Publisher homepage: www.universepg.com, ISSN: 2707-4668 (Online) & 2707-465X (Print)
https://doi.org/10.34104/ajssls.023.01720178
Asian Journal of Social Sciences and Legal Studies
Journal homepage: www.universepg.com/journal/ajssls

GIS and RS Based Monitoring of Bank Erosion Along with Meghna River at Bhola, Bangladesh

Mawya Siddeqa[1]*, Md. Tariqul Islam[2], Md. Saifur Rahman[1], Ananya Mukherjee[3], and Marzia Sultana Shefa[3]

[1]Dept. of Geo-information Science and Earth Observation, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh; [2]Dept. of Environmental Science, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh; and [3]Faculty of Environmental Science and Disaster Management, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh.

*Correspondence: mawyageo@pstu.ac.bd (Mawya Siddeqa, Assistant Professor, Dept. of Geo-information Science and Earth Observation, Faculty of Environmental Science and Disaster Management, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh).

ABSTRACT

One of the common and unpredictably occurring disasters Bangladesh experiences each year is river bank erosion. In Meghna River, erosion is a major issue, particularly during the pre- and post-monsoon seasons. The aim of this study is to evaluate the risk of coastal erosion to the local community by analyzing previous as well as present data. Four Landsat images were utilized in this study to detect changes in the river bank. ArcGIS 10.3 was used for data encoding and analysis. According to the study, the Meghna River's overall changing area from 1992 to 2022 is 21210.38 ha, whereas its overall unchanged area is 56454.18 ha. The study found that, between 1992 and 2022, there was an average erosion rate of 16137.89 ha and an average accretion rate of 37348.27 ha. The people who live in the floodplain are severely impacted by the erosion of the Meghna River bank. Therefore, it is imperative to take appropriate steps to minimize erosion, such as building sustainable embankments, implementing an afforestation program, providing suitable income-generating opportunities for displaced people, etc.

Keywords: Erosion, Accretion, Meghna river, Socio-economic, GIS and RS based monitoring.

INTRODUCTION:

Erosion is the process of movement of loosened or weathered materials from one location to another (Islam, 2008). It happens as a result of natural or artificial processes, including wind, moving water, moving ice, pore water pressures, and moisture levels within the bank (Islam, 2008; Coleman and Wright, 1971; River Survey Project, 1996; Fujita *et al*., 2000). Every year the coastline island of the Bangladesh is eroded and sometimes accreted in a larger rate due to climate change, tidal fluctuation, sea level rise, and other man-made cause (Kratz, 1999; Mutton and Haque, 2004). The volume of water that flows after the upper catchment areas increase the intensity and vulnerability of floods as well as the related riverbank erosion (Hossain & Ferdousi, 2004). The three major rivers of Bangladesh, the Padma, Meghna, and Jamuna, have negatively impacted the lives and livelihood of the people by eroding thousands of the hectares of floodplain and a number of kilometers of roads and railways (Baki, 2014; Rahman, 2010; Haque, 1988; Haque *et al*., 1997). It dislocates thousands of people each year (Hossain & Ferdousi, 2004; Haque, 1988; Islam & Rashid, 2012). Rivers vary from one another in terms of their physical traits and behaviors (Yao *et al.,* 2013; Surian, 1999; Alam and Hossain, 1998). The low-energy, multi-channel Meghna River

fluvial system is made up of a network of connected channels and the inter-channel area (Alam, 1991). Alluvial rivers experience natural channel changes as part of their natural processes and the Meghna is no exception. Flooding, erosion, and drainage system congestion are major problems in the Meghna basin (Shahjahan and Reja, 2012; Nipa *et al*., 2022).

