

Bank Line Dynamics of Trans-Boundary River: A Case Study on the Padma River

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ABSTRACT: The study presents the bank line dynamics and channel change with latent impact of erosion, deposition of the Padma River between India and Bangladesh. The Study is located from Dhuliyān area under Murshidabad District of India to Chapainawabganj District of Bangladesh. Landsat TM satellite images with 30 meter resolution for the year 1995, 2005 and 2015 were used to delineate the confluence and Bank line dynamics. Geographic Information System (GIS) and Remote Sensing (RS) techniques used to analyses the spatial and temporal changes of river channels and bank line dynamics of the river. The bank erosion and deposition area were extracted through satellite image by using interpolation method. These processes perform as a function of bank lines shifting and indicate the dynamic nature of bank line erosion. Findings demonstrate the dynamics of the bank line which signify effect in increasing and degrading of floodplain development. Bank line dynamics are influenced by complex set of hydrological and geomorphological phenomenon, erosion, deposition, flood and earthquake etc. To explain, integrate and analyze the interaction with time and space in a single study is challenging. In coherence with this findings are presented in this research emphasize significant gaps in knowledge that need to be addressed through further research.

KEYWORDS: River bank, Channel, Erosion, Deposition, shifting, Dynamics.

I. INTRODUCTION

The Padma is the major hydrodynamic system that twisted one of the world's largest delta campuses covering a major portion of the country and also a superior part of West Bengal in India[6]. For a long period of expansion of the Ganges Delta, the river shifted southeast and has stretched its present position in the Bengal Basin. The hydrology and drainage systems of the Ganges Delta in the southwestern part of Bangladesh are intimately connected to the mighty Ganges and the fluvial-hydrological setting of the Bengal Basin[11]. The deltaic estuaries of the Ganges-Brahmaputra-Meghna system drain the pooled discharges of these river systems, amounting on an average of 35,000 cumec[13]. However, during the monsoon the discharge of the Padma rises to the order of 750,000 cumec with a consistent increase in its sediment load[18]. The low level discharge of the river through the dry season is of the order of 15,000 cumec and certainly very little sediment is borne by the river during this period[19]. In the deltaic portion the river width ranges from 1.6 to 8.0 km and occasionally it shows a braided character though it is a meandering river[20]. The large discharges and substantial sediment loads conceded by these rivers result in highly variable and dynamic channel morphologies characterized by rapid amendments to the cross-sectional geometry, bank line positions and plan form aspects[15].

The Padma confluence is highly dynamic and persistently changing their channel which eventually affects all aspect of the adjacent floodplains[16]. In Bangladesh there have been numerous studies associated with river dynamics which concentrated on channel, the bank analysis, and morph dynamic changes with precise prominence on bar dynamics and bank erosion of the great rivers[10]. This research desires to investigate the effects of hydraulic parameters in river, how erosion and bank cause changes on the confluence and its channel in the context of Padma in Bangladesh[7].

Remote Sensing (RS), Geographical Information System (GIS) and Global Positioning System (GPS) simplify river morphological analysis[25]. Theodolite is also widely used to monitor dynamic river system by assessing three dimensional (3d) coordinates [14]. Steady collection of spatial data using GPS and theodolite for river channel observing is very problematic. This procedure is time consuming and costly. Whereas, RS and GIS technologies are effective widely used tools for dynamic physical environment variation detection and monitoring [3][2][23]. In this research Geographical Information System (GIS) and Remote Sensing (RS) technologies are applied.

Bangladesh is located at tropical region and vastly populous[8]. Tropical climate is originated in this country with November to February considered as dry season. Usual rainfall is about 15 cm to 20 cm per year[7]. The typical temperature in the dry season is 17°C to 18.5°C[7]. The geology of this area is swamped and delta plain land with peat, silted, acidic brown and grey soil [17][21]. Due to the change of variables river convergence dimension also reformed. There is a relationship among numerous variables that control the shifting of channel belt as well as demolish the adjacent bank line floodplains. To recognize and monitor the dynamics of river bank systems, migration of the confluence, movement of river channels and eroded and deposited river banks is the main dilemma of this research. Bangladesh is however a floodplain riverine country. Almost every year flooding arises in the country. During regular flood, about 2600 sq. km 18% of Bangladesh are flooded and during severe flood, the flooded area surpasses 55% of the total area of the country [22][24]. A massive amount of water flows through the plain land of Bangladesh. The pride of Bangladesh is her waterways [25]. Most of the rivers are alluvial nature with shifting, meandering and braided decoration. Platform caused by erosion and accretion progression as well as show continuous river course migration.

The key factors of bank line dynamics are erosion and deposition especially for the Trans boundary Padma River. The river bank dynamics through time and space is critical to many geo-morphological and river controlling problems [1]. Lateral migration refers to the positional change of a river channel as a response to variations in fluid flow and sediment discharges and is always associated with bank erosion and deposition of the stream bed or channel wall under turbulent flow conditions [4]. Lateral migration is consequently a process that can cause catastrophic local or regional variations[12]. Studied the development of meanders in natural river channels and also did the appraisal of river channel changes [27]. Bank line is the formation of a river. This is the trace of a channel in plan, as shown, for instance, on vertical air photographs or as symbolized on maps. Bank line is used to describe the plan view of a reach of river as seen from an airplane and includes meandering, braiding or moderately straight channels [27]. Channel pattern is used to describe the plan view of a reach of river as seen from an airplane and includes meandering, braiding or relatively straight channels [26]. Meandering patterns and braided patterns transpire widely.

II. AIM AND OBJECTIVES

The main aim of this study is to investigate the erosion and deposition along the river bank of the Padma River at the International boundary zone since 1985. It is evident from available literature that there is a significant hydro-morphological change occurred of the Padma River due to water off-take by the upstream neighboring countries.

To meet the broad aim of this research several specific objectives are given below:

- To develop the database of the trans-boundary rivers in South-western part of Bangladesh.
- To investigate the erosion and deposition rate of the Padma River for the period of 1995-2015.
- To analyze the bank line dynamics of the study site.

III. DATA SOURCES AND METHODOLOGY

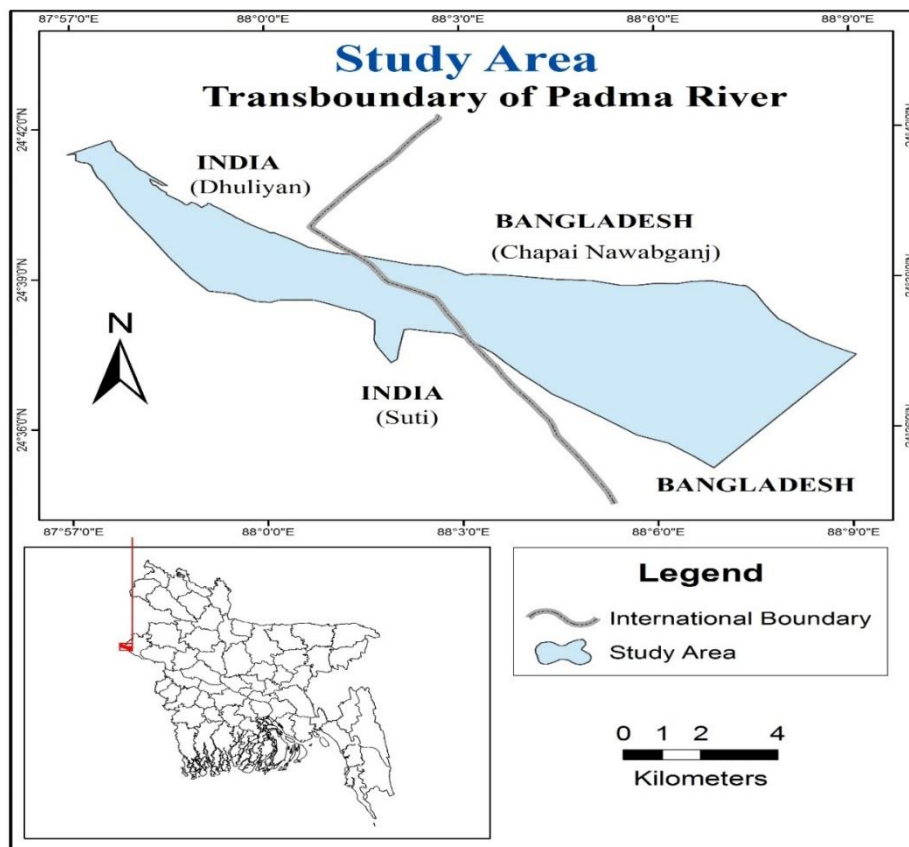
Research methodology is an organized way to solve a problem. Research methodology is utterly responsible for the systematic procedure and dispensation of the research work [9]. All the collected information and data from various sources for instance, statistical data, raw information and digital format database been analyzed by different method with the help of different software. Accretion and erosion on the Padma-Jamuna confluence identified and migration of the river channel pattern has been determined by geographic information system (GIS). In this research GIS software 10.3 version has been used. Various types of physical features such as bar, bank lines, rivers, erosion, accretion etc. can be identified and analyzed by remote sensing (Erdas imagine 2015). GIS or geographical information system and RS or remote sensing technique has become an important methodological tool in geographical research. The use of remote sensing technique allows uncovering the unique data that is unavailable in normal visualization. GIS has been used in this research work to manage, update, analysis of geographically referenced data based for mapping and analysis. Several GIS and RS tools have been also adopted in this research work. For statistical analysis of interpreted data,

