MORPHOLOGICAL CHARACTERICTICS OF INNER BAR AREA OF PUSSUR RIVER IN BANGLADESH

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ABSTRACT

The Pussur is a distributaries of the Ganges river flowing in southwestern region of Bangladesh. This river is at the downstream side of Bhairab river, which is originated from Gorai river. The scouring and siltation phenomenon of a river affects the navigation facility for the transport of products from different firms, factories, mills situated at its bank. In this study, the morphological characteristics of inner bar area of Pussur river has been analyzed. The study area covers from Mongla to Base creek (9.476 Km) which is very important route of national and international trading. Hydrographic charts have been collected from Mongla Port Authority for the years from 2006 to 2017. From the hydrographic chart, 4 longitudinal and 21 cross sectional bed profiles have been analyzed. From those bed profiles, topographical variation in river bed has been studied for different years. This study presents the comparison of erosion and deposition between different years. From 2006 to 2010, the navigation route of inner bar area was siltation dominating that found to be changed to scour dominating from 2010 to 2014. This is probably due to increase of upstream flow in Gorai river because of the dredging in Gorai mouth. After 2014, the navigation route from Mangla to Karamjal area are found to be siltation prone and Sultan Khal to Farid khal area are found to be scour dominating region.

Keywords: *Morphological change; Deposition and Erosion rate; Change in bed elevation; Pussur River.*

1. INTRODUCTION

Southwestern region of Bangladesh is encompassed by the Ganges and the Lower Meghna in the east and by the Indian Border in the west and by the Bay of Bengal in the south. The coastal region of Bangladesh and the rivers in this region exposes a continuing process of siltation progressing generally from northwest to southeast. The significant source of upstream freshwater at Mongla Port is flow through Ganges to Pussur. Pussur River is situated in South Western part of Bangladesh and Mongla Port is established on left bank of this river. Bangladesh is a riverain country. It is a low-lying flat country with significant inland water bodies, including some of the biggest rivers in the world (Kamal et al. 1999). About 700 rivers including tributaries flow through the country constituting a waterway of total length around 24,140 kilometers (15,000 mi). Most of the country's land is formed through silt brought by the rivers. River pollution and degradation occurs, when river water is adversely affected due to the addition of large amounts of external materials to the water and is unfit for its intended use. When due to anthropogenic activities its changes its natural states, river degradation occurs (Rahman et al. 2009). The Pussur river is a continuation of the Rupsa, which is formed of the union of the Bhairab and Atrai rivers. At present, much of its water is from the Gorai diverted through the Nabaganga. From near Batiaghata upazila the Rupsa changes its name to Kazibacha, which is given up near Chalna in favour of Pussur. Near the Mongla port, the Pussur receives Mongla river, and near the forest outpost at Chandpai it receives the Mirgamari cross-channel from the Bhola, both on the leftbank. On the rightbank the Manki, Dhaki and Bhadra are connected with the Shibsa system. In the lower delta, the Rupsa-Pussur is second only to the Meghna in size. Formerly it was third, after the Madhumati, but with the considerable diversion of the Gorai flow through Nabaganga, it is now bigger than that river. From its junction with the Mongla, it is no less than a kilometer and a half in width. Thirty-two kilometres from the open sea, it joins the Shibsa to form the five to eight kilometres wide Morzal river, which empties into the bay of bengal by the Marjat and Pussur estuaries. It continues the Rupsa River. All its distributaries are tidal. It meets the Shibsa River within the Sundarbans, and near to the sea the river becomes the Kunga River. It is the deepest river in Bangladesh. This river is at the downstream side of Bhairav river, which is originated from Gorai river. Moreover, in the developing world, urban rivers are used as endpoints of industrial effluents and municipal sewage discharges (Bhuiyan et al., 2015). The scouring and siltation phenomenon of this river affects the navigation facility for the transport of products from different firms, factories, mills situated at its bank.

