Int. J. Econ. Environ. Geol. Vol. 13 (2) 42-46, 2022
Journal home page: www.econ-environ-geol.org

Open Access
ISSN: 2223-957X

Land Degradation Due to Jamuna Riverbank Erosion: A Case Study at Shahjadpur, Sirajganj District, Bangladesh

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Received:*26 April, 2022* ***Accepted:****25May, 2022*

Abstract: Climate Change in Bangladesh is an extremely crucial issue. Bangladesh is one of the worstly affected countries by the impacts of Climate Change in coming decades. The climate change in Bangladesh causes the degradation of land resources. High intensity and recurrence of floods are due to irregular rainfall and glacier melting of the Himalayas intensified river bank erosion throughout the year. High yielding land resources on the river bank are degraded each year. This study was conducted for riverbank shifting detection, morphodynamics assessment, and estimation of eroded and accreted land by the Jamuna river at Shahjadpurupazila, Sirajganj district, Bangladesh. The investigation is based on multispectral satellite imagery interpretations using ArcGIS software, followed by a field check. Interpretations show that the Jamuna river in the study area has continuously shifted its path from east to west from 1956 to 2020, resulting in a total loss of 51.68 km^2 of landmass. The rate of engulfment was 0.95km^2/year whereas the accretion rate was 0.15km^2/year. The maximum rate of river shifting on the right bank of Jamuna river in the ShahjadpurUpazila is 84.38 meters/year and the minimum shifting is 31.25 meters/year. This study will help to understand the scenario of land degradation by river erosion in the study area. It may be also helpful to the decision-makers to take the proper mitigation measures regarding riverbank erosion and protection.

Keywords: Degradation, climate change, ArcGIS, river shifting.

Introduction

Bangladesh is one of the world's most climate-vulnerable nations. It is also one of the most flood-prone countries because of its geographical location. Recently, floods have become a frequent occurrence and millions of hectares of land are flooded every year, causing riverbank erosion and land degradation in the country. The Jamuna has experienced an expansion of flow over the years. Heavy rain on its catchment area and water level rising by extreme snowmelt will increase discharge in future years due to current global warming (Rajib et al., 2011). The Jamuna river is one of the three main rivers of Bangladesh. It is not a consistent river, as its width varies in dry seasons and heavy rainfall seasons. The observation of Bristlow (1987) from satellite images suggested that the yearly volume of erosion and deposition in the Jamuna is the function of the high discharge and the duration of discharge.

The satellite remote sensing and GIS technique was used to examine fluvial channel migration and identify paleo-braided channels on terrace surfaces and also to investigate the long-term trends and rates of bank degradation and accretion. The work was carried out based on a topographic map and multispectral satellite image analyses from the 1950's up to the recent period followed by field investigations.

The study area lies in the north-western part of Bangladesh under Shahjadpurupazila, Sirajganj district. It lies between latitude 24o 03/N and 24o16/N and longitude $89^{0}31^{/}$E and $89^{0}46^{/}$E (Fig. 1). The total studied area is about 324 km^2. The objective of this study is to find out decade interval bank and bar shifting maps and to estimate decade interval accretion and erosion of new bank and bar formations.

Materials and Methods

Different multispectral satellite imagery (SPOT, Landsat-MSS, Landsat-TM, Landsat-ETM+ Rapid Eye, Google Earth) were analyzed to extract the data for base map and river shifting analyses. The river flow path of the different periods had been extracted using image analyses and GIS operation. The erosional and accretional area of the river is determined by analyzing the derivative maps.

Results and Discussion

The study area comprises Holocene sediments of old Jamuma-Brahmaputra-Karatoa floodplain deposits. The area is mainly characterized by deposition and severe erosion of the Jamuna river. Numerous channels flow over the area and drained the flood water to the Jamuna. The area is mainly composed of silty clay, clayey silt, silt, and sand.

