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Impact of Sand Mining on Bathymetry of the Meghna River

Mst. Asfat Ara Joly and M. Shahidul Islam*

Department of Geography and Environment, University of Dhaka, Dhaka 1000, Bangladesh

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ABSTRACT: This study aims to evaluate the morphological changes of the lower Meghna River in Bhola district due to reckless sand mining from riverbeds. It has been done based on primary data collected from the field and secondary data, such as river bathymetry of 2006, 2012, and 2022 from BIWTA and Landsat Imageries of 2006, 2016, and 2023 from USGS Earth Explorer. The study demonstrates that extensive sand mining activities in the lower Meghna River significantly affect river bathymetry and accelerate riverbank erosion. Lower Meghna River experiences a higher erosion rate due to prolonged and intensive sand mining. The erosion rate increased significantly between 2020 and 2021, with the riverbed eroding at an accelerating rate, highlighting a critical situation in the region. However, FGD and case studies from the field show that the impact of sand mining is not only confined to river morphology change but many more ecological, socio-political, economic, environmental, and governance issues are also linked with sand mining activities.

Keywords: Sand Mining; Meghna River; Geomorphology; River Bathymetry

INTRODUCTION

Sand, once overlooked, has now risen to prominence as the world's second most consumed natural resource, following only water (Rentier & Cammeraat, 2022). Fueled by the rapid expansion of the construction and transportation industries, global demand for sand has skyrocketed (Krausmann et al., 2009; Torres et al., 2017). This surge has significantly increased sand mining activities worldwide, with demand increasing twenty-three times between 1900 and 2010 (Rentier & Cammeraat, 2022; Torres et al., 2017). Presently, annual sand usage is approximately 50 billion tons, projected to soar to an alarming 82 billion tons by 2060 (Fritts, 2019; Koehnken et al., 2020; Schandl et al., 2016). Urbanization and infrastructure development drive this demand, leading to widespread, indiscriminate sand extraction and environmental and social challenges.

Bangladesh, boasting an impressive 8.2% economic growth, reflects broader global trends in its rapid urbanization and industrialization (World Bank, 2018). While industries like ready-made garments and remittances drive much of this growth, the construction sector, contributing 7.0% to the GDP (USD 24 billion in 2019), plays a pivotal role (Bari and Haque, 2022). With 40% of the population already residing in urban areas and projections indicating a rise to 50% by 2050, the demand for sand for building and infrastructure is set to surge (World Bank, 2018). However, concerns loom over the ability of legal operations to meet this demand, potentially exacerbating illegal and unsustainable sand mining practices. Despite legal extraction occurring at 707 permitted sites, reports abound of illegal activities causing significant harm to ecosystems and livelihoods (Bari and Haque, 2022).

Studies on sand mining and its impacts have been conducted in many Asian countries, such as in China by Chen (2017), in Korea by Cho (2006), in India by Aarif et al., (2014) and Tepjal et al., (2014), in Iran by Farahani and Bayazidi (2018), in Malaysia by Ashraf et al., (2011), and in Cambodia by Lamb et al., (2019), there is a dearth of comprehensive research focusing on the specific conditions in Bangladesh. The literature on sand mining explores its ecological, socioeconomic, and mineralogical aspects, highlighting global negative consequences such as riverbank erosion and biodiversity loss (Akon, 2019; Arjun et al., 2023, Hossain et al., 2015; Khalil et al., 2016; Rahman et al., 2022; Rahman et al., 2014). Despite the tremendous growth of

*Corresponding author: M. Shahidul Islam

Email: shahidul.geoenv@du.ac.bd

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the construction sector in Bangladesh, research gaps remain, with sand mining endangering ecosystems and communities. Mineralogical features and economic benefits of sand have little been studied, with the goal of boosting local economies and creating jobs (Bari and Haque, 2022). Therefore, this study aims to provide detailed insights into the effects of sand mining on the morphology of the lower Meghna River and its adjacent regions.