Figure 1: Study reach of Pussur river

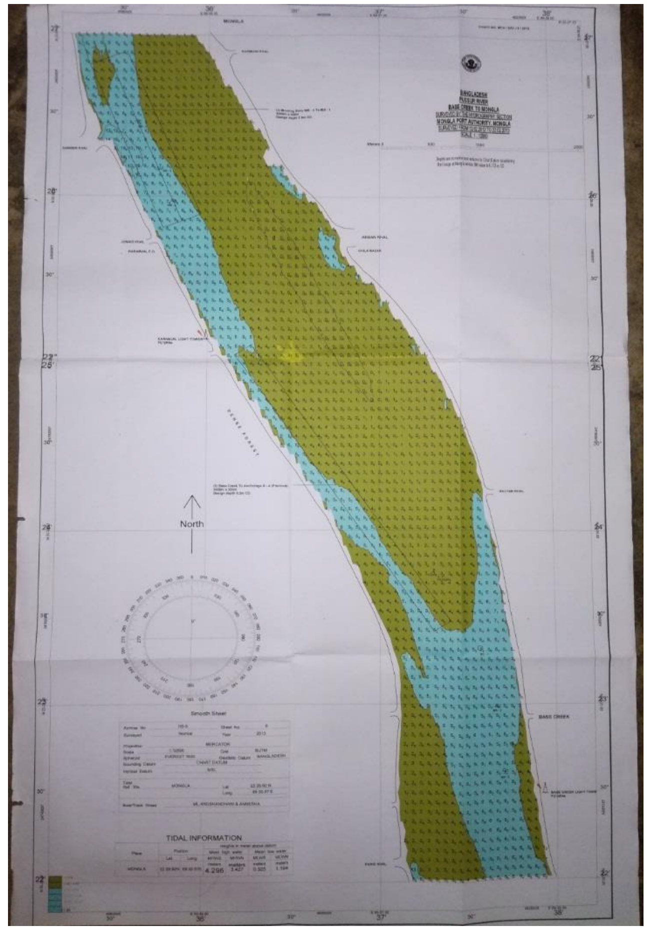


Figure 2: Sample of hydrographic chart (Source: MPA, 2017)

Besides this, river is an important route of international trading. Mongla Port situated at the confluence of Pussur River and Mongla Nulla, approximately 71 nautical miles (about 131 km) upstream from the Fairway buoy (approaches to the Pussur River) of the Bay of Bengal. The Port is well protected by the largest mangrove forest known as the Sundarbans. The Port provides facilities and services to the international Shipping lines and other concerned agencies providing shore based facilities like 5 (five) Jetty berths (total length 914 m), have a capacity of about 6.5 million tones general cargo/break bulk and 50,000 TEUS. The midstream berth (7 buoys & 14 anchorages) have a capacity of about 6.00 million tones. Total 33 ships can take berth in the Port (in the Jetties, buoys & anchorage) at a time. However, alike other modern port of the world Mongla Port is keen to provide highest port facilities, so that bigger draft ships can enter into the port channel safely. The objective of this study is to evaluate the temporal and spatial change in bed topography of the Inner bar area of Pussur river and to determine the erosion-deposition phenomena.

2. METHODOLOGY

The study area covers about 9.476 km of Pussur River from Mongla to Base creek area, which is called inner bar area. Mongla Port is situated on the east bank of Pussur River about 131 km upstream from the fairway buoy. Figure 1 shows the study reach of Pussur River. In this study, hydrographic charts for the year of 2006, 2010, 2013, 2014, 2015 and 2017 has been collected from Mongla port authority. Figure 2 shows one of the hydrographic chart collected from Mongla port authority.