Microsoft office program especially Microsoft office Excel tools have been used. For example, Standard Deviation, Skewness, Kurtosis, Maximum, Minimum, Range etc. have been calculated with the help of Microsoft office Excel. Various types of representation such as data table, line graphs, column diagrams etc. have been produced by this software.

It has evaluated how the river bank line outlines have changed from 1995 to 2015. The historical changes in the study site position, erosion, accretion, and the pattern of dissimilarities are described by using satellite images. The standard of research intensifications as much as information and data castoff in the study. So, a time series of Landsat TM satellite images of the Padma River were important to conduct this research. Required historical time series images were collected from USGS.

IV. STUDY AREA

Study areas are interdisciplinary fields of research relating to particular geographical, national and cultural regions. Primarily as a general description for what are in the practice of research, encompassing both the social sciences and the humanities. Typical area study programs involve history, political science, sociology, cultural studies, languages, geography, literature, and related disciplines. In contrast to cultural studies area often include scattering and emigration from the area. The Study is located from Dhuliyan area under Mushidabad Dristict of India to Chapainawabganj District of Bangladesh.



Map 1. Study area

The Padma jamuna confluence is located at 24°40'62.34" North latitude and 87°58'25.57" East longitude to 24°38'62.92" North latitude and 88°04'45.41" East longitude. The study site is the area from Dhuliyan area under Murshidabad Dristict of India to Chapainawabganj District of Bangladesh. The total length of the study site is about 20 kilometer.

Padma is a major river in Bangladesh. It is the main distributary of the Ganges usually southeast for 120 kilometres (75 mi) to its convergence with the Meghna River near the Bay of Bengal[5]. The city of Rajshahi is located

on the banks of the river. The Padma enters Bangladesh from India near Chapai Nababganj and meets the Jamuna near Aricha and holds its name, but finally meets with the Meghna near Chandpur and assumes the name "Meghna" before rolling into the Bay of Bengal. Rajshahi a main city in western Bangladesh is situated on the north bank of the Padma. The Ganges initiates in the Gangotri Glacier of the Himalaya and turns through India and Bangladesh to the Bay of Bengal. The Ganges enters Bangladesh at Shibganj in the district of Chapai Nababganj. West of Shibganj, the Ganges branches into two distributaries, the Bhagirathi and the Padma Rivers. The Bhagirathi River which streams southwards is also known as the Ganga and was named the Hoogly or Hooghly River by the British. Further downstream, in Goalando, 2,200 kilometres from the source. The Padma is merged by the Jamuna (LowerBrahmaputra) and the consequential mishmash flows with the name Padma further east to Chandpur. The widest river in Bangladesh Meghna joins the Padma and continuing as the Meghna almost in a straight line to the south ending in the Bay of Bengal.

V. RESULT AND DISCUSSION

This research focused on the bank lines shifting due to erosion and deposition of the Trans Boundary River. With the dimension of river spatial and temporal shifting of the bank lines due to geomorphic processes (Erosion and accretion). The research promotes an integration of both hydrological and morphological processes for the shifting and its location, shape, area etc. Channel shifting, erosion and accretion of the study reach have been inspected in this study. The research was proficient based on physical concept with the aid of Geographical information system and Remote Sensing techniques. Research design encompassed a large range of statistical, spatial and temporal data for various section of the study. Tran's boundary of the Padma River was selected as study area as it shows a dynamic nature in different time and space with seasonal fluctuations. The study reach is located between India and Bangladesh border.

Dynamics of the river banks spatial extent of the floodplain development through erosion and accretion process was explored by the analysis of satellite images. Landsat TM satellite images of 1995, 2005, and 2015 were used and collected from United States of Geological Survey (USGS) website. Based on the present study following conclusion can be drawn with the respect to the distinct research questions. The erosion and deposition is not same in every year. The erosion and deposition are occurred disparity in different years from 1995 to 2005, 1995 to 2015 and 2005 to 2015 between Bangladesh and India. From 1995 to 2005, erosion is occurred in 1213.99 hector area and deposition are occurred at 2838.77 hectors area were deposited between Bangladesh and India and their erosion and depositional difference are -265.25 hectors area. The total effect of erosion and deposition river bank might be alike the below:

- i. The Trans Boundary River was enlarged here as the deposition rate is high relatively from 1995 to 2005 and 2005 to 2015.
- ii. For the reason of deposition the river bank and the river depth is declined but total amount of annual discharge has not changes.

Erosion and deposition from 1995-2005 of the study

Erosion and deposition can observe through the ratio temporal variation of the study. Accretion and erosion areas have notorious by overlapping river banks. The bank line of 11 years intermission from 1995 to 2005 has drawn from Landsat TM images. With erosion deliberation which areas have deposited in 1995 than 2005 is known as developed in the particular year. Naturally, development bank line dynamics varies over a larger range of time and space scales due to the difference of accretion areas (Fig. 1). Formation of bank lines mostly controlled through channel lateral movements and channel exchanging. Various geomorphic processes may drive erosion of bar or island surfaces. Bank line and channel has been shifted from 1995 to 2005 in different direction in different point. To analysis the variation of the erosion and accretion from 2000 to 2005 it was found that deposition was maximum than erosion in the year of 2005. In the year of 2005 erosion is less than the deposition of 1995. The erosional and depositional differences found in negatively. Left bank has been shifted right and right bank has been shifted right side that the past bank line position. Erosion and deposition areas have exposed with two different year bank lines. Deposition areas between two years have shown by red dotted point and erosion areas between two years has shown by black cross line in the map (Fig. 1)

