Int. J. Econ. Environ. Geol. Vol. 13 (2) 35-41, 2022
Journal home page: www.econ-environ-geol.org
Open Access
ISSN: 2223-957X

Tidal River Siltation and its Impact in the Coastal Parts of Bangladesh

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Received:*25 April, 2022* ***Accepted:****10 June, 2022*

Abstract: The study area is located in the south-western coastal part of Bangladesh and belongs to the lower deltaic plain of the Ganges delta system, which lies in the Rampal upazila of Bagherhat district. The area is more or less flat with elevation ranges from 1.0 to 2.0 m above mean sea level (MSL) and is blanketed with fluvio-tidal deposits of sandy silt, clayey silt and clay. Right now, water logging is one of the major problems in the area. The present paper is an attempt to expose the causes of water logging as well as its consequences. The satellite images of the last few decades, existing statistical records and simultaneous field checking were employed in this study, which reveals that natural as well as anthropogenic factors are responsible for water logging problem. The rivers and their link channels in the areas are influenced by tidal water regularly. The Water Development Board (WDB) was built embankments along the river courses as well as constructed sluice gates on the head of the tidal creeks to protect the area from regular tidal flooding and sea water intrusion. During monsoon, when rivers carry huge amount of water and sediments due to torrential rain, and these rising waters overtop the natural levees which were artificially modified and raised by coastal embankments. Consequently, the sediments drop down inside the channel and near channel bank rather in the nearby tidal plain. As a result, channels are gradually congested due to siltation, whereas tidal plain areas gradually lower due to subsidence and lack of sedimentation. Moreover, many sluice gates were constructed on the river courses in the coastal areas which also aggravate the situation. Daudkhali river is one of the main rivers in the study area. Image interpretation depicts that in 1977 the width of this river was nearly about 200 m all through its course and the river maintained this width up to 1990. But due to embankments the river starts to squeeze and the width of the river reached about 100 m in 2000. But in 2014, the river was nearly abandoned. A sluice gate was constructed on the course of the river about 30 years ago near Foila Bazar. The sediments carried by the river started to deposit in the mouth of the sluice gate which gradually choked the opening of the gate and now the gate is nearly blocked. During the rainy season, the river cannot carry excess water resulting flooding and water logging for long time. The presence of thick finer sediments in the subsurface as well as climate change further prolongates the situations. Finally, for sustainable development of the area,it is necessary to carry out different development activities with consideration of delta building processes.

Keywords: Ganges delta, tidal river, sustainable development.

Introduction

The study area includes the Rampalupazila (small administrative unit) of Bagherhat district, Bangladesh. It lies within the latitudes 22°30′ N to 22°41′ N and the longitudes 89°32′ E to 89°48′ E, and covering an area of 321 km^2 (Fig. 1). The maximum yearly temperature in 2011 was 34.7 ºC and the minimum was 11.9 ºC. The average rainfall for the year 2006-2011 was about 2024.8 mm yr^{-1} in the area.

Physiographically, it belongs to the Ganges Tidal Floodplain unit (Rashid, 1991) of the Bengal delta, which is one of the largest deltas in the world. Topography mainly flat with gentle relief, formed under fluvio-tidal condition. The elevation ranges from 0.5 to 5.79 m above mean sea level (MSL). Presently, it faces severe water logging problem. Therefore, the present study is an attempt to delineate the water logging problem in the area and its consequences. The output of the research will be helpful to make proper plan of the area for sustainable management as well as to understand the coastal process of the Bengal deltaic coast.

Bangladesh constitutes the major parts of the Bengal basin which was formed during early Tertiary (Paleocene) period (Curry et al., 1983) as the Indian plate broke away from Gondwanaland in the Late Cretaceous and moved toward a collision with the Eurasian plate (Tapponier et al, 1986). About 45 million years BP, Indian plate began to collide with Eurasia plate. Since that time deposition was primarily regressional, and the deposition accelerated after the Himalayan ranges began to rise (20.1 million years BP), resulting in the present submarine Bengal fan and Ganges-Brahmaputra delta. Tectonically the study area falls in the Faridpur trough of the Bengal basin (Alam et al, 1990*)*. The sediments of the area consist mainly of admixture of clay, silt and fine sand. The Holocene sediments covering the area can be divided into eight distinct mapping units including active channel deposit, abandoned channel deposit, levee deposit, tidal floodplain deposit, depression/swamp deposit and intertidal deposits (Fig. 2).

