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AN ANALYSIS OF THE MORPHOLOGICAL CHANGES OF SURMA RIVER IN SYLHET DISTRICT USING MULTITEMPORAL REMOTE SENSING IMAGES

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ABSTRACT

The Surma River is one of the most important rivers in the northeastern part of Bangladesh, which has changed significantly throughout history. Very few studies have taken place to understand this river's complex behavior, which characterizes its morphology. The core objective of this research is to analyze the river dynamics to understand the morphological changes of the river from 1978 to 2021. Remotely sensed satellite images of 1978, 1989, 1999, 2011, and 2021 were secondary data. The whole working procedure is the correction of satellite images, application of normalized difference water index (NDWI), demarcation of the river bank line using bank line methods, quantification of the erosion-deposition using an overlapping method, demarcation of central line shifting, measurement of the river width and finally the sinuosity index metering for 43 years. The river has changed significantly in several locations within the period in Sylhet District. Ten bends, three segments, and 200 points were taken to quantify the change dynamics. The overall analysis found that the left bank shifted more than the right bank. According to the findings, the deposition rate (80.98m/year) of river Surma is almost double the erosion rate (42.11m/year), which causes a significant decline in river width from 163m in 1978 to 123m in 2011. After counting 200 sample points, the result concluded that the average central line shifted more than average (79.50m) at 38 points indicates three major locations-Kanaighat, Dakshin Banigram, and Lalargaon. Finally, the sinuosity index found that the river became more meander following its shifting movement except the ninth bend near Kandigaon. The riverine people indicated several anthropogenic factors, e.g., encroachment, illegal construction, pollution, illegal sand extraction, as the key issues which should be intervened and take necessary action.

Keywords: Surma River, GIS, RS, Morphological Change.

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INTRODUCTION

Surma River acts as a lifeline of the people of greater Sylhet and its ecosystem. After originating from the bifurcation of the Barak at Amalshid, this river runs west through Sylhet until it meets the Baulai River. Due to topography, this river gets little water from the Barak River, but the tributaries coming from Meghalaya feed it (Figure.1). It collects inflows from the 56 percent area of the Surma basin and drains into the Meghna River. Therefore, this river acts as a water carrier from upstream to lower Meghna. A study reported that the influx of sediment in this river has increased with time, and its quantity was 2.276 MT, 3.121 MT, and 3.0971 MT in 1975, 1989, and 1999 respectively (Rahman, 2004).

Any change in its water carrying capacity eventually affects the Meghna River. Moreover, subsequent erosion and deposition changes its plan-form, slope, and meandering rapidly. Therefore, it is vital to study the nature of bank erosion and channel shifting and the morphological change of rivers because it is relevant to many scientific and engineering fields. River morphology describes the shapes of river channels and the way of their shift with time. In order to analyze the morphological change, the variables- the magnitude of Bankline shifting, width, sinuosity, and the quantity of erosion and deposition- are considered. Sinuosity deals with the pattern of the channel of the drainage basin (Pareta, 2012). The sinuosity indices explain the hydrological and topological characteristics of the drainage basin. So it is an important parameter used in morphometric studies to distinguish between the various types of terrain and ascertain the degree of an establishment drainage line in the area of influence (Babar, 2005).

Remote sensing (RS) satellite can capture an image of a large area at a regular time interval, and the integration of RS and Geographic Information System (GIS) make it appropriate to monitor river erosion and bank line shifting (Sarkar et al., 2009). Worldwide, many researchers rely on satellite images, particularly Landsat, because of reduction in data cost, availability of historic Spatio-temporal data such as Nguyen et al. (2010), Das (2010), Gogoi and Goswami (2013). For investigating the morphological change of different rivers of Bangladesh- the Padma, the Jamuna, the Kushiyara, the Manu river- researchers also rely on Landsat satellite images such as the Pahlowan and Hossain (2015), Mithun and Dabojani (2012), Uddin (2011), Uddin (2010), and Islam (2010). Researchers apply NDWI/MNDWI indexing, digitization, and overlaying techniques for this kind of study. However, very few studies have been conducted to assess the morphological change of the river Surma except Rahman (2004). It was found that the Surma River became broader and shallower up to 1989, and after that, the river was becoming narrower and shallower (Rahman, 2004).

Moreover, the author stated that the river's carrying capacity was reduced due to excessive siltation. However, the results are not accurate enough, as this study analyzed two satellite images. Therefore, a comprehensive study should include more satellite images, which was the core inspiration for this study associated with river morphological change.

This research aims to find out morphological change of Surma River in the selected area. In order to analysis the morphological change of this river, the following objectives have to be accomplished. The specific objectives of the research are (i) To identify the historical course change of the Surma river; (ii) To compare the sinuosity index in different bents using spatial and temporal perspective; (iii) To determine the width variation of the river in the selected reach of the river; (iv) To measure the quantity of accretion and deposition.

MATERIALS AND METHODS

The study area was selected after the identification of the problem, later a reconnaissance survey was conducted along the selected river reach, and relevant literature was reviewed. The analysis method was chosen based on the literature review and reconnaissance survey information and observation. Data collection and preparation were done by considering the method of analysis. Steps are shown in Figure 1.

