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River Bank Line Shift Caused by Brahmaputra in Morigaon District, Assam (1996-2021)

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Abstract

The Brahmaputra River, one of the largest rivers in the world, acts as a backbone for the agro-valley region of Assam. But the chronological shifting of the river, frequent flooding and severe erosion, have adverse effect on riverbank stability. Bank erosion of river Brahmaputra has reached an alarming proportion in many parts of Assam including Morigaon district. The objectives of the study are to examine the status of the bank line and the shifting of the bank line of the Brahmaputra River in the Morigaon district (1996-2021). The status of the bank line and its shifting were carried out from three sets of satellite imageries from Landsat-TM and Landsat-OLI for the year 1996, 2016, and 2021. From Mayong Revenue circle in the west to Laharighat in the east, the river along the bank line has been divided into 43 strips at an equal spacing of approximately 1 km and reference cross-sections have been drawn at the boundary of each strip. The result shows that at least 94 villages got eroded fully or partially along the stretch from Mayong to Laharighat. The area eroded between two river bank lines of 1996 and 2021 is about 181.81 sq. km. The average banks line shifting from all the segments (in 43 cross-sections) is calculated to be 1.96 km. The maximum shift was observed to be 4.35 km in Mayong Revenue Circle between 1996-2016. The width of the river bank has been increasing at the rate of 79.6 meters/year and the affected people living in that area are compelled to migrate to other places. The migration of people has generated an acute social and economic problem in the affected area.

Keywords: Erosion, Morigaon, Riverbank line shift, Remote sensing, and GIS

INTRODUCTION

The Brahmaputra, the fifth largest river in the world, known as Tsangpo-Brahmaputra, (called "*Burlung-Buthur*" by the Bodo people of Assam) is a transboundary river and one of the major rivers of India. The river is 3,848 km (2,391 miles) long, and its drainage area is 712,035 km^2 (Gopal, 1990). The average depth of the river is 38 metre and the maximum depth is 120 metre (Goswami, 1998). The river serves as a support for the agro-ecological region of the north-eastern states of India. However, the chronological shifting of the river, frequent flooding and erosion have major adverse effects on riverbank stability. Erosion and flood undoubtedly displace a large number of the population. Every so often, the needy and the landless people results in a change in the demographic profile, income level, the standard of life, traditions and custom as well as socio-cultural and personal behaviour.

The flow pattern of the River Brahmaputra possesses the seasonal tempos of the monsoon and freeze-thaw cycle of the Himalayan snow. Along the channel of the Brahmaputra, bank materials are not homogeneous in composition and result in uneven bank slumping. This disturbs the flow and forces to take a different path. The direction of flow also occasionally changes the bank line at some localities. As the river is characterized by a high energy fluvial environment with non-cohesive banks, its deficit vegetation associates high rates of bank erosion and deposition. The inconsistency of bank materials and the persistent change in the flow direction causes severe undercutting, which enriches the intensity of slumping along the banks (Mamun and Amin, 1999).

Bank erosion and deposition are dynamic and natural processes, as rivers meander across the land. However, bank erosion of the river Brahmaputra has gotten a threatening share in many parts of Assam including the Morigaon district. Every year long term destruction are being made by severe flood and bank erosion. Morigaon is a district in Assam, located on the south bank of the River Brahmaputra, which is highly flood-prone and gets eroded almost every year. The months from May to August experience large-scale bank erosion annually during the rainy seasons under the influence of the southwest monsoon. It is evident that the river Brahmaputra has been shifting slowly southward and became a perennial problem for people living near the bank line of the river in Morigaon district.

Erosion has been a regular occurrence in the subdivision of Bhuragaon, Laharighat and Mayong under Morigaon district. The erosion is especially attributed to extreme sediment charge to the braided river and the formation of sand bars within the midst of the river (Goswami, 1985, Baker, 1998, Kotoky, 2003)

The district faces a critical erosion problem as no proper anti-erosion measures supported by geo-hydrological models are seen adopted thus far. Most of the plains of the district fall under the flood plains of the River Brahmaputra. Since the last four decades, 94 revenue villages have been affected by erosion created by River Brahmaputra and many of the revenue villages have been completely wiped or some are partially eroded. The lost land of the district once produces some of the finest

variety of jute in Assam. Incidentally, the entire Bhuragaon, Laharighat belt was once considered the granary of middle Assam (Alam, 1993, Kar, 1994).