A network of interconnected innumerable major and minor tidal channels, creeks and inlets has formed drainage system of the area. The major rivers are meandering in nature and tidal channels/creeks form dendritic and rectangular drainage patterns. Main rivers are Mongla, Rupsa, Kumerkhali and Daudkhali

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(Fig. 3). The seasonal rain is the cause of general flood in the area. Most of the rivers are flowing southwardly to the Bay of Bengal.

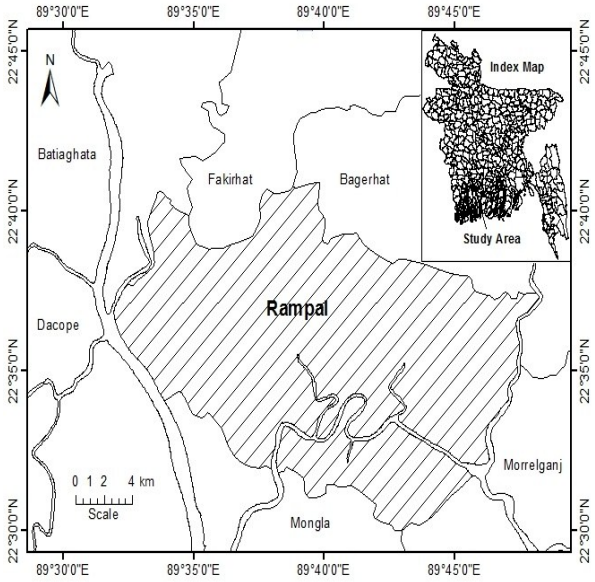

Fig. 1 Location map of the study area

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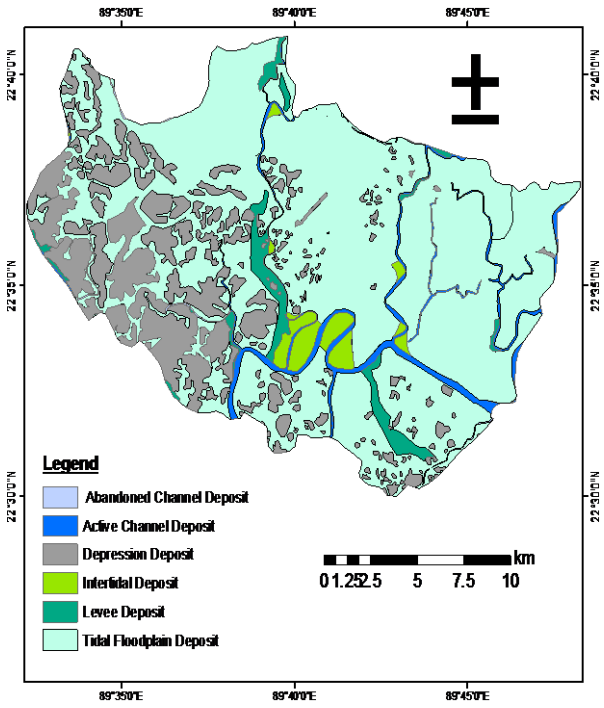

Fig. 2 Geological map of the area.

Materials and Methods

Landsat satellite images (Landsat MSS 1977, Landsat TM 1990, Landsat ETM+ 2000, Landsat L8 2014), topographic maps, historical maps and drainage data interpretation along with field checking were carried out to delineate the adverse impact of the area due to unplanned structure along the river course.

The images were visually interpreted (Rashid, 2020; Alam and Islam, 2017; Rashid et al., 2021) to delineate the adverse impact on drainage system due to unplanned structure along the river course. All the images and maps are georeferenced in UTM/WGS 84 projection system. Required processing of images like layer stack, mosaic and geoprocessing, etc. were done by Erdas Imagine 2010 software. Arc map 10 software was used for digitizing the imageries and historical maps.

