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Research Paper

CHANNEL CHANGE AND PLANFORM IDENTIFICATION OF THE PADMA RIVER

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The course of the Padma River in 1860 occupied about 40% of the enveloped area. In the early 1940s and 1950s the river had widened significantly particularly at the constructing location of the Padma Bridge. The boundary of the river at that period occupied nearly 60% area of the envelope of 1925-2009. During the early 1960s and 1970s the river boundaries gradually shifted in the northeastern direction forming alternate three wide and two narrow reaches. In 2003, the river was wider one and during the current decade the river has occupied almost 90% of the river boundary envelope of 1925-2009. The upstream planform was a single threaded meandering river in 1860 and a multi-threaded braided planform was present at Mawa from 1925 to 1952. A 20 km long multi-threaded reach was present at the upstream in the 1970s. Again the river became single-threaded meandering planform in 1984 and and in the late 1990s almost the whole river turned into a braided river creating multiple channels and continuing to the present time. Total sinuosity of the river varied in a large range, from 1.2 to 2.4 during the last 84 years with an average value of 1.8.

Keywords: Padma, River envelope, River boundary, Planform and channel change

INTRODUCTION

The major rivers in Bangladesh are severe in erosion nature and thus they shift their channels and change the planform (CEGIS, 2005a and 2005b; Islam, 2006; and Rahman, 2015). The Padma River is typically unstable and subject to change over short time periods (CEGIS, 2009). The river is characterized by more channels, separated by bars, and migrates frequently in an environment of unrestricted bank erosion. The planform of the river varies spatially and temporally (Delft Hydraulics and DHI, 1996b; Rahman *et al.,* 2016; and Rahman and Islam, 2017). Understanding on channel morphology and channel instability through time is critical to many geomorphological and river engineering problems (Milton *et al.*, 1995). A detailed knowledge of channel change of rivers is essential for the management of the riverbanks (e.g., floodplain dwellers, riverside structures, riparian

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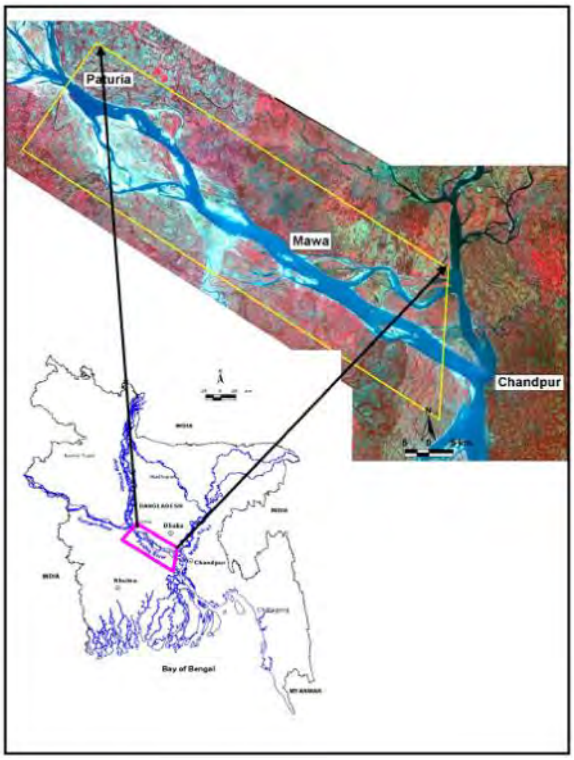
ecosystems) (ASCE, 1998a). Moreover, by analysis of the changes in the pasts insight is developed to help understand the potential course of channel changes and morphology in the future (FAP 24, 1996b). This study explores channel migration and the planform change to attain a more comprehensive understanding of the morphodynamics nature of the Padma River in Bangladesh.

STUDY SITE AND GEOLOGICAL SETTING

The Padma is referred to as the river stretch from Paturia to the confluence with the upper Meghna River at Chandpur in Bangladesh (Figure 1). The length of this reach of the river is 100 km (Delft Hydraulics and DHI, 1996a, 1996c and 1996g; CEGIS, 2015; and Rahman *et al.*, 2016). The physiography of the Padma River is finely attuned to its seasonal flooding and associated water regime. The physiographic unit is plains along both banks of the river comprising of the active Ganges River floodplain (GSB, 1990; and Brammer, 1995). The active Ganges flood plain includes rivers, chars, young flood plain land adjoining the rivers. The relief is slightly irregular, with complex ridges patterns and depositions (Rashid, 1991; and BBS, 2007).