OBJECTIVES OF THE STUDY

a). To study the status of the Bank line of River Brahmaputra in Morigaon district (1996, 2016 and 2021).

b). To study the shift of the bank line of River Brahmaputra from 1996 to 2016 and 2016 to 2021.

MATERIAL AND METHODS

Study area:

The District of Morigaon is located between 26°15' N and 26°5' N latitude and 92° E and 95°5' E longitude (Fig. 1). The district is densely populated, with 560 persons/sq km (957423 persons as per census 2011) living in a 1450.02 sq. km area. There are 641 villages under five sub-divisions in the district.

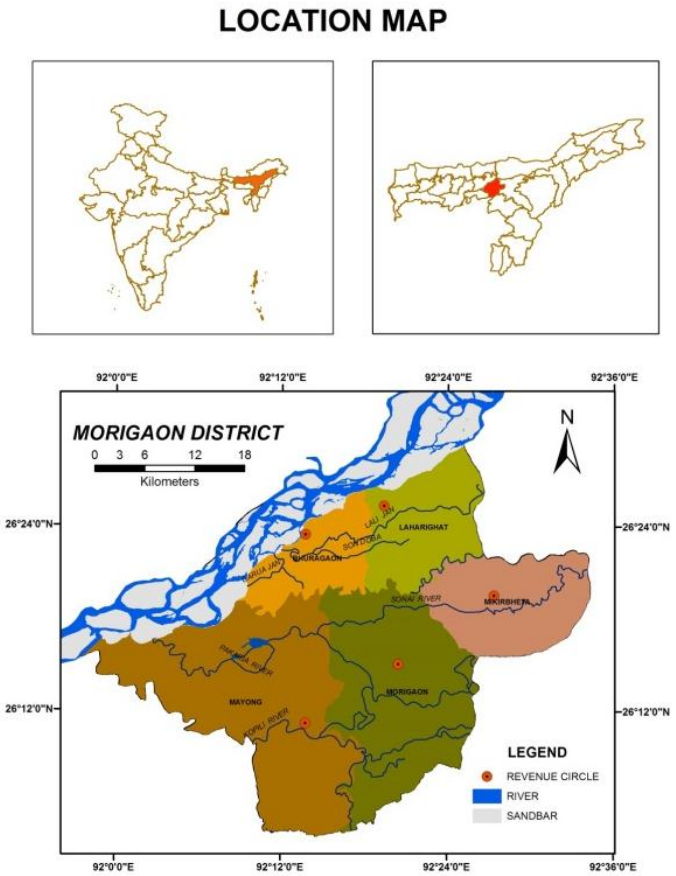

Fig. 1: Locational map of Morigaon district

The physiographical division of the district can be made into three regions viz. the low lying plain in the north-eastern part of the district, the built-up plain in central and the eastern part and interspersed hillocks in the south-western plain. The low-lying plain from the north-western part of the Mayong to the northern part of the mouzas of Bhuragaon, Bokani, Pakri, possesses several swamps and waterlogged areas. The area is flooded by water during the monsoon as there is no embankment on the south bank of the River Brahmaputra. The built-up plain is an extensive alluvial plain covering up to the southern part of the district. It is drained by several river channels and scattered with *beels* and swamplands. This plain is extremely flat where, Kollong and Kopilee are the major rivers, that drain from east to west in an imperceptible gradient. Many isolated hillocks, that is the extension of the Meghalaya plateau lying on the south, includes the Teteliaparbat (272 metres) and the Hatiuthaparbat (219 meters)

Flow chart:

The study is divided into four parts. First is the acquisition of data, followed by the processing of the data. The third is the process of analysis of the different data sets and fourth are derivations of maps. (Fig. 2).

