POTENTIALS OF SIBSA RIVER FOR DEVELOPMENT OF A NEW PORT IN TERMS OF NAVIGABILITY

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ABSTRACT

The Pussur-Sibsa system, a multichannel system in the southwest GBD, is a significant concern for the Mongla Port (MP) and Bangladesh's economy. The river's depths were adequate for 8.5m draft ships, but after 1980, they drastically reduced, requiring regular maintenance dredging. The Mongla Port Authority (MPA) has implemented five capital dredging projects between 1990 and 2020, but high siltation rates still pose a threat to the port's development. The government has established another sea port, Payra Port, on Rabnabad channel, which has sufficient depth to handle over 10m draft ships. However, the port's outer channel is too shallow for ships, and a designed canal needs to be dredged and maintained. This study assesses the suitability of the Sibsa river for the development of a new port in terms of hydrodynamics and morphology. The Pussur-Sibsa river systems are downstream rivers of the GBM delta, with the Gorai River being a major tributary of Padma. The Sibsa River exhibits significantly more tidal activity than the Pussur River.

During the dry season, Sibsa experiences a notable increase in tidal volume ranging from 24% to 35% on average. Conversely, during the monsoon season, the volume of Sibsa exceeds that of Pussur by more than twice, mostly due to a greater influx of freshwater through Sibsa. Tidal volume in the Pussur river has been reduced near Mongla over the last few decades, while in the Sibsa river, tidal volume has increased, resulting in a deeper bed level. The net flow of water that reaches the confluence at Jalma is distributed into two main channels, with approximately 15% sent towards the West via the Lower Solmari River and 85% continuing its course along the Kazibacha River. The Sibsa river's bed level varies between 20 meters and 35 meters below the chart datum, while the Pussur river's bed level fluctuates between 5 meters and 20 meters. A comparative analysis of the bed profiles along the thalweg line of the two rivers revealed shallower bed levels in the Pussur river. The Mongla Port (MP) on the eastern bank of the Pussur River has been dredging since 1979 to maintain a navigable channel, but financial implications and consistent implementation of dredging activities pose significant obstacles to its progress. The Sibsa river has sufficient depth for the movement of more than 10 meters draft ships, with only the entrance channel of the Pussur-Sibsa river needing dredging. The maintenance dredging requirement of the inner channel is predicted to be negligible compared to the 4 million cubic meters of the Pussur River. The establishment of Payra Port (PP) on the Rabnabad channel by the Bangladeshi Government has also been undertaken. The port area near the berth has adequate depth for accommodating vessels with a draft exceeding 10 meters. However, the outer channel needs excavation and regular maintenance to ensure safe passage for vessels. Based on hydrodynamic and morphological advantages, Sibsa river could be considered a suitable location for further development of Mongla Port, with lower operational costs and less required dredging costs compared to other options.

Keywords: *Pussur River, Sibsa River, Mongla Port, Payra Port, Dredging*

1. INTRODUCTION

The Pussur-Sibsa system is a multichannel system within the southwest GBD which flows partly through the Sundarbans and consists partly of a heavily modified delta plain (van Marine et al., 2023). Approximately 30 km from its mouth the river diverges into the Sibsa River (west branch) and Passur River (east branch). The Mongla Port (MP) is situated on the east bank of Pussur river, at around 80 km upstream from Akram point. MP has significant influence on the country's economy (Rahman and Ali, 2018). The river's depths were adequate for an average of 8.5m draft ships at the time of Mongla Port's establishment. However, after 1980, the depths drastically reduced, demanding routine maintenance dredging to maintain adequate depth alongside berths, in berth approaches, and in the approach channel (Rahman and Ali, 2022). Several dredging efforts had been made to restore the navigability of the Pussur River since 1979. But none of the dredging attempts could maintain an effective passable channel because of the high siltation rates that still exist, demanding considerable maintenance dredging. The Mongla Port Authority (MPA) has implemented five capital dredging projects between 1990 to 2020 and has been carrying out regular maintenance dredging. Till 2023, MPA has carried out 33 million cubic meter capital dredging and 5.3 million cubic meter of maintenance dredging. To handle more than 10m draft ship at Mongla port, yearly 5 million cubic meter maintenance dredging may be required in which 1 million is at estuary of Pussur-Sibsa and 4 million is inner channel of Pussur river. The cost of maintenance dredging and implementation of regular dredging is appearing as a severe threat for further development of Port. Government of Bangladesh has established another sea port on Rabnabad channel named Payra Port (PP) which is around 70 km east of Pussur-Sibsa estuary (*Public Private Partnership Authority Bangladesh*, n.d.). This port area (adjacent to berth) has sufficient depth to handle more than 10m draft ship (Hossain, 2023). The Port has an almost 75 Km long outer channel which is too shallow for arrival of ships and a designed canal needs to be dredged and maintained to a particular level that is safe for passage. Around 9.75 million cubic meters of slit has been excavated from the outer channel to obtain 100-125-meter-wide channel, which costs 4950 crore BDT. Moreover, yearly around 5 million cubic meter maintenance dredging will be required to keep the port operational.