The ideal technology for analyzing river bank erosion and accretion is GIS and RS since they can give a synoptic view of a vast area (Winterbottom and Gilvear, 2000). Remote sensing data integrated with GIS makes it an excellent tool for investigating the change in fluvial systems and mapping the likelihood of bank erosion (CEGIS, 2009; Milton *et al*., 1995; Mani *et al*., 2003; Sarkar *et al*., 2012; Green *et al.,* 2000). GIS and DEM techniques were used to describe the morphological change and quantify the temporal-spatial distribution of riverbed erosion and deposition (Sarma *et al*., 2007; Jian *et al*., 2009; Chu *et al*., 2006; Kummu *et al*., 2008; Kotoky *et al*., 2005; Gurnell *et al*., 1994; Mahmoodzada *et al*., 2019; Bedini, 2007). Additionally, theodolite is widely used to track dynamic river systems (Chandler *et al*., 2001; Chu *et al.,* 2006). In earlier research, by using satellite imageries the researcher found that the Meghna River in Chandpur had a higher rate of bar deposition than erosion (Nath *et al*., 2013). A study on the morphological changes of the Jamuna River, found that siltation covers 29.82 km2 and erosion covers 1235.25 km2 (Uddin *et al*., 2011). Another investigation found that the average width of the Jamuna River is increasing. They estimate that the average riverbank accretion is 166 km2 and the average riverbank erosion is 607 km2 (Khan *et al.,* 2014). The Meghna River near Bhola has undergone morphological alteration, but very little research has been done to assess this change. So, it is critical to estimate the erosion and accretion rate of the Meghna River. Therefore, this study tried to identify the landform changes of the Meghna River by analyzing previous as well as present data. The study's conclusions may be useful to the government and other authorities in deciding how to manage riverbank erosion.

METHODOLOGY:

Study Area

This research emphasized mainly at Meghna river channel around Bhola district and tried to identify a trend of river course change. Meghna is one of the largest rivers where the Surma, Dhaleswari, Brahmaputra, Yamuna, and Ganges meet. The study region extents 46.5 km from the upper meghna to the lower Meghna, between latitudes 23 25 11 98N and 23 2 4 84N, and the longitudes 90 35 58E and 90 39E (Banglapedia). This study covered mainly the lower part of the Meghna River which flows across different islands of the Bhola district like Manpura, Tazumuddin, Sona Char, Char Bhuta and the Char Anandaprasad.

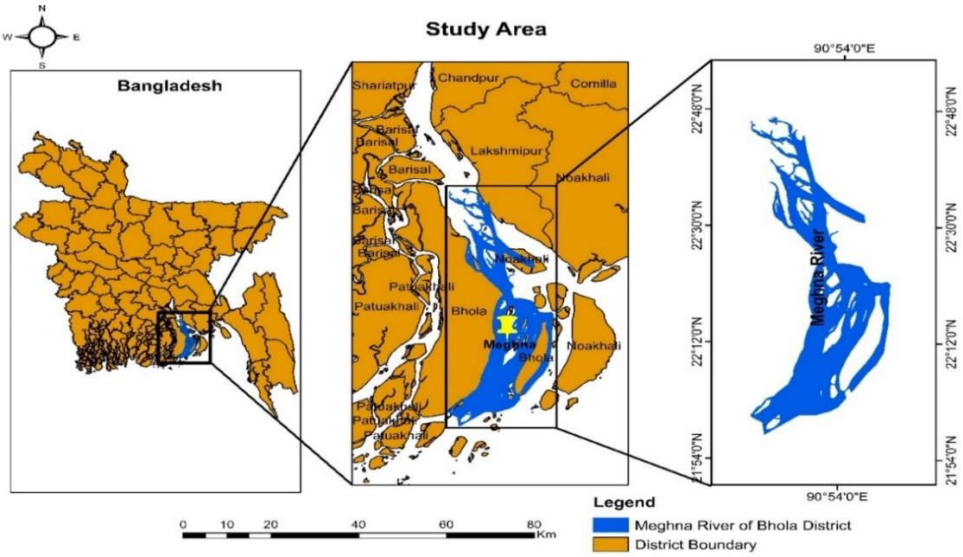

Fig. 1: Study Area Map.

Data Collection

Landsat satellite images were acquired from the websites of the United States Geological Survey (USGS, 2016) to analyze 30 years of erosion and accretion patterns of the Meghna River. The details of these satellite imageries have been shown in the

Table 1. To analyze the change of river bank, the total time was divided into four intervals 1992-2002; 2002-2012; 2012-2022; 1992-2022.

Table 1: Information about the satellite images used in the study.