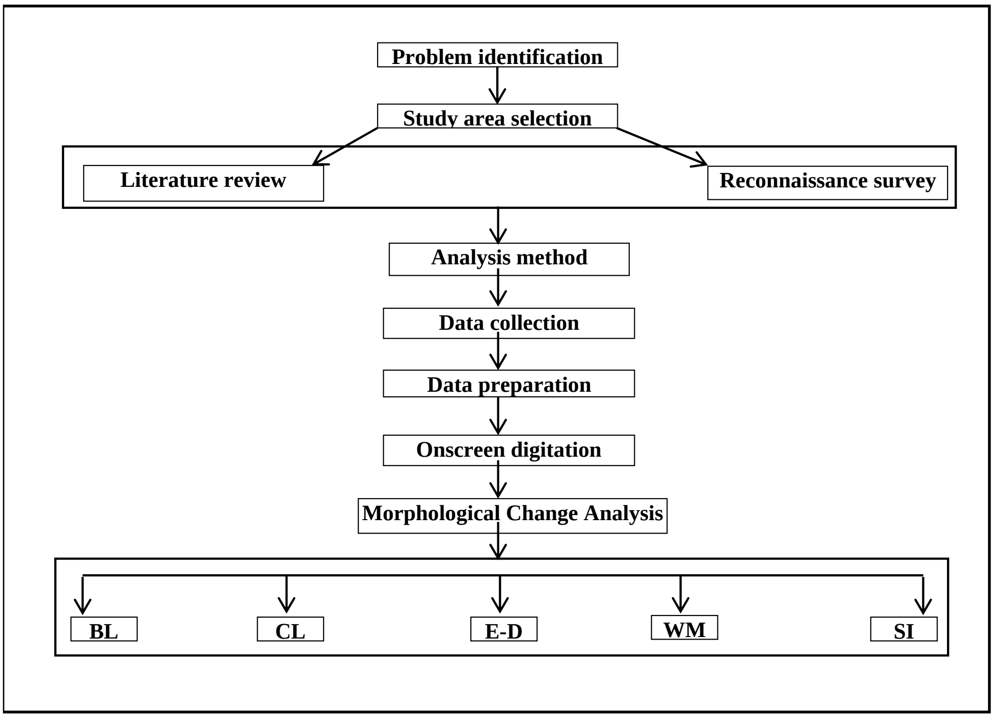

Figure 1: Chronological steps followed in this study. Here, BL= Bank line, CL= Central line, E-D= Erosion-Deposition, WM= Width measurement, SI= Sinuosity Index

Study Area

Sylhet district lies in the northern-eastern part of Bangladesh, located between 24°54' and 24°90' north latitudes and in between 91°52' and 91°867' east longitudes. The Meghalaya state of India encircles it on the north, Moulvibazar and Habiganj Upazila on the south, Sunamganj district on the west, and the Assam state of India on the east. The study area covers the confluence of the Surma-Lubha River at Kanaighat Upazila and its downstream part up to Bishwanath. For the river course's change analysis, the river reach of 110 Km has been taken from Lubachara Point of Lubha River to Mogolgaon and Bishwanath of Sylhet District (Figure 2). Surma River connects with Lubha River at Bandarbari in Kanaighat Upazila. Due to topography, Lubha River's riverbed is steep and flows towards the Surma with the rapid and turbulent flow (FAP, 1992). Surma River is a hilly river, and a flash flood occurs in that area frequently. In addition, the sediment transport through the Surma River has increased. The quantity of sediment was 2.276 MT, 3.121 MT, and 3.0971 MT in 1975, 1989, and 1999 respectively (Rahman, 2004).

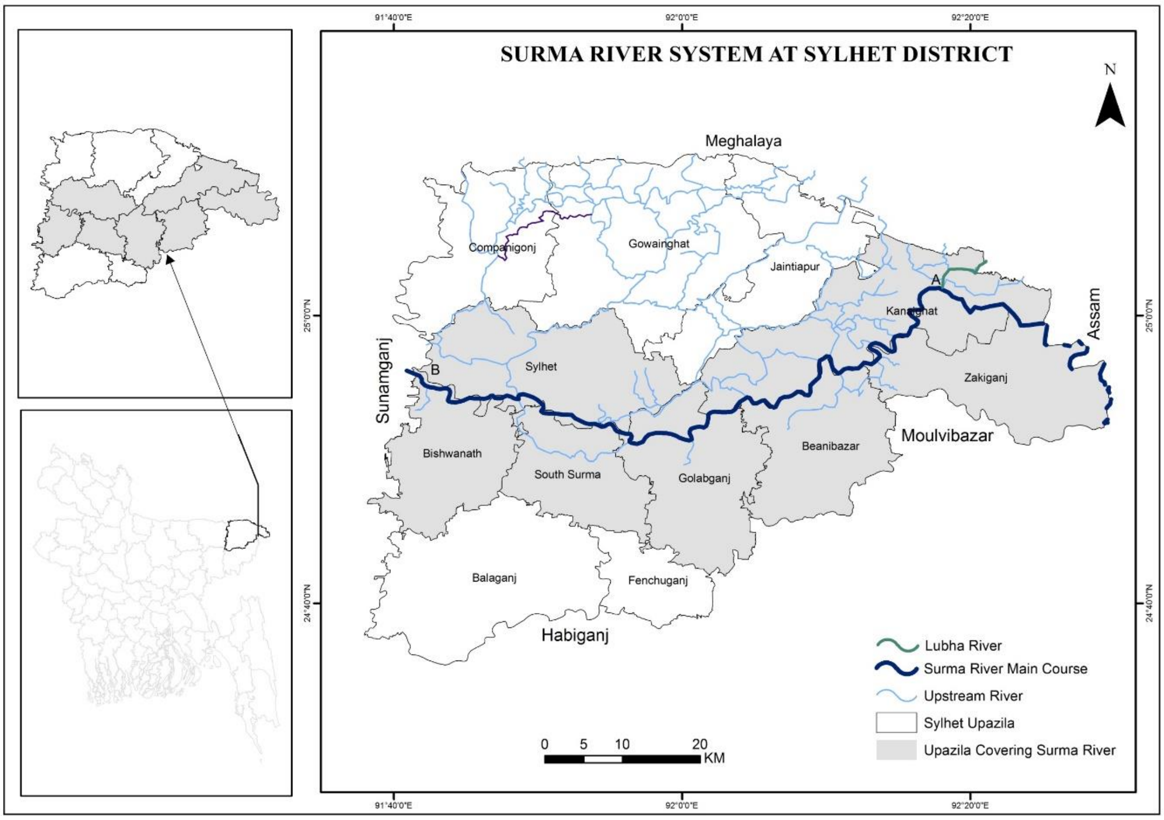

Figure 2: Map of the Surma river System in Sylhet district.