Pussur river is connected with the Sibsa river through four inter-connecting channels (Figure-1). Akram Point is the confluence point of Pussur and Sibsa river. The cross-section at this location on the Sibsa river shows that the depth of the river is 34m CD whereas in the Pussur river depth is 24m CD. Sibsa river is tidally very active compare to the Pussur river in terms cross-sectional area, depth and tidal volume. Generally, the bed level in the Sibsa varies from 20 m to 35 m CD whereas the Pussur river bed level varies in between 5m to 20m CD. The bed profile along the thalweg line of the Pussur river has been compared and analysed with tidally dynamic river Sibsa to figure out the sources of navigation problem in the Pussur river. The bed level is shallower in the Pussur river and within the 30 km reach from Chalna to Joymonirgoal, bed level varies from 5-7 m CD. The reaches downstream of Joymonirgoal maintain a good navigable depth varying from 15 m CD to 25 m CD, although at some of the locations downstream of Joymonirgoal, the depth is less than 10 m CD. Whereas, bed profile of the river Sibsa shows a very deep bed level throughout its length.

But till now all development planning and activities of MP is concerned in Pussur River only. But the Sibsa river could be a suitable and sustainable option for development of port for higher draft ship. As far authors knowledge, this issue not yet focused in any previous study. In this study, the suitability of Sibsa river for development of new port has been assessed in terms of Hydrodynamics and Morphology of the river.