Year	Satellite	Sensor	Path/Row	Source
1992	Landsat 4-5	TM	137/44 137/45	USGS
2002	Landsat 7	ETM+	137/44 137/45	
2012	Landsat 7	ETM+	137/44 137/45	
2022	Landsat 8-9	OLI/TIRS	137/44 137/45	

Data Processing and Analysis

The study used Landsat satellite images of 4-5 TM, 7 ETM+ and 8-9 OLI/TIRS sensors to detect the change of the Meghna River channel covering Bhola district. After collecting the images, pre-processing was done to remove errors and anomalies. Then, Band 1 to Band 7 was composited using the Arc GIS 10.3 program, and the mosaic function was used to merge two images. Then, an unsupervised classification was applied to represent the river flow pattern of the designated area. The unsupervised classification was performed through several steps which included shape file creation, polygon editing, mask extraction, and reclassification. Far ahead, the raster file was transformed into a polygon and the shape of the river was extracted from the entire satellite image. The process was performed for all images of selected years of 1992, 2002, 2012, and 2022, and for the visualization of the change in the Meghna River course, cross-matching was performed. After that, the 'intersect' function was applied to identify the unchanged river area and the 'erase' function was applied to identify the eroded and accreted river area for the period of 1992-2092, 2002-2012, 2012-2022 and 1992-2022. At last, the area of each individual polygon representing of erosion, accretion, previous, current, changed, and unchanged areas was calculated through geometric calculation since the shape files were already projected to Bangladesh Transverse Mercator (BTM) projection with hector (ha) units in ArcGIS software. Finally, GIS maps were created and the whole process was completed carefully for all the datasets.

RESULTS AND DISCUSSION:

Status of Landform Change of Meghna River

Depending on the physical characteristics Meghna River's platform constantly changes and is extremely difficult to predict due to the dynamic nature of these waterways and islands.

Table 2: The area that has been eroded and accreted during the past 30 years.

Duration	Erosion(ha)	Erosion(ha/yr)	Accretion (ha)	Accretion (ha/yr)
1992-2002	11466.41	1146.64	11086.74	1108.67
2002-2012	9943.77	994.38	11868.41	1186.84
2012-2022	8846.89	884.69	28512.30	2851.23
1992-2022 (Average)	16137.89	537.93	37348.27	1244.94

The **Table 2** displays the area that has been added to and lost throughout the course of various time periods. In case of erosion, a declining tendency was seen from the years 1992-2002 to the years 2002-2012, going from 11466.41ha to 9943.77ha and then again decreasing to 8846.89 ha in the years of 2012-2022. Between the years of 1992-2002 and 2012-2022, the erosion rate decreased from 11466.41ha to 8846.89 ha. Likewise, this study, studies conducted on on Meghna river in Chandpur district, found that 3517 square meter area was eroded during 1990 to 2002 (Nath *et al.,* 2013). In case of Amu River during period of 2000-2005, 2005-2010 and 2010-2014, eroded area was calculated 1,984 ha, 1,410 ha, and 1,680 ha respectively (Mahmoodzada *et al*., 2019). On the other hand, in the case of accretion, the study found the rate of accretion was smaller between 1992-2002 and increased steadily between 2002-2012 from 11086.74 ha to 11868.41 ha. A sharp growth is visible from the period of 2002-2012 to the period 2012-2022. Additionally, the findings of this study are consistent with research on Padma

river between 1998 and 2017, found that Padma's average rates of erosion and accretion were 1472.056 and 1610.152 ha/year, respectively (Islam, 2009; Ophra *et al.,* 2018). In the case of the Jamuna River the research found net erosion of 607km2 while the net accretion was 166km2 (Khan *et al*., 2014; Khan and Islam, 2003). Investigations carried out by the Krantz found that during 1990-1995 the erosion on the Meghna River along Bhola island was 4.3 km2 and accretion 20.9 km2 (Krantz,1999).

Landform Change of the Meghna River between 1992 to 2022

The Meghna River channel along the Bhola District is constantly moving due to the intense water flow during the monsoon. From the analyses of satellite images of 1992 to 2022 it can be said that the river bank has been eroded and the channel moves in different directions at different times within several locations. **Fig. 2** depicts Meghan River's erosion and accretion from 1992 to 2022. The study found average erosion in the Meghna River was about 537.93 ha/yr. In a prior study, the author discovered that the Bhola district's total area of erosion and accretion was 399 and 583 km2, respectively (Hassan *et al.,* 2017). Massive water flow, consequent bank slumping, and its dynamics characteristics are responsible for the erosion of the Meghna River similar results also found in different studies (Islam and Rashid, 2011). The average accretion rate OF Meghna was about 1244.94 ha/yr and the probable reason for accretion was siltation (Hassan *et al.,* 2017). The study also reveals that the amount of siltation varies according to the average water discharge, flow rate, watercourse power, unit size and gradation, and temperature (Islam and Rashid, 2011; Islam, 2008; Khan *et al.,* 2014).

