REPORT

Risk informed early warning system and non-migration pattern riverbank erosion areas

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CHAPTER 1: INTRODUCTION

BACKGROUND OF THE STUDY

Riverbank erosion is an important natural and dynamic geomorphic phenomenon, in which shorelines shift their position and bars within the stream migrate from their original location, due to the wearing away of the bank materials from the concave side of the bank *(Islam & Rashid, 2011; Chatterjee & Mistri, 2013)*. It is one of the most critical types of hazards, taking into account a large number of factors *(Hasan et al., 2018)*. The complex interaction between the highly variable channel hydraulic conditions and physical characteristics of the banks results in erosion in many parts of the rivers in the world. As a result, the fluvial and coastal environment of many countries of the world is affected by the physical, social and socio-economic aspects *(Das, Dutta, & Saraf, 2007; Pati, Lal, Prakash, & Bhusan, 2008; Varouchakis et al., 2016; Bhuiyan, Islam, & Azam, 2017)*.

Further, riverbank erosion has a natural trend of fluctuation *(Hasan et al., 2018)*. Alteration of river courses through changes in shape and depth is a continuous process, as rivers try to find a balance between the sediment transport capacity of the water and the sediment supply. Every river changes its course in the long term. However, short term changes are of vital importance, as these tend to affect people living along the banks of the rivers. High sediment load and heavy rainfall create a high volume and velocity runoff in the river, which concentrate in the lower drainages within the river's catchment area. Erosion occurs when the stress applied by these river flows exceed the resistance of the bank materials. With the increasing sediment load, fast flowing rivers erode their banks downstream *(Islam & Rashid, 2011)*. It is essential to identify the areas vulnerable to erosion in order to predict changes in river flow and to assist in stream management or restoration *(Varouchakis et al., 2016)*.

The significant parameters that affect the erosion rate of rivers have been reported by Hooke *(1979)*, Abam *(1993)*, Winterbottom & Gilvear *(2000)*, Atkinson, German, Sear, & Clark *(2003)*, Rinaldi, Mengoni, Luppi, Darby & Mosselman *(2008)*, Luppi, Rinaldi, Teruggi, Darby, & Nardi *(2009)*, Islam & Rashid *(2011)*, Rahman, Islam, & Rahman *(2015)*, Biswas & Islam *(2017)*, Bhuiyan et al. *(2017)* and Hasan et al., *(2018)*. These include: (i) the quantity of rainfall upstream, (ii) amount of runoff, (iii) stream power, (iv) water velocity, (v) changes in river course, (vi) rapid drawdown, (vii) sediment supply, (viii) topography and geomorphology of the riverbank, (ix) types and characteristics of river bank and bed materials, (x) pressure imbalance at the bank face, (x) changes in shear strength of the banks, (xi) vegetation cover and vegetation index (stability), (x) obstacle in the streams wind wave, (xi) structure types along the shoreline, boat wakes, density of development and anthropogenic activities near the bank. Among these, soil composition of the bank is critical, as banks composed of non-cohesive soils like sand and silt are very erodible *(Varouchakis et al., 2016)*, and presence of boulders and large rocks along the shoreline resist erosion *(Islam & Rashid, 2011)*.

Erosion is also facilitated by marine hydrodynamic processes such as tides, wave actions, storm surges and variations in the sea level in the coastal and estuarine areas *(Naus, Broekhoven, Rahmasary, Roosjen, & Waij, 2017)*. The argument about sea level rise facilitating erosion processes is bolstered by the records of tide gauges which show that extensive erosion is present in the areas where water is rising *(Bird, 1996; Goodbred & Kuehl, 1998; Sincavage, Goodbred, & Pickering, 2017; Wallace Auerbach et al., 2015)*. Erosion is a slow onset hazard that affects the environment, local ecosystem services and employment opportunities *(Shamsuddoha, Khan, Raihan, & Hossain, 2012)*. It significantly challenges the adaptive capacity of the people living near a river *(Mallick & Etzold, 2015)*. People affected by the hazard lose their home to the river and become displaced; which often compels them to migrate from their respective community in search of better accommodation and secured and better livelihood *(Shamsuddoha et al., 2012)*. So constant mobility of populace is associated with the continuous erosion of riverbanks and islands *(Nicholls et al., 2018)*.

Migrants are the people who remain outside of their residences for at least three months *(Shamsuddoha et al., 2012)*. The decision to migrate or to not migrate is influenced by multiple factors and is generally context specific *(Kolmannskog, 2008; Mallick & Etzold, 2015)*. Black and his colleagues *(2011)* introduced five drivers- including social, political, economic, environmental and demographic factors- which control the decision to move or to stay. Effects of these drivers are closely intertwined and 'be considered singly *(Black, Bennett, Thomas, & Beddington, 2011)*. However, an environmental change can manipulate all these drivers and force people to decide whether they want to stay or move away from the affected area for a better lifestyle. This decision takes into account various personal or household characteristics and intervening obstructions and facilitators *(Black et al., 2011)*. Whether people choose to migrate or are forced to migrate is still a matter of debate among scholars *(Barnett & Webber, 2009)*. There exist many who do not migrate or cannot migrate to other places even if they are exposed to a hazardous situation. Population Monograph of Bangladesh defined this populace as non-migrants, who have not moved from their residences in the last five years *(BBS, 2015)*. According to Mallick and Etzold *(2015)*, non-migration can be voluntary or forced. While voluntary non-migrants are expected to stable the resilience of the community, the forced or trapped populace de-establishes it *(Mallick & Etzold, 2015)*. Nonetheless, be it voluntary or forced, both are often overlooked and usually do not get any rewards.

EXISTING PRACTICES OF EARLY WARNING DISSEMINATION IN BANGLADESH

Early warning system (EWS) is a critical life-saving tool for river erosion affected community. Bangladesh Water Development Board (BWDB) under the Ministry of Water Resources (MoWR) has mandate to protect public and private properties situated on the banks of the major rivers as well as save the human life ahead of this hazardous event. And the DDM under the Ministry of Disaster Management and Relief (MoDMR) is responsible to provide early warning of the natural disasters. Currently there is no proper river erosion risk map in use in EWS in the country. To generate erosion prediction results initially for the Jamuna and later for the Ganges and the Padma River, the Government of Bangladesh established the Center for Environmental and Geographic Information Services (CEGIS) as a public trust under the Trust Act 1882 through registered Deed of Trust on 16 May 2002 with a view to disseminate the results to the national stakeholders. Since 2016, BRAC is a partner in the joint efforts to develop an integrated institutional framework to establish risk informed early warning system in erosion prone areas, including all relevant organizations concerned ministries. The risk informed early warning system can contribute to save lives and minimize the loss of properties and structural damage. To sustain economic growth of Bangladesh risk informed investment is required in alignment with the Sendai Framework Target E, Sustainable Development Goals 11 and 13.

CHAPTER 2: SELECTED STUDY AREAS

BRAC PROJECT BRIEF

The project '***Riverbank Erosion Risk Prediction and Early Warning Dissemination***' was undertaken by the BRAC and partnership with Center for Environmental and Geographic Information Services (CEGIS) in 2018 (March-June) with aim to establish risk informed early warning system for riverbank erosion at the community level. The project assessed the future risk and vulnerabilities of communities in riverbank erosion prone areas and identified the risk transfer mechanism. As a joint initiative since 2016, BRAC and (CEGIS) have been working on riverbank erosion risk prediction as a pilot project and implemented in two locations of Jamuna Right Bank (Bogra: Sariakandi) and Brahmaputra Right Bank (Kurigram: Char Rajibpur). Its purpose is to ensure that people who have been affected by riverbank erosion can prepare to relocate to safer shelters and minimize the damage sustained to them. The hostile rivers engulf settlements, roads, embankments, haat-bazaars and infrastructures including educational institutions, health centers and office buildings. In 2018, the project implemented in six river locations like: *The Padma Right Bank (Madaripur: Shibchar and Shariatpur: Bhedorganj, Zajira & Naria), Ganges Right Bank (Rajbari: Pangsha) and Jamuna-Brahmaputra Left Bank (Kurigram: Roumari, Bogra: Sariakandi).* Red and yellow flags are being used to indicate extremely risk-prone and moderately risk-prone areas on a community basis for advanced information dissemination on riverbank erosion. This information is being spread to communities through local volunteer teams which are helping people shift their homes to safer locations. In the short run, the project contributed to reduce the loss of property and infrastructural damages from erosion, which helped the communities to relocate to safer zones. In the long-run, BRAC will develop an institutional approach to disseminate early Warning on riverbank erosion at local level (from Union-Upazila-District) as well as at central level. BRAC, in partnership with CEGIS and DDM, will contribute in the development of resettlement framework and response strategy for displaced people in riverbank erosion areas. This initiative will help the government to develop a risk-informed investment plan and need-based budget allocation, as well as take appropriate social protection system for vulnerable group. The total cost of the project was above 13 lacs.