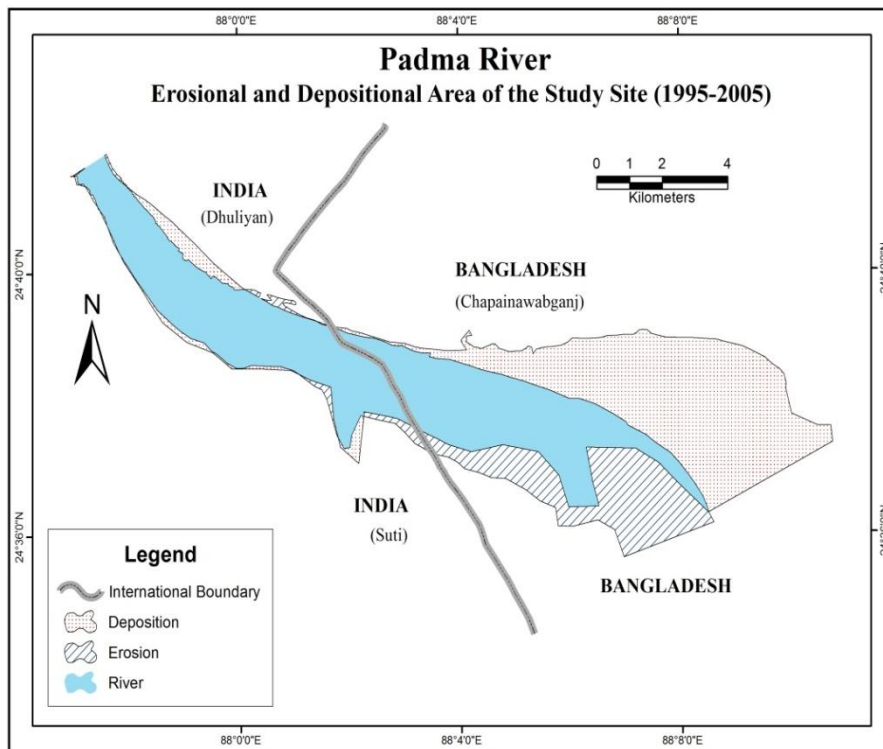


Fig. 1. Erosional and depositional area of the study site from 1995-2005

By the process of erosion and deposition river bank varies one place to another place from its origin. A huge amount deposition was ensued during this period. Erosion and deposition amount of both banks in 1995 and 2005 (Table 1).

Table1. Changing nature of bank line

| Year | Erosion (Hector) | Deposition (Hector) | Difference |
|-----------|------------------|---------------------|------------|
| 1995-2005 | 1213.99 | 2838.77 | -1624.78 |

Because of various morphological and hydrological causes some where it eroded and somewhere sediment deposited in the bank. 1213.99 hector was the amount of total erosion areas at different place in the study reach. Alternatively 2838.77 hector was the amount of total accretion areas at different place in the study reach. The difference of erosion and deposition was -1624.78. Variation of erosion and deposition between 1995 and 2015 are shown in the fig.2.

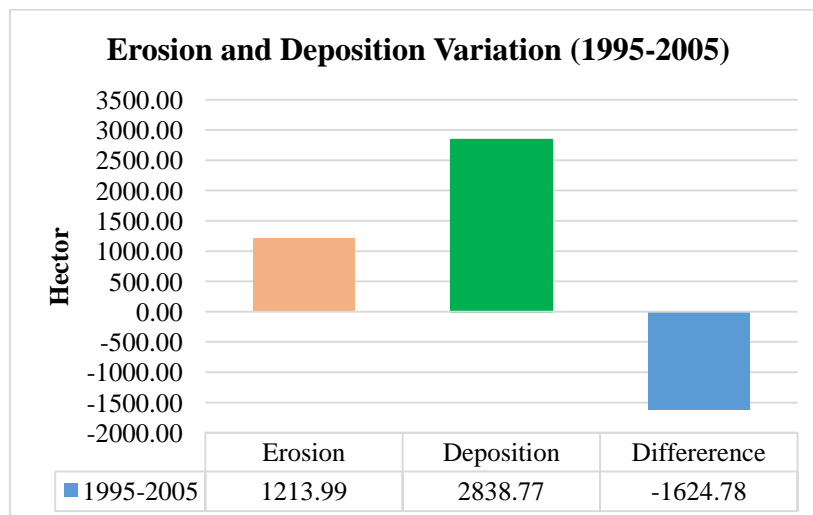


Fig. 2. Variation of erosion and deposition between 1995 and 2015

Erosion and deposition from 1995-2015 of the study

Erosion and accretion can observe through the ratio temporal variation of the study. Accretion and erosion areas have identified by overlapping river banks. The bank line of 11 years intermission from 1995 to 2015 has drawn from Landsat TM images. With erosion consideration, which areas have deposited in 1995 than 2015 is known as developed in the particular year. Naturally, development bank line dynamics varies over a larger range of time and space scales due to the difference of deposition areas (Fig. 3). Formation of bank lines mostly controlled through channel lateral movements and channel switching. Various geomorphic processes may drive erosion of bar or island surfaces. Bank line and channel has been shifted from 1995 to 2015 in different direction in different point. To analysis the variation of the erosion and accretion from 1995 to 2015 it was found that deposition was maximum than erosion in the year of 2005. In the year of 2005 erosion is less than the deposition of 1995. The erosional and depositional differences found in negatively. Left bank has been shifted right and right bank has been shifted right side that the past bank line position. Erosion and deposition areas have shown with two different year bank lines. Deposition areas between two years have shown by red dotted point and erosion areas between two years has shown by black cross line in the map (Fig.3).

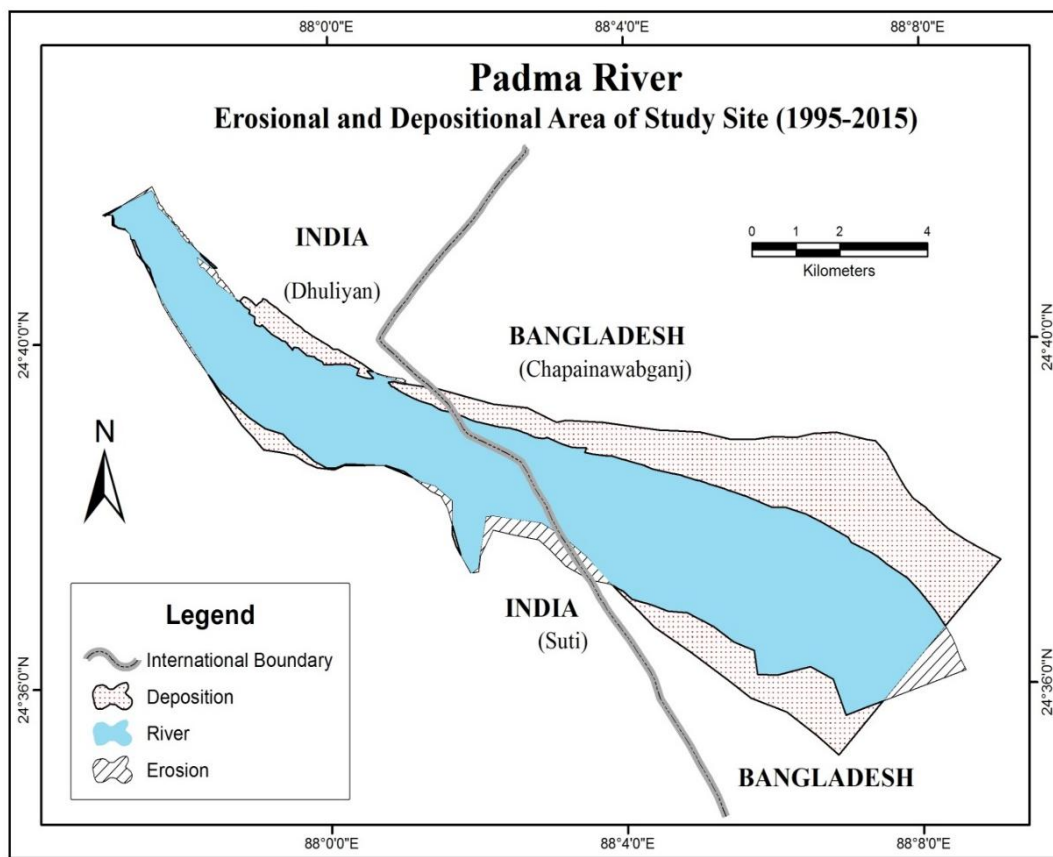


Fig. 3. Erosional and depositional area of the study site

By the process of erosion and deposition river bank varies one place to another place from its origin. A huge amount deposition was ensued during this period. Erosion and deposition amount of both banks in 1995 and 2015 (Table 2).

