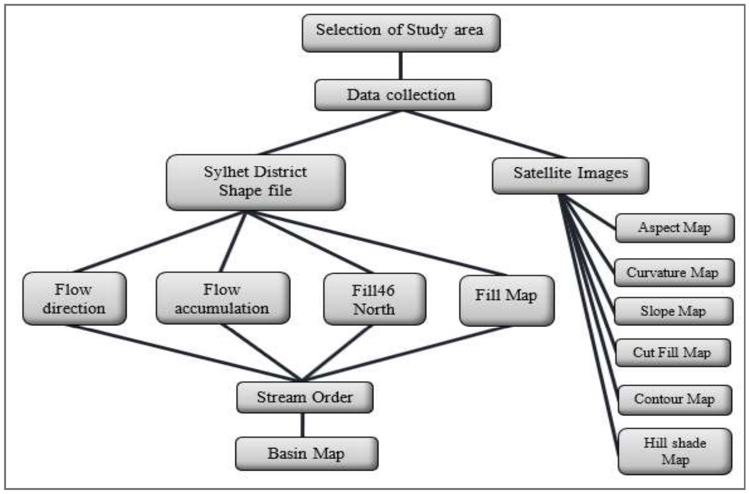


Figure 2. Flow Diagram of Methodology

The study is split into two parts: extraction of the drainage network from SRTM DEM data and morphometric analysis. The Shape file of Sylhet district is collected from shuttle radar topological mission (SRTM) data. The extraction of the drainage network of the study area is carried out using SRTM based DEM with a 30m*30m grid cell size. The Survey of Bangladesh top sheet of scale 1: 25,000 and satellite image are used for delineating the watershed boundary, drainage pattern for the preparation of drainage map. Aspect, curvature, slope, contour, flow direction and flow accumulation map has been created through ArcGIS software to carry the morphometric analysis. Stream order (Su), stream length (Lu), mean stream length (Lsm), stream length ratio (RL), bifurcation ratio (Rb) mean bifurcation ratio (Rbm), relief ratio (Rh) drainage network, weighted mean stream length ratio has been taken as morphometric indicators in this study.

3. Result and Discussion

3.1 Stream Order (Su)

In this study, the stream order of Surma River has been carried out by using Arc GIS10.5 software based on the method proposed by Strahler (1952). The findings showed that the stream frequency decreases along with the increase of stream order. First-order streams comprise the highest frequency followed by second, third, and fourth order respectively (Table 02).

3.2 Stream Number (Nu)

A total number of 72 streams are identified in this watershed by using Arc GIS10.5 software. Among them, 51 are of the first order, 18 of second order, 3 of third order as shown in Table 02. In case of two channel of different order joins together, the higher order is adopted (Moharir et al., 2017). The higher the stream number, the lesser the permeability and infiltration in the catchment (Strahler, 2017). In addition to the stream length of an individual order, the total stream length has also been calculated which was found as 459.58 km.

3.3 Bifurcation Ratio (Ru)

Horton (1945) defined the Bifurcation Ratio (Rb) as the ratio of the number of streams in one order to the number in the next lower order. Rb can be used as a useful indicator of assuagement and dismemberment (Rawat et al., 2017). Rb values depict the highest influence on the drainage pattern while the lower value suggests lower disturbance. The highest Rb value in a catchment signifies the strong structural control to overland flow and discharge. on the other hand, a lower Rb value depicts that the channel has experienced less structural influence (Moharir et al., 2017) and the drainage pattern has not been distorted because of the structural disturbances (Nag, 1998). The weighted mean Bifurcation ratio for the Surma River basins was found as 3.47 which indicates that the drainage pattern is not much influenced by geological structures. It was found that the Rb value ranges between 2.83 and 6. The highest Rb was found in the 3rd order while the lowest on the 2nd order watershed.

Table 01: Morphometric Parameters of Surma watershed

Sr. No.	Morphometric Parameter	Formula	Results
A	Drainage Network		
01	Stream Order (S_u)	Hierarchical rank	1 to 3
02	1st Order stream	Suf=N_1	72
03	Stream Number (N_u)	N_u=N_1+N_2+N_3…..N_n	51
04	Stream Length (Lu)	L_u=L_1+L_2+L_3……L_n	459.58
05	Stream Length ratio (L_{ur})	Table 3	0.38
06	Mean Stream Length ratio ($_{Lur}$)	Table 3	0.055
07	Weighted Mean stream length ratio ($_{Luwm}$)	Table 3	0.25
08	Bifurcation Ratio ($R_{b)}$	Table 2	8.83
09	Mean Bifurcation ratio (R_{bm})	Table 2	4.42
10	Weighted mean Bifurcation ratio (R_{bwm})	Table 2	3.47