Figure 1: The Study Site of the Padma River in Bangladesh



The Padma River lies within seismically active zone of the Bengal Basin (Seijmonsbergen, 1998). The subsurface geology and tectonic features of the Bengal Basin vary considerably from one region to another. Quaternary sediments consisting of calcareous alluvial, calcareous brown and dark gray flood plain soils underlie the river valley (O'Malley, 1917; Wadia, 1953; and Goswami, 1985). Silty soils predominant, but sands occur on some ridges and clays in some depressions. The proportion of silty and sandy alluvial are subjects to change in each flood season (Brammer, 1995; and BBS, 2009). There is no difference between the left and right banks of the floodplains and bank materials can be identified (Alam *et al.*, 1990).

MATERIALS AND METHODS

Based on historical maps from 1925 to 2009 and satellite images of CEGIS (Center for Environmental and Geographic Information Services), an envelope of the river corridor has been prepared. Changes in the river boundaries over time have been studied superimposing the boundaries of the river at different periods from 1860 to 2009 (Figure 2). A brief description of the changes in planform of the river and subsequent changes in channels has been presented in this study based on the centerlines of channels drawn

Figure 2: Shifting of the River Boundaries Over Time

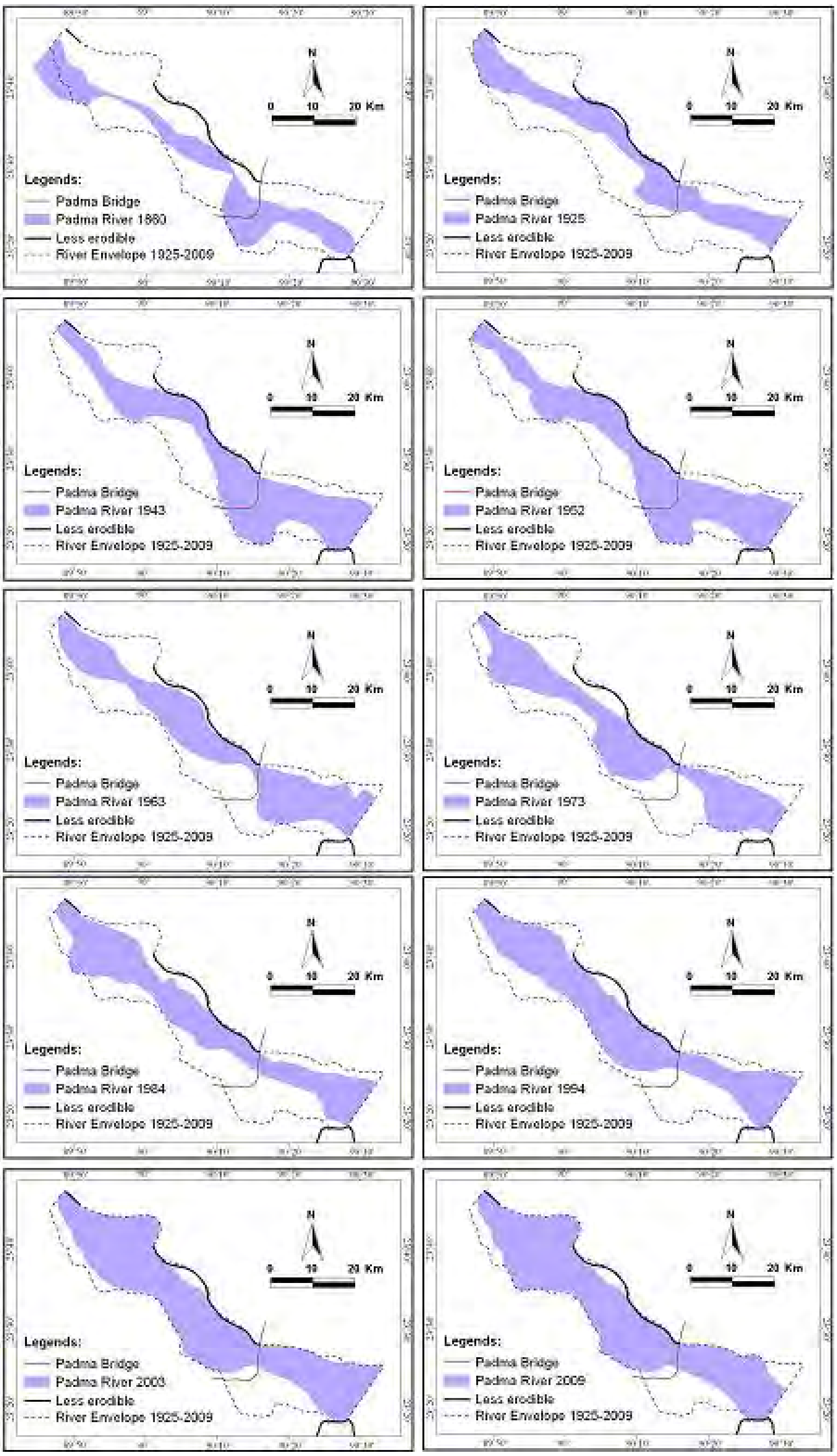
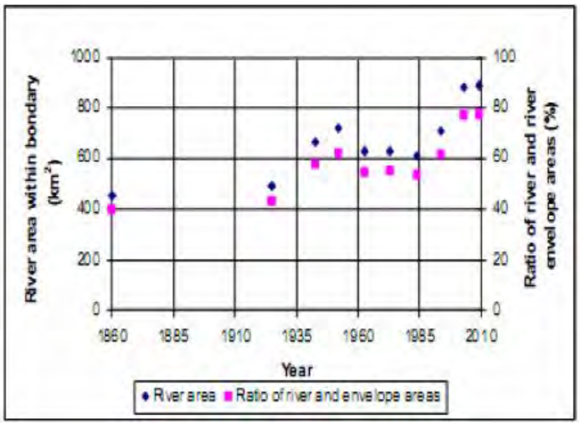