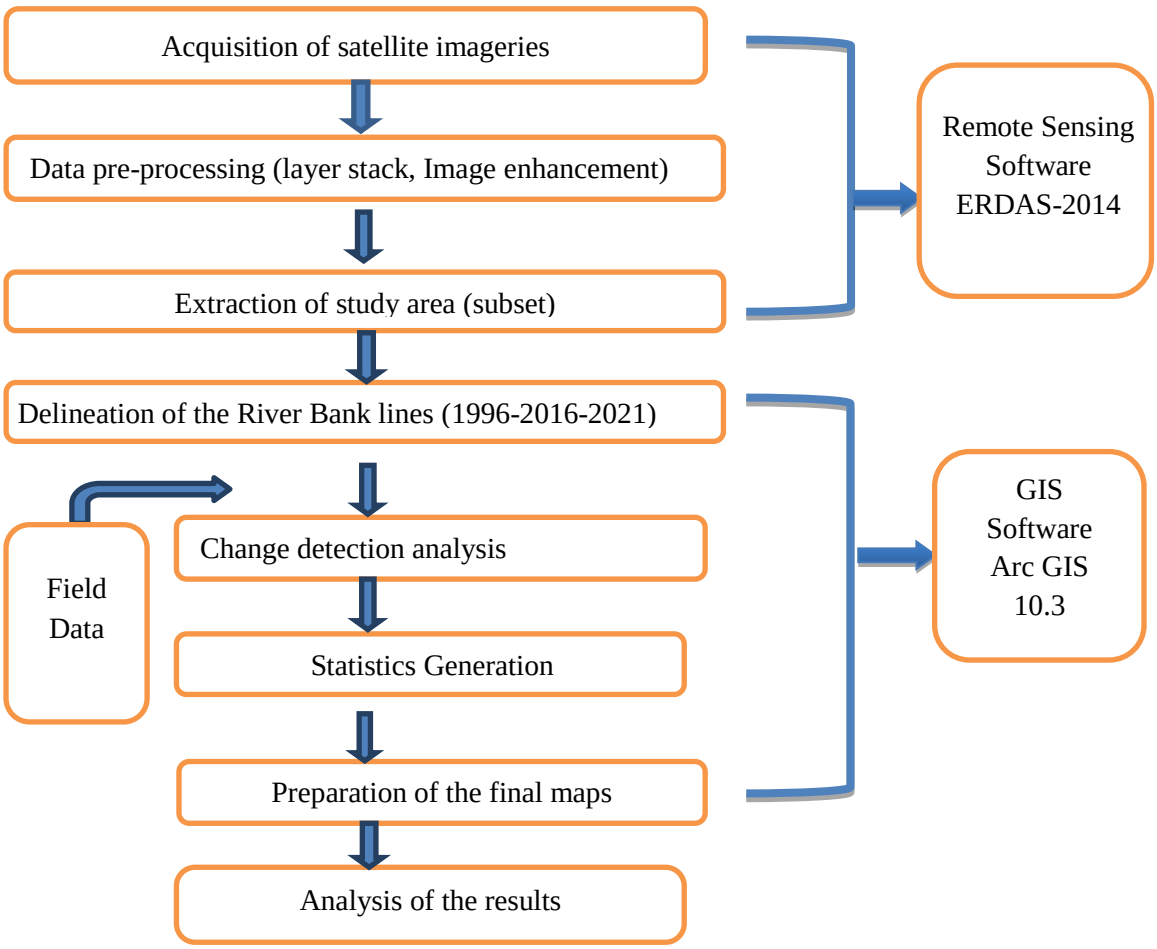

Fig. 2: Flow chart for the study

Data Source:

Bank line shifting of the Brahmaputra River in the study area was carried out using two sets of satellite imageries retrieved for three different periods (1996, 2016 & 2021) from Landsat-TM and Landsat-OLI images from the web portal www.earthexplorer.usgs.gov (Table 1).