Table 2. Changing nature of bank line

| Year | Erosion (Hector) | Deposition (Hector) | Difference (Hector) |
|-----------|------------------|---------------------|---------------------|
| 1995-2015 | 272.93 | 2166.52 | -1893.59 |

Because of various morphological and hydrological causes some where it eroded and somewhere sediment deposited in the bank. 272.93 hector was the amount of total erosion areas at different place in the study reach. Alternatively

2166.52 hector was the amount of total deposition areas at different place in the study reach. The difference of erosion and deposition was -1893.59. Fig. 4 represents Erosion and deposition variation between 1995 and 2015.

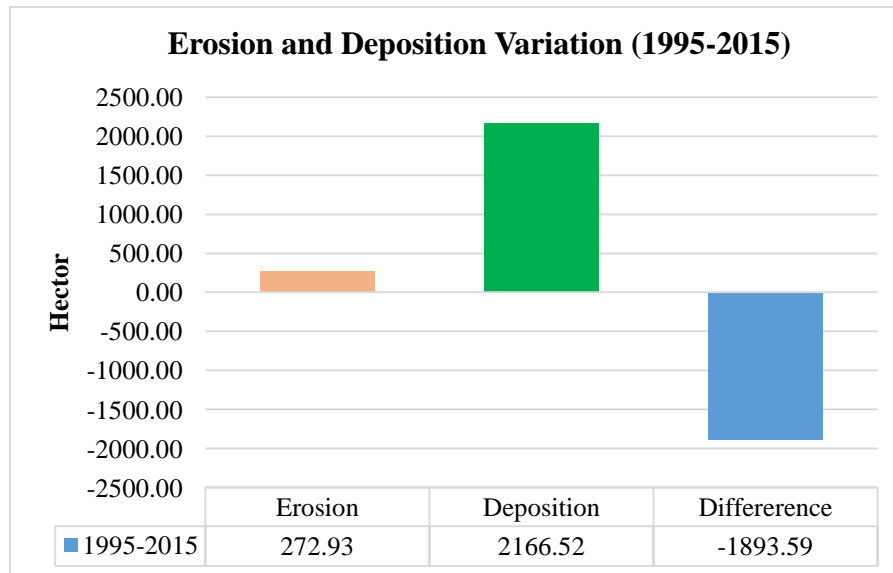


Fig. 4. Erosion and deposition variation between 1995 and 2015

Erosion and deposition from 2005-2015 of the study

Erosion and accretion can observe through the ratio temporal variation of the study. Accretion and erosion areas have identified by overlapping river banks. The bank line of 11 years intermission from 2005 to 2015 has drawn from Landsat TM images. With erosion consideration, which areas have deposited in 2005 than 2015 is known as developed in the particular year. Naturally, development bank line dynamics varies over a larger range of time and space scales due to the difference of deposition areas (Fig. 5). Formation of bank lines mostly controlled through channel lateral movements and channel switching. Bank line and channel has been shifted from 2005 to 2015 in different direction in different point. To analysis the variation of the erosion and accretion from 2005 to 2015 it was found that deposition and erosion were almost same. The erosional and depositional differences found in negatively. Erosion and deposition areas have shown with two different year bank lines. Deposition areas between two years have shown by red doted point and erosion areas between two years has shown by black cross line in the map (Fig. 5). Table 3 shows the Changing nature of bank line of study area.

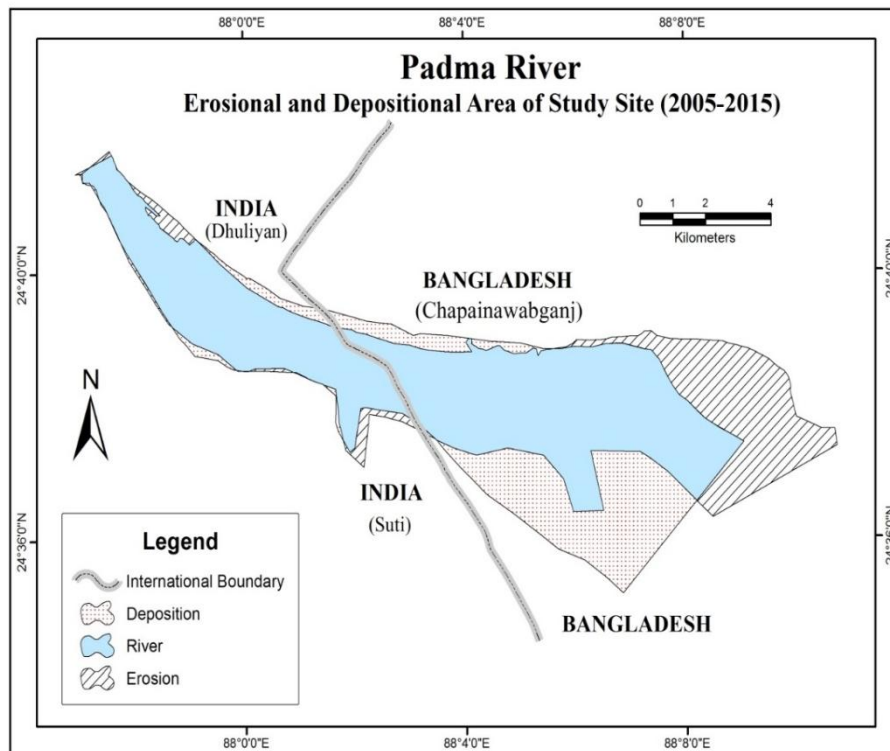


Fig. 5. Erosional and depositional area of the study site from 2005 to 2015

Table 3. Changing nature of bank line

| Year | Erosion (Hector) | Deposition (Hector) | Difference |
|-----------|------------------|---------------------|------------|
| 2005-2015 | 1543.51 | 1808.76 | -265.25 |

Because of various morphological and hydrological causes some where it eroded and somewhere sediment deposited in the bank. 1543.51hector was the amount of total erosion areas at different place in the study reach. Alternatively 1808.76 hector was the amount of total deposition areas at different place in the study reach. The difference of erosion and deposition was 265.25 hector. Fig. 6 shows Erosion and deposition variation between 2005 and 2015.

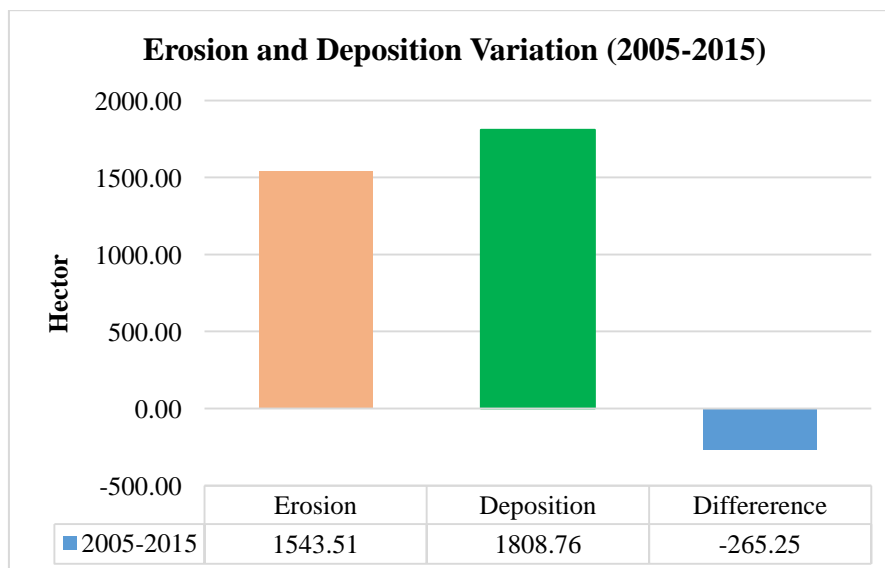


Fig. 6. Erosion and deposition variation between 2005 and 2015



Due to the variations of erosion and deposition the Trans boundary Padma river banks are shifting one side to another side. However, the river channel may be changed and the bank lines may be periodically modified by floods and discharge. Table 4 shows the all year’s erosional and depositional variation of the Trans boundary Padma River. Because of various morphological and hydrological causes some where it eroded and somewhere sediment deposited in the bank.