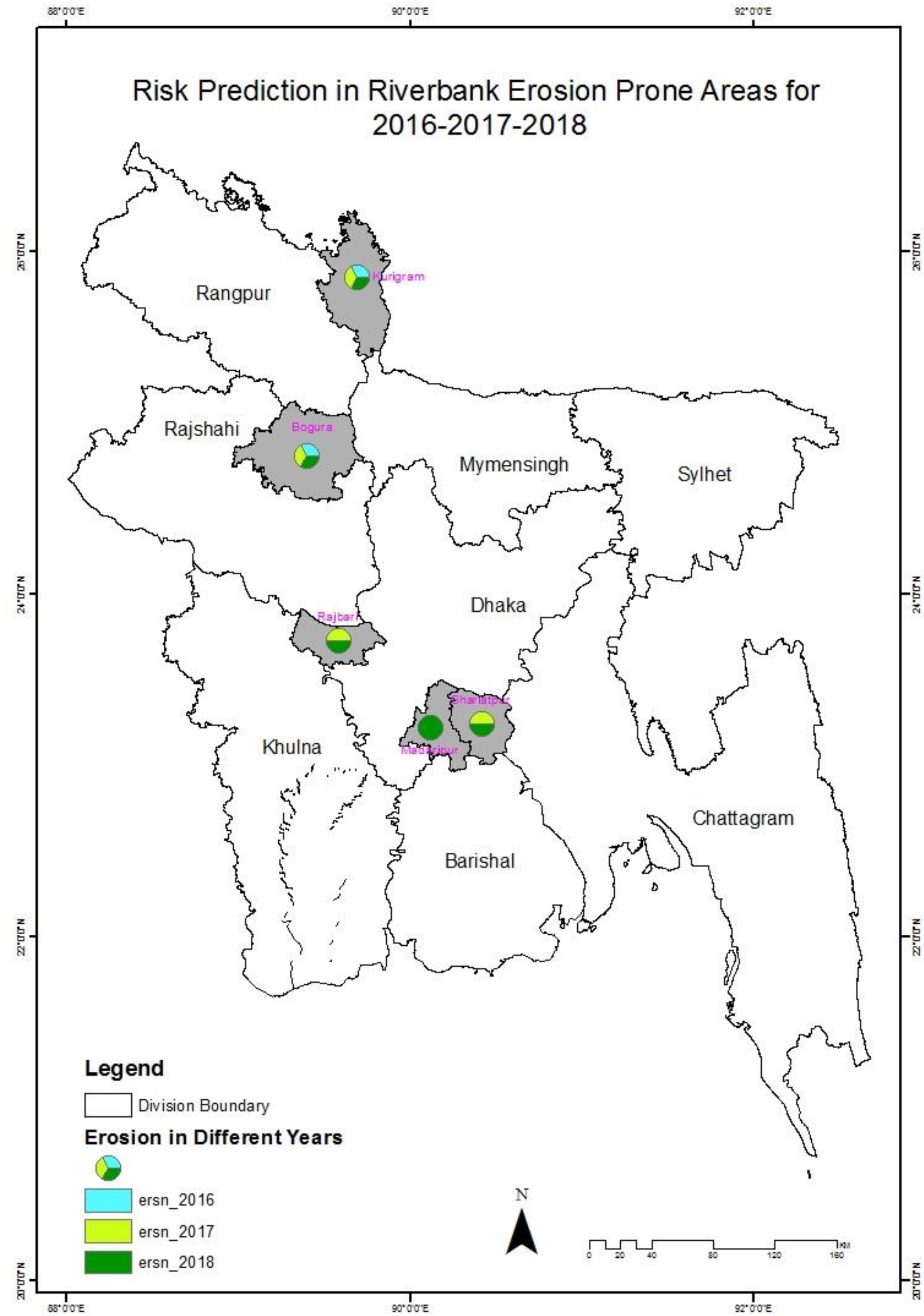


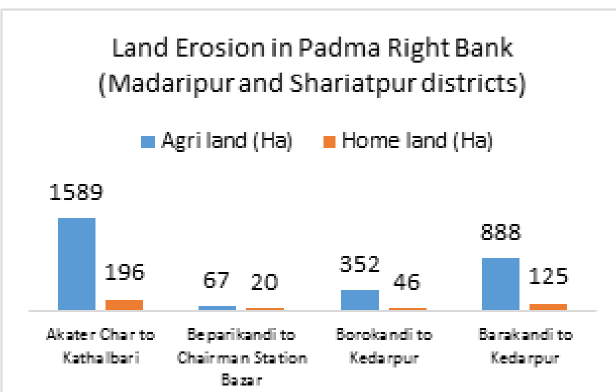
Figure: BRAC Project Location 2016-2018

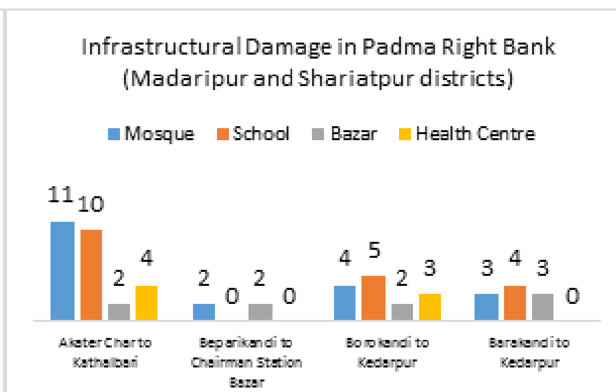
Table: Information from the Project Locations 2016-2018

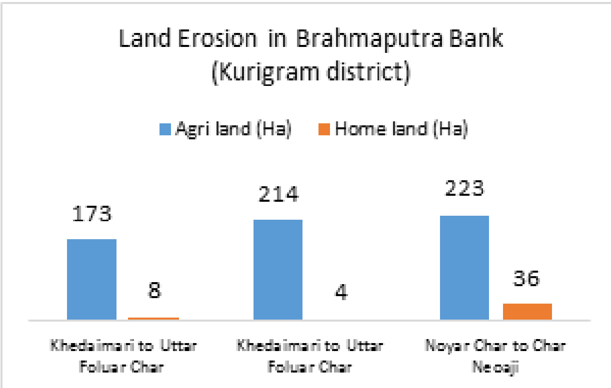
Year	River Locations	BRAC's Project Locations	Total Eroded Areas
2016	Total 2 locations Jamuna Right Bank: 1 Brahmaputra Right Bank: 1	2 districts, 2 sub-districts Bogura- Sariakandi Kurigram- Char Rajibpur	Total 12 km areas Total vulnerable HHs: 795
2017	Total 4 locations Brahmaputra Left Bank: 1 Jamuna Right Bank: 1 Ganges Right Bank: 1 Padma Right Bank: 1	4 districts, 5 sub-districts Kurigram- Raumari Bogura- Sariakandi Rajbari- Pangsha Shariatpur- Zajira & Naria	Total 32.20 km areas Total vulnerable HHs: 1348
2018	Total 6 locations Padma Right Bank: 3 Jamuna Left Bank: 1 Ganges Right Bank: 1 Brahmaputra Left Bank: 1	6 districts, 7 sub-districts Madaripur- Shibchar Shariatpur- Bhedorjang, Zajira & Naria Bogura- Sariakandi Rajbari- Pangsha Kurigram- Raumari	Total 50.2 km areas Total vulnerable HHs: 2339