Table 1: Data source

Image	Year	Path/Row	Spatial Resolution	Source
Landsat- TM	02-02-1996	136/42	30m	USGS
Landsat- OLI	08-01-2016	136/42	30m	USGS
Landsat- OLI	22-02-2021	136/42	30m	USGS

Software and Platforms:

Digital image processing is adopted for Band composition (layer stack), Geometric Correction, Radiometric Correction, Noise Removal, and Image Enhancement which is done by Remote sensing software ERDAS Imagine-14. Images were projected to a common Universal Transverse Mercator (UTM) project system in zone 46 North and the datum is defined by WGS-84. All of the satellite imageries are clipped using the administrative boundary of Morigaon district by using GIS software ArcGIS 10.3. (Fig. 3). False Color Composite (FCC) of Morigaon for different periods is prepared thereafter.

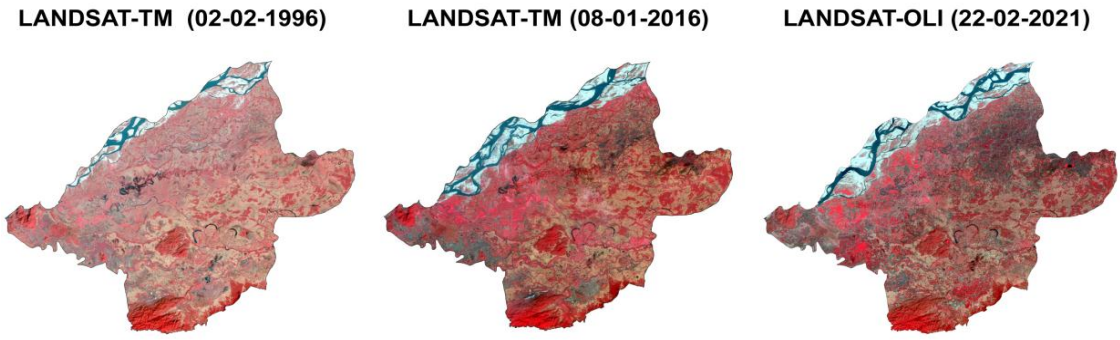

Fig. 3: Temporal satellite images of Morigaon district

Geo-coordinates:

GPS position of 8 places is taken for ground-truthing of the status of the riverbank during a field visit in 2016. The locations are marked with a Garmin etrex10 model. The locations are Katahguri, Gagolmari, Kacharigaon, Baralimari (Purana bazar), Bhuragaon, Kapurpara, Rawmari and GaraimariPathar (Table 2).

Table 2: GPS points of locations near bank line of 2016

Point Reference on Map	Location	Geo-coordinates
A	Katahguri	N-26^{0}16.945′ E-92^{0}4.345′
B	Gagolmari	N-26^{0}17.823′ E-92^{0}07.722′
C	Kacharigaon	N-26^{0}18.701′ E-92^{0}08.527′
D	Baralimari (Purana bazar)	N-26^{0}20.926′ E-92^{0}09.651′
E	Bhuragaon	N-26^{0}24.456′ E-92^{0}14.018′
F	Kapurpara	N-26^{0}26.020′ E-92^{0}16.852′
G	Rawmari	N-26^{0}26.508′ E-92^{0}20.507′
H	GaraimariPathar	N-26^{0}28.236′ E-92^{0}24.345′

Delineation/Digitization of River Bank Line:

The River Brahmaputra, in Morigaon district from Mayong Revenue circle in the west to Laharighat in the east, has been divided into 43 strips at an equal spacing of approximately 1 km and cross-sections have been drawn from north to south along the flow direction of the river. The whole south bank line of the Brahmaputra River has been divided into three segments A^0, A^1 and A^2. Segment 'A^0 ' is the boundary or south bank line of the River Brahmaputra active channel for the year 1996 and segment 'A^1' and segment 'A^2' are the bank lines of the river for the years 2016 and 2021.

On the basis of the 2016 channel flow direction, a base line has been taken as a permanent reference line. It is taken so that it maintains its identity as the morphology is transformed. The river bank-line of 1996, 2016 and 2021 has been identified and delineated by overlaying all the satellite images (Fig. 4).