From the analyses of satellite images with the help of ArcGIS, it was found that there is a significant amount of bank shifting that occurred during this period. In the last 64 years, the Jamuna river has shifted from east to west in the study area (Fig. 2) Study shows that the shifting is abnormal because it has no direction of erosion. The flow of the rivers varies over a wide range of magnitude. It can rapidly shift laterally cutting out old sand bars, forming new ones, and changing the flow alignment.

In the study area, both of the river banks have been shifted frequently (Fig. 3). A total of 9.41 km^2 area has been accreted by the river in this Upazila from 1956 to 2020, whereas it is engulfed 61.09 km^2 areas (Table 1). The total loss of the landmass by the Jamuna river erosion in this Upazila is 51.68 km^2 during the period. The rate of engulfment from 1956 to 2020 was 0.95 km^2 /year whereas the accretion rate was 0.15km^2/year. Most of the land accreted during the 1990-1995 year interval in which the accreted area was 7.31 km^2. On the other hand land, the maximum land engulfed was during the 1995-2000 year interval in which the engulfed area was 7.74 km^2 (Fig. 7.4). The maximum rate of river shifting on the right bank of Jamuna river in the Upazila is 84.38 meters/year and the minimum shifting is 31.25 meters/year.

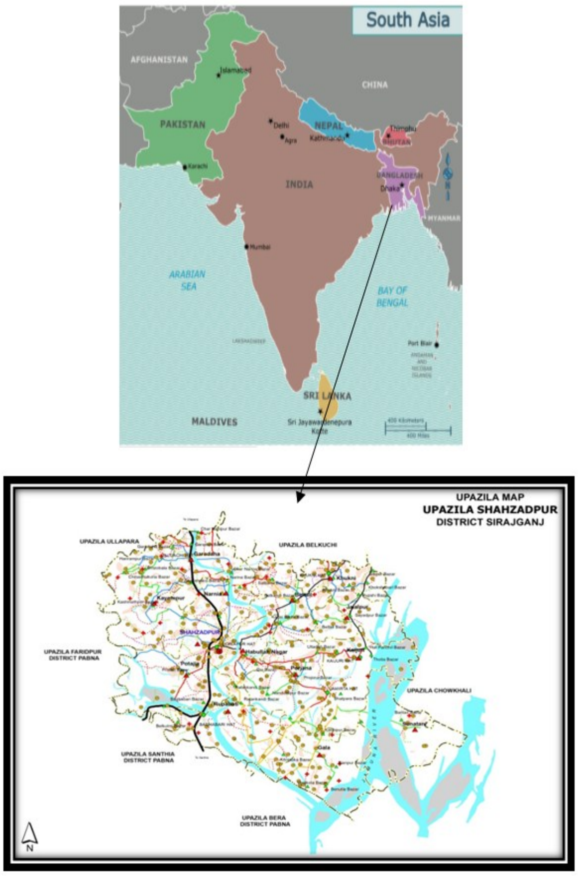

Fig. 1 Location map of Shahjadpurupazila, Sirajganj district.

The Jamuna river is considered a braided river consisting of several channels separated by small islands in their courses. During the monsoon, extensive overbank spills, bank erosion, and bank line shifts are typical. The gradual migration or shifting of channels of the rivers engraved the resources of people who lived near the bank (Fig. 4,5). The intensity of bank erosion varies widely. The rapid recession of floods accelerates the rates of bank erosion in such materials. The Jamuna river bank materials are highly susceptible to erosion.

Rivers constantly alter their course, changing shape and depth, trying to find a balance between the sediment transport capacity of the water and the sediment supply. Jamuna riverbank erosion has many consequences including the sequential loss of land and accretion of land (Fig. 6, 7). During the field investigation, it is observed that many areas of the right bank in Shahjadpurupazila are affected by erosion. Although some embankment measures have been taken to protect the bank, the base erosion of the bank is intensified by impinging of flow which diverts the adjacent channel bar and hence the failure occurred in the protecting bank.