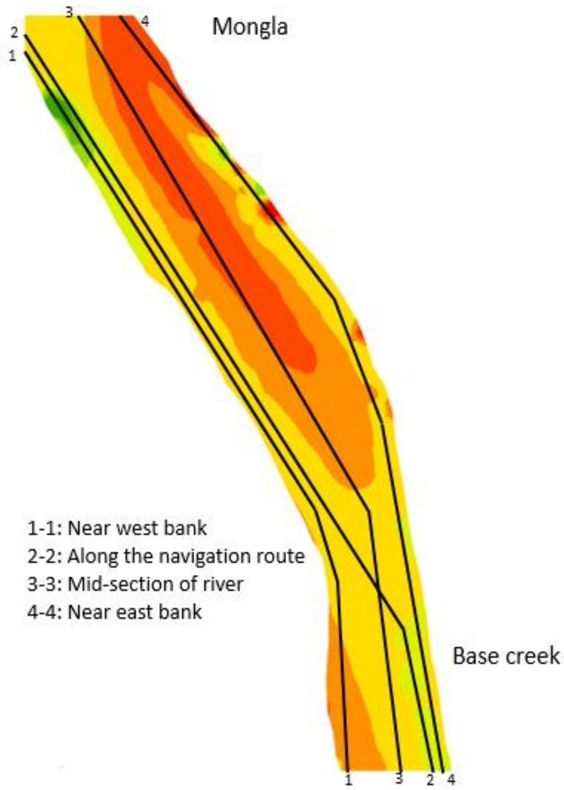


Figure 3: Location selected for longitudinal bed profile

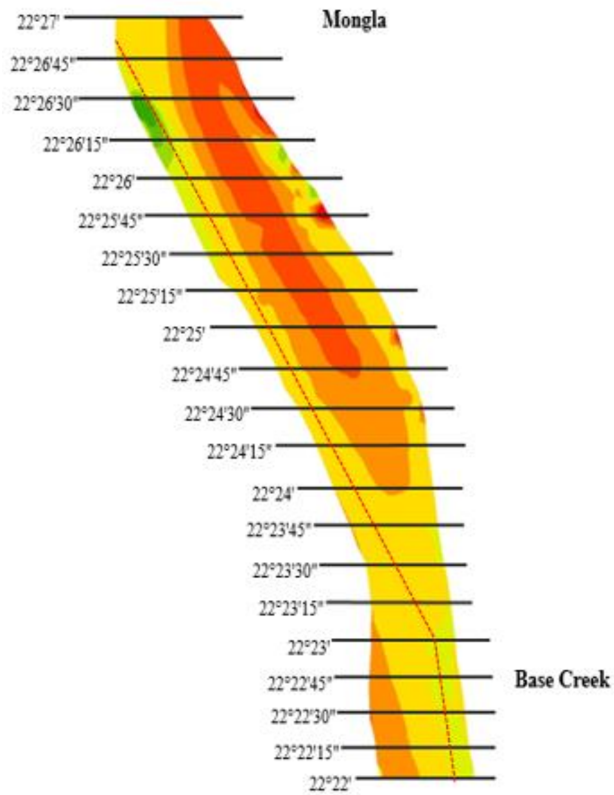


Figure 4: Location selected for cross sectional bed profiles

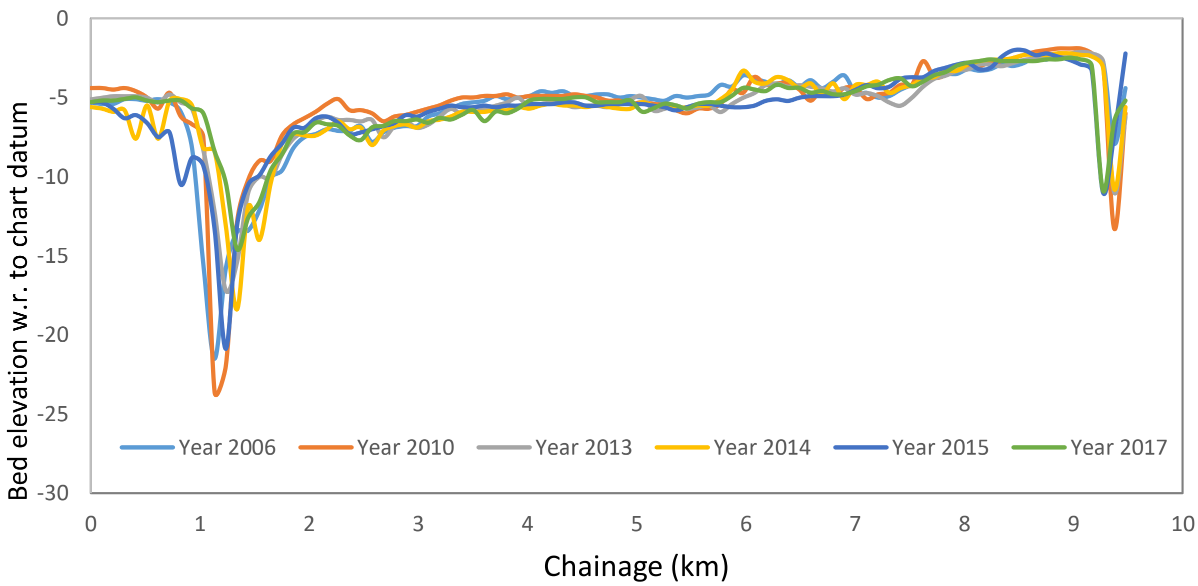
To determine the longitudinal flow profile, 4 Longitudinal sections (near west bank, along the navigation route, along the center and near west bank) are studied. The sections are shown in Figure 3. 21 cross sectional bed profiles (0°0'15" apart) have been considered over the study area of 9.476 km from Mongla to Base creek. The sections are shown in Figure 4. From those bed profiles, temporal changes of scouring and siltation phenomena have been analyzed. It is observed that the navigation route is near the west bank side of the river for the region 22°27' to 22°24' and then from 22°24' to 22°23'15" it is the near the cross over area. The route is shifted to near the east side from 22°23'15" to further downstream.

3. RESULTS AND DISCUSSIONS

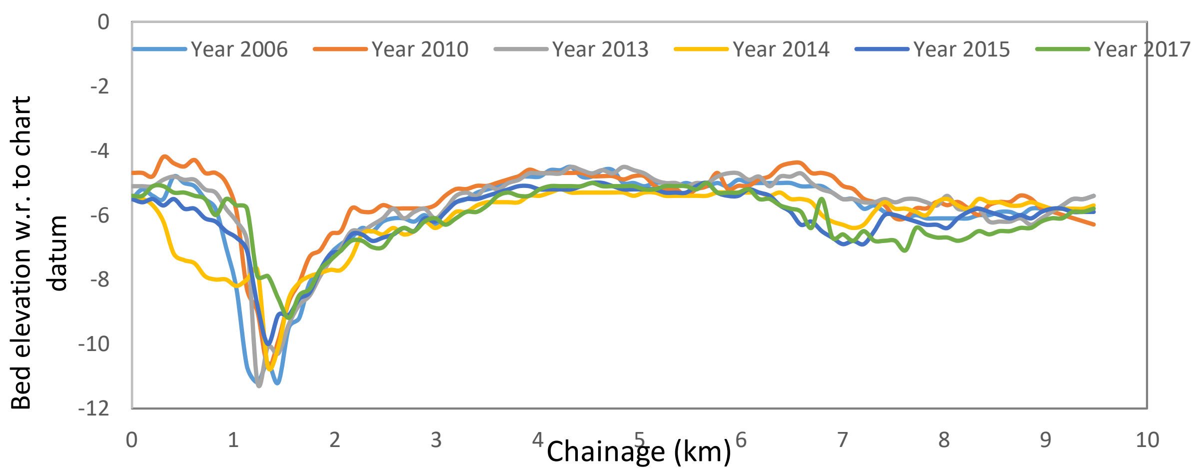
The main purpose of this study is to analysis the scouring and siltation phenomena of inner bar area of Pussur river as well as to investigate the temporal change of morphological characteristics of the study area. Longitudinal and cross-sectional bed profiles for different sections are presented and based on that the morphological change of inner bar area is explained below.