Table 4. Difference of bank line dynamics due to erosion and deposition

| Erosion and Deposition Variation | | | |
|----------------------------------|------------------|---------------------|------------|
| Year | Erosion (Hector) | Deposition (Hector) | Difference |
| 1995-2005 | 1213.99 | 2838.77 | -1624.78 |
| 1995-2015 | 272.93 | 2166.52 | -1893.59 |
| 2005-2015 | 1543.51 | 1808.76 | -265.25 |

In the table 4 it was observed that maximum erosion occurred in the year of 2005-2015 and maximum deposition was occurred in the year of 1995-2005. Negative difference was found in all year. Minimum erosion was occurred in the year of 1995-2015, it was 272 hector and minimum deposition was occurred the year of 1995-2015 and it 2166 hector. Fig. 7 presents the Dynamics of Erosion and deposition all year round.

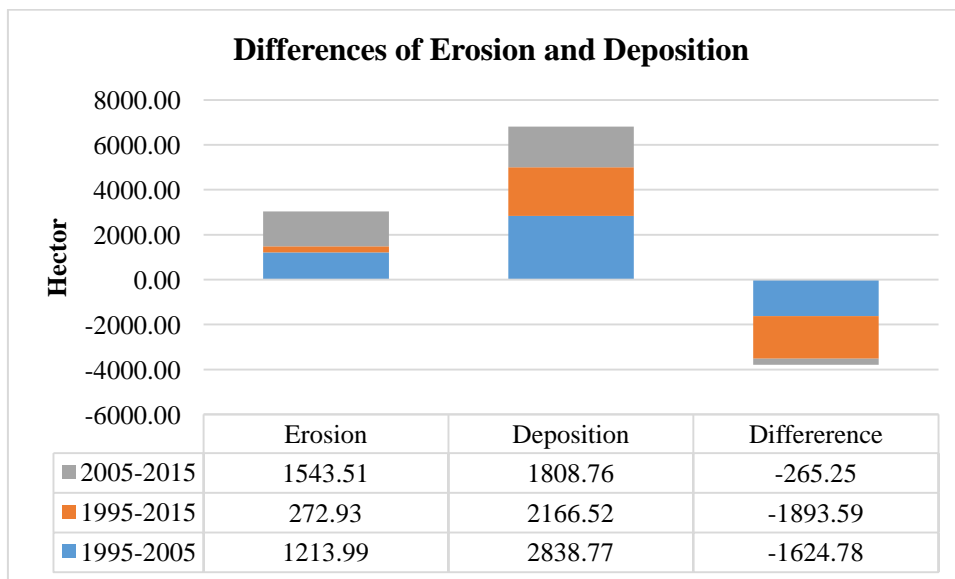


Fig. 7. Dynamics of Erosion and deposition

In every year the cross section 1 and 2 shows a little shifting of channels. Meanwhile, the cross section 4 and 5 displays a vast amount of shifting due to erosion and deposition. However, the amount of deposition is more than erosion. The variations of the bank lines in 1995, 2005 and 2015 are 1.49 km, 1.8km and 1.32 km at cross section 1 respectively. Then the variations of the bank line dynamics in 1995, 2005 and 2015 are 1.84 km, 2.58 km and 2.62 km, 1.32 km respectively at cross section 2. At cross section 3 the variation of the bank line shifting in 1995, 2005 and 2015 are 2.67, 3.51 and 2.42 km respectively. Then the variations of bank lines dynamics in 1995, 2005 and 2015 are 2.86, 3.44 and 5.1 km respectively at cross section 4. Last of all, the variations of the bank line dynamics of the Trans-Boundary River in 1995, 2005 and 2015 are 2.85, 4.28 and 5.37 km at cross section 5 respectively. Finally the average of the bank lines dynamics in 1995, 2005 and 2015 are 2.34, 3.12 and 3.37 km respectively.

Spatial and temporal dynamics of the channel

Continuous shifting of the thalweg from one position to another has been occurred within backlines. Observation of satellite image for 1995, 2005 and 2015 years are usually used to compare the channel shifting from India to Bangladesh, Bangladesh to India. For the each of morphological analysis total study reach is divided in to five cross

sections and these are XS-1, XS-2, XS-3, XS-4, and XS-5, (Table-5). All of these cross sections are located at different absolute and relative location.

Table-5: Summary of the cross sections at the study reach

| Cross Section | Cross Section | Cross Section |
|---------------|---------------|---------------|
| X-1 | 24°39'38.88" | 87°58'46.65" |
| X-2 | 24°38'59.45" | 87°59'29.59" |
| X-3 | 24°37'41.69" | 88°01'46.64" |
| X-4 | 24°37'32.48" | 88°03'30.42" |
| X-5 | 24°36'59.88" | 87°04'61.18" |

Channel shifting from 1995 to 2005 of the study

The bank line of ten years interval from 1995 to 2005 has drawn below by GIS software. The natural channel pattern varies over a larger range of time and space scales. The analysis of the bank line shifting from 1995 to 2005 at different cross section exposes that Trans boundary Padma River between Bangladesh and India continuously changes its plan form through shifting of the channel. It also indicates the erosion and accretion level at different cross section (Fig. 8).