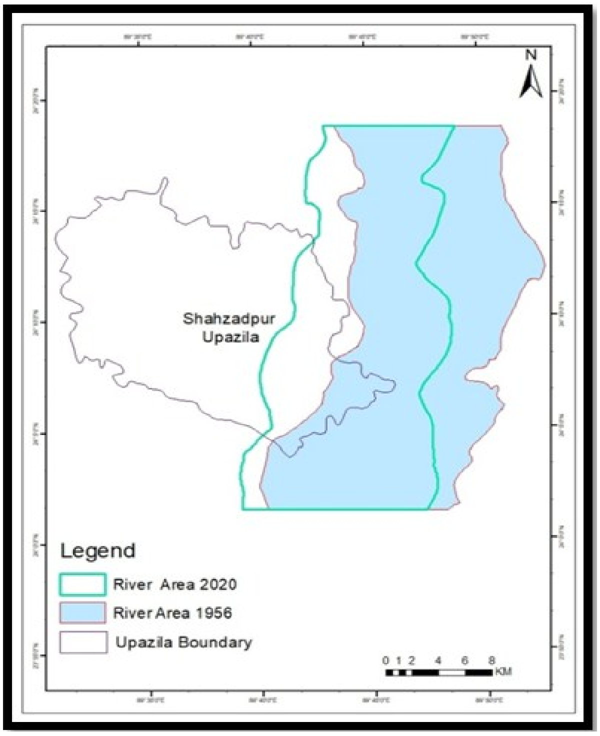

Fig. 2 Jamuna river area in 1956 and 2020

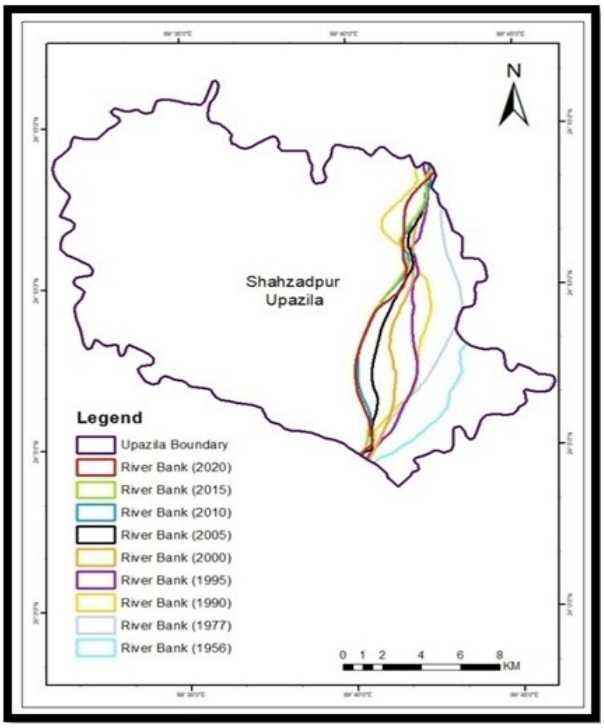

Fig. 3 Bankline of the Jamuna River from 1956 to 2020 in the study area.

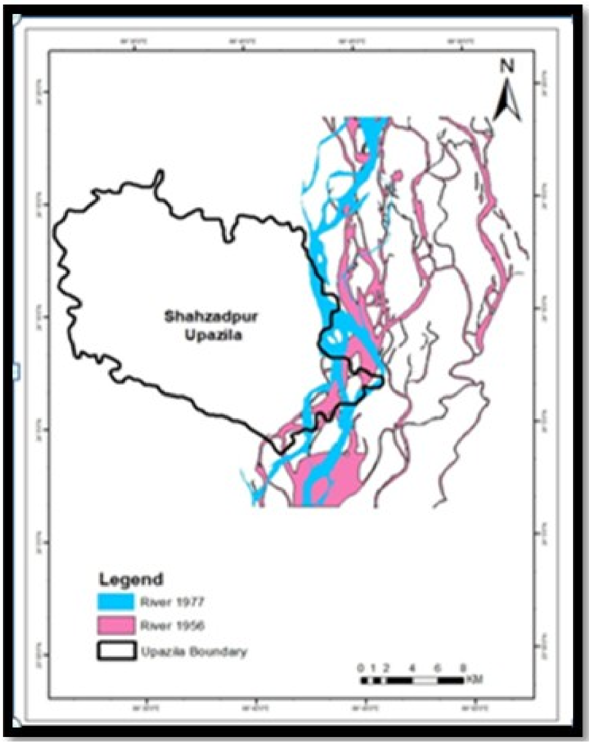

Fig. 4 Channel shifting map from 1956 to 1977.