3.1 Longitudinal Bed Profiles

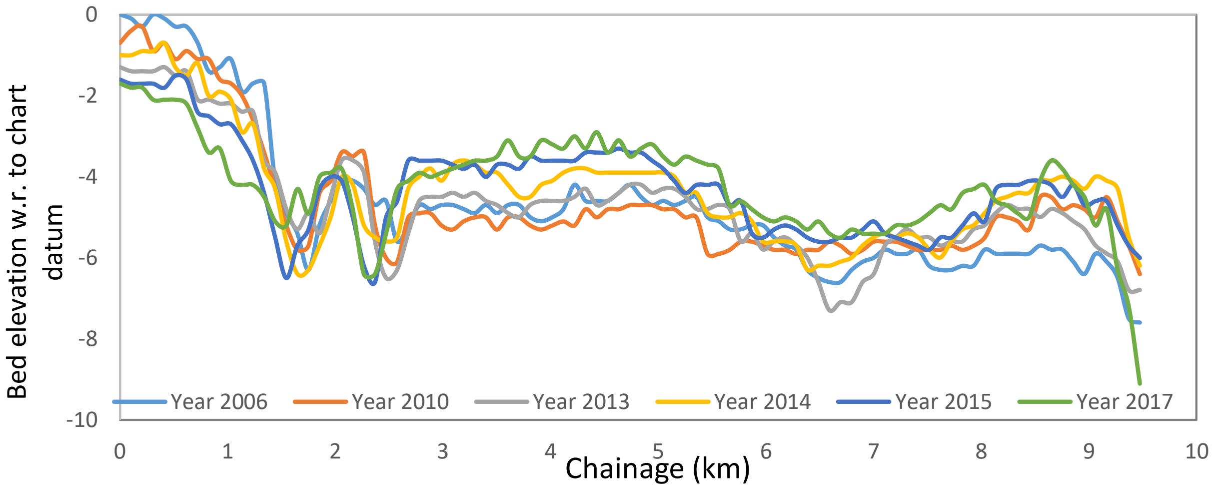
Four longitudinal sections of bed topography have been considered, which are near the west bank, near the east bank, at the center of the river and along the center of the navigation route. Each of them was evaluated for the years of 2006, 2010, 2013, 2014, 2015 and 2017. Figures 5(a), 5(b), 5(c) and 5(d) show the comparison among the bed profiles for Section 1-1 (near west bank), Section 2-2 (at the centerline of the navigation route of the river), Section 3-3 (Mid-section of the river) and Section 4-4 (near east bank) for different years.



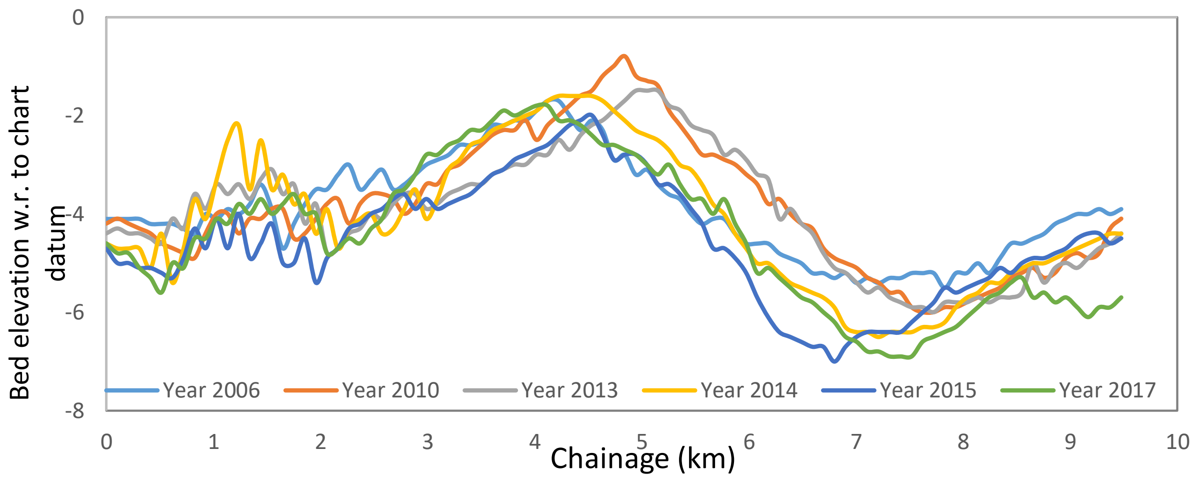
(a) bed profile near west bank of the river (Section 1-1)