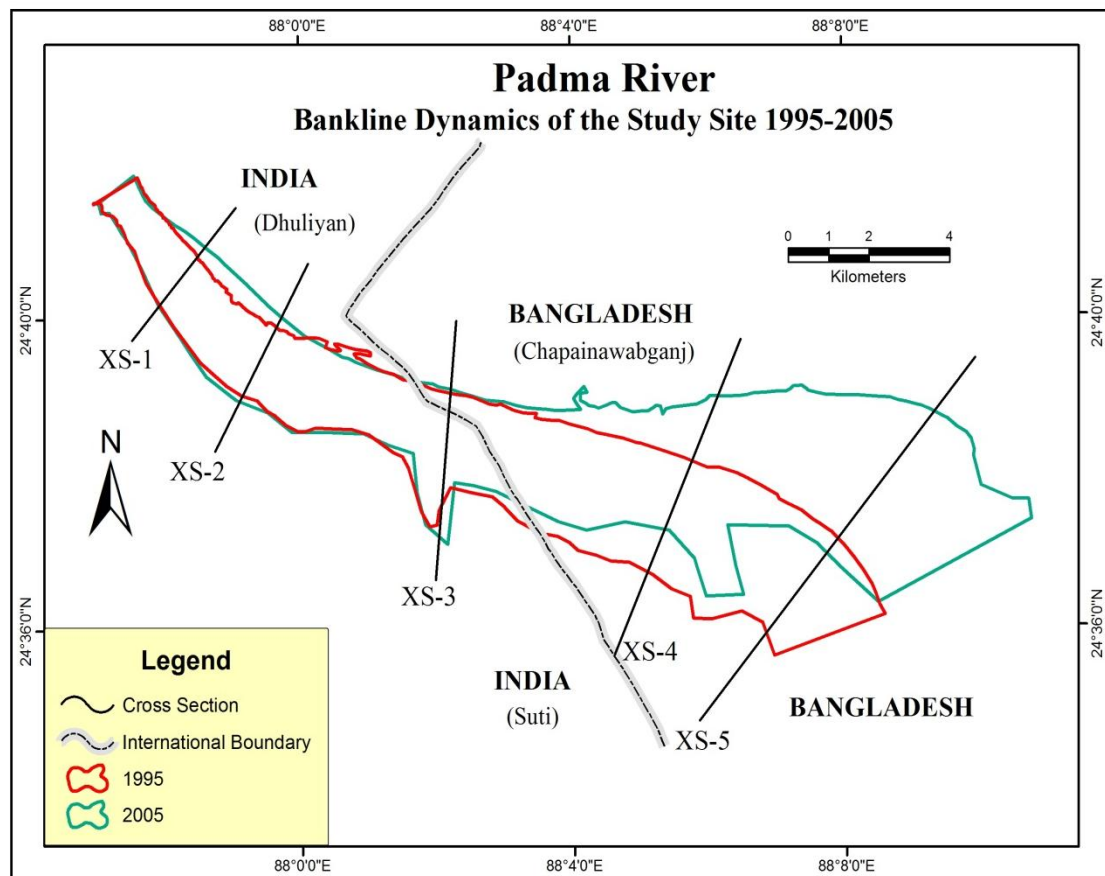


Fig. 8. Channel shifting at cross section of the study site from 1995 to 2005

Fig. 8 illustrates the bank line shifting at different cross section from 1995 to 2005. However the shifting is not same in every point. There was a vast difference at cross section 3 and cross section 4 in the channel of 1995 and 2005. That means vast amount of erosion and accretion occurred at the cross section. But in 1995 river channel was smaller than 2005 at the cross section 1, 2, and 3. In the cross section 2 there was a little difference in the river channel. Again there was a vast difference looking at the cross section 3. In the cross section 1, 2, 3 river bank line in 1995 was narrow than 2005. Left bank 2005 exposes high amount of erosion depicted at the right bank. Cross section 5 shows the quite similar position of river and narrow shape. Maximum channel shifting can be detected at cross section 3, 1 and 4, minimum changing

can identify at cross section 5 (Figure-8). With the process of erosion and accretion river width varies from one cross section to another cross section and that indicate the changes of channel pattern. Width data for all cross section in 1995 and 2005 indicate the variation (Table 6 and Fig. 9).

Table 6. Widening of the River Bank Line at different cross sections from 1995 to 2005

| Cross Section | Width Variations at Cross Section (Km) | | Variations (km) |
|----------------|--|------|-----------------|
| | 1995 | 1995 | |
| XS-1 | 1.49 | 1.8 | -0.31 |
| XS-2 | 1.84 | 2.58 | -0.74 |
| XS-3 | 2.67 | 3.51 | -0.84 |
| XS-4 | 2.86 | 3.44 | -0.58 |
| XS-5 | 2.85 | 4.28 | -1.43 |
| Average | 2.34 | 3.12 | -0.78 |

Table 6 displays the width variation at different cross section from 1995 to 2005. In 1995 and 2005 channel the width was 1.49 km and 1.8 km at cross section 1. In 2005 at this place channel was extended than 1995. For 1995 and 2005 at cross section 5 channel width was 2.85 km and 4.28 km. in 1995 at cross section 1 channel was minimum shifted are and in cross section 5 large amount of deposition was occurred. Cross sectional width variation from 1988 to 1995 shows that more deposition occurred in 1995.

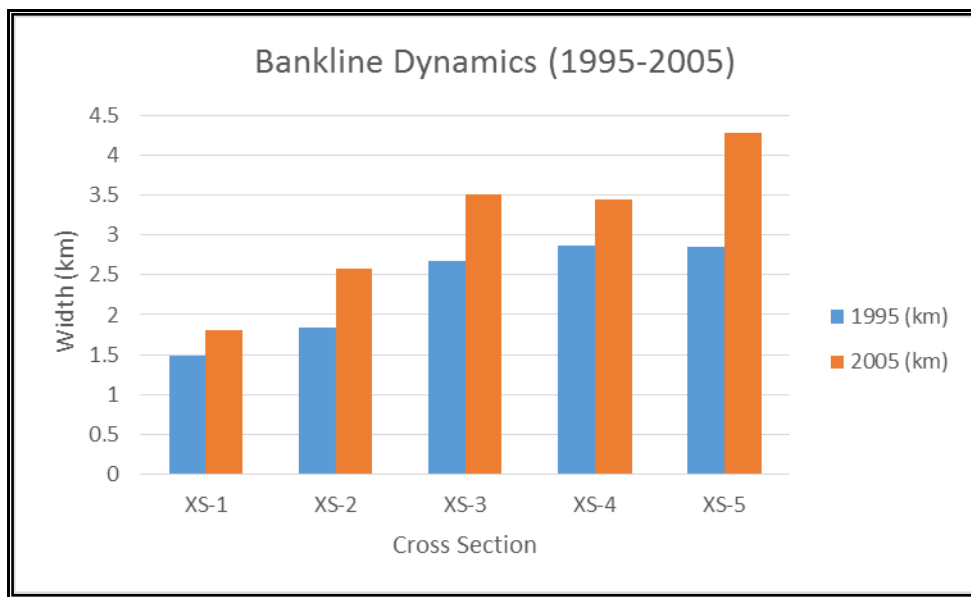


Fig. 9. Widening of the River Bank Line at different cross sections from 1995 to 2005

Channel shifting from 1995 to 2015 of the study site

The natural channel pattern varies over a larger range of time and space scales. The analysis of the bank line shifting from 1995 to 2015 at different cross section exposes that Trans boundary Padma River between Bangladesh and India continuously changes its plan form through shifting of the channel. It also indicates the erosion and accretion level at different cross section (Fig. 10).