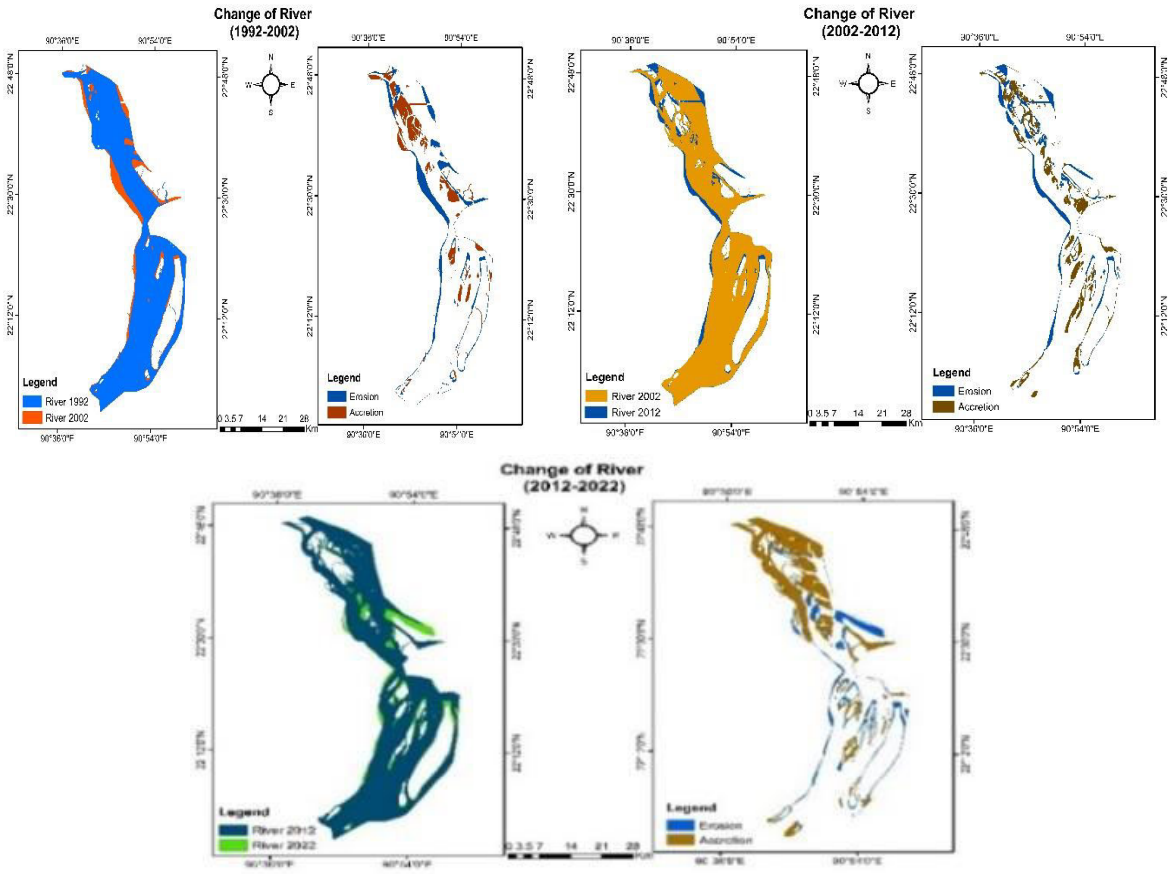

Fig. 2: Erosion and Accretion area of Meghna River from 1992 to 2022.

Status of Total Changed and Unchanged Area

According to the analysis, there were significant and unstable alterations to the river channel. **Fig. 3** indicates the overlapping of rivers in 1992 and 2022. The study found that in 1992 the total area of the Meghna River was about 98350.19 ha but in 2022 the area was about 77139.81ha. In previous work, the author found that the total landmass in a region of the island's northern section was 240.9 km2 in 1990 and 257.5 km2 in 1995 (Krantz, 1999). The study found the overall changed area is about 21210.38 ha and the unchanged area is about 56454.18 ha.