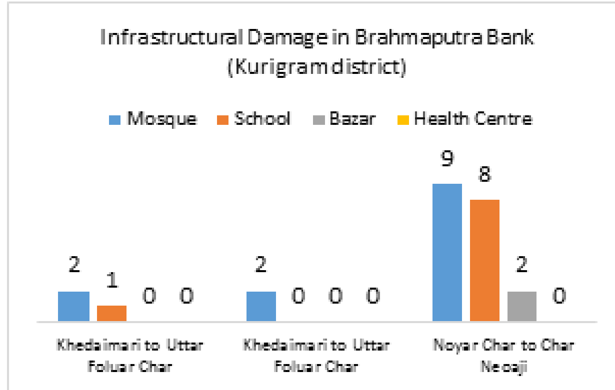
2016-2018: Loss and damages in the Padma-Jamuna-Brahmaputra-Ganges Banks

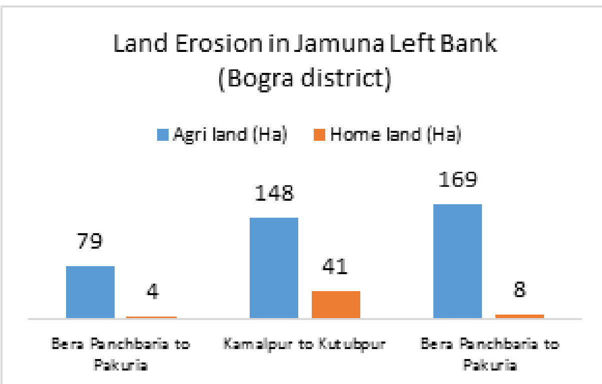
During 2016-2018, projection for loss and damage that a total of 4242 hectares of agricultural land and 514 hectares of homestead land and 4581 households eroded in the selected project locations. Infrastructural damage identified in 93.3 km areas (approx.) including; 36 religious institutes, 34 educational institutes, 18 bazars and 9 health complex and centres.

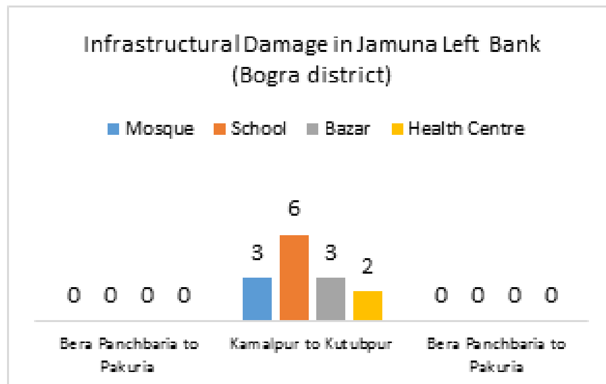


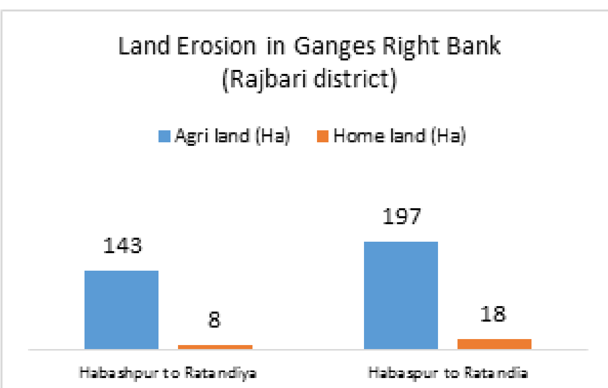


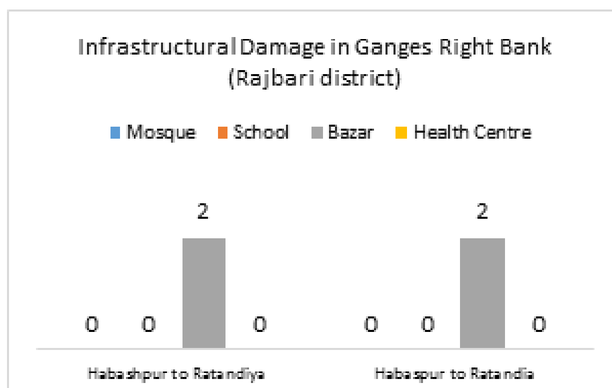












BEYOND THE BRAC PROJECT LOCATIONS: A CASE STUDY IN BHOLA

According to the Bangladesh Delta Plan 2100, the three main rivers of the country can be taken as proxies when considering riverbank erosion hazard. Hectares of land areas adjacent to these dynamic rivers suffer from erosion every year. During the rainy season when the flow of water is excessively high, erosion of the shorelines further increases. Water flow in the Meghna Estuary erodes about 2900 hectares of land every year *(GED, 2015)*. Bhola, the only island district of Bangladesh, is situated in the Meghna Estuary. According to the Bangladesh Meteorological Department, the district suffers from flood and erosion hazards *(BBS, 2011)*. The district falls under two of the six hotspots as mentioned in the Bangladesh Delta Plan 2100, namely the Coastal Zone and the Riverine and Estuarine Zone. These hotspot areas are categorized as having similar types of hydrological and climatological problems. Bhola is a part of both, as it is susceptible to both flood and erosion hazards *(GED, 2015)*. For this study, a small village named Ramdaspur under Rajapur union of Bhola Sadar Upazila was selected.

According to the BBS District Report, Bhola is the largest riverine delta island of the world. This offshore island in the Meghna Estuary has an area of 3403.48 square kilometers. The district lies in between 21°54' and 22°52' north latitudes and 90°34' and 91°01' east longitudes. On the north side of the district lies the Lakshmipur and Barisal district and on the south lies the Bay of Bengal. Lower Meghna River and Shahbazpur Channel are on the east side of Bhola, beyond which lies Noakhali and Lakshmipur districts. On the west are Patuakhali district and the Tetulia River *(BBS, 2011)*.

Bhola district under Barisal division has seven upazilas, 68 unions, 438 villages, five pourashavas, and 45 wards. The selected study area falls under one of the seven upazilas under the district, namely Bhola Sadar Upazila. The total land area of the upazilas 368.74 square kilometers and the area under river includes 44.42 square kilometers *(BBS, 2011)*. Bhola Sadar Upazila is located between 22°32' and 22°52' north latitudes and between 90°32' and 90°44' east longitudes. Sadar Upazila of Lakshmipur, and Mehendiganj Upazila and Hizla Upazila of Barisal are to the north of this upazila. On the east is Daulatkhan Upazila of Bhola. Baufal Upazila of Patuakhali and Burhanuddin Upazila and Daulatkhan Upazila of Bhola are located to the south side. On the west are Mehendiganj Upazila, Barisal Sadar Upazila and Bakerganj Upazila of Barisal district *(BBS, 2013)*.