STUDY AREA

Sand mining in the Meghna River is of particular concern due to the increasing demand for its sand, driven by rapid urbanization. Fine-grained sand, predominantly obtained from the Meghna River and nearby water bodies, is primarily utilized for land reclamation purposes. However, the adverse impacts of these activities extend to changes in river morphology, riverbank erosion, and the well-being of the local community and ecosystem.

Meghna is one of the mighty rivers of Bangladesh and is very dynamic by nature. The wider and deeper characteristics of this river have a great impact on the riverbank people. Existing knowledge shows that the morphology of this river is changing rapidly due to excessive sand mining, which is, in most cases, illegal (Dhaka Tribune, 2022). However, considering the objectives of this research and accessibility to the site, among many other potential locations, the present study is confined to the Meghna estuary in Bhola district between 22°29'31" to 22°24'56" N latitude and 90°47'28" to 90°55'40" E longitude, covering an area of 68 sq. km (Fig.1).

Figure 1: Study Area

METHODOLOGY

The study was conducted based on primary and secondary data analysis. Primary data includes fieldwork in the study area aiming to measure bottom topography changes by direct measurement using a country boat across three sections. Moreover, two FGDs were conducted at Burhanuddin and Lalmohon Upazilas to understand the local people's perceptions about the causes and impacts of sand mining at the local scale.

Secondary data includes analysis of bathymetry data across three cross-sections of 2006, 2012, and 2021, collected from BIWTA (Table 1). BIWTA collected the bathymetry data in January, respectively. The hardcopy data was first converted to digital format using ArcMap 10.8 for further analysis.

Table 1: Cross Section Location of Bathymetry Data

River	Profile	Cross-section location (see figure-1)	Year
Meghna	1	22°29'38.25"N to 22°29'50.25" N latitude and 90°47'40.26" E to 90°52'1.88" E longitude	2006, 2012, 2021
	2	22°27'49.94"N to 22°28'4.95" N latitude and 90°49'8.22" E to 90°53'18.57" E longitude	2006, 2012, 2021
	3	22°26'34.04"N to 22°26'53.83" N latitude and 90°50'8.22" E to 90°54'14.31" E longitude	2006, 2012, 2021

In addition to the bathymetry data, Landsat images from the USGS Earth Explorer for the three available years (2006, 2016, and 2023) have also been studied (Table 2).

Table 2: List of Landsat Images

Date	Type	Band Used	Resolution	Purposes	Path and Row
2006-12-21	LT_05	3,5	30m	NDWI	137044
2016-02-16	LC_08	3,5	30m	NDWI	137044
2023-04-16	LC_09	3,5	30m	NDWI	137044

The collected Landsat imagery data of different years for the study area was analyzed to determine the changes in land cover and assess the changes in riverbeds. From the images of each year, the NDWI calculation was operated for the selected year images. Here, showing the river area of Meghna with path and row 137044 was sufficient as this tile covers the expected area perfectly. In this step, all the procedures were done in ArcMap 10.8.

RESULTS

Three bathymetry charts of three different years were collected from BIWTA to study the change in the bottom topography of the Meghna River at three different sections. These charts show a significant change in bottom topography, which, to some extent, relates to indiscreet sand mining from the river bed.

Profile 1 shows that the average depth across this section is 12 meters, with a trend of more water depth towards the right side of the river course. In 2006, the river bed was almost flat with little undulation topography and a moderate bankside slope. However, by 2012, there had been significant changes in the river bed topography and a sudden increase in water depth of up to 27 meters. Such an increase of water depth of about 14 meters only in 6 years adjacent to the right bank had accelerated the river bank erosion at the Hakimuddin area in Bhola district. This was also the period of massive sand mining in this section. By 2021, there had been natural sand filling at this section, and the depth also reduced. Despite erosion continuing, which largely relates to sand mining from the river bed,

Profile 2, about 3 km down from section-1, also shows significant changes in the bottom topography of the riverbed, mostly in the middle part of the course. The river depth was high in the middle of the course in 2006 and 2021, except lower river depth at this point in 2012. How this rapid change of river depth relates to sand mining is difficult to prove from such a profile study. However, despite natural changes in bed configuration, sand mining activities continued at this site recklessly during the study period.