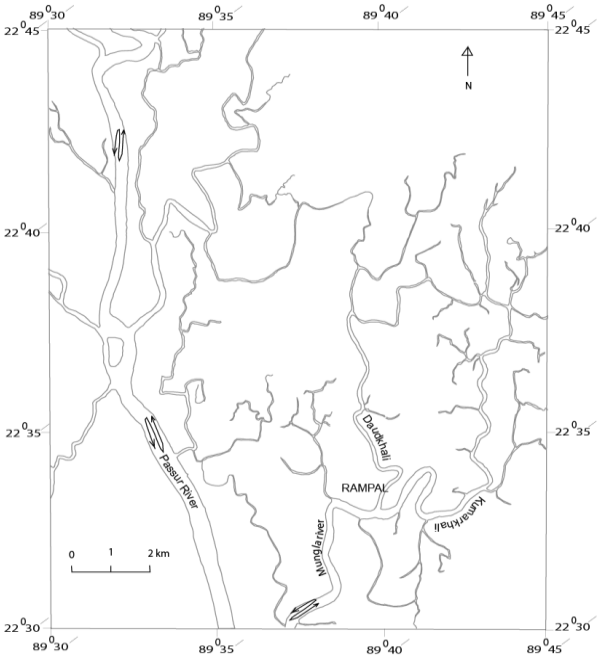

Fig. 3 Drainage map of the area.

Topographic maps at the scale of 1: 50,000 published by the Survey of Bangladesh were also interpreted to outline topography of the area.

Both the natural conditions as well as anthropogenic activities are responsible for the creation of the following problem in the study area.

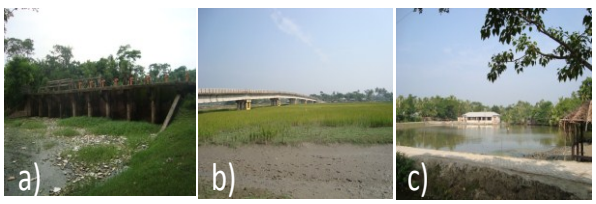

Fig. 4 a)Water logging due to construction of sluice gate at Foila Bazar; b) bridge on the Daudkhali river course which enhance sedimentation in the river bed at Talbunia, Rampal, Bagherhat; c) playground of Talbunia primary school, Talbunia, Rampal, Bagherhat becomes a permanent water body.

Natural Phenomena

Decease of water flow and siltation in the river bed: In the study area, the Mongla, Passur, Khumarkhali and Daudkhali are main rivers. All these rivers are tidally influenced. Passur is connected with Bhairab river, a distributary of the Ganges river. Rampalupazila is included in the mature deltaic region of the Ganges river. Due to the shifting of the Ganges towards east (Rashid et al., 2014) and construction of barrage on

this river, the distributaries of the Ganges river are now receiving less amount of water and sediments (Khan 2010; Higgins et al., 2018). Topographical map (1:50000) of Survey of Bangladesh published in 1964 showed that Daudkhali was a big river in the study area but now this river has been silted up (Figs. 3, 9). Due to silt up of the river, it cannot carry excess water in the monsoon which causes flooding and water logging in the areas.

Subsidence: Due to more river bed siltation, less siltation takes place in the adjacent tidal and fluvio-tidal plains. The tidal plain of the Ganges deltaic plain is also subsiding rapidly by natural compaction, loose and compressible sediments as well as tectonic factors under normal circumstances. This subsidence is also being enhanced by low sedimentation as the subsidence is compensated by deposition of transported sediments that maintains a balance between sedimentation and subsidence (Ali and Ahmed, 2001; Rashid et al., 2022). In the deltaic part of Bangladesh, subsidence rate is 4 mm yr^{-1} (Umitsu, 1993), whereas in the middle-western part of the Ganges delta, the rate of subsidence is about 1.5-2 mm yr^{-1}, while it is 5-5.5 mm yr^{-1} near the southeastern part (Khan et al., 2001). On the other hand, the coastal area of the country as a whole had an average sedimentation rate of about 4.59 mm yr^{-1}, with a minimum of about 1.16 mm yr^{-1}, and a maximum of about 8.1 mm yr^{-1} (Rashid et al., 2022).The estimated range of relative sea-level rise is 1-9 mm yr^{-1}. Therefore, water logging problem in the area is caused by low sedimentation, subsidence and sea level rise (Rashid, et al., 2013; Rashid, et al., 2016; Milliman et al., 1989; IPCC 2001; Pethick and Orford, 2013).