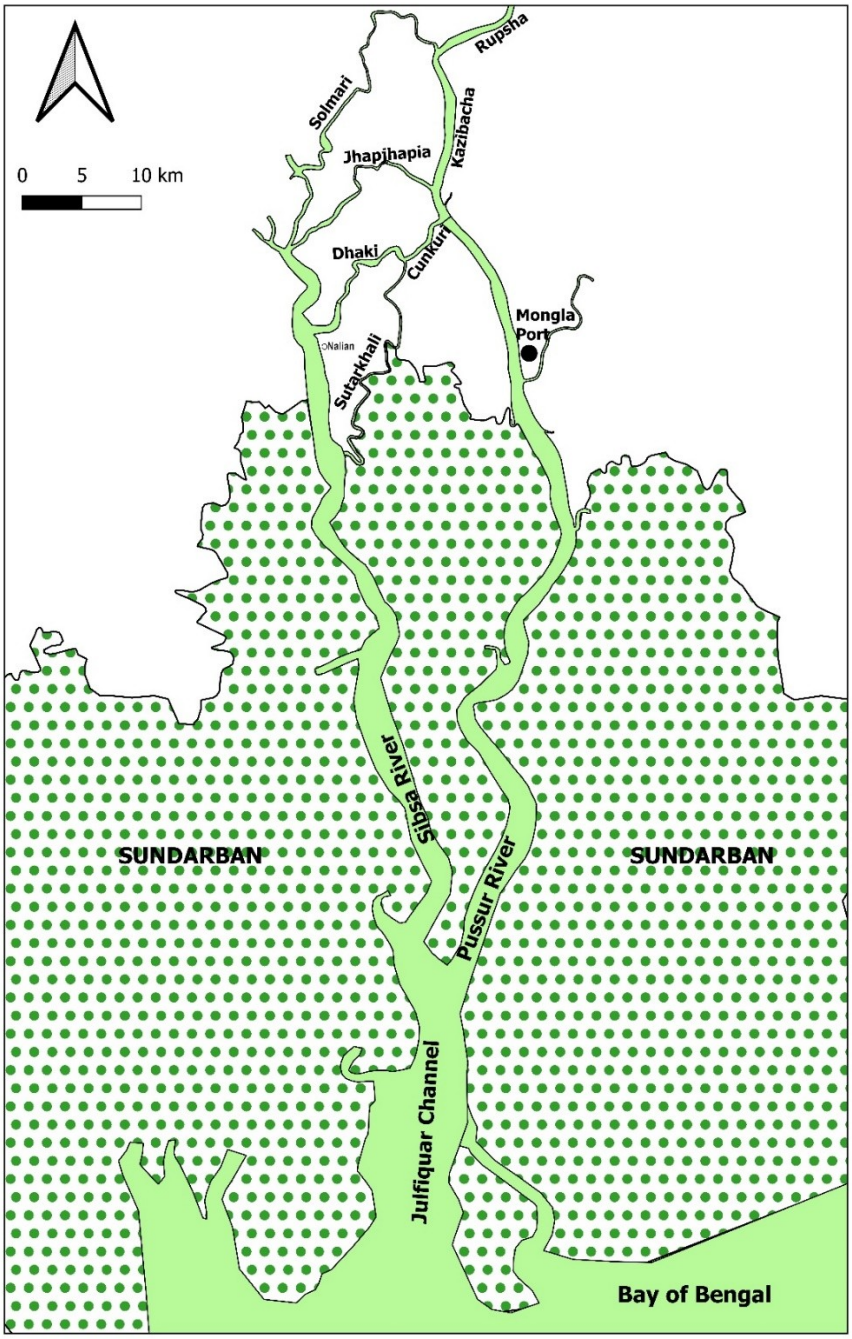


Figure 1: River system within the study area.

2. Study area and Methodology

The study area focused on the Pussur-Sibsa River system starting at Khulna on north and Bay of Bengal on South (Figure-1). World's largest mangrove forest "The Sundarban" also falls within the study area. The main two rivers within the study area are Pussur River and Sibsa River. In this study two types of tidal river systems were considered: (1) primary rivers (the Passur and the Sibsa tidal rivers, which are typically-one to several km wide), (2) connecting channels (tidal channels linking primary rivers). Due to

mild topography of these rivers (0.016 m/km) tidal effect propagates upto approximately 200km towards inlands (van Maren et al., 2023). This study also mildly concerned on the hydrography and dredging of Payra Port.

In this study the hydrographic profiles of both of primary river has analysed. Based on several study reports, the required annual maintenance dredging quantity of the study areas has been assessed. The approximate costing of dredging has compared to justify the viability of new location.

3. RESULT AND DISCUSSION

3.1 River Geometry

The Pussur Sibsa river systems are the downstream rivers of GBM delta. Gorai river is one of main tributaries of Padma which is originated after 175 km of entering in Bangladesh. The flow of Gorai has diverted after 195 km into Pussur-Sibsa River and Modhumoti-Baleshwar River system at Bordia (Figure-2).