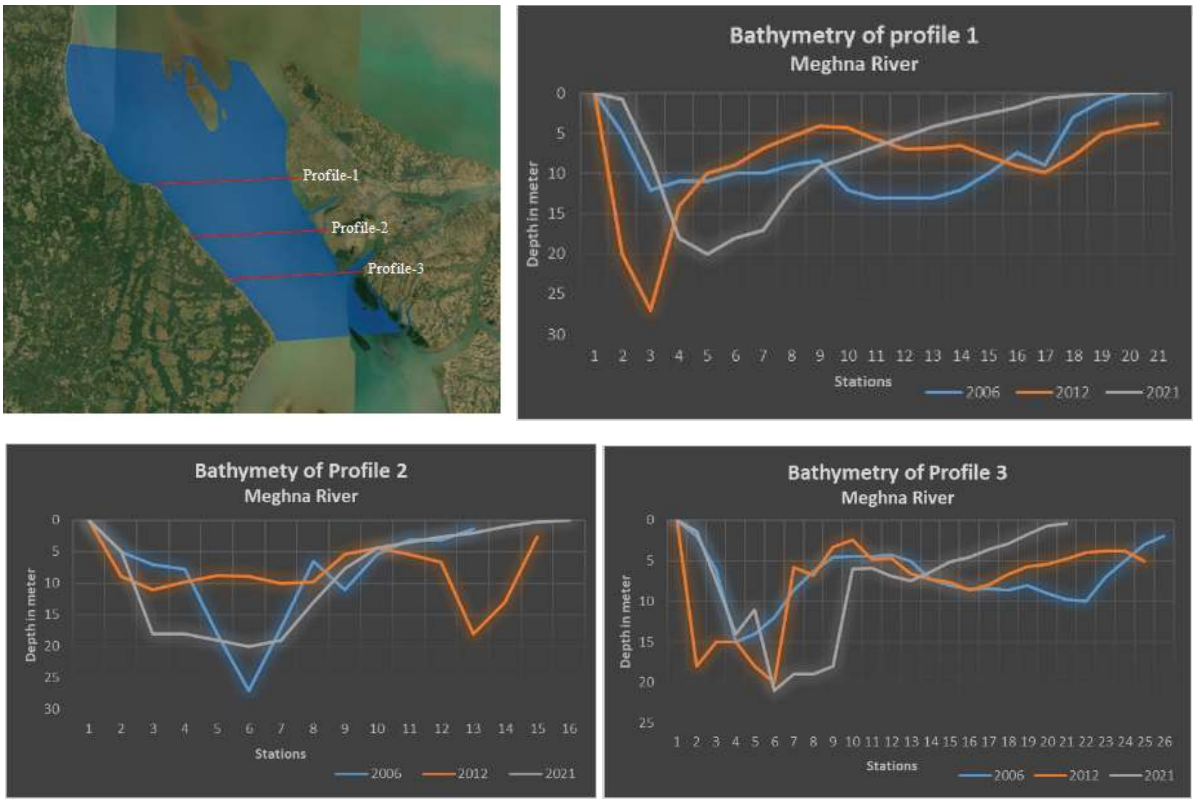

Figure 2: Cross Sections at Three Different Locations

Profile 3, further 3 km down, shows a deep-water course closer to the right bank of the river. The maximum depth was 23 meters both in 2012 and 2021. The turbulent flow of river water along this deem course has always been the main cause of river bank erosion in and around this part of Tamizuddin upazila of Bhola district. The depth decreases in the eastern part of the river course, particularly in 2021, indicating rapid siltation and accretion of new landmass (chars) in the east. However, despite continuous changes in river bed configuration, extraction of sand from river bed remains during this process.

Based on Landsat Imageries of 2006, 2016, and 2023 and 3-bathymetry profiles, it has been attempted to reconstruct the shoreline shifting and bottom topography changes of the river course within the study area. The NDWI calculation was operated for the selected years within the path and row of 137044 covering the study area. Using ArcMap 10.8, the river bed model was developed to project the morphological changes of the river course within the study period (Figure 3). It is found that there has been significant change in the river course, both horizontally and vertically, due to lateral erosion, scouring, and rapid siltation. In the upper part of the study area, while the deepest channel was less than 1 km wide in 2006, it was about 2.5 km in 2012. Such a change in bottom topography in only six years not only reflects the dynamic nature and instability of the river course but also how human interventions, such as unplanning river bed digging, have made the channel susceptible to scouring and lateral erosion.