Anthropogenic Activities

Sluice Gates: Unplanned construction of sluice gate on tidal channel sometime brings havoc. A sluice gate was constructed on the Daudkhali river at about 20 years ago near Foila Bazar (latitudes 22°38′10″ N and the longitudes 89°38′54″ E) to control tidal water (Fig 4a). Due to construction of the sluice gate, fine clay carried by the tidal water started deposited within the channel which gradually choked the opening of the sluice gate. By 10 years the gate was completely closed. Passur river carries huge water during rainy season. Closed sluice gate create obstacle to carry through the channel. Excess water creates flooding and remains stagnant in the upstream and adjacent areas.

Embankments: Rivers of the area and their link channels are influenced by tidal water every day during high and low tides. The Water Development Board (WDB) has built embankments along the river courses on the head of the tidal creeks to protect the area from tidal flooding/surge, cyclones and heavy rainfall from water logging and salinity (Fig. 5). During monsoon, rivers carry huge amount of water and sediments due to torrential rain. The old meandering rivers of the western part of the coastal belt are unable to carry huge pressure of rising water which causes flooding. For the coastal embankment, the rising water cannot overtop the natural levees which are artificially modified and raised. So the sediments drop down inside the channel and near channel bank.

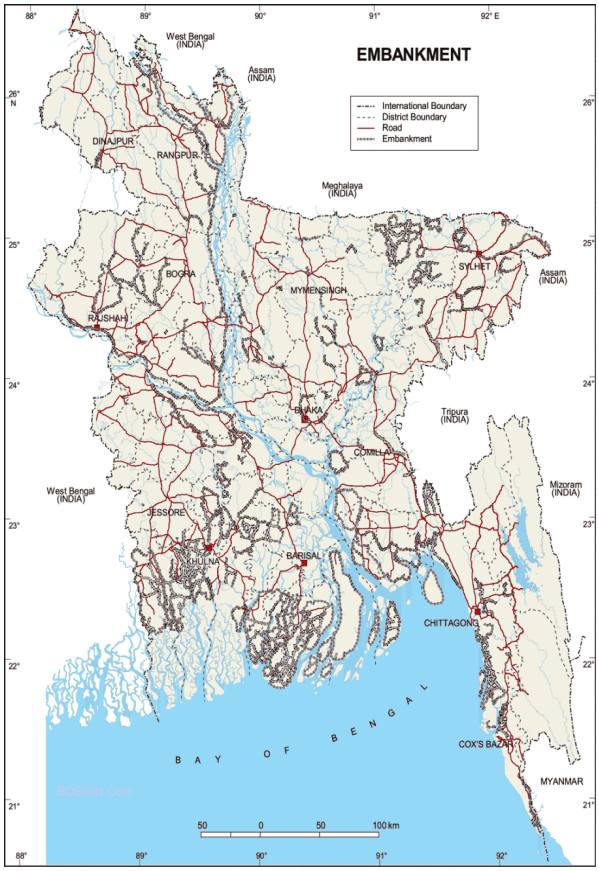

Fig. 5Map showing the embankment location of the country (BWDB).

Roads and Bridges: Ongoing development activities require good communication network, north south aligned Khulna to Mongla port road is the main road in the area. There are numbers of east west tending road, some of which cross these north-south flowing tidal rivers through the heavily constructed bridges, are obstructing the natural drainage and become prevailing factor for dropping down tidal mud in the channel (Fig 4b). About 2.0 meter of tidal mud deposit was observed in the Daudkhali river bed at Talbunia under the east-west road during field investigation in the year 2008.

Use of Salt Water for Shrimp Cultivation: Adverse effect of climatic change and huge shrimp farming in Khulna, Bagherhat with other coastal districts at about 84,633.93 metric tons of shrimps were collected from 21,773.05 hectares of land yr^{-1}. Shrimp cultivation is performed by confining saline water in paddy field for more benefit. Local farmers introduce salt water to the low land and paddy fields by water pump from the nearby rivers during high tide. As a result, water remains stagnant in the fields all over the year, and salt settles on paddy field.