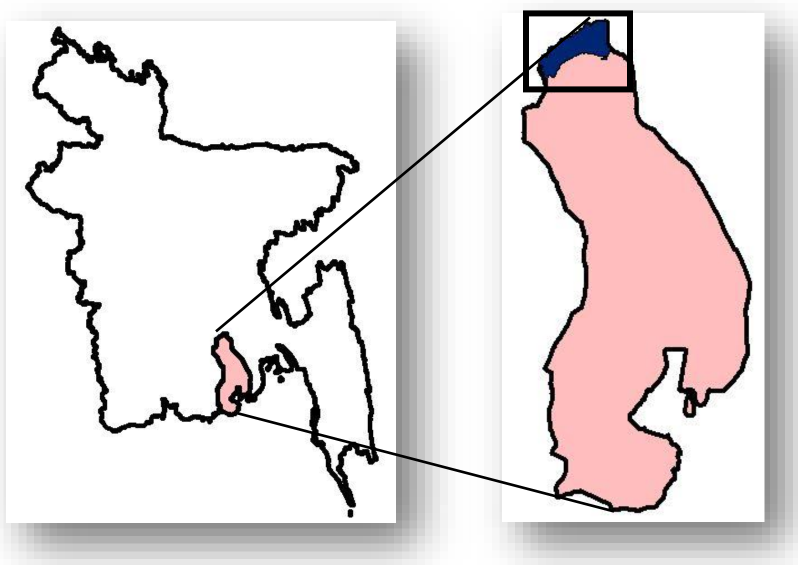


Figure: Geographical position of the study area

There are 13 unions and 108 villages under Sadar upazila. Out of these thirteen, the study village named Ramdaspur falls under the jurisdiction of Rajapur Union. Rajapur union is the northernmost union under this Upazila *(BBS, 2011)*. Very few information is available about this village, excluding the ones presented in the 2011 census report.

Figure: Position of Ramdaspur village in Rajapur union (Source: Google Earth Image, 2018)

CHAPTER 3: STUDY APPROACHES

METHODOLOGY ADOPTED BY BRAC PROJECT

The project 'Riverbank Erosion Risk Prediction and Early Warning Dissemination' was undertaken by the BRAC with technical assistance of Center for Environmental and Geographic Information Services (CEGIS) from 2016 to 2018 with an aim to establish risk informed early warning system for riverbank erosion at the community level. The project assessed the future risk and vulnerabilities on communities in river bank erosion prone areas and identify the risk transfer mechanism.

The riverbank erosion prediction results were developed using scientific and empirical methods of CEGIS to identify the high and moderate erosion risk prone areas of Bangladesh along the rivers Brahmaputra, Jamuna, Ganges, Padma and Lower Meghna. The prediction is made mainly based on the multi-spectral dry season satellite images of IRS LISS III (24m X 24m resolution) and LANDSAT (30m X 30m resolution) covering the above mentioned rivers. The predictions are made one year ahead using information on the planform characteristics of the river as observed in dry season satellite images. After geo-referencing of the images, a number of field visits were made for ground truthing. The characteristics of bank materials along the study reaches of the rivers are covered along with field data collection. Different features such as erosion pattern along the banks of the rivers for different periods, meandering bend development, life of meandering bends, changes in platform over time, future planform development etc. are analyzed based on optical images. The flow diagram below depicts the overall methodology adopted by CEGIS for erosion prediction.

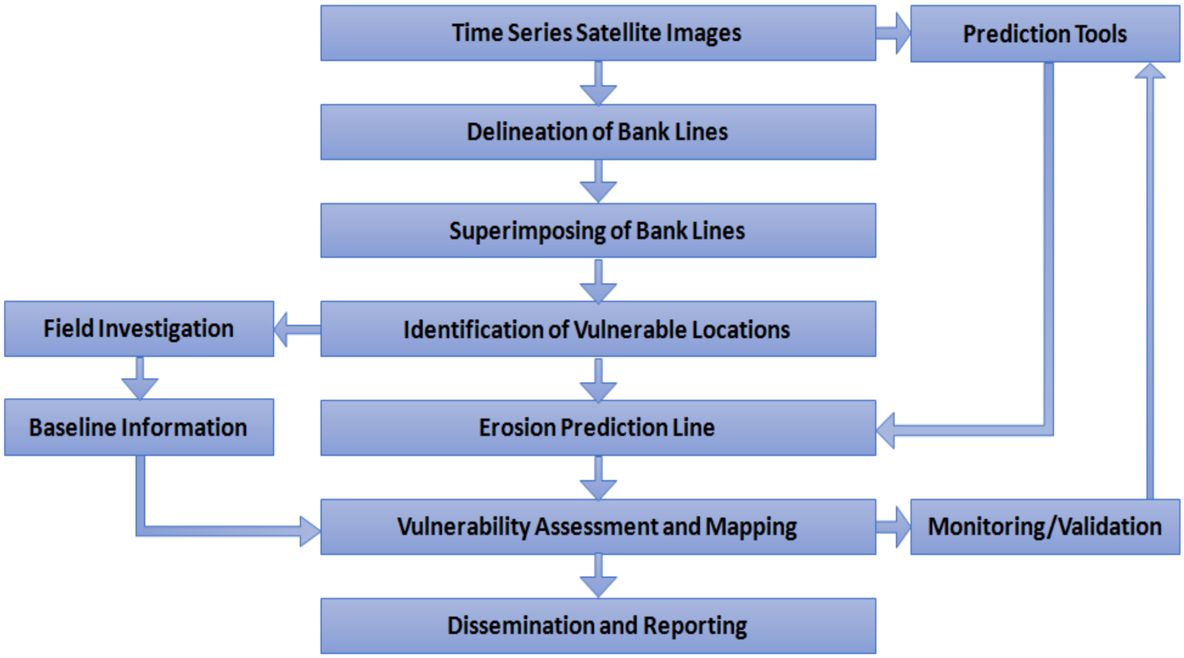


Figure: Riverbank Erosion Prediction Methodology

METHODOLOGY ADOPTED FOR THE STUDY AREA IN BHOLA

The study broadly contains two different parts. The first part employed GIS tools to delineate the change in the shoreline of the village to see the rate of erosion and accretion in the study village during the period of 1993 to 2018. The second part consisted of a field visit to the village to survey the households with some prepared structured questions.

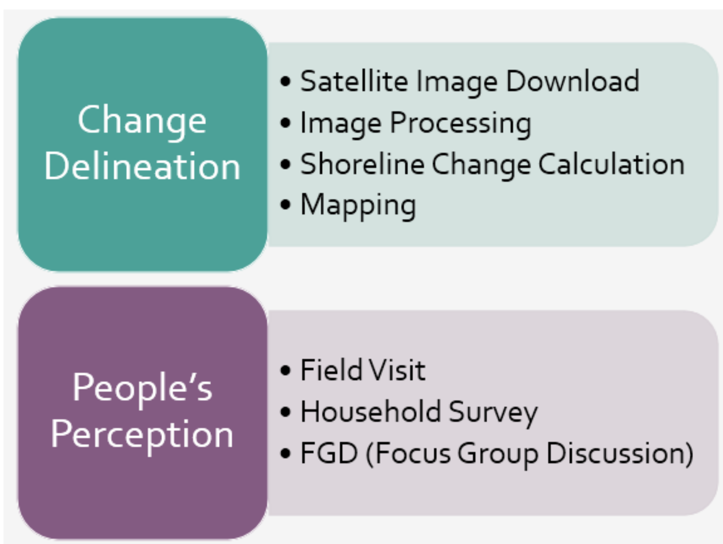


Figure: Study approaches adopted for Ramdaspur village

CHANGE DELINEATION

Six Landsat satellite images from six different years with a resolution of 30 meters were downloaded to delineate shorelines of the study area. Landsat path 137 and row 44 captures the whole study area, so all the images are selected from this scene only. The following table represents the important information about the images. As the study area is predominantly influenced by fluvial activities, tidal influences have not been taken into account. All the scenes were taken at the day time. Images from 2003 and 2013 were not available or were with high cloud cover. So, instead, images of 2004 and 2014 were downloaded for the analysis.

Table: List of Landsat images used in the study

Date	Dataset	Sensor	Cloud Cover
11/15/1993	Landsat 5	TM	1%
10/28/1998	Landsat 5	TM	0%
11/29/2004	Landsat 5	TM	0%
11/24/2008	Landsat 5	TM	0%
11/25/2014	Landsat 8	OLI-TIRS	0.01%
11/20/2018	Landsat 8	OLI-TIRS	2.97%

In order to differentiate land from water, MNDWI approach has been adopted. For this, only Green band and MIR band are required. According to the USGS website, bands 2 and 5 in Landsat 5 and bands 3 and 6 in Landsat 8 represent the previously mentioned bands *(USGS, 2014)*. Raster Calculator in ArcMap 10.3 calculates the value of MNDWI, which ranges from -1 to +1. The higher reflectance of the built-up area and lower reflectance of water in the SWIR band result in negative values of the built-up area, and positive values of water features in the MNDWI derived image *(Xu, 2006)*. From the derived raster file, the shoreline of the study village has been generated automatically. It has been done by converting the raster file to vector (polygon) file, and then by converting the polygon to polylines using Spatial Analyst tools.