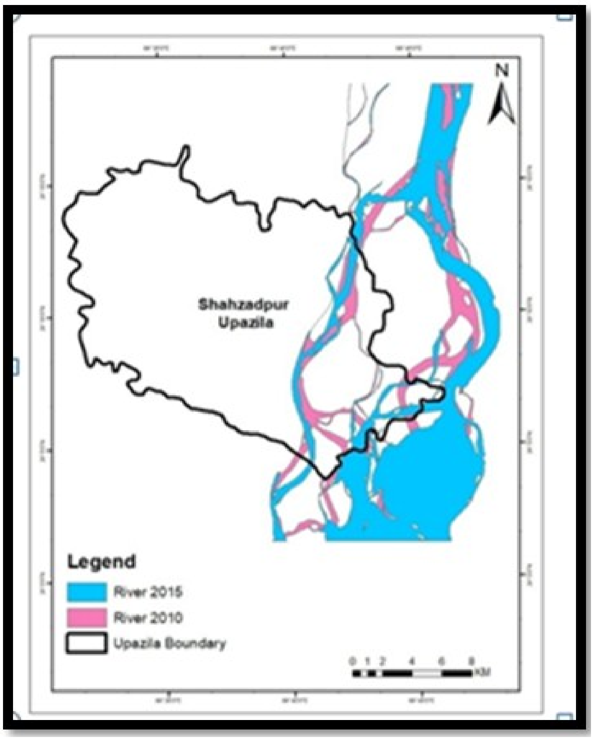

Fig. 5 Channel shifting map from 2015 to 2020.

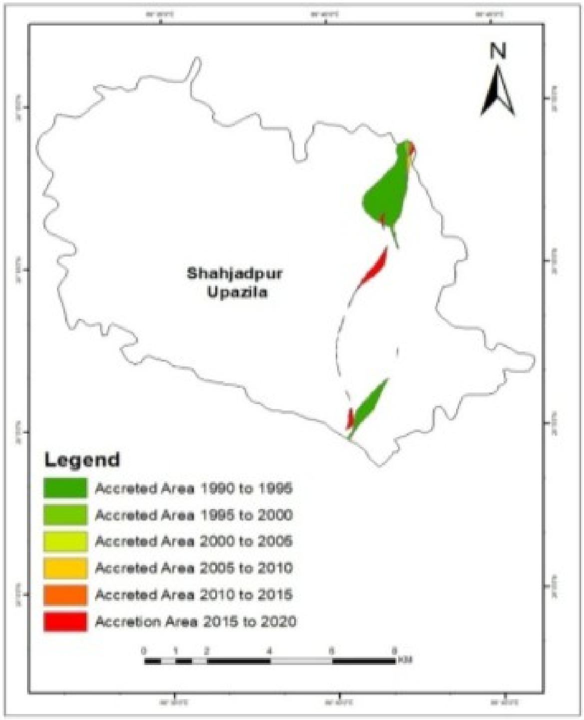

Fig. 6 Land accretion by the Jamuna River from 1990 to 2020.