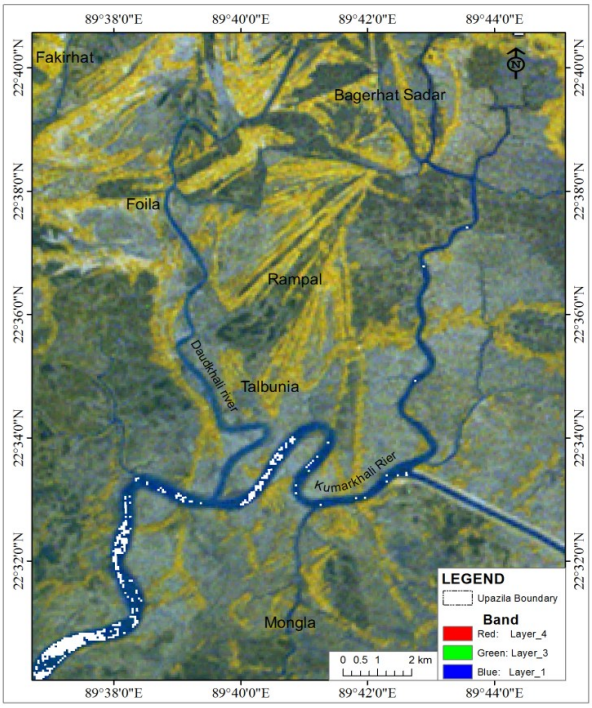

Fig. 6 Drainage system in Landsat MSS Ver1.0 image of 1977.

Consequences

Change of River Morphology

Earlier, the Daudkhali is one of the major rivers in the study area, which has changed to minor river (Figs. 3, 6-9). The image interpretation shows that in 1977 the width of the river was nearly about 200 m in most parts of its course and up to 1990 the river maintained the same, but in 2000 the width of the river was about 100 m in most parts of its course and in 2014 the river was nearly abandoned.

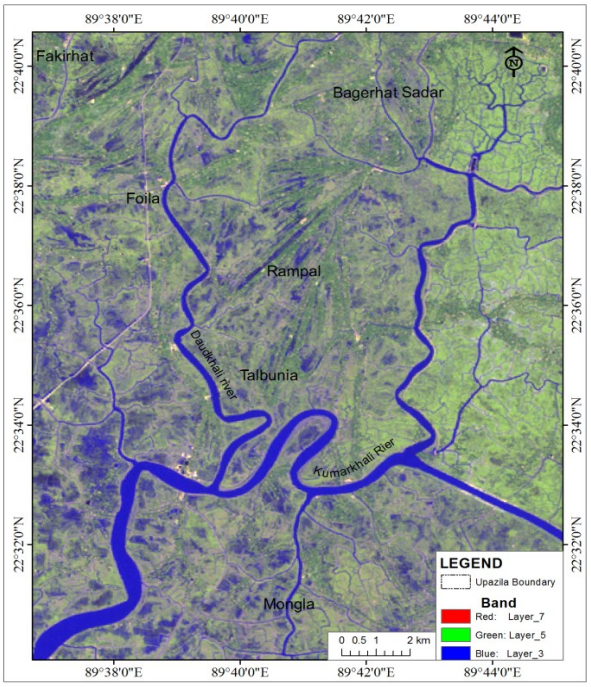

Fig. 7 Drainage system in Landsat TM GLS-1990 Ver1.0 image of 1990.

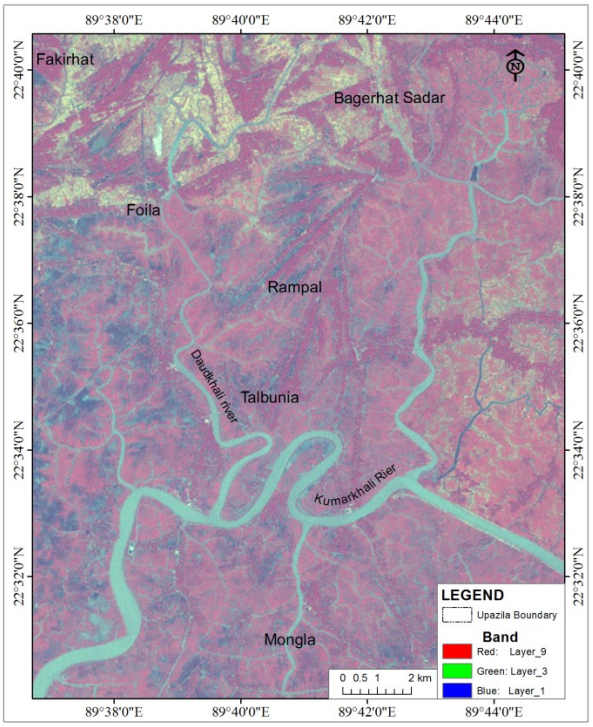

Fig. 8 Drainage system in Landsat ETM+ image of 2000.