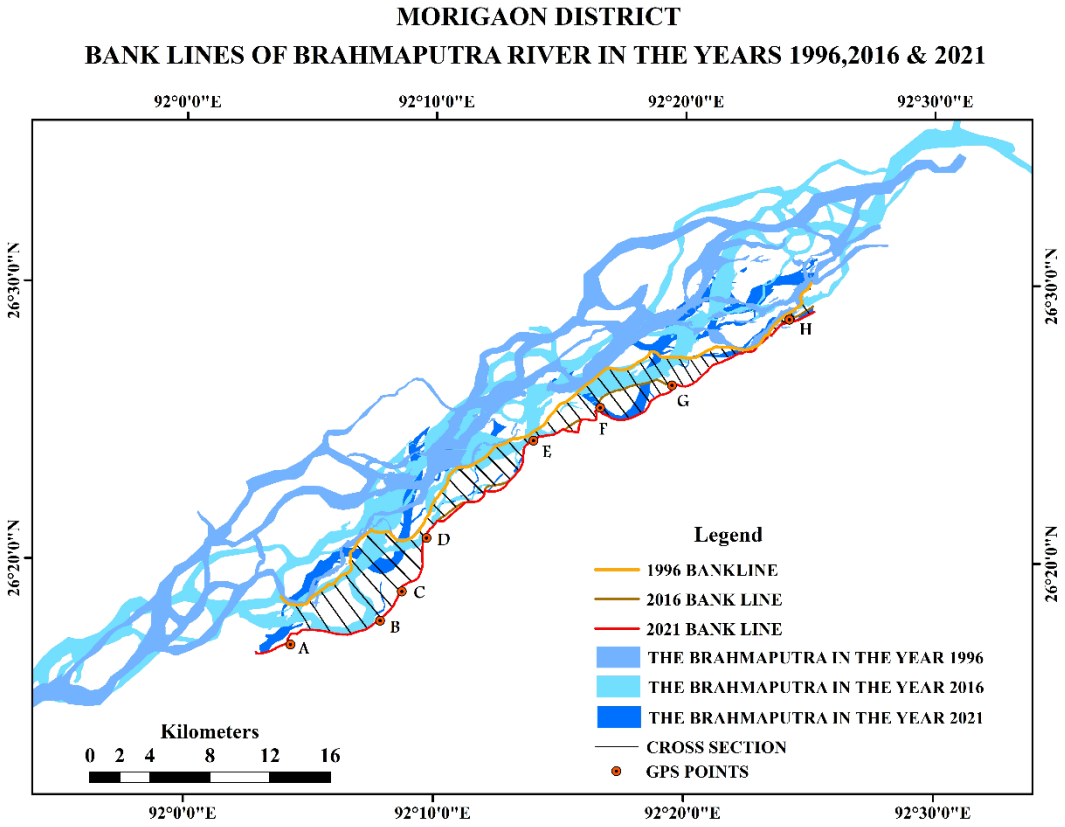

Fig 4: Delineation of riverbank line shifting of the Brahmaputra along the cross-sections 1996-2021

All the delineated river bank lines, for the years 1996, 2016 and 2021, for the south banks of the River Brahmaputra have been digitized and prepared. The length of banks for all three years has been calculated (Table 3). An estimate of the shifting bank lines in the study period for erosion is calculated.

Table 3: Variation of the width of the channel in different cross-sections (in km)

Cross-section	Eroded land from A^0 to A^1 (in Km)	Eroded land from A^1 to A^2 (in Km)	Cross-section	Eroded land from A^0 to A^1 (in Km)	Eroded land from A^1 to A^2 (in Km)	Cross-section	Eroded land from A^0 to A^1 (in Km)	Eroded land from A^1 to A^2 (in Km)
1	1.99	0	16	2.45	0	31	1.57	1.2
2	2.55	0	17	2.01	0.57	32	2.30	0.4
3	3.47	0	18	2.24	0	33	2.25	0
4	3.73	0	19	2.24	0	34	1.98	0
5	3.78	0	20	1.46	0	35	1.19	0