The river reaches A to B, colored in dark navy, is the selected river reach for this study. The upstream river means those rivers originate from Meghalaya Hills and flow towards Sylhet District.

Data Collection

Landsat Satellite Image and Rapid Eye- was used in this study. Landsat satellite images were collected from USGS (earthexplorer.usgs.gov) website. The Rapid Eye satellite image was collected from Bangladesh Space Research and Remote Sensing Organization (SPARRSO). Besides this, relevant literature from the library of CEGIS and other sources such as books, newspapers, and online sources. Basic information of the collected satellite data is presented in Table 1.

Table 1: Collected Satellite Data

Features	**1978**	**1989**	**1999**	**2011**	**2021**
Spacecraft ID	Landsat 2	Landsat 4	Landsat 7	Rapid Eye	Landsat 8
Sensor type	MSS	TM	ETM	MSPBI*	OLI/TIRS
Acquisition Data	1978-11-17	1989-01-05	1999-11-17	2011-11-17	2021-02-22
Resolution (m)	30	30	30	5	30
Cloud cover	0.00	0.00	4.00	0	0.00

**MSPBI= Multi-Spectral push-broom imager*

Data Preparation

Many images processing and analysis techniques have been developed to aid the interpretation of remote sensing images and extract as much information as possible from the images. Necessary elements related to image processing are mentioned in the following section are described below.

Subset

The satellite images from USGS and SPARSO were subset using the shapefile of the study area in RS software. First, the study area was clipped from the district shapefile of Sylhet in a GIS platform. Then the clipped shapefile was transformed into an AOI file format using RS software. For transforming the shapefile into an AOI file, the shapefile of selected areas was re-projected into UTM Clarke 1866 North. Finally, the satellite images were subset using the AOI file.

Radiometric Correction

The radiometric and atmospheric correction was performed for only the green and near-infrared bands of each image using equation 1. First, the DN value had been converted into radiance value using the following formula:

$$L_\lambda = \frac{(\text{Lmax}L_{max} - L_{min})}{(Q_{calmax} - Q_{calmin})} \times (Q_{cal} - Q_{calmin}) + L_{min} \quad \text{.............................(Eq. 1)}$$

For performing the conversion, a model (Appendix) was created in Erdas Imagine using where Q_{calmax}, $Qcalmin$, L_{max}, and L_{min} values were taken from the Metadata file provided with an Image file. The DN value for each image's Green and NIR bands was converted this way. After converting the DN value into radiance value ($L\lambda$), Eq. 2 was used to get Top of atmospheric reflectance. Similarly, this conversion was done by creating a model in Erdas Imagine-

$$\rho = \frac{\pi \times L_\lambda \times d^2}{E_{Sun} \times \mathrm{Cos}(\theta s)} \text{.............................}(\text{Eq. } 2)$$

The value of Earth-Sun distance, d, was calculated using Julian calendar and solar zenith angle $\theta s$was taken from the MLT file. E_{sun} is the mean solar exo-atmospheric irradiance in w m^2 µm, and the E_{sun} value varies with the super craft and sensor of the satellite. The E_{sun} value for Landsat 7 and Landsat 5 were collected from Landsat 7 handbook (Irish, R, R. 2000) and a report titled "Summary of Current Radiometric Coefficients for Landsat MSS, Tm, ETM+, and EO-1 ALI Sensors" by (Chander et al.,2009).

Atmospheric Correction

Dark object Subtraction is a straightforward image-based method of atmospheric correction that assumes that there are at least a few pixels within an image which should be black (% reflectance) and suck black reflectance termed as the dark object which is clear water body and shadows whose DN values zero (0) or close to the zero in the image (Chavez, 1988).

Dark Object Subtraction (DOS)

Dark Object Subtraction is a simple empirical atmospheric correction method for satellite imagery available in ENVI, which assumes that reflectance from dark objects includes a substantial component of atmospheric scattering. Dark object subtraction searches each band for the darkest pixel value, and the scattering is removed by subtracting this value from every pixel in the band. This simple technique effectively hazes correction in multispectral data, but it should not be used for hyperspectral data. Usually, the dark objects are water bodies. The principles of DOS Includes:

i. find the darkest point of image;
ii. assume that its spectral reflectance should be all zero (target audience);
iii. the measured values above zero are assumed to be the atmospheric noise;
iv. subtract the path radiance from each pixel radiance of the image, and then get a relatively atmospheric free image.

Data Analysis Relevant Techniques

It includes bank line shifting, centerline shifting, erosion and deposition measurement, and river sinuosity analysis. Microsoft Excel was used for analyzing data, and the data was prepared and analyzed in Excel. The secondary data were analyzed using ArcMap, and this software is used to analyze remotely sensed data and make vector maps. The following techniques were used to analyze the data-

NDWI

The formula for deriving NDWI the formula varies with the Landsat sensor. For Landsat 4 TM, Eq. 3 had been used for the NDWI.