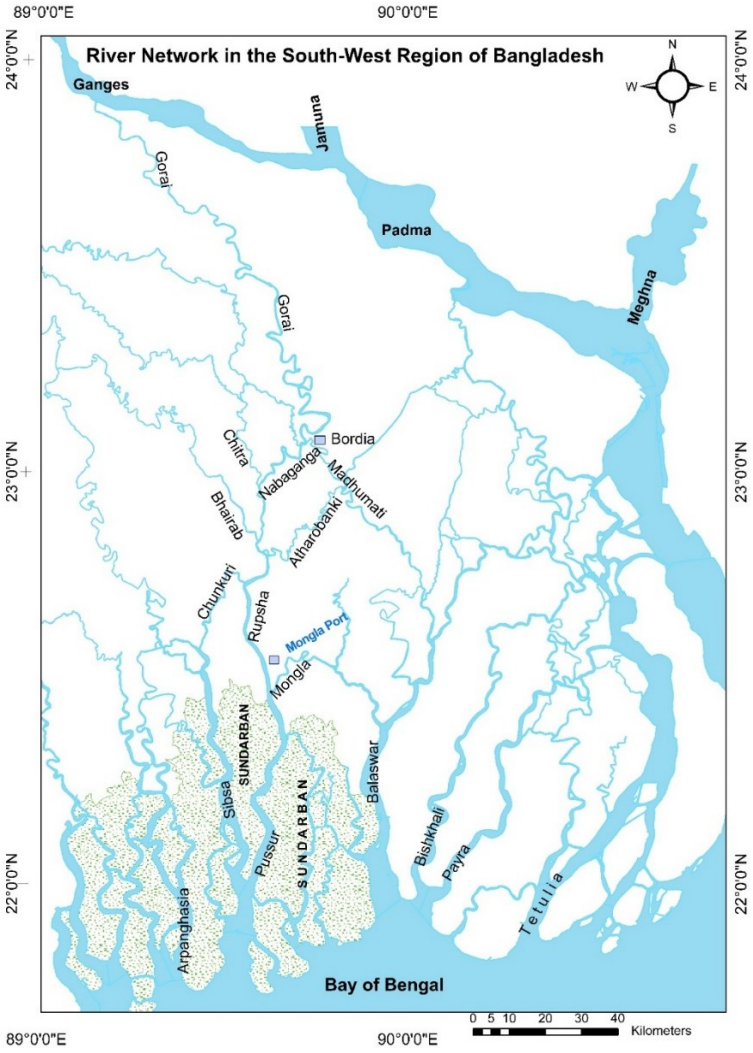


Figure 2: River system in the south west region of Bangladesh.

According to Aziz & Paul (2015), around 15% of Gorai flow diverted to Modhumoti-Baleshwar River and remain 85% flows to Pussur-Sibsa River system through Nabaganga and Rupsha River. Another two

important river named Chitra and Bhairab has met with this system at 22km and 40 km downstream of Bordia. The Khulna city is located at 45 km downward of Bordia, where the river named as Rupsha. After 11 km downstream of Khulna, the river changes the name to Kazibacha at Bathiaghata and again after 16 km named as Pussur at Chalna. There are three connecting rivers between Pussur and Sibsha. First connecting river is Solmari at Bathighata, second river is Jhapjhapia at Pankhali (3km upstream of Chalna) and third river is Chunkuri at Dacope. Chunkuri river has divided into two channels named Dhaki and Sutarkhali and finally both of them has falls in Sibsa.

These connecting rivers are the main source of upstream flow of Sibsa river. The Pussur and Sibsa rivers flows almost parallelly towards sea and met at Akram Point. However, the Pussur river shows more meandering pattern than Sibsa resulting longer river route. The river route following the thalweg line from Dacope to Akram Point is 78 km through Pussur and 70 km through Sibsa. The width of Pussur river varies between 900m at Dacope and 3000m at Akram Point. Sibsa river is wider than Pussur, in most of the areas 2000m and at Akram point is 4500m. After meeting at Akram point, the Pussur-Sibsa is named as Zulfiqar Channel and meets with Bay of Bengal at around 30 km downstream.