In order to measure the rate of change, Digital Shoreline Analysis System (DSAS) extension in ArcGIS has been used in this study. DSAS version 4.3 is compatible with ArcMap 10.3. The change is analyzed from a pre-defined baseline, which has been generated relative to existing shorelines with a buffer area of 150 meters. The transects are created at 20 meters interval, with a 95% confidence interval and 5 meters of uncertainty. Various statistical approaches are available within the tool to help calculate the shoreline change. For this study, the End Point Rate (EPR) is deemed most appropriate. EPR is measured by dividing the distance of shoreline movement due to erosion or accretion by the time elapsed between these shorelines from two years *(Thieler, Himmelstoss, Zichichi, & Ergul, 2009)*. As the change in shoreline for the study area is very complex, shorelines of two years at five years interval have been taken for analysis. DSAS calculation represents erosion in negative values and accretion in positive values *(Sarwar & Woodroffe, 2013)*.

FIELD VISIT AND SURVEYING THE HOUSEHOLDS

Quantitative data were collected from the questionnaire surveys conducted during the field visit. One hundred fifty households from the village had been randomly selected for the survey. According to the

2011 census, the village has about 1760 households *(BBS, 2011)*. This number is expected to increase in the following years. With 95% confidence level and 8% margin of error, the required sample size would be 140 for approximately 2000 households. So, selection of 150 households was considered statistically precise, even if the number of households increased. There were 30 different questions regarding their necessary household information, riverbank erosion scenarios and the factors influencing their non-migration decisions.

CHAPTER 4: RESULT AND DISCUSSION

RIVERBANK EROSION PATTERN IN BRAC PROJECT LOCATIONS

In 2016, total 38 erosion prone locations were identified from three major rivers by CEGIS. BRAC selected 2 locations for early warning disseminations. In 2017, the total number of predicted erosion vulnerable locations were 29. Bank erosion was predicted for 20 locations of the Jamuna, 5 locations of the Ganges River, and 4 locations of the Padma River. BRAC selected 4 locations for the project intervention. In 2018, bank erosion was predicted for 22 locations. 15 locations of the Jamuna, 4 locations of the Ganges River and 3 locations of the Padma River were identified as vulnerable to erosion. Among these, BRAC expanded its project intervention in 6 locations. A total of about 270 hectares and 515 hectares of land along the right and left banks respectively of the Jamuna River, about 205 hectares of land along the Ganges River, and about 1280 hectares land along the Padma River are identified as vulnerable to erosion in 2018 considering 50% probability range.

Table: Selected River Locations for the Project Implementation in 2016-2018

Year	River Locations	BRAC's Project locations 2016-2018	Total eroded areas (km) and risk identification system
2016	**Total 2 locations** Jamuna Right Bank: 1 Brahmaputra Right Bank: 1	**2 districts, 2 sub-districts** Bogura- Sariakandi Kurigram- Char Rajibpur	**Total** 12 km areas **Demarcation system:** Red flags used: 50 Yellow flags used: 70 Total vulnerable HHs: 2339 Total Budget: 880000 BDT
2017	**Total 4 locations** Brahmaputra Left Bank: 1 Jamuna Right Bank: 1 Ganges Right Bank: 1 Padma Right Bank: 1	**4 districts, 5 sub-districts** Kurigram- Raumari Bogura- Sariakandi Rajbari- Pangsha Shariatpur- Zajira & Naria	**Total** 32.20 km areas **Demarcation system:** Red flags used: 122 Yellow flags used : 165 Total vulnerable HHs: 1348 Total Budget: 655276 BDT
2018	**Total 6 locations** Padma Right Bank: 3 Jamuna Left Bank: 1 Ganges Right Bank: 1 Brahmaputra Left Bank: 1	**6 districts, 7 sub-districts** Madaripur- Shibchar Shariatpur- Bhedorjang, Zajira & Naria Bogura- Sariakandi Rajbari- Pangsha Kurigram- Raumari	**Total** 50.2 km areas **Demarcation system:** Red flags used: 235 Yellow flags used: 254 Total vulnerable HHs: 894 Total Budget: >1000000 BDT

PREFERRED DESTINATION FOR MOVEMENT IN BRAC PROJECT LOCATIONS

In 2018, the inhabitants of Madaripur and Rajbari districts, who are vulnerable to riverbank erosion, mentioned their preferred destination if displaced by the disaster. A radar chart has been formulated to show this preferred movement pattern.

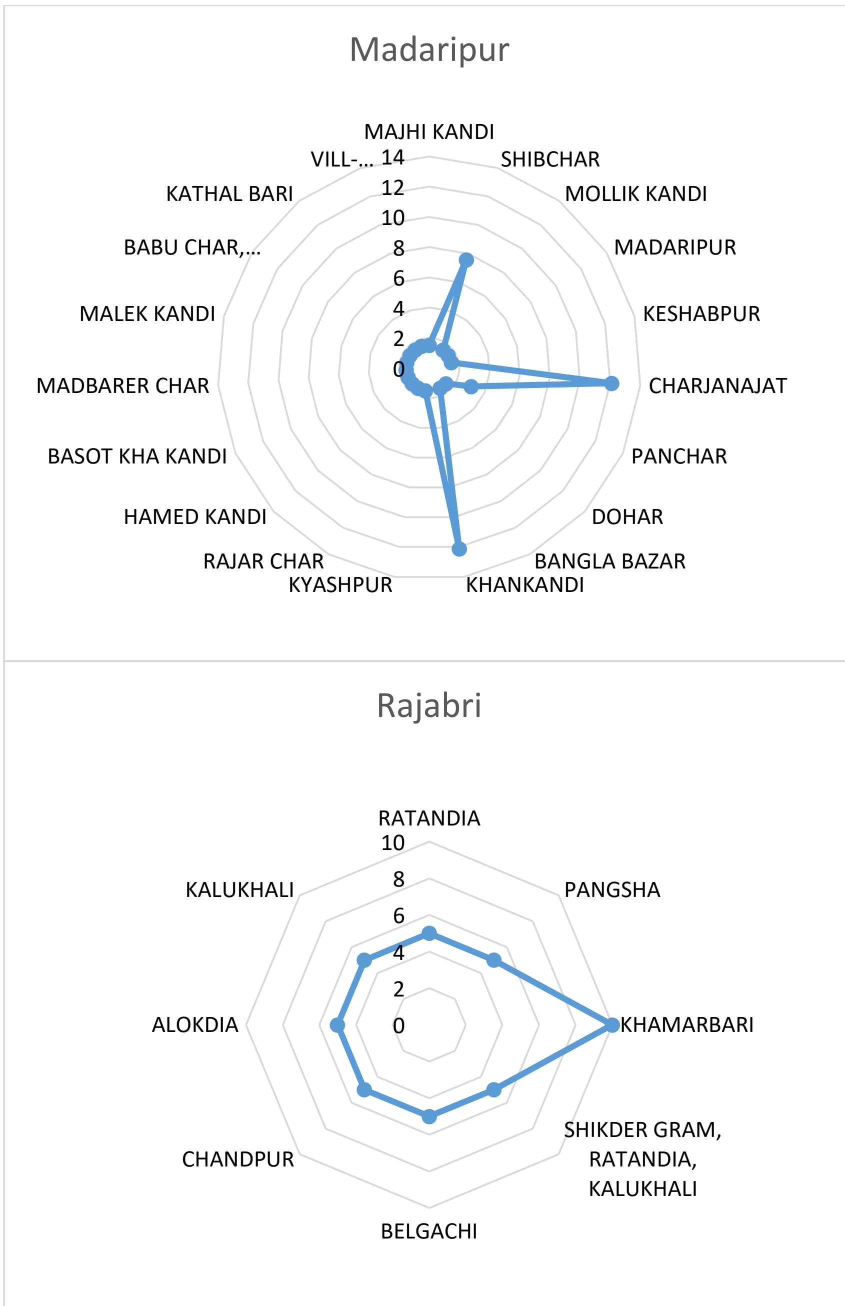


Figure: Percentage of people of Madaripur and Rajbari towards their preferred destination