$NDWI = \frac{Green - NIR}{Green + NIR}$...............................(Eq. 3)

Moreover, for Landsat, ETM Eq. 4 was used to extract the NDWI index.

$NDWI = \frac{SWIR - NIR}{SWIR + NIR}$...............................(Eq. 4)

The NDWI value for water fluctuates from +1 to -1. The pixel represents water, having a value close to 1, and the pixel represents sediment or soil, having a value near zero.

After deriving the NDWI (Appendix), the Gaussian stretch in Erdas Imagine enhanced the image. The NDWI image was resampled by the Nearest Neighbor method in ArcGIS 10.0. This method is suited for visualizing continuous data.

Onscreen Digitation

Das (2012) applied the bank method for demarcation and digitizing the bank line of the river for every successive year. After bank line delineation using the method of Das (2012), the left and right bank of river Surma was identified by a conventional method described by Leopold and Wolman (1957). Conventionally, the left and right bank of a river or channel is determined by considering that particular river or channel (Leopold and Wolman, 1957).

Morphological Change Analysis

Following parameters were studies for the morphological investigation of the Surma River utilizing ArcGIS techniques and capabilities.

Sinuosity Index (SI)

The sinuosity was calculated for each band using Eq. 5 mentioned below-

$Sinuosity\ Index(SI) = \frac{Length\ of\ the\ stream\ channel}{Length\ of\ the\ stright\ line\ distance}$................(Eq. 5)

The Bank method is applied to study the movements in channel courses, where two backlines are digitized for each year, and the morphological change was measured in each bend of the river. Riverbank erosion and deposition have been calculated by superimposing two successive bank lines. The results obtained by analyzing Satellite images and information collected by key informant interviews were compared, and thus, the final remark has been made.

In total, ten bends (Figure 4) were selected from the predetermined river based on a reconnaissance survey for analyzing the shifting of the bank line. After bank line demarcation, the total reach of the river was divided into three segments for analyzing the spatiotemporal erosion-deposition scenario based on critical observation, and these three segments in descending order are situated at Sylhet, Golabganj, and Kanaighat Upazila, respectively (Figure 5). For central line shifting (CLS) analysis, 200 sample lines were constructed by subtracting the distance between the central line of 2021 and 1978. Major CLS locations were identified by calculating the mean distance of the sample points. To understand the changing character, sinuosity is another major indicator calculated for each band using the formula mentioned by Leopold and Wolman (1957) (Figure 3). Leopold and Wolman (1957) divided river channels into three types based on the sinuosity index: straight, meander, and sinuous (Table 2).

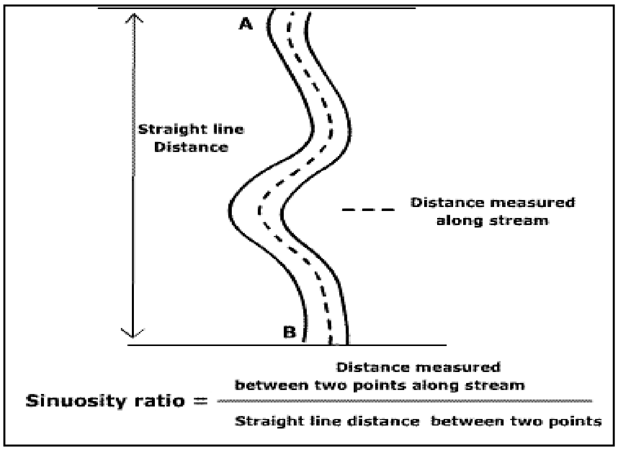

Figure 3: Sinuosity Measurement

Table 2: Sinuosity Index

Channel type	SI
Straight	1.05
Sinuous	1.05 to 1.5
Meander	>1.5

Riverbank/Central Line Shifting Rate

The EPR provides Bankline change rates in meters per year, measured by dividing the distance of bank lines movement by the time elapsed between the earliest and most recent bank line. In this model, only two bank line dates (earliest and recent) are required for computation. The model assumes that the observed periodical rate of change of bank line position is the best for predicting the future bank line. Any prior knowledge regarding the sediment transport or hydraulic interference is not required, as the cumulative effect of all the underlying processes is assumed to be captured in the position history. However, the EPR method is applied for two dates of bank line viz. 1978 – 1989, 1989 – 1999, 1999 – 2011, and 2011 - 2021 for calculating the riverbank shifting rate and trend on a short-term basis and 1978 - 2021 for a long-term basis.

The EPR model is employed to calculate the rate of riverbank shifting (Mukhopadhyay et al., 2012) and central line shifting using the 'Y' for positions of earliest (Y_{ebl}) and recent (Y_{rbl}) bank line. In this case, it is used as 'Y' to denote the predicted bank line position, which is estimated following Eq.6.

$Y = \alpha_{EPR} + \beta_{EPR} X$……..……(Eq. 6)

where 'X' is the time interval(X_{rbl}-X_{ebl}) between recent bank line(X_{rbl}) and earliest bank line(X_{ebl}), α_{Pre} notes model intercept, and β_{EPR} is the rate of riverbank shifting (slope or regression coefficient).

Equation 7 calculates the EPR intercept:

$\alpha_{EPR} = Y_{ebl} - \left\{\left(\frac{Y_{ebl}-Y_{rbl}}{X_{rbl}-X_{ebl}}\right)\right\} X_{ebl} = Y_{ebl} - \left\{\left(\frac{Y_{ebl}-Y_{rbl}}{X_{rbl}-X_{ebl}}\right)\right\} X_{rbl}$……………(Eq. 7)

The rate of Bankline shifting for a given set of transects, the β_{EPR} is calculated by following Eq. 8.