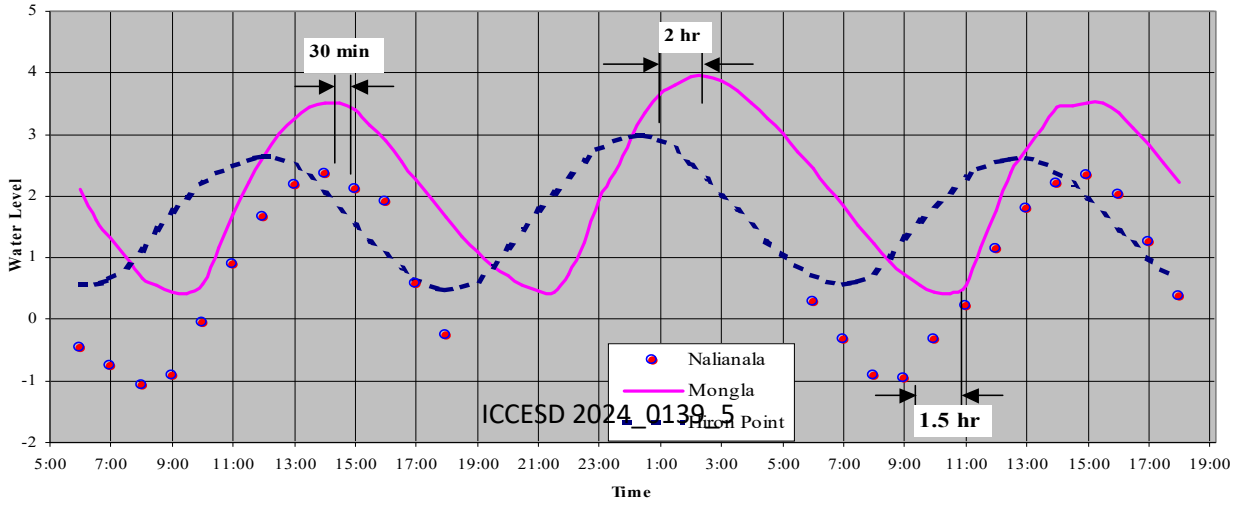
3.2 Hydrodynamics of the Rivers

The Sibsa River receives a negligible amount of fresh water from upstream and disperses into a complex network of blind peripheral channels. Most of the part of Sibsa river is wider and hydrodynamically active than Pussur river. The Sibsa river exhibits significantly more tidal activity in terms of cross-sectional area, depth, and tidal volume when compared to the Pussur river. The Sibsa exhibits a higher tidal volume in both dry and monsoon seasons, resulting in the maintenance of a deeper bed level compared to the Pussur (IWM, 2004). A comparison of flow in Pussur and Sibsa river is shown in Table1.

Table 1: Tidal volume in Sibsa near Nalainala and Pussur near Mongla (IWM, 2004)

River	Dry Season Discharge				Monsoon Season Discharge			
	Spring		Neap		Spring		Neap	
	Flood (mill.m3)	Ebb (mill.m3)	Flood (mill.m3)	Ebb (mill.m3)	Flood (mill.m3)	Ebb (mill.m3)	Flood (mill.m3)	Ebb (mill.m3)
Sibsa	186	196	100	109	305	258	306	215
Pussur	137	144.5	83	85	167.5	110	157	72

During the dry season, Sibsa experiences a notable increase in volume ranging from 24% to 35% on average. Conversely, during the monsoon season, the volume of Sibsa exceeds that of Pussur by more than twice, mostly due to a greater influx of freshwater through Sibsa. Tidal volume in the Pussur river has been reduced near Mongla over the last few decades both in rising and falling tide. On the other hand,



in the Sibsa river, tidal volume has been increased. The propagation of tide through Sibsa river is faster than Pussur, as shown in Figure 3.

Figure 3: Tide propagation in the Sibsa river and Pussur river

The approaching speed of tide through Sibsa river is faster than Pussur River. The parallel point of Mongla in Sibsa river is Naliana, where tide reaches about 30 minute earlier than Pussur. The main fresh water source in the pussur-Sibsa River System is the inflow from the Gorai River through Halifax Cut. In the wet season this amount to 4,000-6,000 m^3/s, whereas the inflow in the dry season from January to May is almost negligible. According to IWM (2004), the net flow of water that reaches the confluence at Jalma is distributed into two main channels. Approximately 15% of the flow is sent towards the West, specifically the Polder area, via the Lower Solmari River. The remaining 85% of the net flow continues its course along the Kazibacha River. During the monsoon season, an estimated 25% of the net flow that travels southward through Kazibacha is diverted to the Jhapjhapia River.

In the dry season, there is a reversal in the net flow direction of the Jhapjhapia River, which shifts towards the east. A comparable phenomenon is observed in the Chunkuri River in Chalna, wherein the direction of water flow undergoes a reversal from the dry season to the monsoon season. The observed phenomenon can be attributed to the dynamic interplay between the powerful upstream tide of the Sibsa River and its consequential eastward water displacement in the connecting channels leading to the Pussur River. Once the ebb flow commences, a portion of the water will proceed downstream along the Pussur River, encountering reduced hydraulic resistance. In August, approximately 20% of the total flow that reaches the confluence via Kazibacha divert to Sibsa River. The manner in which net fluxes are distributed within a river system significantly influences long-term morphological changes.