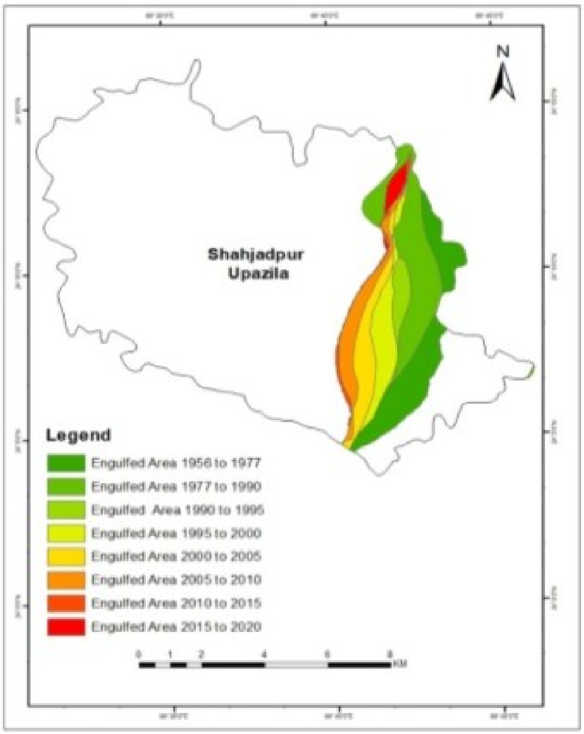

Fig. 7 Land engulfment in the study area from 1956 to 2020

Morphodynamics of meandering channels plays an important role in sedimentation patterns and processes (Nanson and Beach, 1977) in floodplain environments. The dynamic feature of the river causes riverbank erosion, a devastating natural hazard in Bangladesh that permanently brings about thousands of people homeless and landless every year causing tremendous suffering (Hossain, 1993).

Riverbank erosion generally occurs at the outer banks of flanking meandering channels and the rate of bank erosion largely depends on the characteristics of bank materials (Leopold and Wolman, 1957; Coleman, 1969). Developments like sand mining, infrastructure building on the riverbank, artificial cutoffs, bank revetment and land use alterations have changed the natural geomorphological dynamics of rivers (Lane and Richards, 1997; Surian, 1999; Rinaldi, 2003).

Table 1. Accreted and engulfed landmass by the Jamuna river in the study area from 1956 to 2020.

Year Interval	Accreted Area (km^2)	Engulfed Area (km^2)	Rate of Accretion (km^2/year)	Rate of Engulfment (km^2/year)
1956-1977	-	15.93	-	0.76
1977-1990	-	17.33	-	1.33
1990-1995	7.31	3.13	1.46	0.63
1995-2000	0.21	7.74	0.04	1.55
2000-2005	0.09	7.52	0.02	1.50
2005-2010	0.16	6.43	0.03	1.23
2010-2015	0.31	1.40	0.06	0.28
2015-2020	1.33	1.61	0.27	0.32
Total	09.41	61.09		

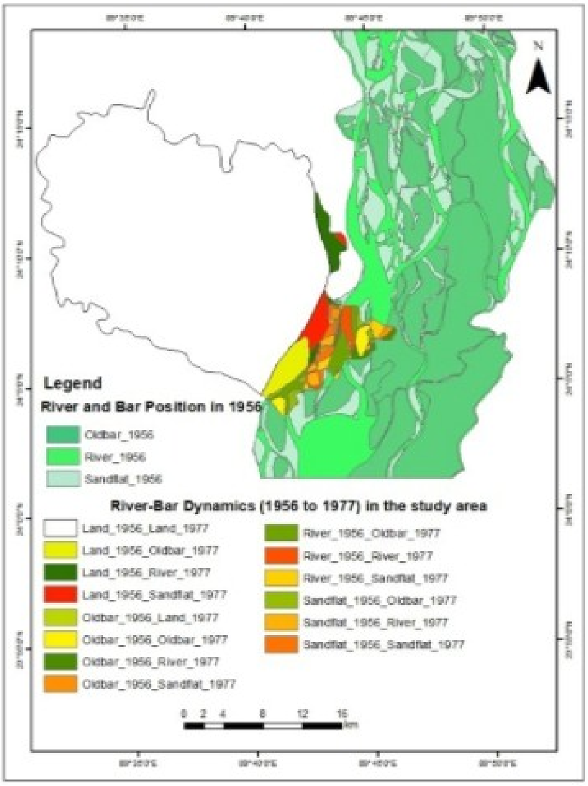

Fig. 8 River-bar dynamics of Jamuna River from 1956 to 1977.