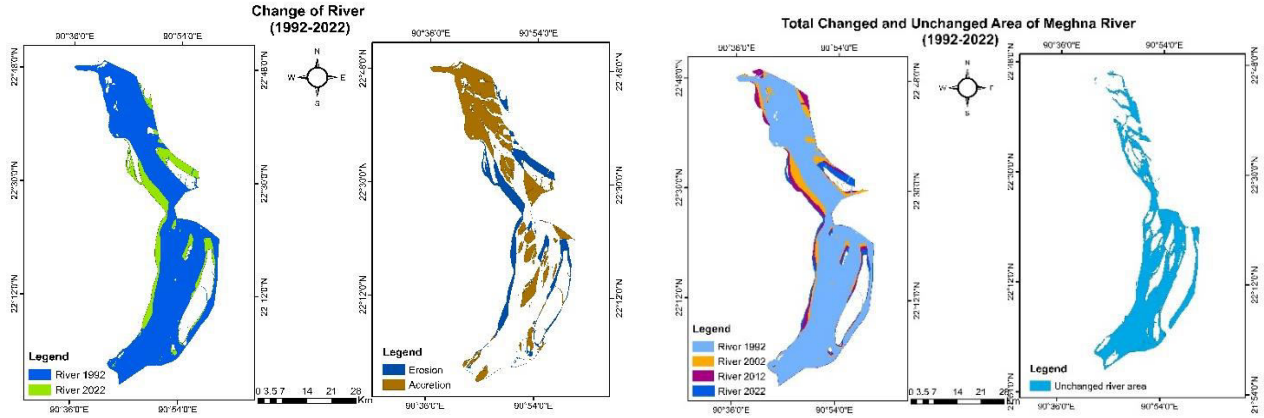

Fig. 3: Overlapping of Meghna River between 1992 to 2022.

CONCLUSION:

In this study, the dynamic characteristics of the Meghna River bank are shown through the analysis of a collection of Landsat images from 1992 to 2022. The analysis found that the erosion rate significantly decreased between 1992 and 2022. The analysis also revealed that in 2022 accretion was greater than erosion. The main factors contributing to erosion at the Meghna are believed to be tides, the combined Padma and Meghna flows, sediment load deposition, floods, and bank shifting. The rivers' irregular changing behavior has an adverse effect on the rural floodplain population of the Bhola. Future channel shifting patterns and erosion rates should be determined by additional research, and effective steps should be made to lessen the severity of erosion and its detrimental effects.

ACKNOWLEDGEMENT:

Authors' heartiest thanks go to others who were involved and helped directly and indirectly throughout the research work.

CONFLICTS OF INTEREST:

Regarding the research, writing, and publication of this paper, the authors indicated they had no potential conflicts of interest.

REFERENCES:

1) Alam, MM. (1991). Some distinctive aspects of braiding and anastomosing with reference to the Jamuna and Meghna Rivers in Bangladesh. *J. of Bangladesh academy of sciences*, **15**,113-121.
2) Alam, MS., & Hossain, MD. (1998). Impact of River Dynamics on coastal Geomorphology: A case study on Feni River, Bangladesh. *J. of Remote Sensing and Environment*.
3) Baki ATM. A. (2014). Socio-Economic Impacts of Gorai Riverbank Erosion on People: A Case Study of Kumarkhali, Kushtia, *MS Thesis*, Brac University, Bangladesh.
4) Bedini, E. (2007). Use of GIS and Remote Sensing to Detect Change along the Coastline Segment between Shkumbini and Semani Rivers, Central Albania. Proceedings of the 11th International Congress Bulletin of the Geological Society of Greece, XXXX, Athens.
5) CEGIS, (2009). Center for Environment and Geographic Information Services. *Flood and Erosion Prediction Division*.
6) Chandler, J., Gooch, M., and Varkaris, F. (2001). Monitoring river channel change using terrestrial oblique digital imagery and automated digital photogrammetry. *Annals of the Association of American Geographers*, 631-644.
7) Chu, ZX., Sun, XG., and Zu, KH. (2006). Changing pattern of accretion/erosion of the modern Yellow River (Huanghe) subaerial delta, China: Based on remote sensing images. *Inter J. of Marine Geology, Geochemistry and Geophysics, Marine Geology*, **227**(1), 13-30. https://doi.org/10.1016/j.margeo.2005.11.013
8) Coleman, JM., & Wright, LD. (1971). Analysis of Major River Systems and Their Deltas: Procedures and Rationale, with Two Examples. *Coastal Studies Series 28, Louisiana State University Press, Baton Rouge*. (pp.125).
9) Fujita, Y., Kawaguchi, M., & Hai, TP. (2000). A conceptual model for erosion processes of high river bank. *Annual journal of hydraulic engineering*, 753-758.
10) Green, EP., Mumby, PJ., & Clark, CD. (2000). Remote Sensing Handbook for Tropical Coastal

Management. AJ Edwards (Eds), Coastal Management Sourcebook, UNESCO, Paris, France. (PP. 316).