Figure 3: Changes in the River Area within the Boundaries Over Time



from historical maps from 1925 and onward as well as satellite images (Figure 3). A chainage system starting '0' km from Paturia has been used to describe the changes. For preparing channel incidence, satellite images have been classified using digital image processing techniques because there have been many efforts to evaluate the use of Landsat Multispectral Scanner (MSS) and Landsat Thematic Mapper (TM). Two broad land cover classes have been assigned to each of the available images acquired between 1973 and 2009, water and land. Each Landsat MSS, TM, ETM+ and LISS III image has been classified independently using an iterative classification procedure. An unsupervised classification algorithm has been used to derive signature statistics. The results have been examined and acceptable classes have been assigned to water and land categories.

RESULTS AND DISCUSSION

Changes in the River Boundaries

The Padma in 1860 was very narrow at the upstream but the presence of two channels at Mawa made the river course very wide. At two locations the boundary of the river touched the right boundary of the river corridor and at one location it touched the left boundary at the immediate upstream of Mawa (Figure 2). Almost the whole channel was accommodated within the channel envelope of 1925-2009, except a short reach at the upstream. The course of the Padma River in 1860 occupied about 40% of the enveloped area (Figure 3). In the early 1940s and 1950s the river had widened significantly and the widening was very much pronounced at the location of Mawa. The presence of a minor channel at the southern boundary made the river very wide at the constructing location of the Padma Bridge. The right boundary was along the right boundary of the envelope at the immediate upstream of Mawa.

The boundary of the river at that period occupied nearly 60% area of the envelope of 1925-2009 (Figure 3). The river had formed alternate wide and narrow nodal reaches in the early 1960s and these forms were continued in the following decades. There were three wide and two narrow reaches during the early 1960s and 1970s with the most downstream nodal reaches at Mawa.