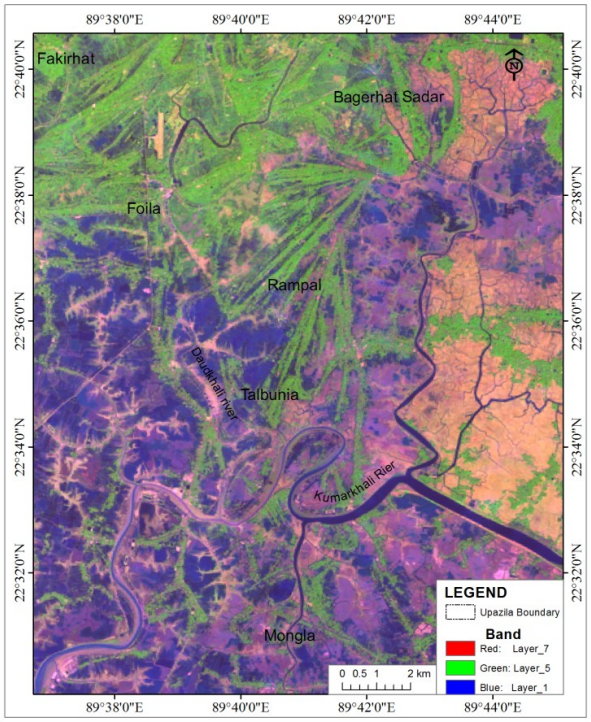

Fig. 9. Drainage system in Landsat L8 image of 2014.

Impact

a) Water Logging: Water logging in Rampalupazila is a major problem in recent years. In the southwestern part of Bangladesh, the total waterlogged area was about 71,144 hectares of which 47,550 hectares are anthropogenic waterlogged area and 23,850 hectares are natural waterlogged area (Ali and Ahmed, 2001). This problem is resulting from low sedimentation as well as subsidence of the area due to compaction sediments. During monsoon, rivers carry huge amount of water and sediments. The rivers of the area are

unable to carry huge pressure of rising water that causes flooding and water logging. Hundreds of polders and sluice gates were constructed on the tidal channels and creeks to protect these areas from flood and sea water. These structures disrupted the balance between the sedimentation and subsidence, resulting in rapid sedimentation in the tidal channels and creeks, and very little sedimentation on the surrounding plains (Rashid, et al., 2013; Rashid, et al., 2016).

Table 1. Land utilization (Temporary Cropped Area) 1978-79 & 2008 in RampalUpazila (Source: Statistical Year Book of Bangladesh).

Year		1978-79	2008
Total area		168960	20358
Current fallow		1560	99
Temporary Cropped area	Single	27817	11721
	Double	1185	808
	Triple	106	356
	Net	29108	12885
	Gross	30506	13916
Productivity of crop		42	43

Note -Land area in hectares

Thus channel beds are elevated, which create water logging problem. As time goes major part of the lands inside the polders become permanent brackish water lake or marsh. The image interpretation from the last few decades indicates that in 1990 the water logged area was about 455.6 hectares but in 2010 the water logged area was about 622.5 hectares (Figs. 10, 11).

