

**VULNERABILITY, RISK PERCEPTION, AND LIVELIHOOD STRATEGIES AMONG
RIVERSIDE COMMUNITIES OF RAMGATI UPAZILA IN BANGLADESH: THE
ROLE OF EMBANKMENT**

By

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Due to its geographical location and socioeconomic conditions, the country of Bangladesh is vulnerable to the hazard of riverbank erosion, which poses a significant threat to homes, property and livelihoods. In recent years, the government of Bangladesh has intensified efforts to mitigate riverbank erosion by hardening shorelines, including the building of concrete revetments, but the local dynamics of these interventions is not well-documented. This thesis presents results from a study of risk perception and livelihood adaption following the construction of a 3.5 kilometer concrete revetment in the administrative district of Ramgati in the lower Meghna River basin of Bangladesh. Drawing on data from a community survey (n=381), as well as interviews (n=24) with key informants and local households, this research has three principle aims: first, to document the socio-economic conditions of local residents and their vulnerability to the impacts of riverbank erosion; second, to identify local adaptation responses against riverbank erosion in Ramgati, including the factors leading to the construction of the revetment; and third, to examine the changing livelihood patterns and risk perceptions of Ramgati residents in the context of the newly-built revetment. To do so, the study assessed the association between location and socioeconomic

status and perceptions and livelihood responses, and compared the views of households now protected by the revetment and those who live in areas still subject to riverbank erosion. This study concludes that households in Ramgati are vulnerable to riverbank erosion due to their dependence on primary occupations. Riverbank erosion has led to the loss of houses and lands, and has had a negative impact on the socioeconomic development of the Ramgati area. Results from this study show that the recently built revetment has had a positive impact on local livelihoods and has altered the risk perception of residents. Households protected by the revetment report that they are doing well in their occupations and are less worried about riverbank erosion than households that remain unprotected.

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CHAPTER 1

Introduction

1.1 The Problem of Riverbank Erosion in Bangladesh

Riverbank erosion is a common geomorphological phenomenon in fluvial and coastal environments, particularly under dynamic hydrological conditions such as flood events. It is a natural ecological process but it can have negative impacts on property and infrastructure (Florsheim et al., 2008) as well as people who live near the river (Bhuiyan et al., 2017).

Every year Bangladesh loses a significant amount of lands due to riverbank erosion, making it one of the most common disasters in Bangladesh. Due to riverbank erosion the riverside communities lose not only land, but houses and other infrastructure (Bhuiyan et al., 2017; Rabbi et al., 2013). In severe cases, it can push local residents toward *monga*, a Bengali word that refers to the cyclical phenomenon of hunger and poverty (Rabbi et al., 2013). Riverbank erosion also forces affected households to migrate, often putting them in an even more vulnerable situation (Bhuiyan et al., 2017; Rahman and Gain, 2020). Ultimately, riverbank erosion hinders the socio-economic, cultural, psychological and environmental development of riverside areas (Rahman & Gain, 2020), and decreases the economic potential of its victims (Alam et al., 2017).

Bangladesh is particularly vulnerable to riverbank erosion due to its geographical location. It is located in the downstream portion of the Ganga-Brahmaputra-Meghna (GBM) river system, which comprises the largest delta in the world. The delta region has 700 rivers, canals, and streams, with a total length of approximately 22,155 kilometers (Bangladesh Bureau of Statistics, 1984). More than 90 percent of the annual runoff generated in the GBM area flows through Bangladesh, resulting in significant seasonal flows of water from upstream, particularly during the monsoon

season (Ahmad, 2000; Islam, 2001). These variations in the delta can be considered a natural cause of riverbank erosion in Bangladesh (Rashid, 1991).

But the phenomenon is also influenced by socio-economic conditions, adaptive capacity, and livelihood strategies of riverside areas. Vulnerability in the face of riverbank erosion differs depending on the adaptive capacity among riverside communities; less adaptive capacity makes households and communities more vulnerable to erosion (Bhuiyan et al., 2017). Livelihood strategies that depend on primary occupations (agriculture, forestry, fisheries) can also make people vulnerable to riverbank erosion (Alam et al., 2017).