11) Gurnell, AM., Downward, SR., & Jones, R. (1994). Channel planform change on the River Dee meanders, 1976-1992. *Regul Rivers Res Manag*, 187-200. https://doi.org/10.1002/RRR.3450090402
12) Haque, C. (1997). Hazards in a fickle environment: Bangladesh. *London, Kluwer Academic Publishers*.
13) Haque, CE. (1988). Impacts of Riverbank erosion Hazard in Brahmaputra Jamuna Flood plain: A study of population displacement and response strategies. *PhD Thesis*, Dept. of Geography, University of Mintoba, Canada.
14) Haque, E. (1991). Human Response to Riverbank Erosion Hazards in Bangladesh: Some Lessons from Indigenous Adjustment Strategies. In K. Maudood Elahi, K. S. Ahmed & M. Mafizuddin (Eds), River Bank Erosion, Flood and Population Displacement in Bangladesh. (pp 191-217). *REIS, JU, Dhaka*.
15) Hassan, ST., Syed, MA., and Mamnun, N. (2017). Estimating erosion and accretion in the coast of Ganges-Brahmaputra-Meghna Delta in Bangladesh. In 6th Int. *Conference on Water & Flood Management*. https://en.banglapedia.org/index.php/Meghna_River
16) Hossain, MM., & Ferdousi, S. (2004). Assessment for role of GIS Based Natural Disaster Database in Environmental Management and Planning Activity in Bangladesh. *Environ. Informatics Archives*, 119-125.
17) Islam, MF., and Rashid, ANM B. (2011). Riverbank erosion displaces in Bangladesh: Need for institutional response and policy intervention. *Bangladesh Journal of Bioethics*, **2**(2), 4-19.
18) Islam, MF. & Rashid, ANM.B. (2012). Riverbank erosion displacees in Bangladesh: need for institutional response and policy intervention. *Bangladesh Journal of Bioethics*, **2**(2). https://doi.org/10.3329/bioethics.v2i2.9540
19) Islam, MS. (2008). River bank erosion and sustainable protection strategies. *In Proceedings 4th International Conference on Scour and Erosion* (ICSE-4). (pp. 316-323), Tokyo, Japan.
20) Islam, MT. (2009). Bank Erosion and Movement of River Channel: A Study of Padma and Jamuna Rivers in Bangladesh Using Remote Sensing and GIS. Division of Geo informatics, *Royal Institute of Technology, Stockholm, Sweden*.
21) Islam, MT. (2010). River Channel Migration: A Remote Sensing and GIS Analysis. Conference: ESA Living Planet Symposium, Bergen, Norway.
22) Jian, W., Guixian, Q., & Guangjie, C. (2009). Channel sedimentation and erosion of the Jiangsu reach of the Yangtze River during the last 44 years. *Earth Surface Processes and Landforms*, **34**, 1587-1593. https://doi.org/10.1002/esp.1841
23) Khan, I., Ahammad, M., & Sarker, S. (2014). A Study on River Bank Erosion of Jamuna River Using GIS and Remote Sensing Technology. *Inter J. of Engineering Development and Research*, **2**(4), 3365-3371.
24) Khan, NI., & Islam, A. (2003). Quantification of erosion patterns in the Brahmaputra-Jamuna River using geographical information system and remote sensing techniques. *Hydrological Processes*, **17**(5), 959 - 966. https://doi.org/10.1002/hyp.1173
25) Kotoky, P., Baruah, J., & Sarma, JN. (2005). Nature of bank erosion along the Brahmaputra river channel, Assam, India. *Current Science*, **88**(4), 634–640.
26) Krantz, M. (1999). Coastal Erosion on the Island of Bhola, Bangladesh. Earth Sciences Centre: *Göteborg University*.
27) Kummu, M., Juha, S., & Jorma, K. (2008). Riverbank changes along the Mekong River: remote sensing detection in the Vientiane-Nong Khai area. *Quaternary International*, **186**(1), 100-112.
28) Mahmoodzada, AB., Hqbin, M. & Mahmoodzada, AS. (2019). Monitoring of Riverbank Erosion and Shoreline Movement at Amu River Using Remote Sensing and GIS: A Case Study in Jowzjan, Afghanistan. *Inter J. of Environmental and Rural Development*, **10**(1), 140-145.
29) Mani, P., Kumar, R., & Chatterjee, C. (2003). Erosion study of a part of Majuli River-Island using remote sensing data. *J Indian Soc Remote Sens*, **31**(1), 12-18.