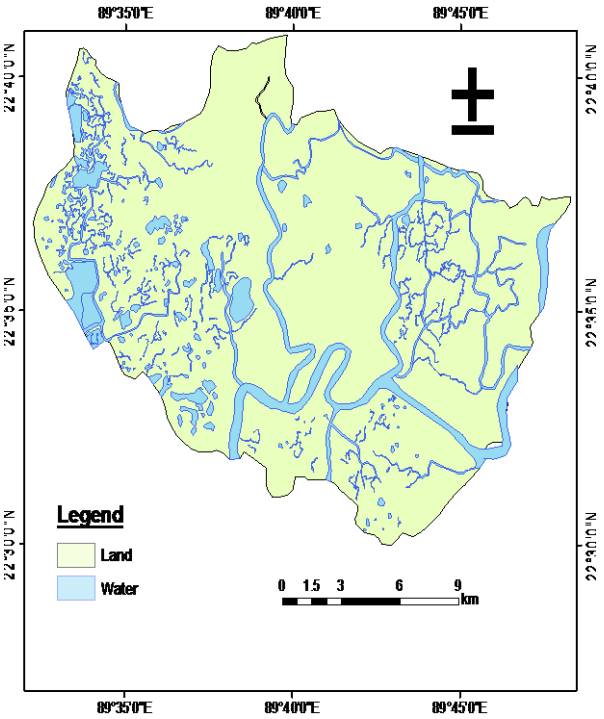

Fig. 10 Water logging area at Rampal area of 1990

Salt Water Problem: Increasing salinity is considered an important factor in limiting further agricultural and industrial development in the coastal area of Bangladesh (Siddique et al., 2021). The area is also facing an acute salt water problem. Surface water is not drinkable during summer. In monsoon, people harvest rainwater in the small pond adjacent to their houses for coming months, but it becomes salty with the passage of time. Groundwater aquifers are badly affected by salinity. Saltwater limits irrigation potential and damages crops by flooding during high tides. Salinity of water in the area exceeds WHO and Bangladesh standards (SRDI, 1997).

Loss of Agricultural Land: Inearlier, the agricultural land in this area was usable in most times of the year. But due to water logging problem it is not possible now. Statistical accounts of the last few decades also imply the same view. In the fiscal year 1978-79 the total agricultural land in the area was about 168960 hectares but in 2008 the agricultural land decreased to about 20358 hectares (Table 1).

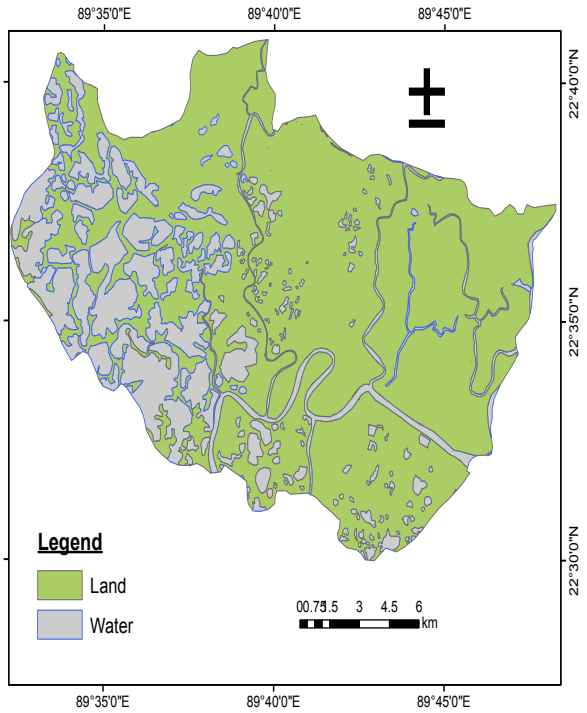

Fig. 11 Water logging area at Rampal area of 2010

Damage of Play Ground: School yard of the Talbunia Primary School, Talbunia, Rampal, Bagherhat was the only play ground of the village Talbunia during nineties. The estimated area of this field is about 8000 m^2. It becomes a permanent water logged area for the last 20 years (Fig. 4c).

Migration of Local People: Migration of local people from the area to another place is now important factor. Due to water logging, the people are gradually losing their agricultural land, household, etc. and finally they migrated from the area to another place. In 1981 the population density in the area was about 432 per km^2. In 1991 the density increased to about 497 per km^2 and in 2001 the density was about 533 per km^2. But in 2011 the density of population decreased to about 462 per km^2 (Table 2).

Table 2. Population in the study area (Source: Statistical Year Book of Bangladesh)

Year	Population	Density (Sq km)
1961	157610	470.47
1974	202944	605.80
1981	144992	432.23
1991	167070	497.81
2001	179000	533.58
2011	155000	462.04

Conclusion

Water logging is one of the major problems in the study area. The study implies that both natural and anthropogenic factors are responsible for water logging problem. The sluice gate and embankments have been constructed on and along the river courses, as well as upstream barrage. These activities enhance sedimentation within the channel rather than in the adjacent plain. As a result channels are gradually congested and cannot maintain the excess water in the rainy season, resulting flood and water logging. Due to flood and water logging salinity increases, and the crop production is gradually decreasing. At present, the people are migrating from this place to another place in the country due to inappropriate situation. Finally, it can be concluded that to overcome these problems, it is necessary to have an action of integrated plan.

Acknowledgement

The authors express their thanks and gratitude to, DG, Geological Survey of Bangladesh (GSB) for permission to publish this paper. The authors also like to express their thanks to the authority of the USGS for permission to use satellite images.

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