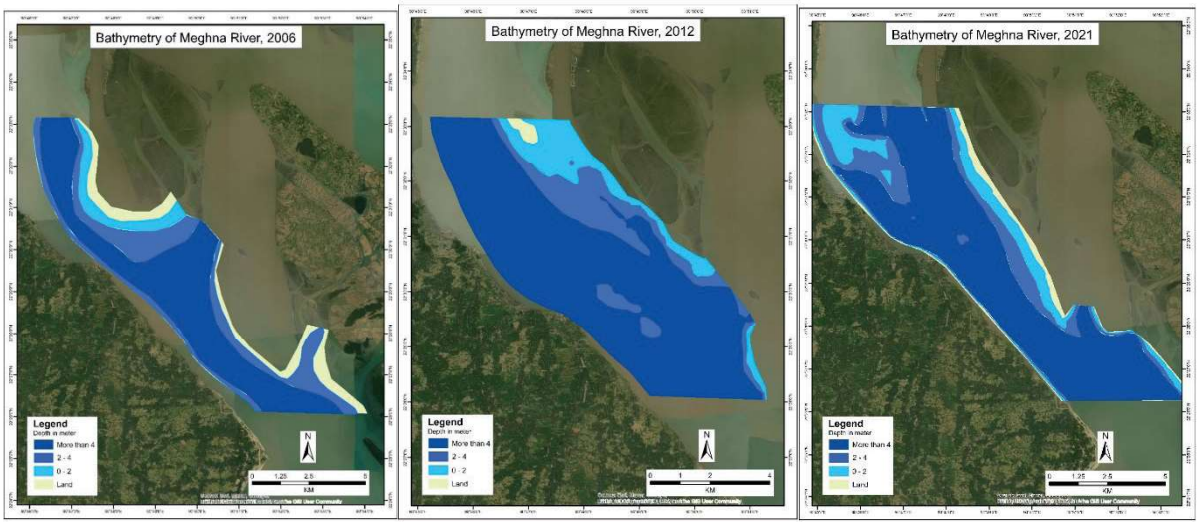

Figure 3: Map of Bathymetry of Lower Meghna River 2006-2021

The middle and lower parts of the course also show the shifting nature of the channel, both vertically and horizontally. However, the general observation is that the deepest channel within the study area always remains on the western side of the course, leading to massive riverbank erosion on the west bank. The Mirzakalu and Tazumuddin launch ghats had to shift several times due to massive riverbank erosion in the past. Such bank erosion was accelerated due to unplanned sand mining from the river bed adjacent to the river banks.

DISCUSSION

Bangladesh, a densely populated country, faces increasing pressure on its natural resources due to urbanization, construction, and land reclamation. Sand, a vital component in concrete production and essential for building roads, bridges, and buildings, is extracted from riverbeds, floodplains, and coastal areas. Bangladesh is a deltaic country with vast sand resources in its rivers and riverbeds. However, these resources are not evenly distributed, leading to intense sand mining activities in specific locations, legally and illegally. Considering the increasing demand for sand resources for construction and other purposes, the government has identified 707 sites as *Balumohol*, from where sand can be extracted with proper permission from the district administration (JBN, 2009). Until now, 382 *Balumohals* have been leased for sand extraction (Land Ministry, 2023). A recent study by Islam (2023) has identified 93 illegal sand mining sites throughout the country, mostly located in the major river courses of Bangladesh, predominantly in the downstream of the Meghna river, including the present study area.