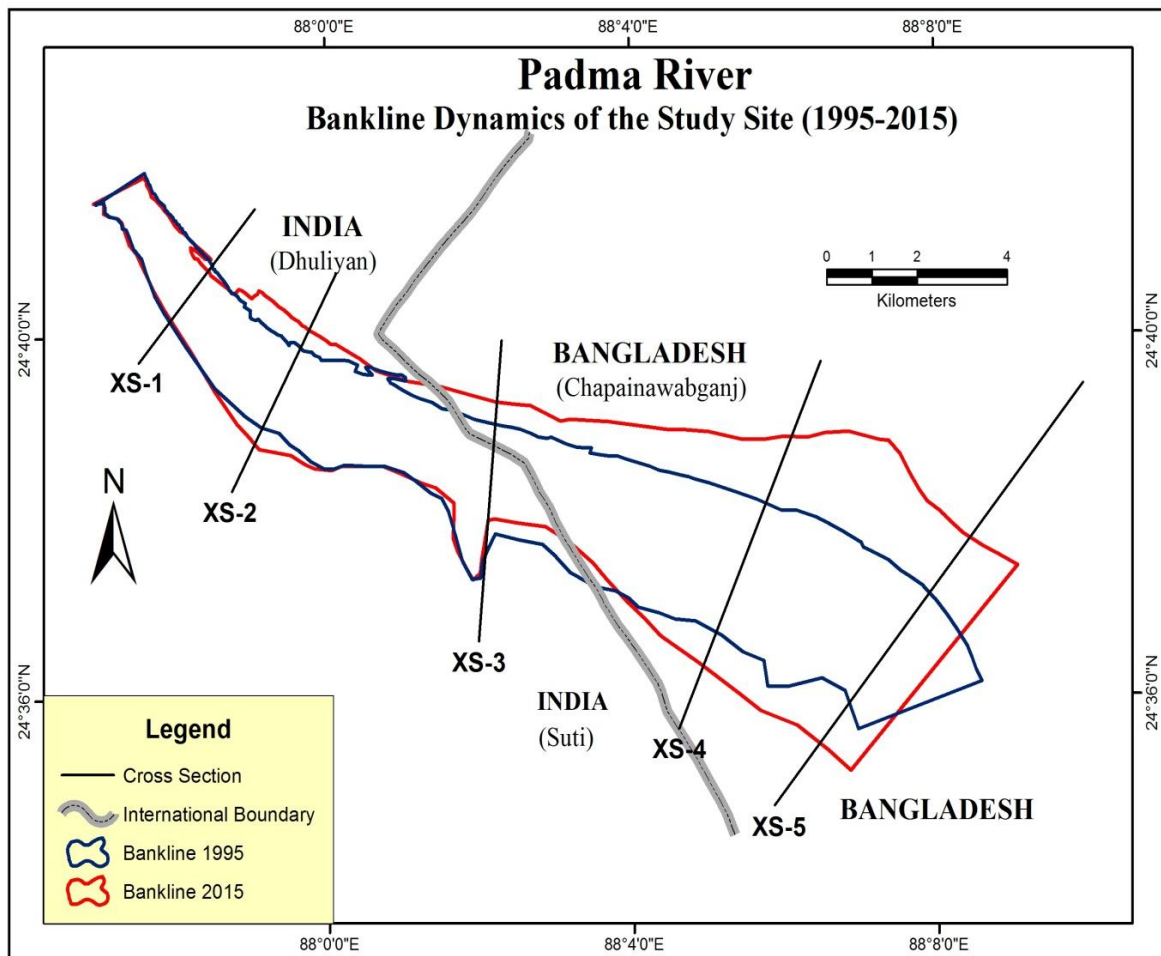


Fig. 10. Channel shifting of the study site from 1995 to 2015

Fig. 10 shows the dynamics of shifting river bank from 1990 to 2015. From the figure it is clear that shifting is not same in every point. There was a vast difference at cross section 3 and cross section 4 in the channel of 1995 and 2015. That means vast amount of erosion and accretion occurred at the cross section. But in 1995 river channel was smaller than 2015 at the cross section 1, 2, 3, 4, and 5. In the cross section 2 there was a little difference in the river channel. Again there was a vast difference looking at the cross section 4. In the cross section 1, 2, 3 river bank lines in 1995 was narrow than 2005. Left bank 2015 exposes high amount of erosion depict at the right bank. Cross section 5 shows the quite similar position of river and narrow shape. Maximum channel shifting can detect at cross section 4, and 5, minimum changing can identify at cross section 1, 2 (Fig. 10). With the process of erosion and accretion river width varies from one cross section to another cross section and that indicate the changes of channel pattern. Width data for all cross section in 1995 and 2015 indicate the variation (Table 7).

Table 7. Widening of the River Bank Line at different cross sections from 1995 to 2015

| Cross Section | Width Variations at Cross Section (Km) | | Variations (km) |
|----------------|--|-------|-----------------|
| | 1995 | 2005 | |
| XS-1 | 1.49 | 1.31 | +0.18 |
| XS-2 | 1.84 | 2.63 | -0.79 |
| XS-3 | 2.67 | 2.43 | +0.24 |
| XS-4 | 2.86 | 5.09 | -2.23 |
| XS-5 | 2.85 | 5.38 | -2.53 |
| Average | 11.71 | 16.84 | |

Table 7 shows the width variation at different cross section from 1995 to 2015. In 1995 and 2015 channel the width was 1.49 km and 1.31 km at cross section 1. In 2015 at this place channel was extended than 1995. For 1995 and 2015 at cross section 5 channel width was 2.85 km and 5.38km. In 1995 at cross section 1 channel was minimum shifted are and in cross section 4 large amount of deposition was occurred. Cross sectional width variation from 1995 to 2015 shows that more deposition occurred in 2015 (Fig. 11).

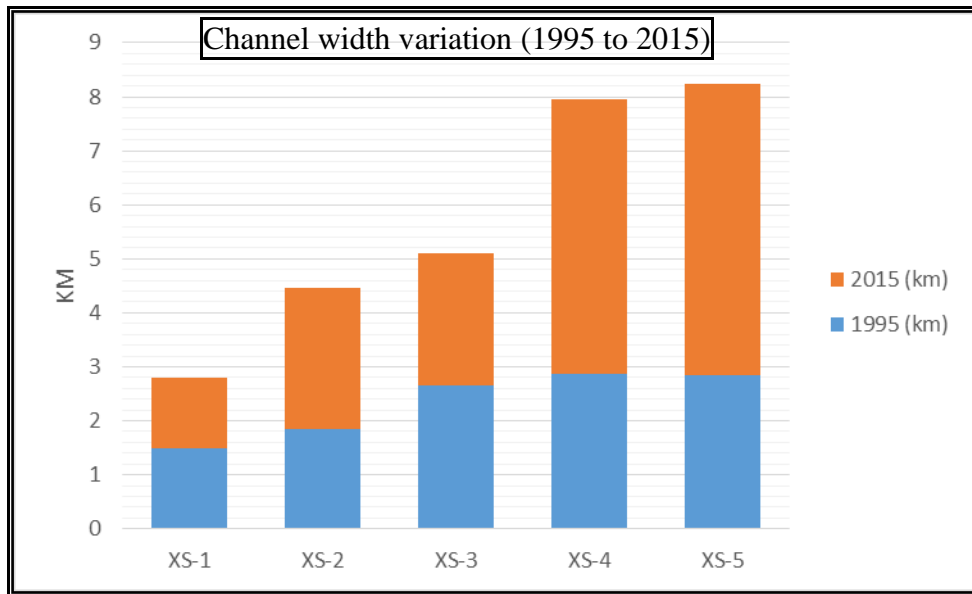


Fig. 11. Channel width variation from 1995 to 2015

Channel shifting from 2005 to 2015 of the study site

The bank line of ten years interval from 2005 to 2015 has drawn from satellite images. The natural channel pattern varies over a larger range of time and space scales. The analysis of the bank line shifting from 1995 to 2015 at different cross section exposes that Trans boundary Padma River between Bangladesh and India continuously changes its plan form through shifting of the channel. It also indicates the erosion and accretion level at different cross section (Fig. 12).