The ability of people to respond to environmental threats can depend on their demographic characteristics and socio economic conditions. Households affected by riverbank erosion often have no recourse but to accept their fate. They often survive by selling their lands, livestock, housing materials and personal belongings, and by taking shelter in the houses of friends or relatives (Haque 1988; Hutton and Haque, 2004; Rahman et al. 2014). People may have to cope with their situation by reducing meals, and children may be forced to drop out of school (Rahman & Gain, 2020).

1.2 Measures to Control Riverbank Erosion

The government of Bangladesh has a long history of responding to riverine hazards through both structural and non-structural measures. Common structural measures are building earthen or concrete embankments, or placing geo-bags (sand-filled geo-textile containers) along the shoreline (Dewan et al., 2015; Khatun, 2019; Thompson, 1996; Wilde, 2011). In recent years, the construction of concrete embankments has become a common and effective means to control

erosion. One such a concrete embankment has recently been built in Ramgati Upazila along the lower left bank of Meghna river near the Bay of Bengal (see Figure 1.1).



Figure 1.1 Embankment in Ramgati Upazila, Bangladesh (Source: Author)

The new embankment is the only structural measure in place to protect this area, and it covers only about one third of the Upazila (the Upazila is the second lowest administrative district in Bangladesh). The embankment protects the center of Ramgati, but there are no embankments in either the north or the south of the Upazila. This provides a unique opportunity to compare the impacts and perceptions of households that are now protected by the new embankment and those that are not.

Accordingly, this study focuses on the new embankment in Ramgati Upazila. Ramgati is located within the coastal zone of Bangladesh, a region that has been largely neglected in previous studies of riverbank erosion. The majority of the residents of Ramgati are dependent on agriculture and

fisheries, and the lands and marine resources of the Upazila contribute to the national economy of Bangladesh. So this study seeks to better understand the vulnerability of residents to riverbank erosion and assess the impact of erosion on the socio-economic conditions of a coastal area. The study will also identify the adaptation and mitigation strategies taken by individuals, the government, and Non-Governmental Organizations (NGOs). In addition this study will reveal why the embankment was built in the center of the Upazila, and determine its impact on livelihood strategies and the risk perceptions of the local community. This thesis has four primary research objectives:

1. To document the socio-economic and environmental conditions and livelihood practices of the residents of Ramgati Upazila.
2. To characterize the hazard of riverbank erosion in Ramgati, including its impacts, household adaptation strategies, and government responses.
3. To describe the history and impact of the recently-built concrete embankment in Ramgati.
4. To identify factors that influence resident perceptions about riverbank erosion and the Ramgati embankment.

The remainder of this thesis is structured as follows. Chapter Two provides an overview of the existing literatures on environmental geography and natural hazards, focused around key concepts of vulnerability, risk perception and adaptation. Chapter Three describes the research setting of Ramgati and describes the methodology, including data collection and analysis, for this study.

The next four chapters present the findings of the four objectives of this research. Chapter Four documents the socioeconomic and demographic conditions of Ramgati and also assesses the vulnerability of residents to riverbank erosion. Chapter Five identifies the impacts of riverbank

erosion as well as the responses by local residents to mitigate and adapt to erosion in Ramgati. Next, Chapter Six reveals the history and impact of the new embankment. Finally, Chapter Seven, identifies the factors that influence risk perception in the riverside communities. Chapter Eight Summarizes the findings and discusses the contributions of this thesis and its future considerations.

CHAPTER 2

Literature Review

This study is informed by four key bodies of research focusing on vulnerability, risk perception, adaptation, and river hazards and interventions.

2.1 Environmental Geography and Hazards Research

Geography is a discipline that works to bridge insights from the natural and physical sciences, on the one side, and the social sciences and humanities on the other. While many geographers focus their research in pure human or physical geography, a significant number are working to understand the entanglements of people and the non-human world. This subdiscipline is generally referred to as environmental geography, and can be seen as part of the human-environment or man-land traditions of geography (Castree et al., 2016; Turner, 2002).

As illustrated in Figure 2.1, environmental geography provides a unifying link holding the two halves of the discipline together, acting as a middle ground between human and physical geography (Castree et al., 2016).