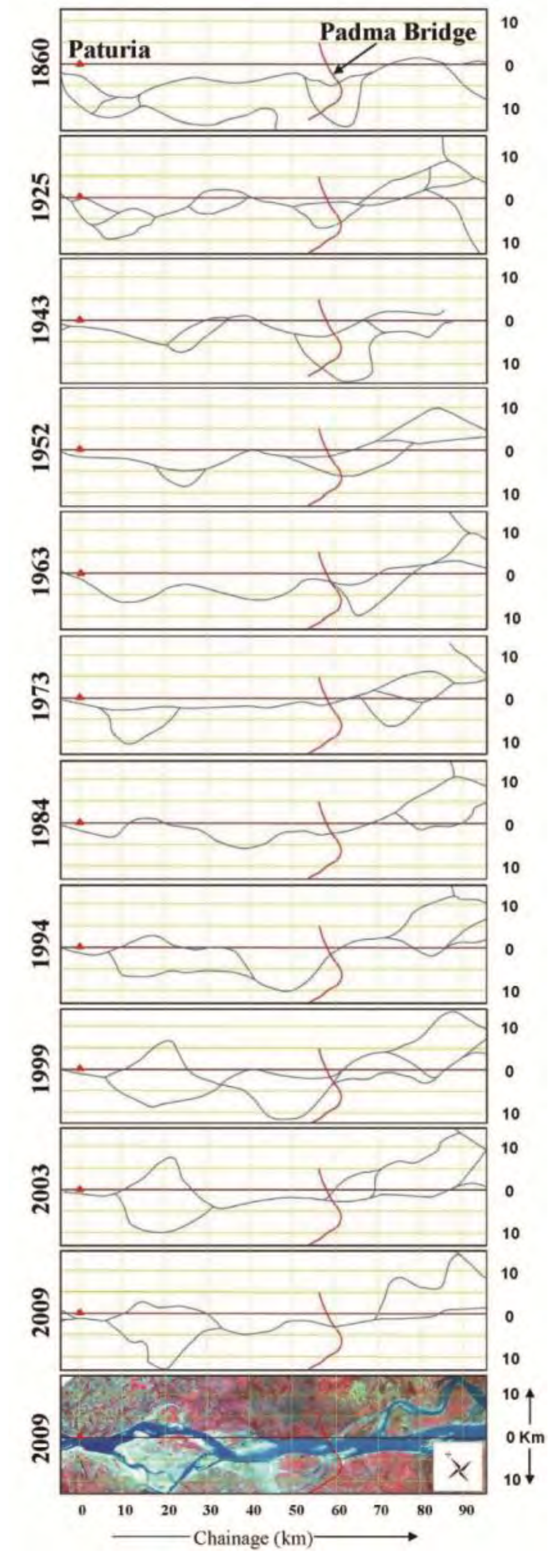
Since the middle of the nineteenth century the widest part of the river boundary was located at the downstream reach. The location of the widest reach reversed in the 1980s. Due to the widening of the river propagated downstream in the mid 1990s and abandonment of a right flanking channel, downstream propagation has halted at the immediate upstream of Mawa at the beginning of the current decade. In 2003 the river had widened significantly and the left boundary of the river had filled the highly curved and deep embayment at the upstream reach. During the current decade the river has occupied almost 90% of the river boundary envelope of 1925-2009. The widest reach of the river has remained at the upstream. The large gap between the boundary and the envelope of the river in the current decade is at the right bank of Mawa. The average width of the river is the highest during this decade since it has evolved in the present course. After shifting to the present course, the Padma River had shifted in northeastern direction. During the process of shifting, the left river boundary encountered less erodible bank materials (Figure 2) several times and not significant movement of the bank line was observed at those locations since 1925. Both upstream and downstream of this reach, bank lines migrated in northeastern direction.

Changes in Planform and Channels

The planform of the river varied between meandering and braiding over time. The upstream reach of the river from chainage 0 to 50 km, especially upstream of Mawa was a single threaded meandering river in 1860 (Figure 4). In 1925, most of the river showed a braided planform, although the river width was not very high. At the immediate downstream of the confluence of the Ganges and Jamuna Rivers, the Padma had started to braid and almost whole the Padma River showed braided planform with two alternating gaps of a few kilometers filling with a single threaded channel. A multi-threaded braided planform was present at Mawa from 1925 to 1952. In 1860 the planform at Mawa was also braided. The braided reach was elongated in both the upstream and downstream direction during 1925 to 1943. Later this reach migrated downstream from chainage 50 km to 75 km until 1984 with a rate of about 600 m per year.

A 20 km long multi-threaded reach was found at the upstream in the 1970s. In 1984, the planform became single-threaded again. This single-threaded meandering planform, stretched

Figure 4: Changes in Planform and Channels Over Time



from 0 km to 75 km, was the longest single threaded reach as observed from available maps and satellite images. The braided planform increased again gradually and in the late 1990s almost the whole river turned into a braided river (Figure 5). In the following years, the braided planform reduced 50% in length again (Figure 6). The braided planform was found in all available maps and images at the downstream reach of the Padma River. At the location of the bridge crossing the planform was braided from 1860 to 1952. Later, except for a few years in the late 1990s, a single-threaded channel mainly dominated the planform. At the downstream of the confluence of the Ganges and Jamuna Rivers, the Padma River demonstrated a divergence planform, often by multi-threaded channels.