Cross-section	Eroded land from A^0 to A^1 (in Km)	Eroded land from A^1 to A^2 (in Km)	Cross-section	Eroded land from A^0 to A^1 (in Km)	Eroded land from A^1 to A^2 (in Km)	Cross-section	Eroded land from A^0 to A^1 (in Km)	Eroded land from A^1 to A^2 (in Km)
6	4.22	0	21	0.54	0	36	1.09	0
7	4.18	0	22	0.51	0	37	0.82	0
8	4.35	0	23	1.18	0	38	0.15	0
9	3.56	0	24	1.43	0.5	39	0.21	0
10	1.26	0	25	1.54	0	40	0.32	0
11	0.55	0	26	2.07	0	41	0.39	0
12	0.73	0	27	1.44	0.8	42	0.62	0.1
13	1.11	0.29	28	1.39	2.13	43	0.19	0.23
14	1.41	0.22	29	1.68	1.68			
15	2.14	0	30	1.19	2			

RESULTS

As the bank line shifting of River Brahmaputra is happening from time unknown, but considering the south bank line of the year 2016 as the base in Morigaon district, the main and the major channel of the Brahmaputra River in the year 1996 was flowing about 3.78 km north of Gagolmari (GPS point B) and 4.18 km north of Kacharigaon (GPS point C) in Mayong Revenue Circle. Similarly, the river was flowing 0.57 km north of Baralimari (GPS point D), 0.55 km north of Bhuragaon (GPS point E) and 1.39 km north of Kapurpara (GPS point F) in Bhuragaon Revenue Circle and 1.98 km north of Rawmari (GPS point G) in Laharighat Revenue Circle (Table 2).

By the year 2016, the Brahmaputra River has eroded many revenue villages of which 24 villages were from the Revenue circle of Laharighat, 27 villages from Bhuragaon and 13 villages from Mayong Revenue Circle. The total stretch of the portion eroded between Mayong Revenue Circle in the west to the Lahorighat Revenue Circle in the east is estimated to be around 49.19 km.

Channel shifting measure by Cross-section

The whole south bank line of the Brahmaputra River in the study area has been divided into three segments A^0, A^1 and A^2. Segment 'A^0 ' is the boundary or south bank line of the River Brahmaputra active channel for the year 1996 and segment 'A^1' and segment 'A^2' are the bank lines of the river for the years 2016 and 2021 (Table 4).

Table 4: Erosion between selected cross-sections from 1996 to 2021

Cross-section number	Erosion between 1996-2016 from A^0 to A^1 (in Km)	Newly eroded land between 2016-2021 from A^1 to A^2 (in Km)	Total length (in Km)
13	1.11	0.29	1.4
14	1.41	0.22	1.63
17	2.01	0.57	2.58
24	1.18	0.5	1.68
27	1.44	0.8	2.24
28	1.39	2.13	3.52
29	1.68	1.68	3.36
30	1.19	2	3.19
31	1.57	1.2	2.77
32	2.3	0.4	2.7
42	0.62	0.1	0.72
43	0.19	0.23	0.42

The most significant shifting of riverbank line from 1996 to 2016 where the river intruded into the mainland covering many villages is found at the cross-section numbers - 2 (2.55 km), 3 (3.47 km), 4 (3.73 km), 5 (3.78), 6 (4.22 km), 7 (4.18 km), 8 (4.35 km) and 9 (3.56 km) under Mayong Revenue Circle. Similarly, cross-sections 15 (2.14 km), 16 (2.45 km), 17 (2.01 km), 18 (2.24 km),19 (2.24 km) and 26 (2.07 km) under Bhuragaon Revenue Circle and sections 32 (2.30 km) and 33 (2.25 km) in Laharighat Revenue Circle displays a major shifting of the bank line (Fig. 5). While the bankline shift during 2016 – 2021 is found to be more severe under Laharighat Revenue Circle. The cross sections between 27 to 32 noticed aggressive erosion during these five years. The average length of erosion in those sections is found to be 2.96 km (Table 3 and 4). The average bankline shifting from all the segments (43 cross-sections) is calculated to be 1.99 km (1996-2021). The area eroded in between the two bank lines of 1996 and 2021 is about 181.81 sq. km where the river eroded 94 villages fully or partially. The width of the river bank has been increasing at the rate of 79.6 meters/year