$\beta_{EPR} = \left\{\left(\frac{Y_{ebl}-Y_{rbl}}{X_{rbl}-X_{ebl}}\right)\right\}$………………(Eq. 8)

This study used this model for both bankline shifting and central line shifting.

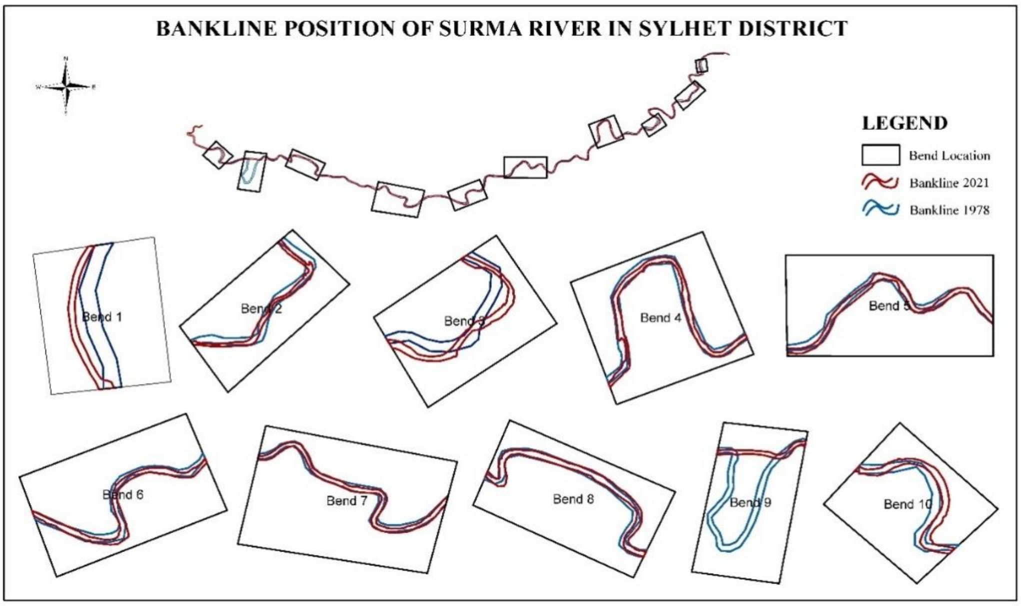

Figure 4: Selected River Bends

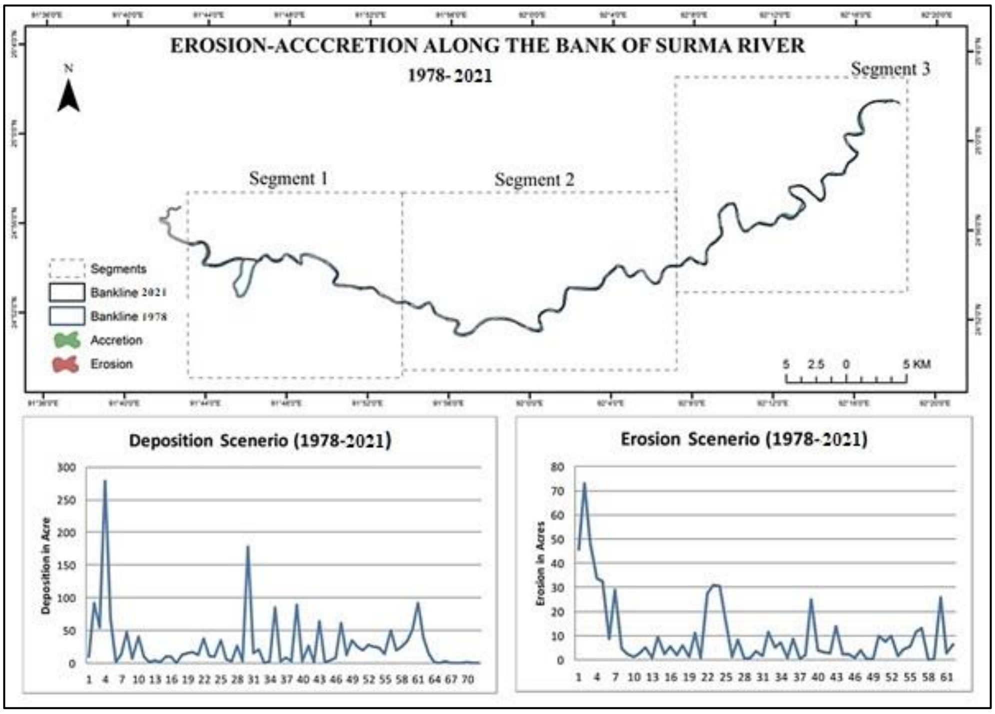

Figure 5: Erosion and Deposition along the Bank of River Surma from 1978 to 2021

RESULTS AND DISCUSSION

Historical Bankline Position of Surma River

With time, a marked pattern was noticed in the changing course of river Surma. Bankline shifted either rightward or leftward direction before 2021. Maximum left bank shift (LBS), and right bank shift (RBS) was estimated at 663.51m and 572.34m respectively at bend nine near Bolaura Bazar, whereas minimum LBS and RBS was 31.94m at bend eight near Tukerbazar and 27.62m at bend four near Gachbari Bazar respectively (**Table 3**). Overall, the left bank shifted more than the right bank within the period.