The present study focuses on the changes in river morphology due to the extraction of sand from the riverbed. River cross-profile and Landsat imageries show that there have been significant changes in the river morphology, particularly in riverbed configuration, during the study period. Such morphological changes of river course in a deltaic and estuarine environment in Bangladesh is a common phenomenon. However, the challenge is to justify how sand mining triggers the morphological shifting of river courses. It has been attempted to measure the depth of the riverbed at mining sites to identify the extent of sand mining. We have identified unusual changes in bottom topography due to indiscreet digging of the riverbeds by miners, creating many potholes upto 3-5 meters deep. In a recent study, Islam et al. (press) identified similar potholes up to 20 meters deep created by sand dredgers at the Someshwari River in Netrokona district. Such holes trigger turbulence, divert the river flow towards the bank, and accelerate riverbank erosion. The local people have justified it during the FGD and also by individuals. Local people are the human archive to observe, monitor, and evaluate the riverine process and justify the links between natural phenomena and human interventions. From FGD and local-level interviews, it has been found that sand mining is a prolonged environmental issue in the study area. It affects the morphological changes, river dynamics, riverine ecology, and socio-political environment.

Among many others, one respondent, 55 years old, revealed that many inhabitants in the vicinity of the Meghna River had lost their land and homes more than seven occasions. These displaced individuals were forced to migrate to higher ground or different administrative regions. The abrupt and unpredictable erosion robbed their agricultural lands and homes of any opportunity for survival. The constant threat of displacement left these people unable to acquire new land; instead, they had to settle on government-owned land (*khas land*). The residents of this area unanimously pointed out that unregulated sand mining is the sole reason behind the alarming increase in erosion rates in recent times. Despite their profound understanding of the impact of unregulated sand mining on erosion patterns and livelihoods, these individuals feel powerless in the face of influential people who control all aspects of the sand mining operations in this area. According to local residents, the alterations in bathymetry have led to an increased influx of water during high tide, resulting in more pronounced erosion in areas typically free from permanent water cover. Households in the vicinity of Mirzakalu Launch Ghat Bazaar are currently grappling with erosion despite the absence of permanent water coverage in this area, with water only encroaching during high tide. The heavy instruments used during sand extraction create enormous sounds and vibrations in the watermass, adversely affecting the ecosystem and the fish's lives. In recent years, the number of natural catches has declined significantly. Local people also reported that the extracted sands are stored and pilled near the river bank, which occupies valuable and fertile agricultural land. Dust pollution also affects human health. Islam et al. (press) also identify similar sound and air pollution from sand mining in the Someshwari River area.

CONCLUSIONS

This research focuses on the morphological changes of the river course, particularly the riverbed topography due to sand mining at the lower Meghna River. However, the experiences from the field show that the impacts of sand mining are not only confined to river morphology, but many more ecological, socio-political, economic, environmental, and governance issues are linked with sand mining activities. Sand mining has created work opportunities for a few local people in the mining operation, but it is responsible for significantly reducing the livelihood diversity. The United Nations Environmental Program (UNEP), in their sand governance reports for 2019 and 2022, has documented the absence of a sand governance system and research activities globally (UNEP, 2019; 2022). This is also true for Bangladesh, where a robust regulatory framework for sand mining is lacking. Lack of scientific knowledge on sand quality, stock, economic value, marketing, and environmental issues are also the challenges. The Balumohal and Soil Management (Amendment) Act (2023) in Bangladesh reveals that in the lease agreement, the outline for extractable sand in the *Balumohal* (sand mining site) has to be properly complied with. A major challenge remains with the regulatory process of mining operations at the local level. The local administrations apparently have little control over the sand mining supply chain. Once the *balumohal* is leased out to the traders, they look for maximum economic return, with little attention given to environmental issues, and they expand their mining operations beyond the leased area. This study has comprehensively explored the morpho-ecological and socio-economic impacts of sand mining in the lower Meghna River. The findings reveal that irresponsible sand extraction, fueled by urbanization and construction demands, has significantly altered the river morphology. A major concern of local people is to protect riverbank erosion for their existence. The research also highlights the gaps in scientific knowledge about sand as a resource, its environmental issues, and inadequacies in current governance and regulatory framework, which fail to control irresponsible mining and ensure sustainable practices. The study calls for further studies on river morphology, ecology, economic significance, environmental challenges, and policy gaps in sand mining in Bangladesh.

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