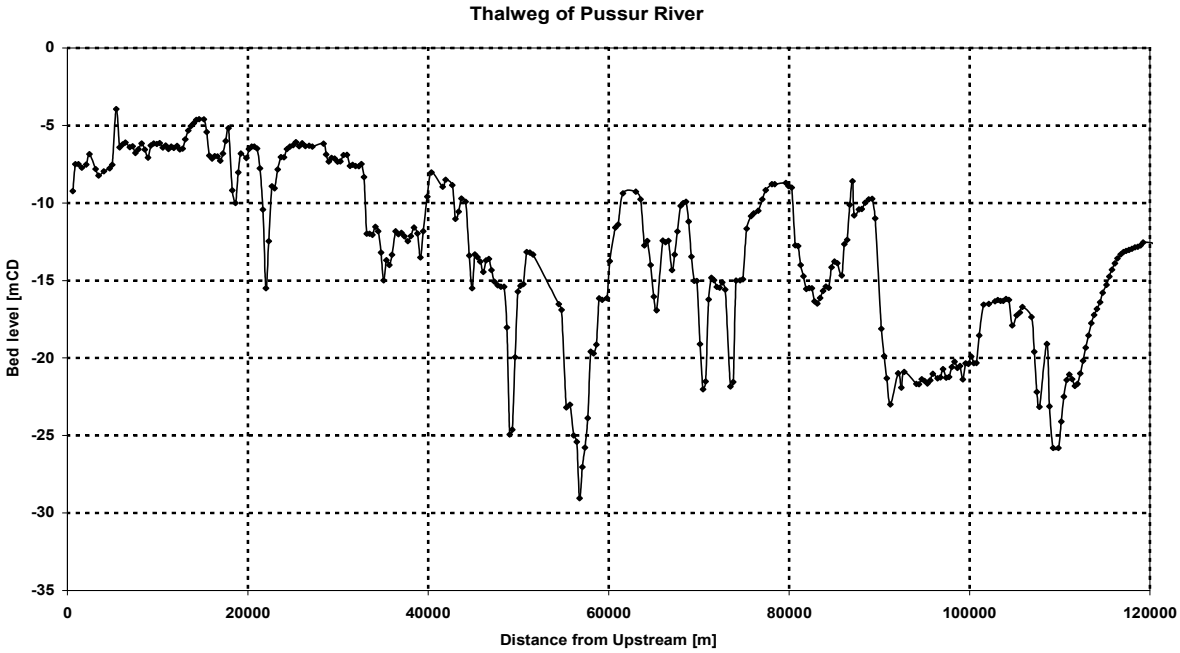
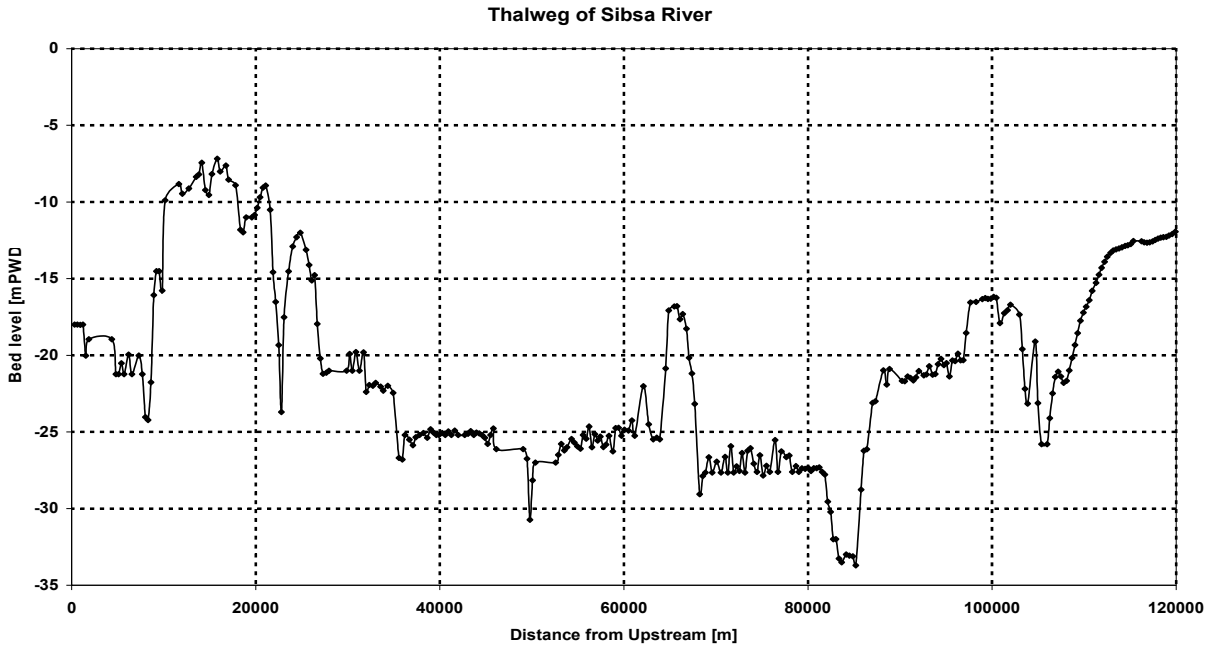