(b) bed profile along the center of navigation route (Section 2-2)



(c) bed profile along the center of the river (Section 3-3)



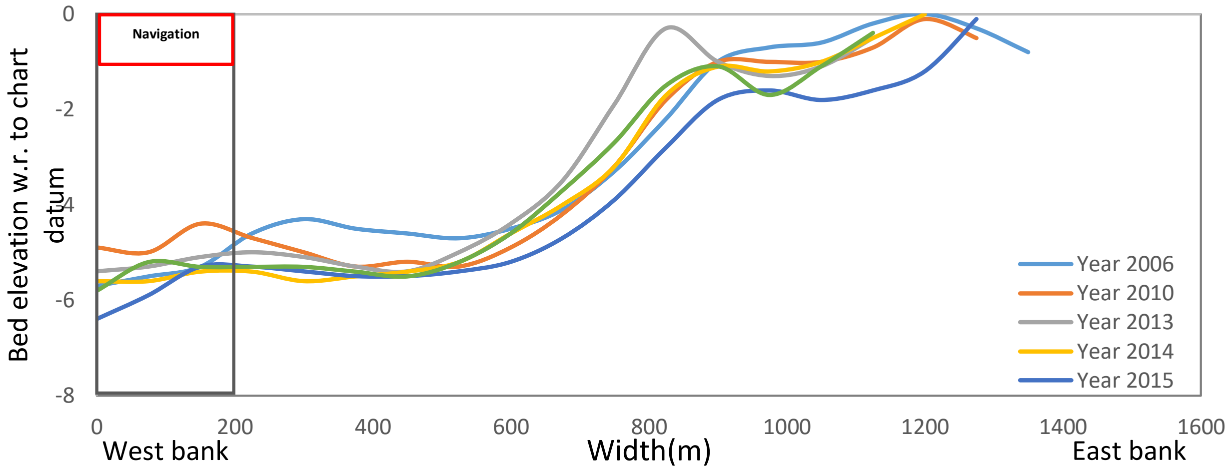
(d) bed profile near east bank of the river (Section 4-4)

Figure 5: Comparison of bed profile along different longitudinal sections for different years

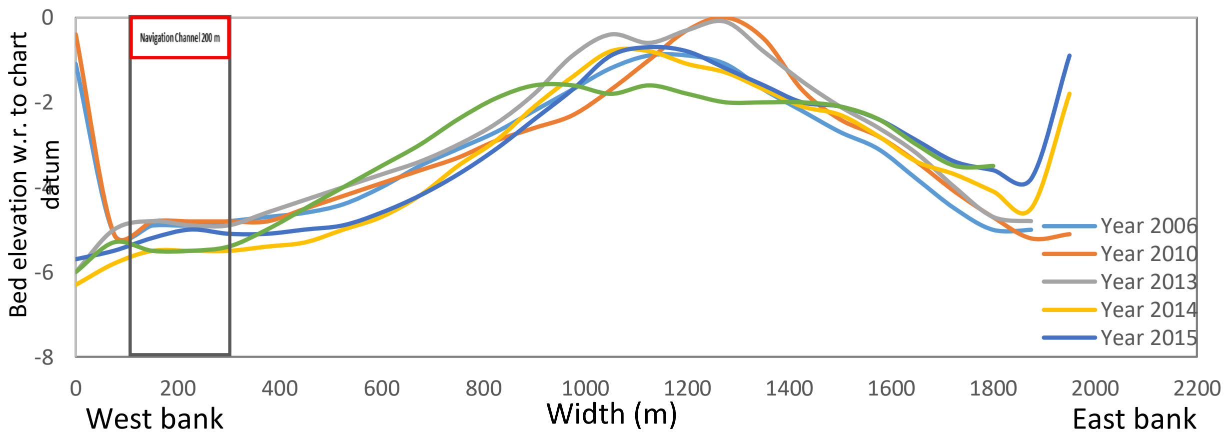
It is observed that section 3-3 and 4-4 are passed over the shallower bar area and the bed profile fluctuates highly year to year. However, the temporal variations of bed profiles are minimum in the deeper part of the channel as observed in sections 1-1 and 2-2.