Table 3: Left and Right Bank Shift in Each Bend from 1978 to 2021

Bend no.	Location	LBS (m)	RBS (m)	Time Period
1	Confluence of Surma and Luva River	123.53	202.79	1978-2021
2	Kanaighat Bazar	71.86	70.35	
3	Bardesh Bazar	136.14	146.33	
4	Gachbari Bazar	52.77	27.62	
5	Rajbari Bazar	46.55	30.62	
6	Bagha	53.85	32.30	
7	Border between Sylhet Sadar and Golabganj	46.80	30.58	
8	Tuker Bazar	31.94	45.95	
9	Bolaura Bazar	663.51	572.34	
10	Lalargaon	115.31	83.56	

Quantitative Analysis of Riverbank Erosion and Deposition

The deposition rate was higher than the erosion rate from 1978 to 1989, which decreased drastically later. The erosion rate decreased from 1989 to 1999, and after it increased significantly from 1999 to 2011, it also more decreased in the time frame of 2011-2021. The overall erosion and deposition scenario in the three segments mentioned in the methodology section is illustrated in figure 6, 7, and 8, respectively. The net accretion was 3157.84 acres in 43 years, while net erosion was 1613.77, nearly half of the total accretion (Table 4 and 5). Overall, excessive sedimentation occurs along the bank of river Surma.

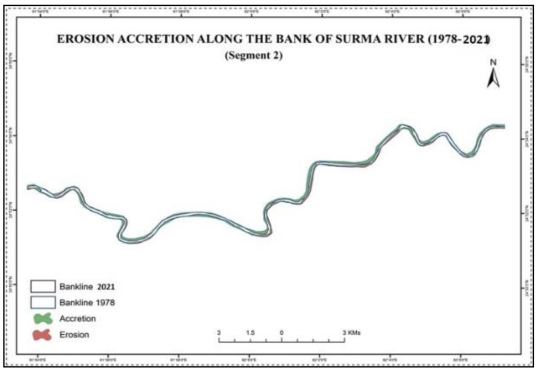

Figure 6: Erosion and Deposition in Segment 1

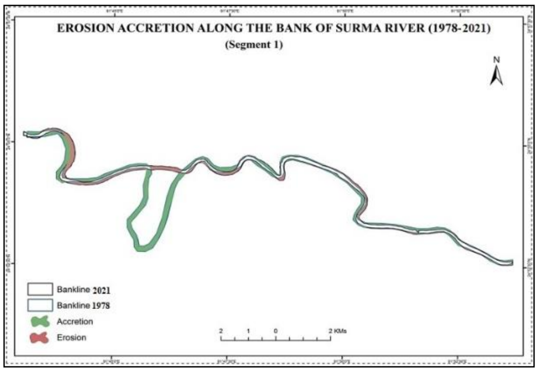

Figure 7: Erosion and Deposition in Segment 2

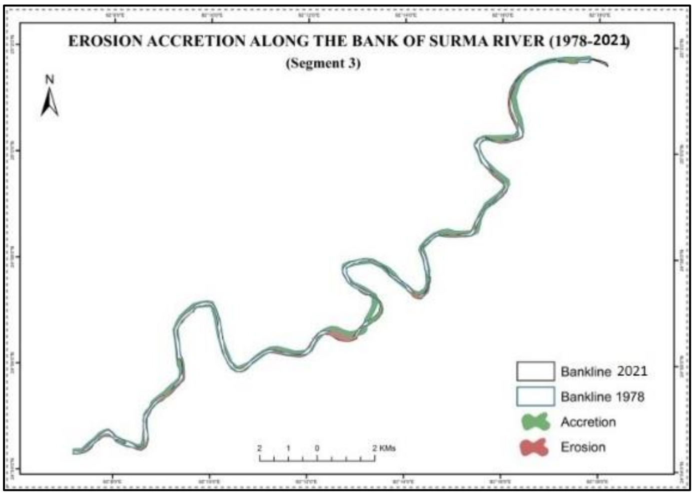

Figure 8: Erosion and Deposition in Segment 3

Table 4: Deposition in Different Time Periods

Period	Deposition rate (acres/year)	Average deposition (acres)	Maximum deposition (acres)	Minimum deposition (acres)	Total deposition (acres)
1978-1989	159.31	24.34	279.14	0.32	1752.41
1989-1999	66.81	4.00	22.70	0.16	668.08
1999-2011	20.99	2.01	31.76	0.011	251.90
2011-2021	15.54	1.24	42.84	0.054	485.45
1978-2021	102.85	46.87	340.25	0.26	3157.84

Table 5: Erosion in Different Time Periods

Period	Erosion rate (acres/year)	Average Erosion (acres)	Maximum Erosion (acres)	Minimum Erosion (acres)	Total Erosion (acres)
1978-1989	52.23	6.92	54.16	0.09	574.58
1989-1999	27.82	2.03	24.55	0.046	278.19
1999-2011	44.66	3.37	43.73	0.07	535.98
2011-2021	52.82	4.25	59.94	0.014	225.02
1978-2021	57.27	14.26	75.24	0.29	1613.77

Analysis of Central Line Shifting

At 200 points of 10 locations, the central line (CL) shifted more than 12 meters (Figure 9), and the average of CL shifting at 200 points was calculated 79.50 meters. It was found that more than 79.5 meters of CL shifting occurred at 38 points of three bends 1, 2, and 10 **(**Figure 10). Barahal (Kanaighat), South Banigram, and Lalargaon, respectively. Zoom-in view of the locations of Central Line Shifting is in Figure 11.