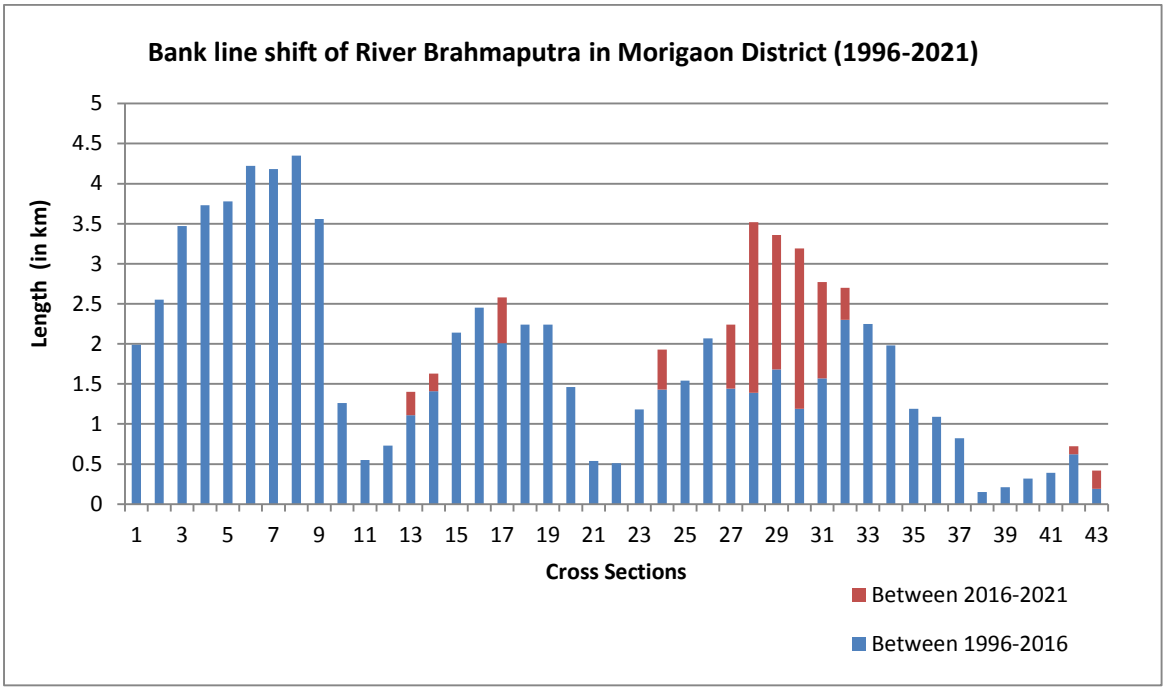

Fig. 5: Bank line shifting along cross-sections (1996-2021).

DISCUSSION

Riverbank line migration of the Brahmaputra in the study area is severe. Riverbank erosion and Sandbar deposition are a common phenomena in any big river system and it is farther true for the Brahmaputra River also. One of the most important reasons for erosion and deposition in the lower plains of the River Brahmaputra is heavy siltation. The cause of the siltation is supposed to be deforestation in the upper catchment area and also of the consequence of the 1950 earthquake in Assam had loosen the debris and barren slopes (Sarma and Acharjee, 2018). This resulted in the input of 45 billion m^3 of sediment into the river system which ultimately choked the bed of the river (Pandit *et. al*, 2007). Similarly the quality of soil in the plains, which is mostly fine sand and silt that cannot resist erosion. The slope of the river near Guwahati, which is located a few kilometres downstream recorded a slope ratio of 1:8875 or around 11 cm per kilometre.

The data reveal that amount of bank line erosion and fill up by the alluvial Brahmaputra River in different cross-sections are not uniform. The river frequently changes its course through bank erosion and channel migration. The high rate of southward shift in all the cross sections is due to materials composed of non-cohesive river banks silt. These changes are dependent on river discharge, sediment load, bank and bed materials, the level difference between river bed and its surroundings resulting from unplanned embankments and longitudinal profile of the river.