3.2 Cross Sectional Bed Profiles

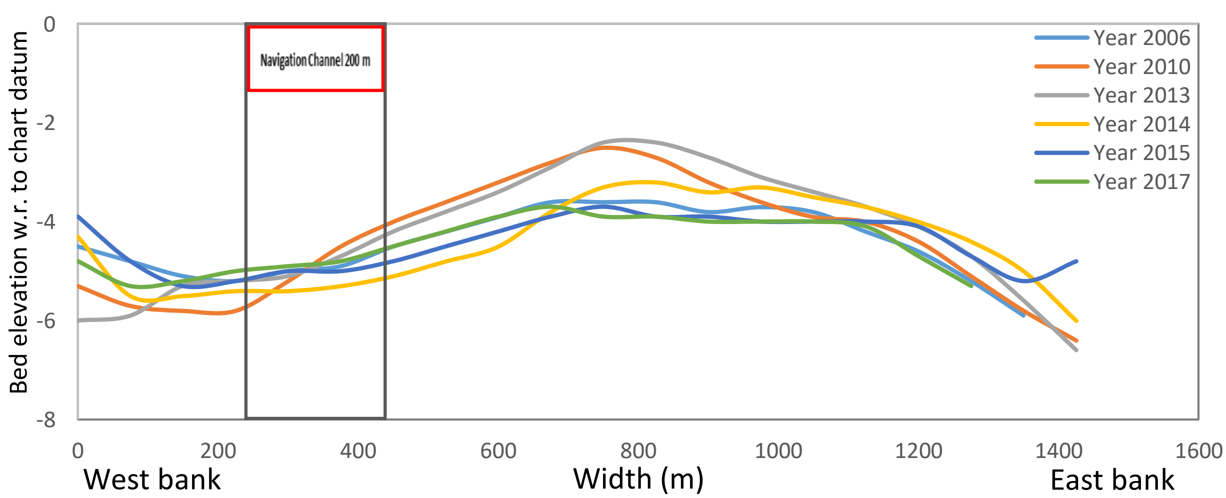
21 cross-sections each of 0°0'15" apart have been calculated for the cross sectional bed profiles. In a bed profile, the variation of river bed with respect to the year 2006, 2010, 2013, 2014, 2015 and 2017 are illustrated and the navigation channel of 200 m width is also shown in the figures. It can be noted that the width of the river in the studied portion is varied from 100 m to 1900 m. From the 21 different sections of bed profiles some sample sections located at 22°27', 22°25', 22°24', 22°22' are shown in Figure 6. In Figures (a), (b) and (c), the navigation route is located at west bank side and in Figure (d) the route is near the east bank of the river.



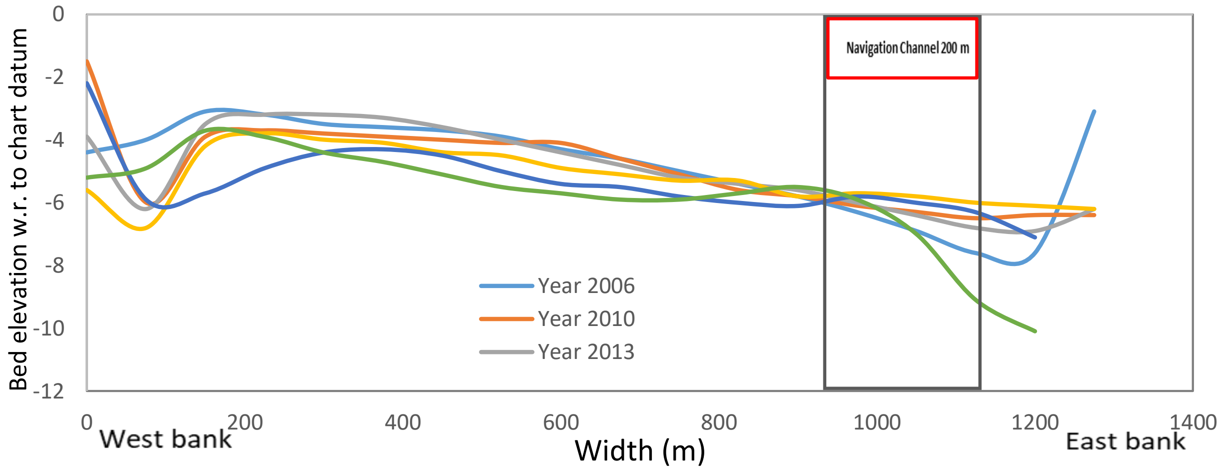
(a) Cross sectional bed profile at 22°27'



(b) Cross sectional bed profile at 22°25'



(a) Cross sectional bed profile at 22°24'



(a) Cross sectional bed profile at 22°22'

Figure 6: Temporal change in cross-sectional bed profile for different years

3.3 Morphological Changes in the Navigation Channel

The width of the navigation channel is 200 m. From the analysis, a comparison between the amount of siltation-erosion volume for different years have been prepared and the net change is presented in Tables 1 to 5.