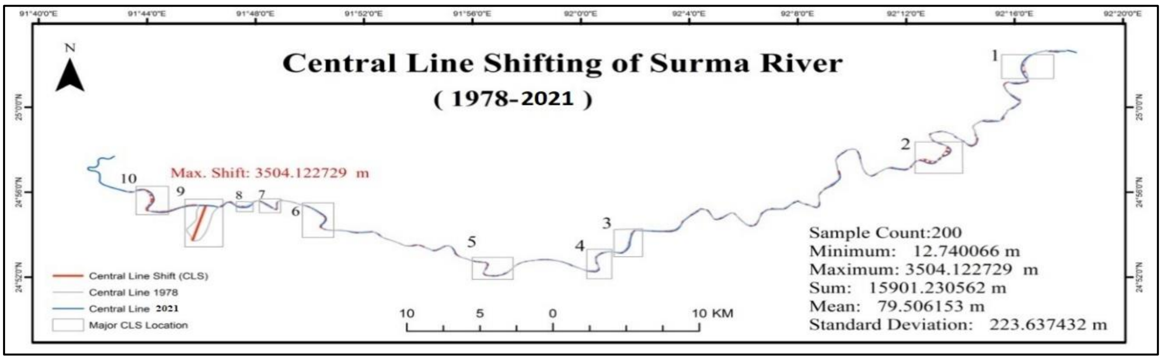

Figure 9: Ten Bends where CL Shifted More than the Minimum Value (12) along Surma River Reach.

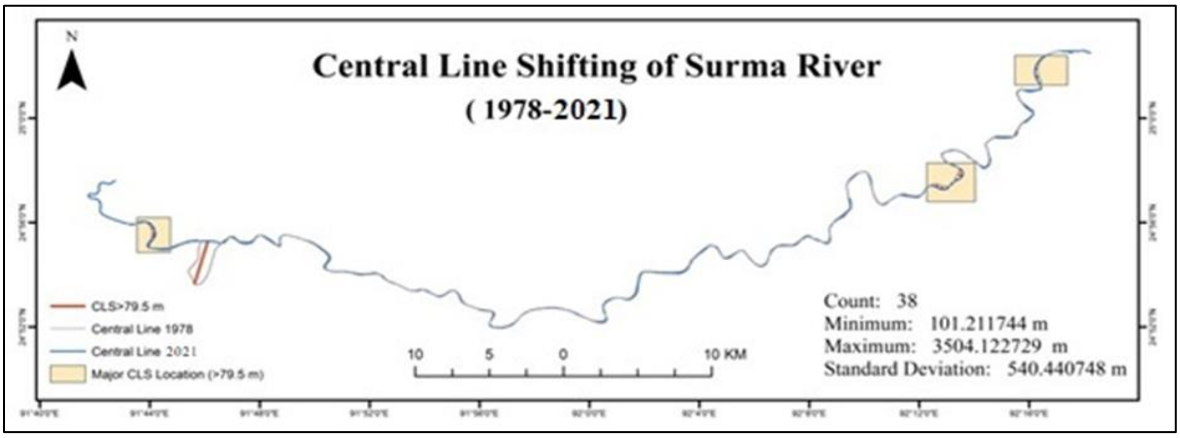

Figure 10: Three Bends where CL Shifted >79.50

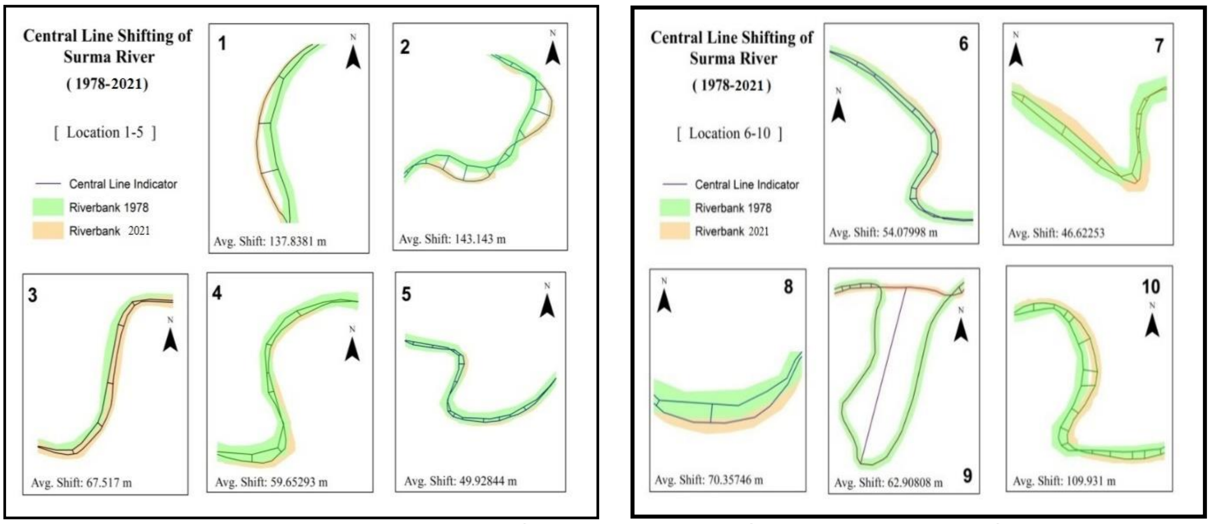

Figure 11: Zoom-in View of the Locations of Central Line Shifting.

Analysis of Channel Widening

Measurement of channel widening of the channel is another measure to understand the morphological dynamics. The analysis summarizes that the width of the Surma River decreased from 1978 – 1999 after that width of the Surma river increased in 2011-2021 (Table 6).

Table 6: Calculated River Width at Different Years

Year	Avg. Width (m)	Max Width (m)	Min Width (m)
1978	163.20	246.24	91.83
1989	117.95	182.85	56.30
1999	98.65	179.17	0.31
2011	123.49	206.32	4.55
2021	134.45	215.68	8.45

Analysis of Sinuosity

Overall, the SI value increased in 2021 compared to 1978 (Table 7), indicating the river is becoming more meander within 43 years.