RIVERBANK EROSION PATTERN IN RAMDASPUR VILLAGE

The entire village Ramdaspur under Rajapur Union in Bhola went through rapid erosion in the last 25 years (1993-2018). When analyzing the satellite images, two images- each 4 or 5 years apart- are considered to understand the whole picture of erosion and accretion. It is done by measuring the rate of change of shorelines in the village using the Digital Shoreline Analysis System (DSAS) tool in ArcMap. Though there are some data indicating accretion in these 25 years, this is negligible considering the amount of total land eroded. Thus the shoreline changed drastically in this timeline. Maps showing erosion and accretion in the study village with five years interval each for the timeline above is given in Appendix A.

The following table depicts the data found from measurements derived using the DSAS tool in ArcMap. The average rate of erosion for the 25 years (1993-2018) was 260.66 meters per year.

Table: Highest rates of erosion and accretion in Ramdaspur village between the years 1993 and 2018

Years	***1993-2018***	***1993-1998***	***1998-2004***	***2004-2008***	***2008-2014***	***2014-2018***
Erosion rate (m/yr)	260.66	219.57	126.88	552.10	706.30	141.42
Accretion rate (m/yr)	0	29.15	215.55	180.54	0	1.74
No. of eroding transects	167	600	401	397	4745	332
No. of accreting transects	0	30	172	237	0	1
No. of unchanged transects	0	0	0	35	0	0
Total no. of transects	167	630	573	669	4745	333
Interval between transects (m)	20	20	20	20	1	10
Uncertainty (m)	5	5	5	5	5	5
Confidence Interval (%)	95	95	95	95	95	95

Maximum erosion occurred during the 2008-2014 timeline, with erosion rate about 706.30 meters per year. No accretion occurred during these years. Highest accretion rate of about 215.55 meters per year can be seen during 1998-2004 timeline. Erosion process also continued during this period, with a rate of 126.88 meters per year. No specific trend of erosion and accretion is present in this area. However, the erosion rate has significantly decreased in recent years (2014-2018). The land has eroded at a rate of 141.42 meters during this timeline, with a negligible amount of accretion of about 1.74 meters per year.

NON-MIGRATION PATTERN OF INHABITANTS IN RAMDASPUR VILLAGE

Only a few of the surveyed households have migrant family members working and living outside the village. They are mostly in Dhaka. About 70% of the surveyed households have no migrant member in the family. Only two households out of the 150 reported that they are planning to migrate from the village within one year. One of these two families has the house very near the riverbank to the east of the village, which is on the verge of being eroded.

Only 24% of the surveyed households own land outside Ramdaspur Village. These families have the chance to migrate to those places to save them from continuous erosion. Most of these owned lands are in Noakhali District. The rest 14 households among the 36 surveyed households bought land in another union in Bhola, or Barisal. Only a few had land in Dhaka.

34% of the respondents said that they have no plans to move somewhere else other than the village. They will take measures if they are compelled to move out due to riverbank erosion. Another 21% of the surveyed households want to remain in this village no matter the situation. So, more than half of the surveyed households (55%) are non-migrant out of their own free will. The rest 45% wants to move away from the village, but are not capable of doing so due to several driving factors. These households were asked about their preferred destination for migration, given that they get the chance to migrate to a safe place. The respondents mentioned different places, which in most cases preferred for having a better chance of finding a job to support the family. These places include- another village within the same union (Rajapur Union) of Bhola on the other side of the river, another union within Bhola district, MehendiganjUpazila of Barisal district, Noakhali district and Dhaka district. Noakhali district is chosen by maximum as their preferred place to move to, with Dhaka being the second in this list. Noakhali was chosen due to being close to the village. Dhaka was chosen because of better employment opportunities. The following graph shows the percentage of people towards their preferred destination.

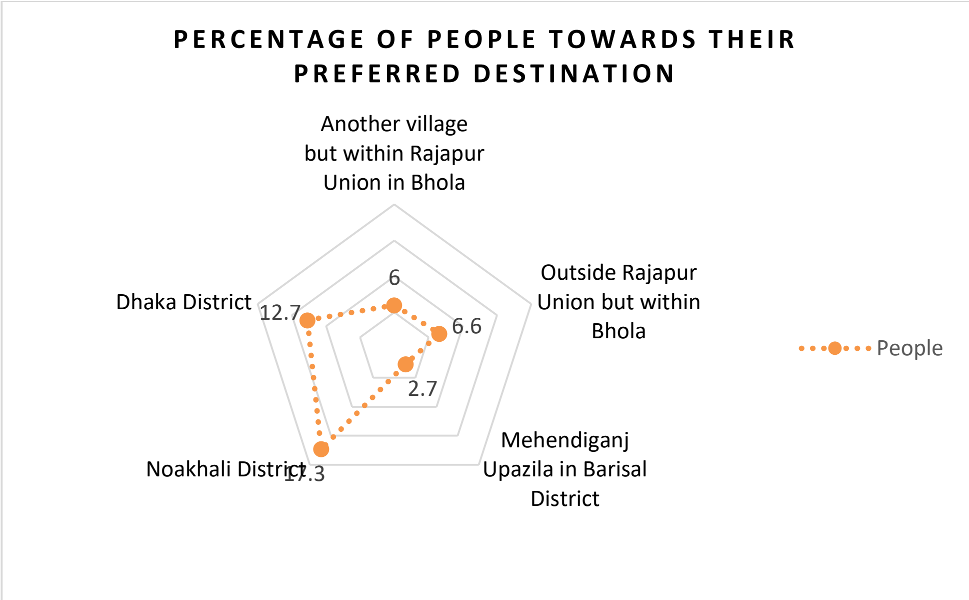


Figure: The preferred destination for the surveyed forced non-migrants

The respondents were asked to point out the factors which influence them not to migrate from the village to another location. By employing principal component analysis, a total of 11factors have been observed which influence a households' decision to migrate or not.