Incidence of the River 1943 to 2009

Overlaying of channel boundaries of several years has produced a river incidence map (Figure 7). The river was 2 to 5 km wide. At the bridge location and along a 15 km long reach at the upstream of Mawa, incidence of rivers was 100% along the left bank. Both at the upstream and downstream of this reach the highest incidence of rivers was at the middle of the river corridor. The proposed bridge approach road at the left bank is beyond the river incidence limit. Within the bridge span, incidence of the rivers varies from 100% to 50%. On the other hand, the alignment of the proposed right bank approach road is within the river corridor and 25 to 50% river incidence limit. The average width of the river incidence limit or the river envelope of 1925-2009 is 13.5 km. The maximum width is about 21.2 km and the minimum width is

Figure 5: Changes in Length of the River Reaches Having Different Planform Over Time

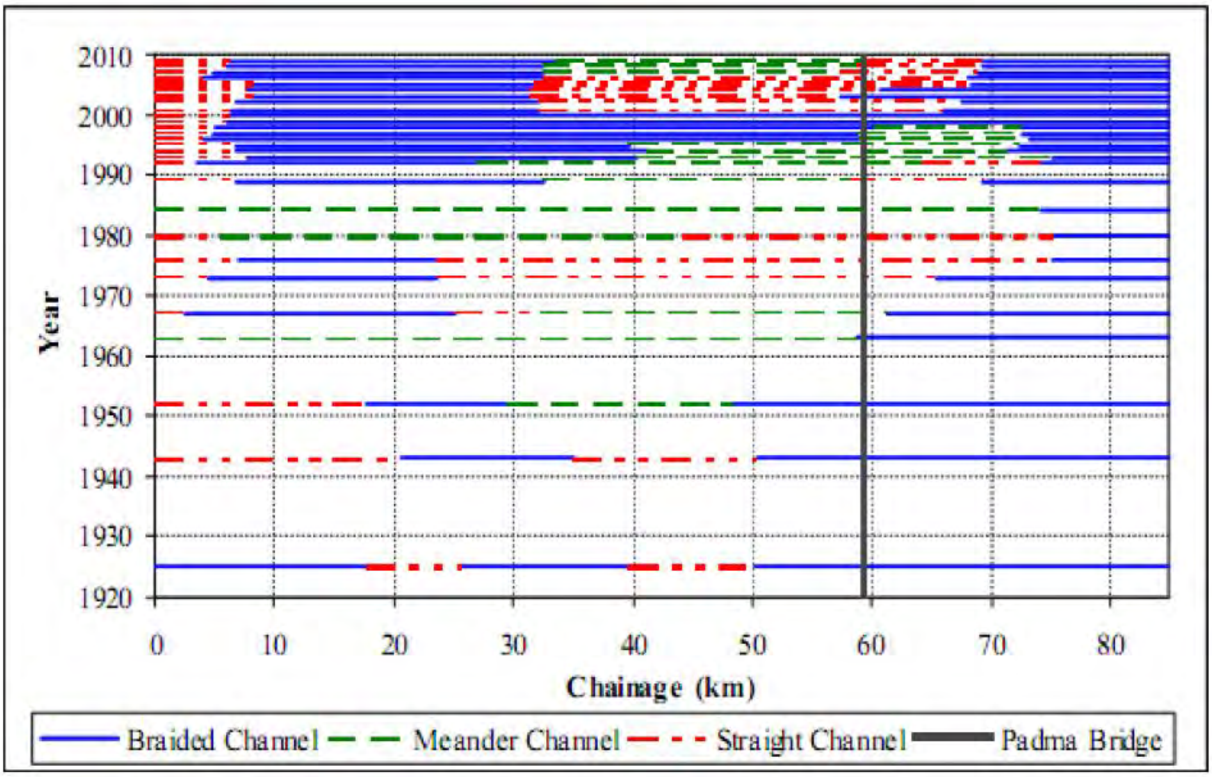


Figure 6: Ratio of Length of the River Reaches Having Different Planform

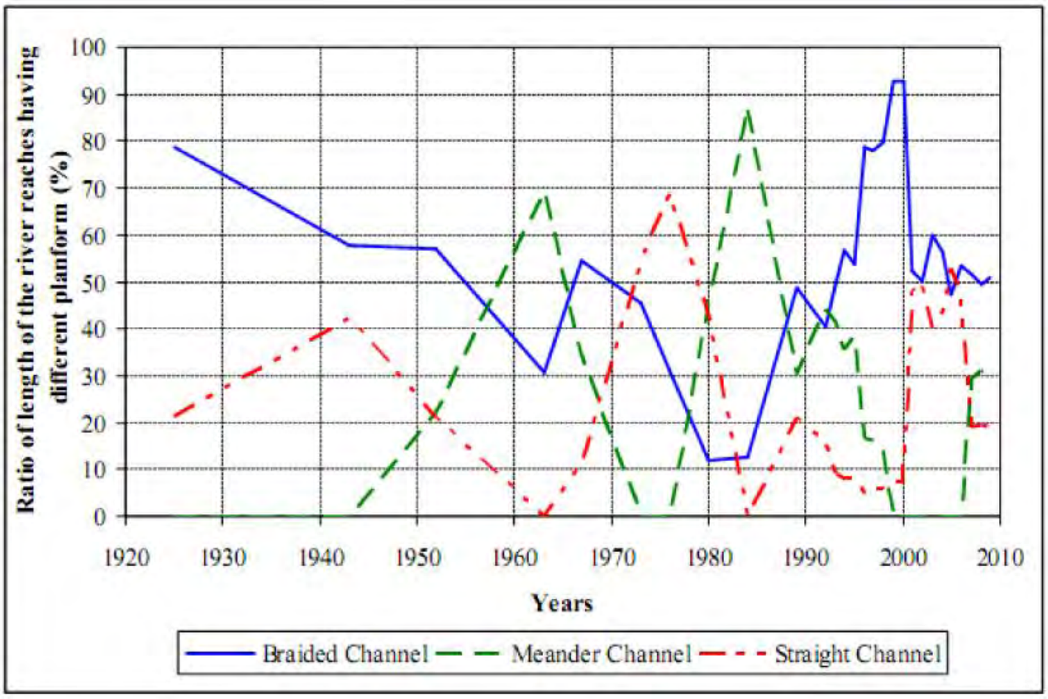


Figure 7: Incidence of the Rivers During 1943 to 2009

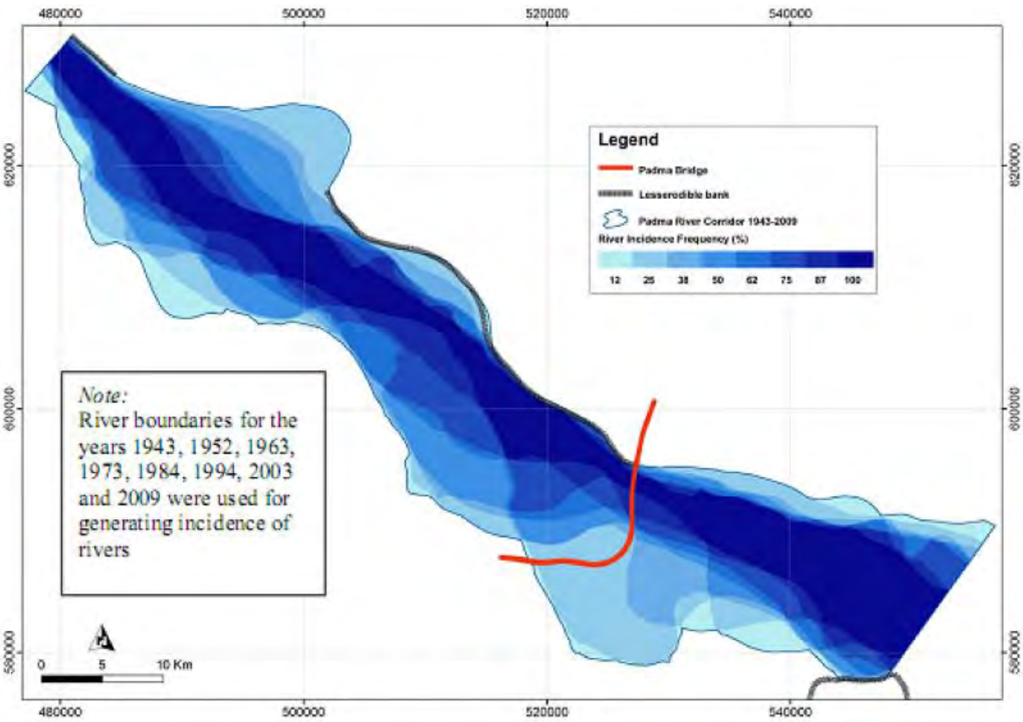
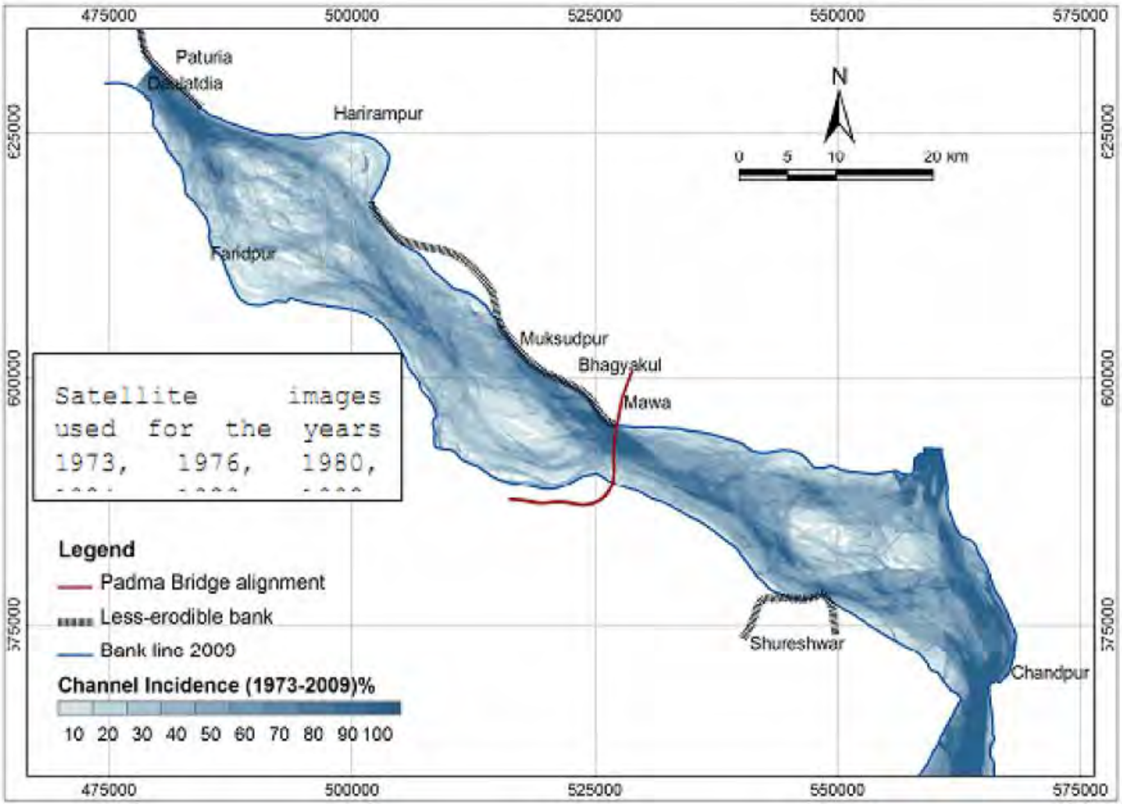