30) Milton, EJ., Gilvear, DJ., and Hooper, ID. (1995). Investigating change in fluvial systems using remotely sensed data. In: A, Gurnell. and G, Petts (Eds), Changing river channels. (pp 276-301), *Wiley, New York*.

31) Mutton, D., and Haque, CE. (2004). Human Vulnerability, Dislocation and Resettlement: Adaptation Processes of River-Bank Erosion-Induced Displacees in Bangladesh. *Disasters*, **28**, 41-62. https://doi.org/10.1111/j.0361-3666.2004.00 242.x

32) Nath, B., Naznin, SN., & Alak, P. (2013). Trends analysis of riverbank erosion at Chandpur, Bangladesh: A remote sensing and GIS approach. *Inter J. of Geomatics and Geosciences*, **3**(3), 454-463.

33) Nipa N, Seddique AA, Hossain M, and Amin A. (2022). GIS based mapping and assessment of noise pollution in Gazipur city, Bangladesh. *Aust. J. Eng. Innov. Technol*., **4**(6), 121-129. https://doi.org/10.34104/ajeit.022.01070115

34) Ophra, SJ., Begum, S., Islam, R. & Islam, MN. (2018). Assessment of bank erosion & channel shifting of Padma River in Bangladesh using RS & GIS techniques. *Spat. Inf. Res*, **26**(3), 599-605. https://doi.org/10.1007/s41324-018-0202-2

35) Rahman, MR. (2010). Impact of Riverbank Erosion Hazard in the Jamuna Floodplain Areas in Bangladesh. *J. Sci. Foundation*, **8** (1&2), 55-65.

36) River Survey Project (1990). Morphological Characteristics. Final Report- Annex 5, FAP, Govt. of Bangladesh, Dhaka, pp. 10.1-10.5.

37) Sarkar, A., Garg, R., & Sharma, N. (2012). RS-GIS Based Assesssment of River Dynamics of Island of Brahmaputra River in India. *J. of Water Resources and Protection*, **4**, 63-72.

38) Sarmaet, JN., Borah, D., and Goswami, U. (2007). Change of river channel and bank erosion of the Burhi Dihing River (Assam), assessed using remote sensing data and GIS. *J. of the Indian Society of Remote Sensing*, **35**(1), 93-100.

39) Shajahan, A., & Reja, MY. (2012). Riverbank Erosion and Sustainable Planning Guidelines for Bangladesh with Emphasis on Padma River. *Inter Society of Habitat Engineering and Design*, **4**(2), 145-156.

40) Surian, N. (1999). Channel changes due to river regulation: the case of the Piave River, Italy. *Earth Surface Process and Landforms*, **24**, 1135-1151.

41) Uddin, K., Shrestha, B., & Alam, MS. (2011). Assessment of Morphological Changes and Vulnerability of River Bank Erosion alongside the River Jamuna Using Remote Sensing. *J. of Earth Science and Engineering*, **1**, 29-34.

42) United States Geological Survey, (2016). Retrieved October 2016 from the website: http://earthexplorer.usgs.gov

43) Winterbottom, JS., & Gilvear, JD. (2000). A GIS-based approach to mapping probabilities of river bank erosion: regulated River Tummel, Scotland. *Regulated Rivers Research & Management*, **16**(2), 127-140. https://doi.org/10.1002/(SICI)1099-1646(200003/04)16:23.0.CO;2-Q

44) Yao, Z., Ta, W., and Jia, X. (2013). Planform channel dynamics along the Ningxia–Inner Mongolia reaches of the Yellow River from 1958 to 2008: analysis using Landsat images and topographic maps. *Environmental Earth Science*, **70**(1), 97-106. https://doi.org/10.1007/s12665-012-2106-0

Citation: Siddeqa M, Islam MT, Rahman MS, Mukherjee A, and Shefa MS. (2023). GIS and RS based monitoring of bank erosion along with Meghna river at Bhola, Bangladesh. *Asian J. Soc. Sci. Leg. Stud.*, **5**(5), 172-178. https://doi.org/10.34104/ajssls.023.01720178