Figure-4: Bed profile of the Pussur river along the thalweg line
Figure-5: Bed profile of the Sibsa river along the thalweg line

3.3 Morphology and Navigability

In the Sibsa river, the bed level typically ranges from 20 meters to 35 meters below the chart datum (CD). On the other hand, the Pussur river bed level fluctuates between 5 meters and 20 meters below the chart datum (CD). A comparative analysis was conducted on the bed profile along the thalweg line of the Pussur River and Sibsa River in order to identify the factors contributing to navigation issues in the Pussur River. The bed profile along the thalweg line of the Pussur river (Figure-4) and Sibsa river (Figure-5) depict the shallower bed level seen in the Pussur river.
The profile analysis reveals that, along the 30 km stretch between Chalna and Joymonirgoal, the bed level exhibits variations ranging from 5 to 7 m CD. The downstream areas of Joymonirgoal exhibit consistent navigable depths ranging from 15 m CD to 25 m CD, with certain sections seeing depths below 10 m CD. In contrast, the bed profile of the river Sibsa has a consistently deep bed level along its entire course.

3.4 Requirement of Dredging and Costing



3.4.1 Pussur River

The Mongla Port (MP) is located on the eastern bank of the Pussur River, approximately 80 kilometers upstream from Akram Point. MP wields a substantial degree of influence over the nation's economy. During the development of Mongla Port, it was observed that the river's depths were sufficient to accommodate ships with an average draft of 8.5 meters. Subsequently, following the year 1980, there was

a significant decrease in water depths, necessitating regular maintenance dredging in order to sustain sufficient depth in proximity to berths, berth approaches, and the approach channel. Numerous dredging initiatives have been undertaken since 1979 in order to reinstate the navigable state of the Pussur River. However, all of the efforts to dredge have proven unsuccessful in maintaining a viable navigable channel due to the persistently high rates of siltation, hence necessitating substantial ongoing maintenance dredging.

The Mongla Port Authority (MPA) has undertaken a series of five major dredging projects spanning the period from 1990 to 2023, in addition to conducting routine maintenance dredging operations. As of 2023, the MPA has conducted capital dredging of 330 million cubic meters and maintenance dredging of 53 million cubic meters. The expenditure of this huge dredging was approximately 10 billion BDT. In order to accommodate vessels with a draft of 9.5-10 meters at Mongla port, minimum 7.5-8 m CD depth should be maintained which may require annual maintenance dredging of 5 million cubic meters. This dredging operation would involve the removal of 1 million cubic meters of sediment from the estuary of the Pussur-Sibsa, while the remaining 4 million cubic meters would be extracted from the inner channel of the Pussur river. Yearly expenditure of this maintenance dredging will be approximately 1.75 billion BDT. The financial implications associated with maintenance dredging and the consistent implementation of dredging activities are emerging as significant obstacles to the further progress of the Port.