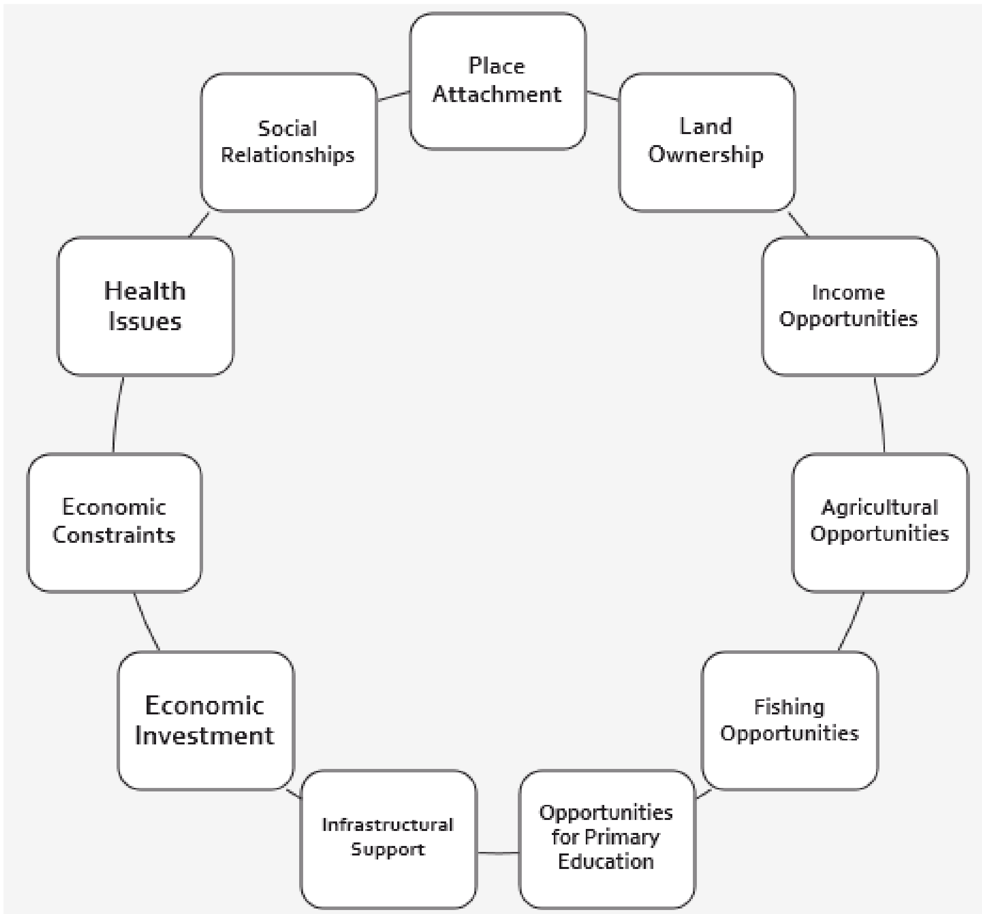


Figure: Driving factors to non-migration for the study area

The reasons behind choosing these factors, as stated by the surveyed households, are as follows.

1. Place Attachment
    - Attachment to the village as the birthplace
    - Presence of house and trees in the village
2. Land Ownership
    - The low price of land near the river
    - Low cost of living in the village
    - Presence of owned land in the village
    - No land owned outside of the village, so nowhere else to go
3. Income Opportunities
    - Fewer options for suitable livelihood outside the village
    - Easy and better income source in the village than outside

4. Agricultural Opportunities
    - Cheaper access to agricultural land
    - Better productivity in the village
    - Easy to rear cattle in the village because of open spaces
5. Fishing Opportunities
    - Easy to catch fish from the village than elsewhere
    - Fisherman card provided by the government for ration
6. Opportunities for Primary Education
    - Cheaper access to primary education in the village
    - Presence of primary schools in close distance
7. Infrastructural Support
    - Wants to live near the river due to work
    - Financial support provided by migrant family members
    - Easy to commute to surrounding places through water-vehicles
8. Economic Investment
    - Has a business in the village
9. Economic Constraints
    - Limited financial ability to move elsewhere
    - Indebtedness of the household
10. Health Issues
    - Presence of sick and disabled family member
11. Social Relationships
    - Strong bonding among neighbors
    - Presence of other family members in the village
    - Gets benefit from staying in the village

Policy implications: River Erosion Displacement Management Framework

Pre Displacement: Preparedness, Risk reduction, pre-financing (only migrants)

Strategic Response: Preventing displacement while also ensuring that migration/displacement that takes place is managed. In the context of environmental degradation, such as sea-level rise or desertification, which can render some areas uninhabitable, it also means preparing for relocation/resettlement.

Major Activities (Prevention & Preparedness):

1.1 Understanding the Risk and Decision Making Supports:

1.3 Investing in DRR and CCA

1.4 Creation of Employment through Encouraging Decentralization of Urban Growth Centres

1.5 Disaster Risk Responsive Land Use Plan and Programme

During Displacement Phase: Response (focused on non-migrant community, forced migration)

Strategic Response: When displacement occurs, it is important to intervene quickly and decisively to manage it and address urgent humanitarian needs as well as to ensure effective protection.

Major Activities (Management of Displacement – Emergency Response)

2.1 Strengthening Humanitarian and Disaster Relief Assistance

2.2 Protection: Safe Shelter and Housing Facilities, Identify available Khas land in consultation with the Ministry of Land and in line with the National Land Use Policy (2001) for ensuring access of homeless, social allowances for displaced people,

Post Displacement: Long term solution-resettlement, Occupation restoration (both)

Strategic Response: Displacement needs to be addressed to avoid protracted situations through durable solutions – return, local integration and relocation/resettlement or ensuring sustainable return. If return is not possible or not wanted, local integration or resettlement should be considered. The durable solution is achieved only when displaced persons no longer require any specific assistance and protection needs that are connected with their displacement.

CHAPTER 5: RIVERBANK EROSION PREDICTION FOR 2019 AND 2020

CEGIS has provided erosion prediction for the Jamuna, the Ganges and the Padma rivers for the years 2019 and 2020. Information about the prediction is given in this chapter.

Table: Erosion Prediction for 2019

River	District	Land (ha)	Settlement (ha)	Educational Institute	Hat/ Bazar	Health Center	Mosque/Mondir
Jamuna	Kurigram	254	40	6	0	0	3
	Jamalpur	16	5	1	0	0	0
	Gaibandha	165	38	7	0	1	4
	Bogura	106	9	1	0	0	0
	Sirajganj	194	43	8	0	1	5
	Tangail	376	109	3	1	0	7
	Manikganj	131	19	1	0	0	0
Ganges	Pabna	50	1	0	0	0	0
	Rajshahi	44	1	0	0	0	0
	Rajbari	326	18	2	0	0	1
Padma	Faridpur	260	13	1	0	0	1
	Shariatpur	352	125	5	4	3	11
	Madaripur	588	74	0	0	0	1
Total		2862	495	35	5	5	33

Table: Erosion Prediction for 2020

River	District	Land (ha)	Settlement (ha)	Educational Institute	Hat/ Bazar	Health Center	Mosque/Mondir
Jamuna	Kurigram	363	62	6	0	0	5
	Gaibandha	292	68	7	0	1	5
	Bogura	136	12	1	0	1	0
	Sirajganj	278	61	20	1	1	5
	Tangail	556	164	4	1	0	7
	Jamalpur	24	10	1	0	0	0
	Manikganj	161	24	1	0	0	0
Ganges	Rajshahi	86	1	0	0	0	0
	Pabna	110	5	0	0	0	0
	Rajbari	564	26	3	1	0	1
Padma	Faridpur	435	21	1	0	0	1
	Shariatpur	600	226	11	4	3	18
	Madaripur	875	105	0	0	0	1
Total		4480	785	55	7	6	43