Figure 8: Channel Incidence Maps for the Period 1973 to 2009



8 km. The minimum width is about 30 km upstream of the bridge location.

Incidence of Channels

A channel incidence map of the Padma River has been prepared by superimposing the water from the 12 classified images (with varying intervals from 2 to 5 years) (Figure 8). The map shows that the frequency of channel incidence is very high along the banks where bank materials are less erodible. This is especially true for Paturia, Muksudpur, Mawa and Sureshwar (Figure 8). In the Lower Meghna River, the channel incidences are very high at Chandpur mainly due to the existence of bank protection works. It has been found that channel incidences at Muksudpur, Mawa and Sureshwar are 60%, 90% and 70% respectively. There are evidences that bank protection structures attract flow (Mosselman et al., 1995; and Mosselman, 1995) and for the same reason, less erodible bank materials happen the same event.

CONCLUSION

Actually, the river Padma is dynamic and its course shifting varies spatially and temporally. Considering both spatial and temporal variations during the last eight decades, the braided planform nearly occupied about half of the river reach. The straight and meandering planform varied, interchanged their extent. Decrease in the braided channel was generally replaced initially by the straight channel, which in turn converted into a meandering channel. The planform changes occurred through channel shifting by erosion and accretion process and understanding of planform changes and channel migration through time is critical to many geomorphological and river management problems. Therefore, detailed investigation may be undertaken on precise observation and quantification of the Padma fluvial process-form systems. The more data base at ground level along with satellite image and combination of collective work can provide the spatial pattern of river morphology and overall planform which would be the future indicator of the river training work.