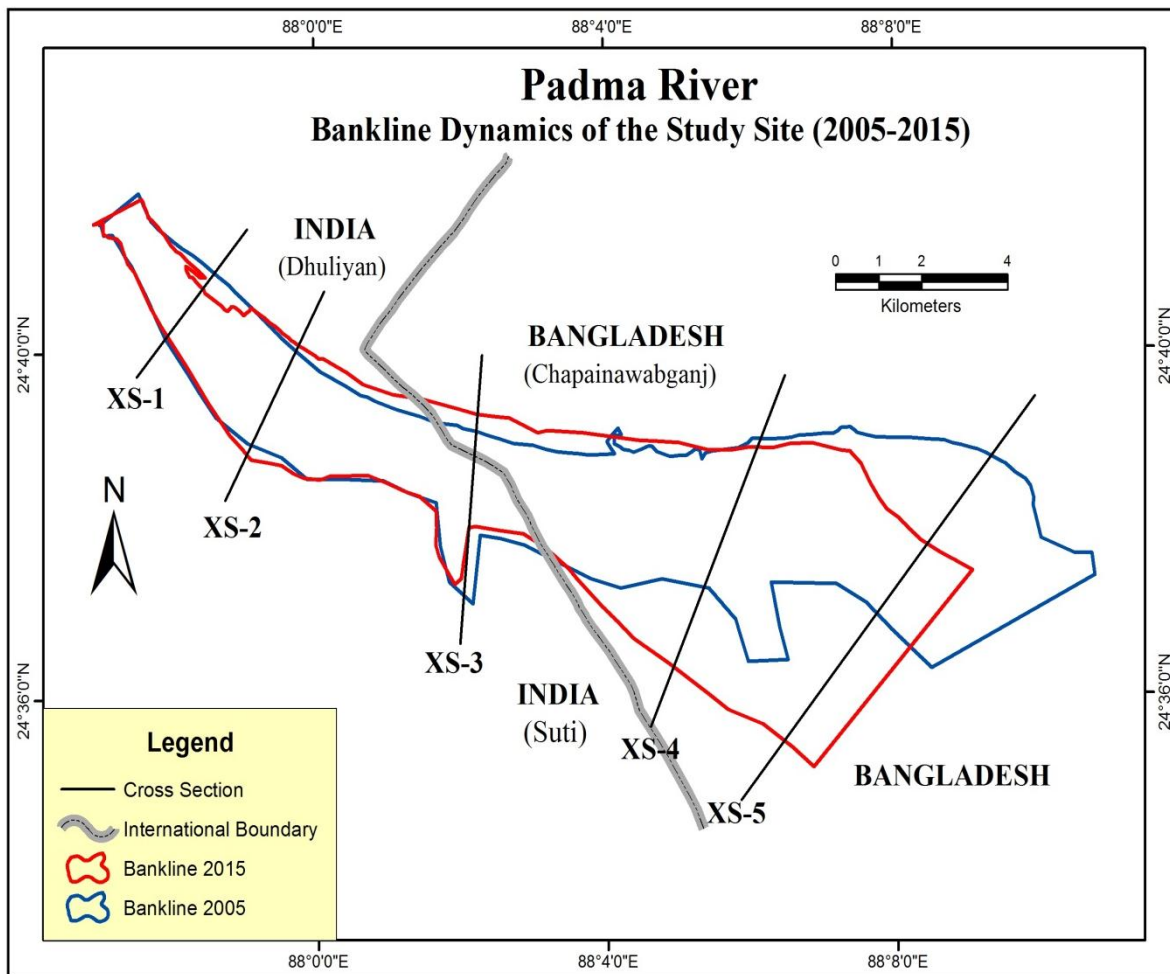


Fig. 12. Channel shifting of the study site from 2005 to 2015

Fig. 12 displays the dynamics of shifting river bank from 2005 to 2015. There have minimum erosion and deposition rate prevailing at cross section 1 and 2. There was a vast difference at cross section 4 and 5 in the channel of 2005 and 2015. That means vast amount of erosion and accretion occurred at the cross section. But in 2005 river channel was smaller than 2015 at the cross section 1, 2, 3, 4, and 5. In the cross section 2 there was a little difference in the river channel. Again there was a vast difference looking at the cross section 4. In the cross section 1, 2, 3 river bank lines in 1995 was narrow than 2005. Left bank 2015 exposes high amount of erosion depict at the right bank at cross section 4 and 5. Cross section 5 shows the maximum erosion of study site.

Table 8. Widening of the River Bank Line at different cross sections from 1995 to 2015

| Cross Section | Width Variations at Cross Section (Km) | | Variations (km) |
|----------------|--|------|-----------------|
| | 2005 | 2015 | |
| XS-1 | 1.8 | 1.32 | +0.48 |
| XS-2 | 2.26 | 2.62 | -0.36 |
| XS-3 | 3.51 | 2.42 | +1.09 |
| XS-4 | 3.46 | 5.1 | -1.64 |
| XS-5 | 4.3 | 5.37 | -1.07 |
| Average | 3.07 | 3.37 | |

Table-8 displays the width variation at different cross section from 2005 to 2015. In 2005 and 2015 channel the width was 1.8 km and 1.31 km at cross section 1. In 2015 at this place channel was extended than 1995. For 2005 and 2015 at cross section 5 channel width was 4.3 km and 5.37 km. in 1995 at cross section 1 channel was minimum shifted are and

in cross section 4 large amount of deposition was occurred. Cross sectional width variation from 2005 to 2015 shows that more erosion occurred in 2015. Fig. 13 shows Channel width variation from 2005 to 2015.

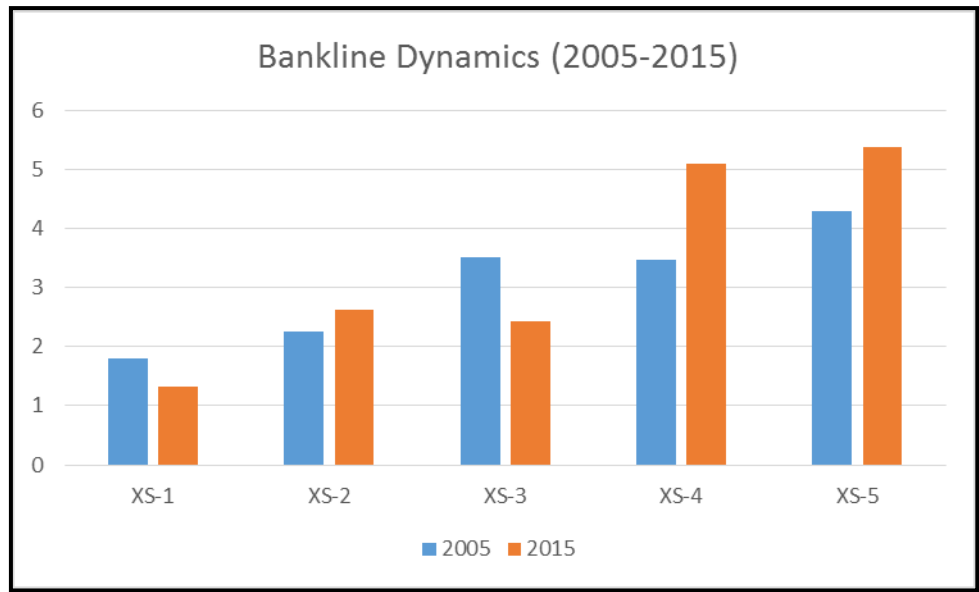


Fig. 13. Channel width variation from 2005 to 2015

To do the research work of Trans Boundary River between India and Bangladesh some data has been developed due to erosion and deposition of river bank. Table 9 displays the widening variation of cross sections from 1995 to 2015. Erosion and Deposition variation from 1995 to 2015 indicates in Table 10.

Table 9. Widening variation of cross sections from 1995 to 2015

| Cross Section | Width Variations at Cross Section (Km) | | |
|---------------|--|------|------|
| | 1995 | 2005 | 2015 |
| XS-1 | 1.49 | 1.8 | 1.3 |
| XS-2 | 1.84 | 2.58 | 2.62 |
| XS-3 | 2.67 | 3.51 | 2.42 |
| XS-4 | 2.86 | 3.44 | 5.1 |
| XS-5 | 2.85 | 4.28 | 5.37 |
| Average | 2.34 | 3.12 | 3.37 |

Table 10. Erosion and Deposition variation 1995 to 2015

| Erosion and Deposition Variation | | | |
|----------------------------------|--------------|-----------------|-----------------|
| Year | Erosion (Ha) | Deposition (Ha) | Difference (Ha) |
| 1995-2005 | 1213.99 | 2838.77 | -1624.78 |
| 1995-2015 | 272.93 | 2166.52 | -1893.59 |
| 2005-2015 | 1543.51 | 1808.76 | -265.25 |

VI. CONCLUSION

Bangladesh is sited at the downstream of the Padma flood plain flat terrestrial. So migration of river channel of the Padma is moderately ordinary phenomenon. But river channel migration of the Padma is transpired too fast. River channel migration, erosion and deposition of riverbank are one of the leading natural disasters responsible for poverty of Bangladesh. It has the great impact on rural unemployment between Bangladesh and India. Regular monitoring of riverbank line, understanding the trend of river channel migration and strategies setting for adaptation on probable effect could minimize potential risk and loss. Finally, the present research has established the spatial and temporal variation of bank line, erosion and deposition of the study area and causes of this discrepancy. The further result has demonstrated the presented findings in contrast with climatic and cultural variability as well as their impacts. Implication of these findings is necessary to improve our indulgent and the relevant extension and advance research of this research. Findings of this research signify the relationship in between channel shifting and erosion and deposition of the Trans boundary Padma River between Bangladesh and India. In context with result imply that erosion and deposition plays major role in channel movement. But the total outcomes of research draw attention that there are several parts need to be followed through further research.

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