3.4.2 Sibsa River

Most of the part of Sibsa River has sufficient depth for movement of more than 10 m draft ship. Only the entrance channel of Pussur-Sibsa river, i.e the outer bar area has to be dredged approximately 1 million cubic meter which is common for both Pussur and Sibsa river, where dredging is convenient in terms of technical and environmental aspects. Based of hydrodynamics, morphology and stability of Sibsa river, it could be predicted that, the maintenance dredging requirement of inner channel will be almost negligible compared to 4 million cubic meters of Pussur River.

3.4.3 Payra Port

The establishment of Payra Port (PP) on the Rabnabad channel, situated approximately 70 km east of the Pussur-Sibsa estuary, has been undertaken by the Government of Bangladesh. The port area in close proximity to the berth possesses a depth that is adequate for accommodating vessels with a draft exceeding 10 meters. The Port features an outer channel spanning around 75 kilometers in length, which currently suffers from insufficient depth to accommodate ship arrivals (Askari et al., 2022). To address this issue, a canal must be excavated and regularly maintained to ensure a safe passage for vessels. Approximately 9.75 million cubic meters of sediment has been extracted from the outer channel in order to create a canal with a width ranging from 100 to 125 meters. This excavation process has incurred a cost of 4950 crore BDT. In addition, an annual maintenance dredging volume of approximately 5 million cubic meters will be necessary to ensure the continued functionality of the port.

4 CONCLUSION

Based on the hydrodynamic and morphological advantages of Sibsa river, it could be considered a suitable location for further development of Mongla Port. The operational cost of this location will be less than the existing Mongla port or Payra Port. However, hinterland connectivity to be improved, specially bridges over Chunkuri and Jhapjhapia river to connect with Khulna. This could be a more convenient and suitable location compared to Present location of Mongla port in terms of operational cost specially dredging cost. The required dredging cost of Sibsa river is also negligible compared to Payra port. The hydrodynamic and morphological features of Sibsa river are in more advantageous status than Pussur River or Payra Port. If a new port could be developed in this location, then the channel maintenance cost

will be lesser than other two options. Almost without any extra dredging, more than 10 m draft ship would reach there. However, a detailed hydrodynamic and morphological study and hinterland connectivity will be required before selecting this location.

REFERENCES

Aziz, A., & Paul, A. (2015). Bangladesh Sundarbans: Present Status of the Environment and Biota. Diversity, 7(3), 242–269.

Askari, H.R., Hossain, M.N., Bushra, R.T., Rafe, I.H., Islam, M., Nahid, N.H., & Alamgir, M.Z. (2022). Rabnabad Channel Dredging project: Challenges and Prospects. BMJ Vol 6 Issue 1 ISSN 2519-5972

Hossain, S. (2023, March 26). Country's deepest channel dredged at Payra Port. The Daily Star. https://www.thedailystar.net/business/news/countrys-deepest-channel-dredged-payra-port-3281041

IWM. (2004). Feasibility Study for Improvement of Navigability of Mongla Port, Mongla Port Authority, Mongla, Bagerhat, Bangladesh

Public Private Partnership Authority Bangladesh. (n.d.). https://www.pppo.gov.bd/projects-payra-port-dredging.php

Rahman, M. and Ali, M. S. (2022). "Potential Causes of Navigation Problem in Pussur River and Interventions for Navigation Enhancement". Proceedings of 4th International Conference on Civil Engineering for Sustainable Development (ICCESD 2018), KUET, Khulna, Bangladesh.

Rahman, M. and Ali, M. S. (2022). "Morphological response of the Pussur River, Bangladesh to modern-day dredging: Implications for navigability". *Journal of Asian Earth Sciences: X*, Vol. 7, 100088.

van Maren, D., Beemster, J., Wang, Z., Khan, Z., Schrijvershof, R., & Hoitink, A. (2023). Tidal amplification and river capture in response to land reclamation in the Ganges-Brahmaputra delta. CATENA, 220, 106651.