The river flow maintains an overcritical speed until Silghat, due to the presence of hilly expanded rocks in the middle part of the Brahmaputra River. As the river enters

in to the alluvial plain and the speed slows down, the river starts depositing its silt load. The position of embankments, especially during the summer months, contributes to increased suspended loads that get deposited in the riverbed contributing to the braided nature of the river, accelerating the bank erosion (Kar, 1994).

The intensity and extensity of bank erosion vary widely from the river to river. It depends on the characteristics as bank material, water level variations, near bank flow velocities, plan form of the river and the supply of water and sediment into the river. . Loosely packed deposited bank materials, consisting of silt and fine sand are highly susceptible to erosion. Rapid depression of floods accelerates the rates of bank erosion in such materials. The erosion and the bank line shift in the Morigaon district is the outcome of this process (Kotoky *et. al,* 2005)

Numerous techniques and protection measures both structural and non-structural are taken for long-term protection by the government. These structural measures like hard material protection also and barrier across the river aims to protect the bank and redirects flow and energy of stream flow away from eroding bank. Agencies like the Water resource dept (WRD) of Assam, Brahmaputra and Flood and River Erosion Management Agency of Assam (FREMAA) funded by Asian Development Bank (ADB) that prioritizes to implemented riverbank protection. Pro-Siltation measures with RCC porcupines, sand-filled geo-bags, bank-slope pitching, embankment and protection work, etc are some of the methods that helped in checking river bank erosion at various locations in Assam. In Morigaon too, the WRD has taken measures to control erosion by setting up embankments of porcupine and on the bank of the river. Structural measures like concrete bank pitching have been carried out in various locations in Bhuragaon Revenue Circle and also non-structural measures like low-cost bamboo wall and banding and geotextile sandbags are used in Gagolmari and Kacharigaon to arrest the bank erosion on a temporary basis.

The situation of erosion in certain locations was found to be deteriorating as the river has advanced further inside and eroded some villages. The erosion of the river Brahmaputra has washed away 94 villages either partially or completely under the three Revenue circles of Bhuragaon, Laharighat and Mayong in the district since till 2021 for an area of about 181.81 sq km. The width of the river bank due to erosion has been increasing at an alarming rate. The average shifting of the bank line in a certain parts of the study area between 2016 and 2021 (from cross-section 23 to 34) is found to be of 200.8 meters/year. The affected people living in that area are forced to migrate to other places. The displaced people are either staying in the makeshift huts on the river bank or the embankments with great hardship. Resettlement and rehabilitation of these persons are the major problems within the district. Most of the land lost was agricultural land where jute and paddy were cultivated in large quantities. Now, the dislocated cultivators had to engage themselves as petty traders, rickshaw/thela pullers in the nearby urban centers or as daily wage labour in agricultural sectors for their livelihood.

CONCLUSION

Erosion in the Morigaon district is quite intensive and aggressive. Thousands of people are rendered homeless. The bank line migration has generated an acute social and economic problem in the affected area. Anti-erosion measures adopted by the government are proved to be not truly effective in Morigaon though some measures at other places are successful. Some suggestions are therefore forwarded. The first and foremost strategy is raising awareness programs in the upstream areas about the importance of trees, afforestation and reforestation. This will reduce soil erosion, which will lessen the effects of flood and bank erosion. Due attention is needed while taking up developmental activities in the upper catchment areas so that drainage systems, including wetlands, are not disturbed. Soil conservation measures to check bank erosion needs to be intensified. Involvement of the community living therein is needed in achieving success. Fisibiality of embankments cum highways along the banklines need to be tested. The most conceivable measure for control of floods and bank erosion is to dredge the river for a smooth flow of the water. Scientific studies are needed for the construction of small check dams and taming of rivers in certain areas. An early warning system to evacuate and relocate people from the affected areas is obligatory. But this is not a permanent solution. A rational co-operation among Government, general people, and N.G.Os is very much needful. For a consistent as well as integrated development of the affected area, using the latest technologies is an emergent need.

PHOTOGRAPHS

Image: Bank erosion at Boralimari.

Image: Properties of Bank line.

Field survey with GPS points.Preventive Measure at Bhuragaon Revenue Circle.

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