Table 1: Changes of sedimentation in navigation channel with respect to year 2006

Sedimentation Pattern	Changes between years (m^3)				
	2006-2010	**2006-2013**	**2006-2014**	**2006-2015**	**2006-2017**
Deposition	1437880	848720	298700	263680	407880
Erosion	-98880	-74160	-1324580	-964080	-1124760
Net change	1339000	774560	-1025880	-700400	-716880

Table 2: Changes of sedimentation pattern with respect to year 2010

Sedimentation Pattern	Changes between years (m^3)			
	2010-2013	**2010-2014**	**2010-2015**	**2010-2017**
Deposition	220420	100940	96820	195700
Erosion	-784860	-2465820	-2136220	-2251580
Net change	-564440	-2364880	-2039400	-2055880

Table 3: Changes of sedimentation pattern with respect to year 2013

Sedimentation Pattern	Changes between years (m^3)		
	2013-2014	**2013-2015**	**2013-2017**
Deposition	199820	121540	203940
Erosion	-2000260	-1596500	-1695380
Net change	-1800440	-1474960	-1491440

Table 4: Changes of sedimentation pattern with respect to year 2014

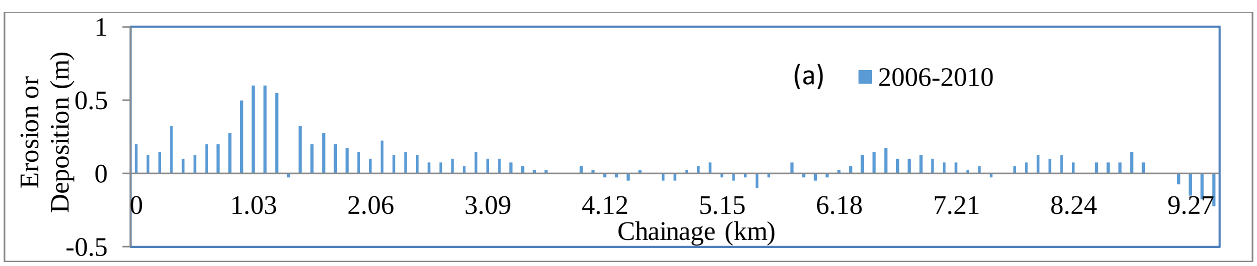
Sedimentation Pattern	Changes between years (m3)	
	2014-2015	**2014-2017**
Deposition	640660	793100
Erosion	-315180	-484100
Net change	325480	309000

Table 5: Changes of sedimentation pattern with respect to year 2017

Sedimentation Pattern	Changes between years (m3)
	2015-2017
Deposition	286340
Erosion	-302820
Net change	-16480

4. DEPOSITION OR EROSION RATE

For the calculation of deposition or erosion rate, the longitudinal bed profile of different years along the center of the navigation route have been considered. The center of the navigation route are taken into account by averaging three bed profile along the navigation route. From longitudinal bed profiles of two different years the erosion and deposition rate have been calculated. .From the 6 different years bed profile here only one deposition or erosion in the year 2014 is shown below. The erosion or deposition is shown in the Table 6. Where "-'' sign represents erosion and "+" sign represents deposition. Table 4.6 shows that the deposition rate varies from 2.2 m to 0.1 m and the erosion rate varies from -0.1 m to -0.7 m between the year 2006 to 2010; the deposition rate and erosion rate are varied from 1.5 m to 0.1 m and -2.2 m to -0.1 m between the year 2010 and 2013, from 3.5 m to 0.1 m and -2.7 m to -0.1 m between the year 2013 and 2014; from 1.8 m to 0.1 m and -1.2 m to -0.1 m between the year 2014 and 2015; from 2.1 m to 0.1 m and -1.0 m to -0.1 m between the year 2015 and 2017.