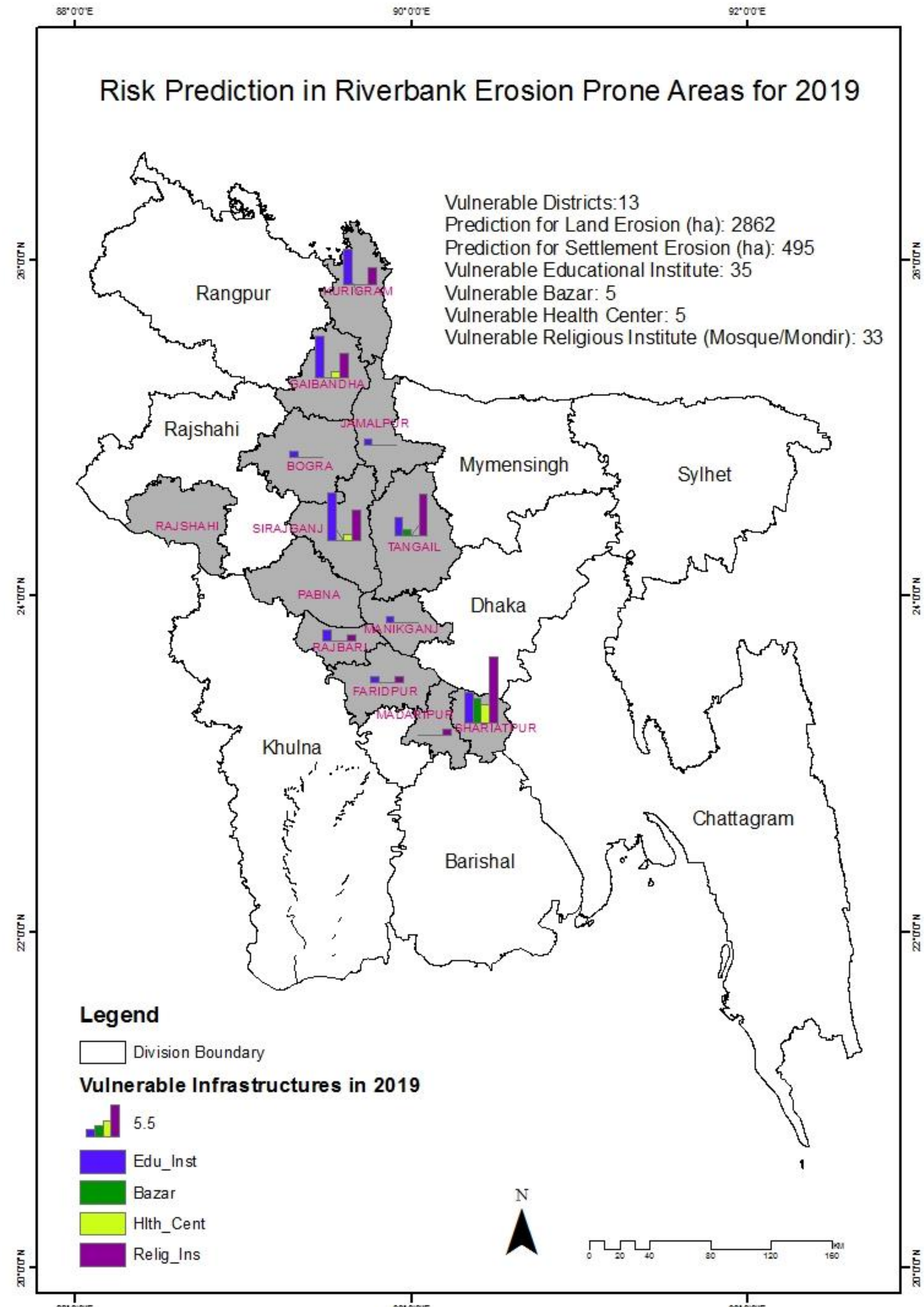


Figure: Riverbank erosion prone areas for 2019

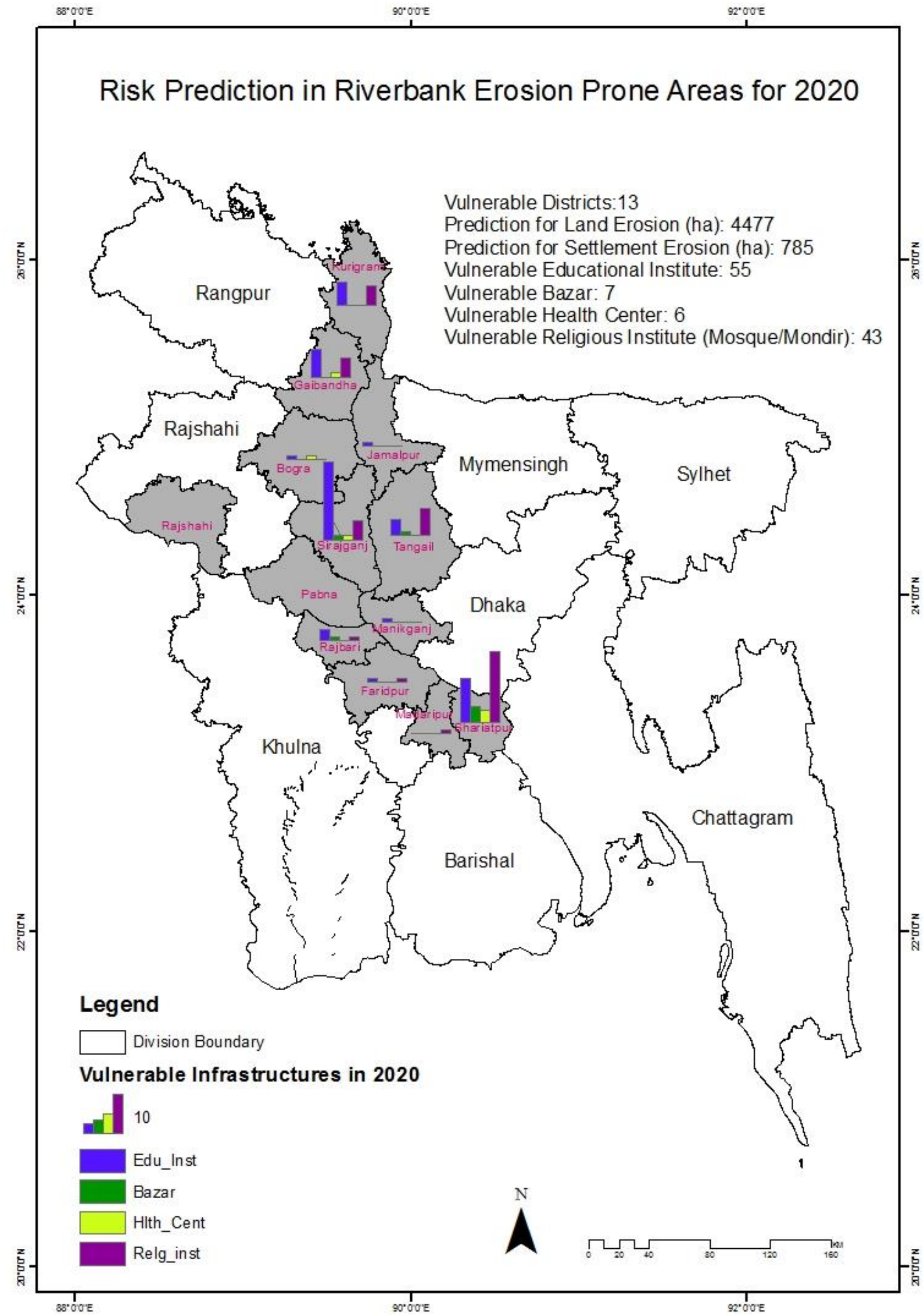


Figure: Riverbank erosion prone areas for 2020

CHAPTER 6: CONCLUSION

At present, there exists no policy which focuses on the rehabilitation of the displaced populace due to riverbank erosion. It is mostly due to the lack of means to identify the people who suffer from riverbank erosion. The Center for Environmental and Geographic Information Services (CEGIS) in Bangladesh provides erosion prediction information for the two main rivers except for the Meghna River, making the already vulnerable people living in this area more at risk for not getting any information on erosion hazard. Structural measures against riverbank erosion are costly and mostly limited to the area with historical, economic and political significance. Therefore, villages like Ramdaspur village in Bhola are at risk of being eroded without any proper measures against the phenomenon. These people should be included in the erosion prediction measures taken by various institutions. It is also recommended that a policy is formulated focusing on the rehabilitation of the populace who are living in the erosion-prone areas. Such steps can make them less vulnerable to erosion disasters and can save the possible loss of public and private assets at those locations.

Integrated plans must be accepted to minimize damages caused by riverbank erosion and relocate people to safer shelters. This is needed to decrease the risk of natural disasters and make people feel relatively less helpless due to nature. The matter of ensuring social safety net coverage to those who have been relocated due to riverbank erosion needs to be given importance. Families affected by riverbank erosion usually make concerted efforts to make sure that they do not have to forsake their society and culture and can maintain their standards of living. More specific organizational planning and services are required if these disaster-stricken areas and helpless people are expected to adapt to this reality.

Considering all, a joint-venture erosion prediction program of DDM-CEGIS-BRAC would initiate to institutionalize the early warning system of river bank erosion to the community and local level stakeholders for reducing livelihood risk and lessen the loss of public-private properties through disaster preparedness ahead of the incidences as well as to bring the erosion victims under an appropriate Social Safety Net Programs (SSNP).

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