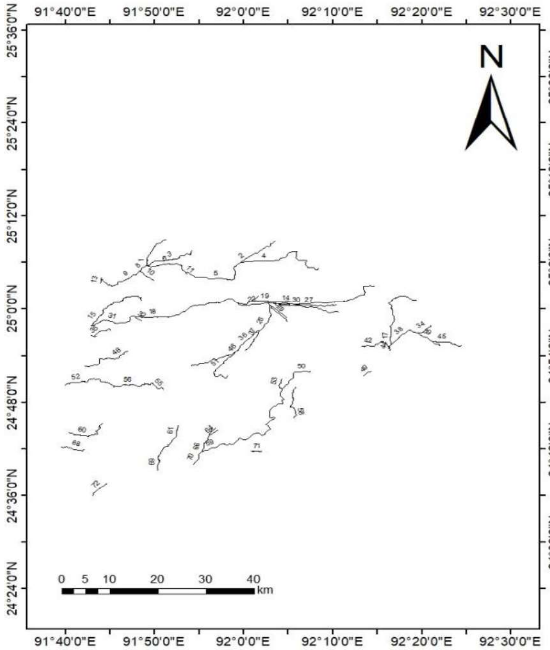
Table 02: Stream Order, Stream Number, Stream Length and Stream Length Ratios and Bifurcation Ratios in Surma River

S_u	N_u	R_b	N_{ur}	R_b*N_{ur}	R_{bwm}	L_u	L_u/S_u	L_{ur}	L_{ur-r}	L_{ur}* L_{ur-r}	L_{uwm}
I	51	-----	----	-----		341.87	6.70	-----	------	-------	
II	18	2.83	69	195.27		108.52	6.02	0.30	450.39	135.117	
III	3	6	21	126	3.47	9.19	3.06	0.08	117.71	9.4168	0.25
Total	72	8.83	90	321.27		459.58	15.78	0.38	568.1	144.54	
Mean		4.42				153.19		0.19			

Su: Stream order, Nu: Number of streams, Rb: Bifurcation ratios, Nur: Number of streams used in ratio, Rbm: Mean bifurcation ratio*, Rbwm: Weighted mean bifurcation ratios, Lu: Stream length, Lur: Stream length ratio, Lur-r: Stream length used in the ratio, Lurm: Mean stream length ratio*, Luwm: Weighted mean stream length ratio.

3.4 Ratio of Stream Length and Stream Order

Ratio of stream length and stream order has been calculated for different stream orders. Highest value for Lu/Su has been found in the 1st stream order whereas lowest Lu/Su has been found in the 3rd stream order (Table 01 and 02).



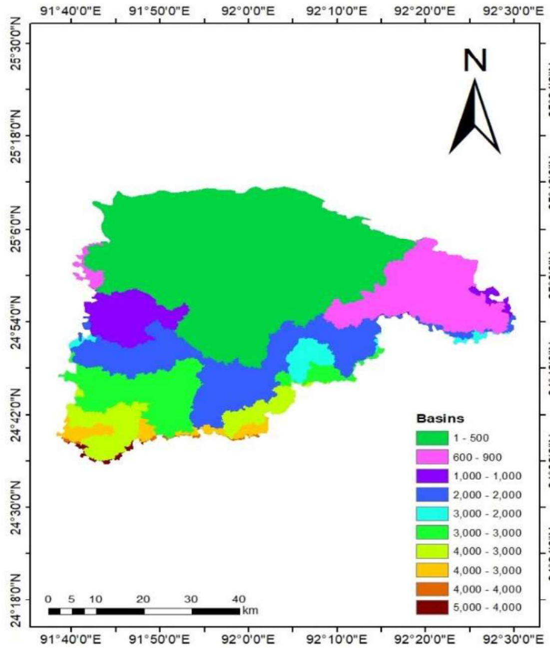


Figure 3: Stream Order Map **Figure 4:** Basin Map

4. Conclusion

Remote Sensing and GIS techniques have used in this research to carry the morphometric analysis of Surma river may be further adopted for efficient forethought and supervision of water resources. The drainage networks of the sub-basins exhibit dendritic to sub-dendritic patterns with mild drainage texture. Variation in stream length ratio might lead to changes in slope and topography.

This morphometric study extracted morphological characteristics of the Surma river basin and critical hydrological parameters, including prioritizing watersheds for soil water protection, controlling natural resources, and targeting groundwater capacity for efficient planning and maintenance.

5. References

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