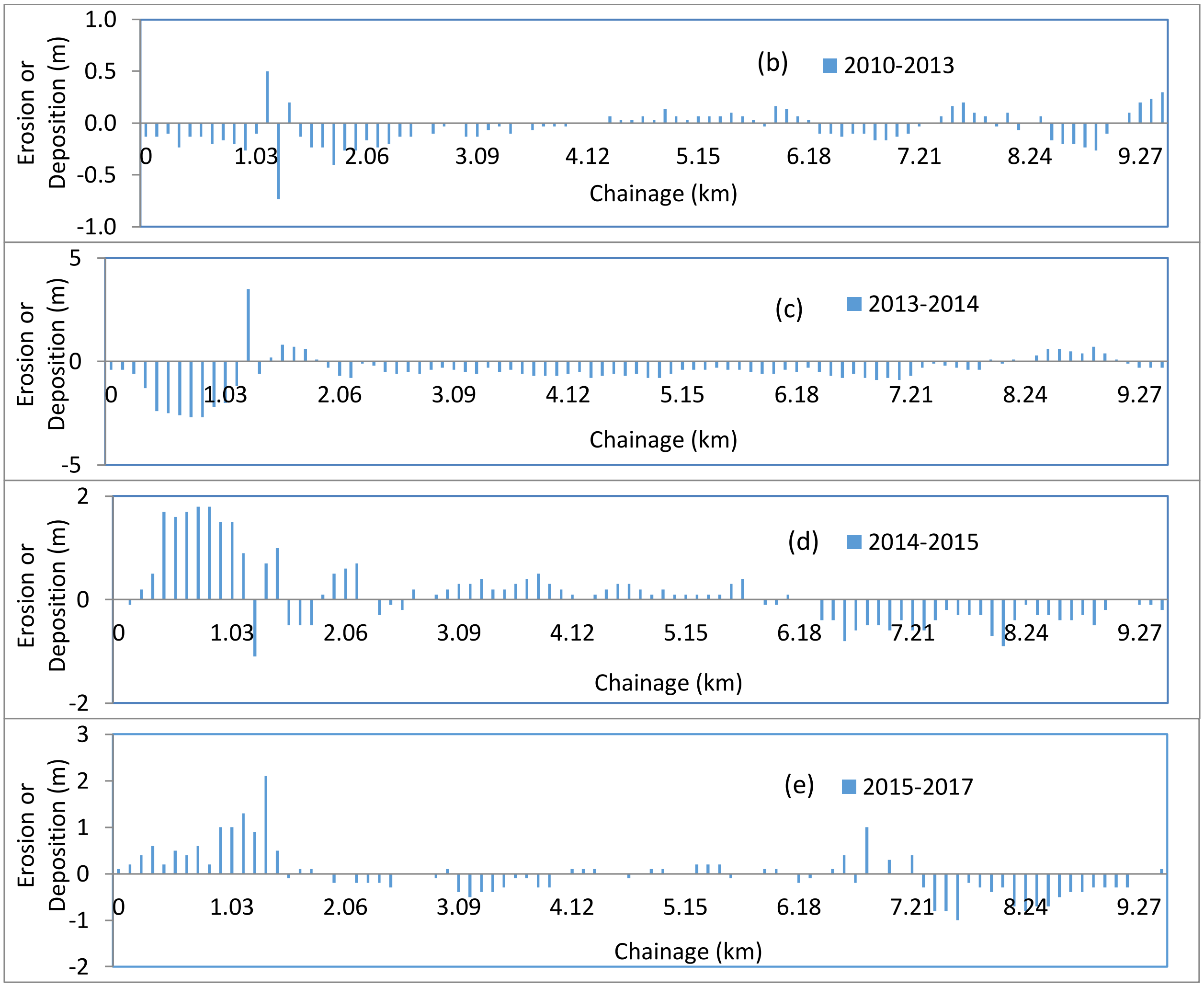


Figure 7: Yearly erosion (negative value) and deposition (Positive value) at different chainages of the inner bar area considering different time spans: (a) 2006 to 2010 (b) 2010-2013 (c) 2013-2014 (d) 2014-2015) (e) 2015-2017.

Figure 7 shows the graphical representation of yearly erosion (negative value) and deposition (Positive value) rate at different chainages of the inner bar area considering different time spans. The study area can be divided into five different locations such as Mongla to Danger khal, Danger khal to Karamjal, Karamjal to Sultan khal, Sultan khal to Base creek, Base creek to Farid khal area. In Table 7, the calculated erosion-deposition are presented for different time spans for those five regions. From 2006 to 2010, the navigation route of inner bar area was siltation dominating that found to be changed to scour dominating from 2010 to 2014. This is probably due to increase of upstream flow in Gorai river because of the dredging in Gorai mouth. After 2014, the navigation route from Mangla to Karamjal area are found to be siltation prone and Sultan Khal to Farid khal area are found to be scour dominating region.

Table 7: Defining Siltation and scouring prone area of inner bar for different time spans.

No.	Location	2006-2010	2010-2013	2013-2014	2014-2015	2015-2017
1.	Mongla to Danger khal	Siltation (1.13 m/yr)	Scouring (-0.39 m/yr)	Scouring (-1.19 m/yr)	Siltation (0.91 m/yr)	Siltation (0.66 m/yr)
2.	Danger khal to Karamjal	Siltation (0.44 m/yr)	Scouring (-0.39 m/yr)	Scouring (-0.29 m/yr)	Siltation (0.12 m/yr)	Scouring (-0.15 m/yr)
3.	Karamjal to Sultan khal	Scouring (-0.01 m/yr)	Siltation (0.12 m/yr)	Scouring (-0.63 m/yr)	Siltation (0.16 m/yr)	Siltation (0.02 m/yr)
4.	Sultan khal to Base creek	Siltation (0.16 m/yr)	Scouring (-0.008 m/yr)	Scouring (-0.52 m/yr)	Scouring (-0.23 m/yr)	Souring (-0.03 m/yr)
5.	Base creek to Farid khal	Siltation (0.08 m/yr)	Scouring (-0.01 m/yr)	Siltation (0.10 m/yr)	Scouring (-0.30 m/yr)	Scouring (-0.36 m/yr)

5. CONCLUSIONS

In this study, the temporal and spatial change in bed topography of the Inner bar area of Pussur river was evaluated and the erosion-deposition phenomena is studied. The depth of the Pussur river over the study area of 9.476 km was found to be varied from 0 m to 7.9 m with a deep pocket varies from 23.3 m to 11.2 m near west bank close to Base creek. It is found that, from 2006 to 2010, the navigation route of inner bar area was siltation dominating that found to be changed to scour dominating from 2010 to 2014. This is probably due to increase of upstream flow in Gorai river because of the dredging in Gorai mouth. After 2014, the navigation route from Mangla to Karamjal area are found to be siltation prone and Sultan Khal to Farid khal area are found to be scour dominating region.

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