Table 7: Sinuosity Index at Different Years

Year	Curvilinear Length	Linear Distance	Sinuosity	Characteristics
1978	96317.46	59623.49	1.61	Meandering
1989	96718.97	62,258.68	1.55	Meandering
1999	95820.07	61,659.55	1.55	Meandering
2011	109227.30	60402	1.80	Meandering
2021	120425.54	74244.45	1.85	Meandering

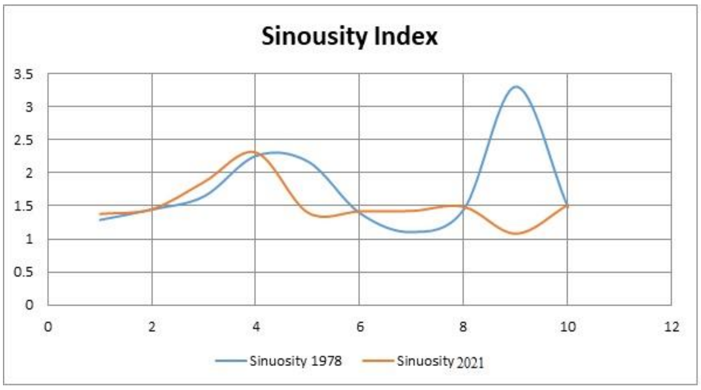

Figure 12: Change in Sinuosity Index along the River Bends

The sinuosity index varies from upstream to lower stream regions. Table 8 shows the calculated sinuosity index at different bends identified (Figure 12). The analysis finds that the maximum-minimum sinuosity index was 3.30 and 1.28 respectively in 1978, which decreased to 2.32 and 1.02 respectively in 2021. The river became straight from meander at only two positions (Bend five and Bend nine) as the change of the SI value was negative in those two positions. On the contrary, the change of SI value at all bends except these two bends was positive. In addition, the maximum positive change occurred at bend no three near Bardesh Bazar.

Table 8: Sinuosity index at Different Section

Bend	Sinuosity 1978	Sinuosity 2021	Difference	Bend	Sinuosity 1978	Sinuosity 2021	Difference
1	1.28	1.42	0.22	6	1.38	1.45	0.07
2	1.44	1.46	0.02	7	1.10	1.48	0.38
3	1.64	1.90	0.26	8	1.45	1.47	0.02
4	2.25	2.32	0.07	9	3.301	1.02	-2.281
5	2.17	1.37	-0.8	10	1.48	1.56	0.08

Key Findings

- The analysis of the morphological change of the Surma River is the key point of this research. The study finds that deposition occurs more than erosion in the river Surma considering the total magnitude of erosion and deposition in 43 years. However, the present trend shows that the erosion rate is slightly higher than the deposition rate. In 1978-1989 the deposition quantity was double that of subsequent time. The disastrous flood of 1988 may cause a vast amount of sediment influx from 1978 to 1989.
- Deposition and erosion are more in Kanaighat and Lalargaon, and therefore, the centerline shifting was more in these two locations.

- The left bank shift is more than the right bank shift due to the direction of water flow. Nevertheless, the right bank shift was also significant due to the higher deposition rate. The resultant impact of the shift of both banks is decreasing river width with time.
- The value of the sinuosity index has increased with time, so the river is becoming sinuous to meander.
- A significant bank line shift happened near Kandigaon in Bishwanath Upazila, where a u-shaped bend became disappeared between 1978 and 1989, and a straight channel emerged. As a result, the erosion rate increased, and the deposition rate decreased in the downstream location near Mollargaon, Bishwanath.

CONCLUSION

Surma River is characterized by the significant shifting of the left bank, decreasing channel width, increasing siltation (deposition), and increasing sinuosity. Considering the total magnitude of erosion and deposition, deposition was more than erosion in this river within 43 years. The study finds that the deposition quantity (7.1 km2) was more than double between 1978 and 1989, which is the highest during all other time intervals in this study. The disastrous flood of 1988 may cause a tremendous amount of sediment influx, which results in an excessive deposition during that time. However, the study finds that the recent trend of erosion rate was (about 50%) higher than the deposition rate. According to the experts, naturally, excessive sedimentation occurs in the Surma River as it connects with several hilly rivers that carry massive sediment from the upstream and human encroachment facilitates to increase more sediment in the river. The experts also opine that continuous human intervention, including sand and stone extraction, is changing the channel bed topography, which might cause the recent increasing trend of erosion. Due to lack of flow, pollutants and sediments continuously envelop the riverbed, and so, the frequency of flood has increased, which ultimately causes increasing erosion in several parts. Simultaneous deposition and erosion occur at Kanaighat and Lalargaon. Therefore, the centerline shifted more in these two locations. The left bank shifted more than the right bank due to the direction of water flow. Nevertheless, the right bank shift was also significant due to the higher deposition rate. The resultant impact of the shifting of both banks and increasing sedimentation causes the decrease in river width with time. The riverine people observed that the gap between the outer part and inner part of the riverbank increased with time. The value of the sinuosity index increased with time, so the river was becoming sinuous to meander. A significant bank line shift happened near Kandigaon in Bishwanath Upazila, where a u-shaped bend disappeared between 1978 and 1989, and a straight channel emerged. As a result, the erosion rate increased, and the deposition rate decreased in the downstream location near Mollargaon, Bishwanath. The study seeks to find out the spatial and temporal change of the river Surma. Overall, the river's width has decreased due to excessive siltation, and the pattern of the river has become more meander. These findings can be a powerful component for further investigating the Surma River. This river is the lifeline of the northeastern part of Bangladesh; any imbalance of the river will eventually create an imbalance in the people's livelihood, so a comprehensive study should be conducted.

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