Table 2. Land, river, old bar and Sandflat areas in the Shahjadpurupazila from 1956 to 2020

Year	Land	River	Old Bar	Sandflat
1956	301.55	10.01	05.72	05.92
1977	284.96	11.39	16.59	10.26
1990	263.46	13.92	18.15	27.64
1995	267.86	12.51	18.20	24.62
2000	260.28	25.04	19.64	18.23
2005	252.79	24.92	30.80	14.67
2010	246.56	17.36	32.35	09.98
2015	245.19	13.71	27.16	22.99
2020	244.95	16.27	12.06	15.68

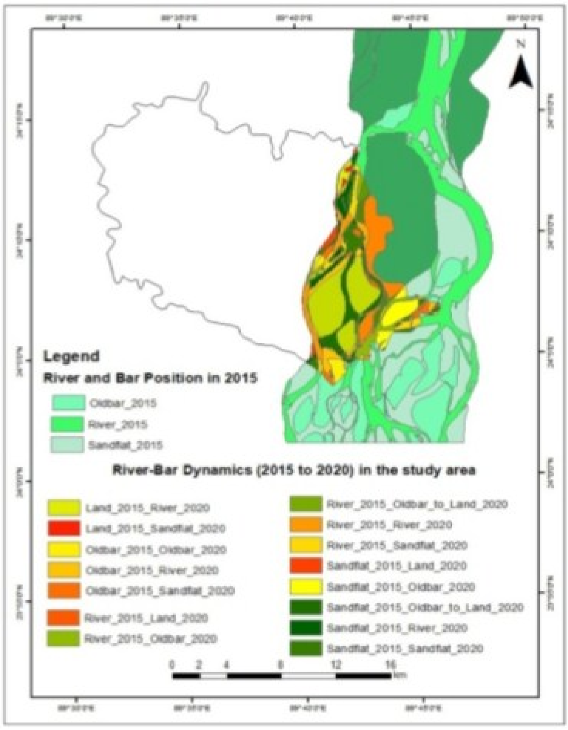

Fig. 9 River-bar dynamics of Jamuna River from 2015 to 2020.

The behaviour of the Jamuna is continuously changing, the productive agricultural land in the bank area is degraded into unproductive bars and river areas. For this reason, estimated the distribution of land, river, and bar area including their conversion to land and land to the river to obtain present river and bank status (Table 2, Fig. 8, 9).

Conclusion

Bank erosion is the most common problem in the study area. Productive agricultural land in the bank area is decorated each year. It has a serious impact on the people who are living in and around the bank area. The riverbank continuously has changed its course from East to West during 1956 to 2020. A total of 09.41 km^2 areas are accreted by the river in this upazila, whereas it engulfed 61.09 km^2 area. The total loss of the landmass by the Jamuna river in this upazila is 51.68 km^2 during that period. The rate of engulfment from 1956 to 2020 was 0.95km^2/year whereas the accretion rate was 0.15 km^2/year. The maximum rate of river shifting on the right bank of Jamuna river is 84.38 meters/year and the minimum shifting is 31.25 meters/year.

To mitigate erosion propensity have to adopt protection planning following geological suitability and morphological characteristics along with the plane form evolution of Jamuna river. It is necessary to understand the dynamic and complex geological and morphological processes of the Jamuna river. For the planning of the Jamuna river bank protection and productive land, degradation should also consider the width of the erodible corridor. The map of relatively erosion-resistant bank line, moderately erosion-resistant bank line and highly erodible bank line should superimpose a geomorphic and geological map of the area. The rate of erosion per year along the bank line of the Jamuna river should also be considered for sustainable bank protection and land conservation measures.

Acknowledgement

The authors are grateful to the Director-General of the Geological Survey of Bangladesh (GSB) for his kind permission and approval for this research work. The authors would also like to express their gratitude to the Director and Branch Chief of Operation and Coordination, for his assistance throughout field preparation and fieldwork and valuable suggestions. The Deputy Commissioner (D.C), Sirajganj district, the UpazilaNirbahi Officer (UNO), the local authority of the Water Development Board (BWDB), and the Local Government and Engineering Department (LGED) are also to be thanked for their cooperation during the field investigations.

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