REFERENCES

1. Alam M K, Hassan A K M S, Khan M R and Whitney J W (1990), "Geological Map of Bangladesh", Published by Geological Survey of Bangladesh, Dhaka, Bangladesh.
2. ASCE (1996b), "River Width Adjustment. Đ: Modeling Task Committee on Hydraulics, Bank Mechanics, and Modeling of River Width Adjustment", *Journal of Hydraulic Engineering*, Vol. 124, No. 9, pp. 903-917, ASCE.
3. BBS (2007), "Agriculture Sample Survey of Bangladesh-2005", Zila Series Manikganj, Planning Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.
4. BBS (2009), "Year Book of Agricultural Statistics of Bangladesh, Bangladesh Bureau of Statistics", Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.
5. Brammer H (1995), "Geography of Soils of Bangladesh", The University Press Limited, Dhaka, Bangladesh.
6. CEGIS (2005a), "Developing Methods for Predicting Morphological Changes in the Padma River, Prepared for Jamuna-Meghna River Erosion Mitigation Project", BWDB, Dhaka, Bangladesh.
7. CEGIS (2005b), "Prediction of Bank Erosion and Morphological Changes of the Jamuna and Padma Rivers 2005", Prepared for EMIN and JMREM Projects, Dhaka, Bangladesh.
8. CEGIS, JMREMP (2009), "Prediction of River Bank Erosion along the Jamuna, the Ganges and the Padma Rivers in 2009".
9. CEGIS (2015), "Prediction of River, Bank Erosion and Morphological Changes along the Jamuna, the Ganges, the Padma and the Lower Meghna Rivers in 2015".
10. Delft Hydraulics and DHI (1996a), "Floodplain Levels and Bankfull Discharge", Special Report No. 6, River Survey Project (FAP 24), Prepared for Water Resources Planning Organization (WARPO), Dhaka, Bangladesh.
11. Delft Hydraulics and DHI (1996b), "Geomorphology and Channel Dimensions", Special Report No. 7, River Survey Project (FAP 24), Prepared for Water Resources Planning Organization (WARPO), Dhaka, Bangladesh.
12. Delft Hydraulics and DHI (1996c), "Morphological Processes in the Jamuna River", Special Report No. 24, River Survey Project (FAP 24), Prepared for Water Resources Planning Organization (WARPO), Dhaka, Bangladesh.
13. Delft Hydraulics and DHI (1996g), "Bed Material Sampling in the Ganges, Padma, Old Brahmaputra and Jamuna", Special Report No. 8, River Survey Project (FAP 24), Prepared for WARPO, Dhaka, Bangladesh.

14. FAP 24 (1996b), "River Survey Project: Morphological Characteristics", Final Report-Annex 5, Flood Action Plan, Water Resources Planning Organization, Dhaka.

15. Goswami D C (1985), "Brahmaputra River, Assam, India: Physiography, Basin Denudation, and Channel Aggradations", *Water Resources Research*, Vol. 21, No. 7, pp. 959-978.

16. GSB (1990), "Geological Survey of Bangladesh", Dhaka.

17. Islam M N (2006), "Braiding Morphodynamics of the Brahmaputra-Jamuna River", A H Development Publishing House, New Market, Dhaka.

18. Milton E J, Gilvear D J and Hooper I D (1995), "Investigating Change in Fluvial Systems Using Remotely Sensed Data", in Gurnell A and Petts G (Eds.), *Changing River Channels*, pp. 277-301, John Wiley & Sons, Chichester.

19. Mosselman E (1995), "A Review of Mathematical Models of River Planform Changes", *Earth Surface Processes and Landforms*, Vol. 20, pp. 235-247.

20. Mosselman E, Huisink M, Koomen E and Seijmonsbergen A C (1995), "Morphological Changes in a Large Braided Sand-Bed River", in *River Geomorphology*, Hickin E J (Ed.), pp. 235-247, Wiley.

21. O'Mally L S S (1917), "Bengal, Bihar and Orissa, Sikkim", pp. 71-84, Cambridge University Press, London.

22. Rahman M M (2015), "Interrelationship Between Hazard and Environmental Degradation: A Geo-Ecological Appraisal on Manikganj District", Unpublished PhD Thesis, Department of Geography and Environment, Jahangirnagar University, Savar, Dhaka, Bangladesh.

23. Rahman M M, Islam M N and Islam M N (2016), "Integrated Approach of Remote Sensing and Field Survey Data in Assessment of Bank Erosion Intensity of the Padma River in Bangladesh", *International Journal of Geomatics and Geosciences*, Vol. 7, No. 2, pp. 285-297.

24. Rahman M M and Islam M N (2017), "Bank Erosion Pattern Analysis by Delineation of Course Migration of the Padma River at Harirampur Upazila Using Satellite Images and GIS Part II", *J Geol Geophys,* Vol. 6, p. 284, doi:10.4172/2381-8719.1000284.

25. Rashid H (1991), *Geography of Bangladesh*, The University Press Limited, Dhaka, Bangladesh.

26. Seijmonsbergen A C (1998), "The Influence of Neo-Tectonics on River Patterns in Bangladesh: A Preliminary Study Based on Landsat MSS Imagery", *Geologic En Mijnbouw*, Vol. 77, No. 2, p. 129.

27. Wadia D N (1953), *Geology of India*, pp. 385-393, Macmillan and Co Limited, London.