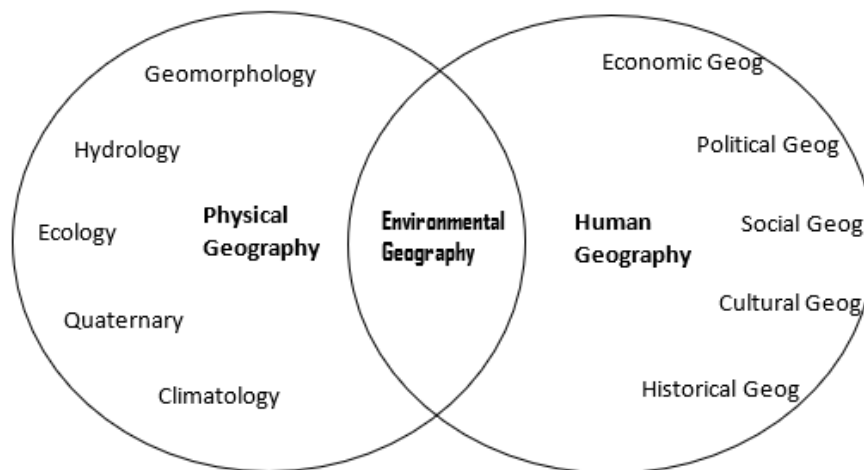


Figure 2.1 Environmental Geography as Disciplinary ‘middle ground’ (Castree et al., 2016)

Environmental geography devotes attention to both human activity and nature, as well as their interactions, an approach that Castree et al. (2016) call a symmetrical approach (Castree et al., 2016).

The environmental geography tradition has a long history. In 1887, Mackinder argued that geography can bridge the natural sciences and human sciences, a view also held by William Morris Davis and Friedrich Ratzel. They saw the need to study nature as a whole, and not as a set of discrete parts. Whereas the pure sciences (chemistry, physics, botany) investigate select elements of the natural world, geography would study all these elements in combination. Although few geographers supported this argument at the time, environmental geography is now well established. Geographers are now working to bridge the human and natural sciences, and funding agencies are looking to support research programs that bring together different sorts of specialist expertise to address pressing problems and issues (Agnew et al., 2011; Castree et al., 2016; Turner, 2002).

One of the important traditions within environmental geography is the study of hazards. Initially, attention was placed only on physical factors (meteorological, geological, and hydrological) in the study of natural hazards. But hazard geographers now consider both physical and social factors of hazardous events together. Gilbert White was a pioneer for this approach, arguing that the history of hazardous events demonstrates that losses result from a combination of natural, social, economic and political factors. Considering all of the physical and social factors associated with hazardous events in natural hazard research is called an integrated approach. This approach can help us to better understand natural hazards, their occurrence, their impacts, how they are viewed, and how societies cope with them.

Today, the core focus is on the relationships among physical, social and technological systems, because hazardous events are the consequence of these interconnected and complex systems. The application of Geographical Information System (GIS) techniques and remote sensing has become common in hazard mapping, environmental management (including disaster management), and rescue operations. Geographers make an important contribution by bringing together all of these considerations in hazard research (Agnew et al., 2011; Gaile & Willmott, 2005; Montz et al., 2017).

2.2 Risk and Vulnerability

Risk is the product of hazard and vulnerability. Risk can be determined by studying the source of a potential hazard, knowing the nature of the hazard as well as estimating the frequency of occurrence.

$$\text{Risk} = \text{Hazard} + \text{Vulnerability}.$$

The risk of a hazardous event can be influenced by physical, political and economic factors or characteristics. In most cases, physical factors determine the probability of occurrence, while political and economic factors determine the severity of harm or outcome. At the same time, physical, political and economic factors combine to determine the level of vulnerability to an individual hazardous event. Hazard, risk and vulnerability are interconnected, so to understand the natural hazard process we should study all of those factors combined (Montz et al., 2017).

Cutter (1996) developed a hazard of place model (Figure 2.2) on the basis of the work of Hewitt & Burton (1971) on hazardousness of places, in which they proposed a multi-hazard mapping to delineate a regional ecology of natural hazard events.

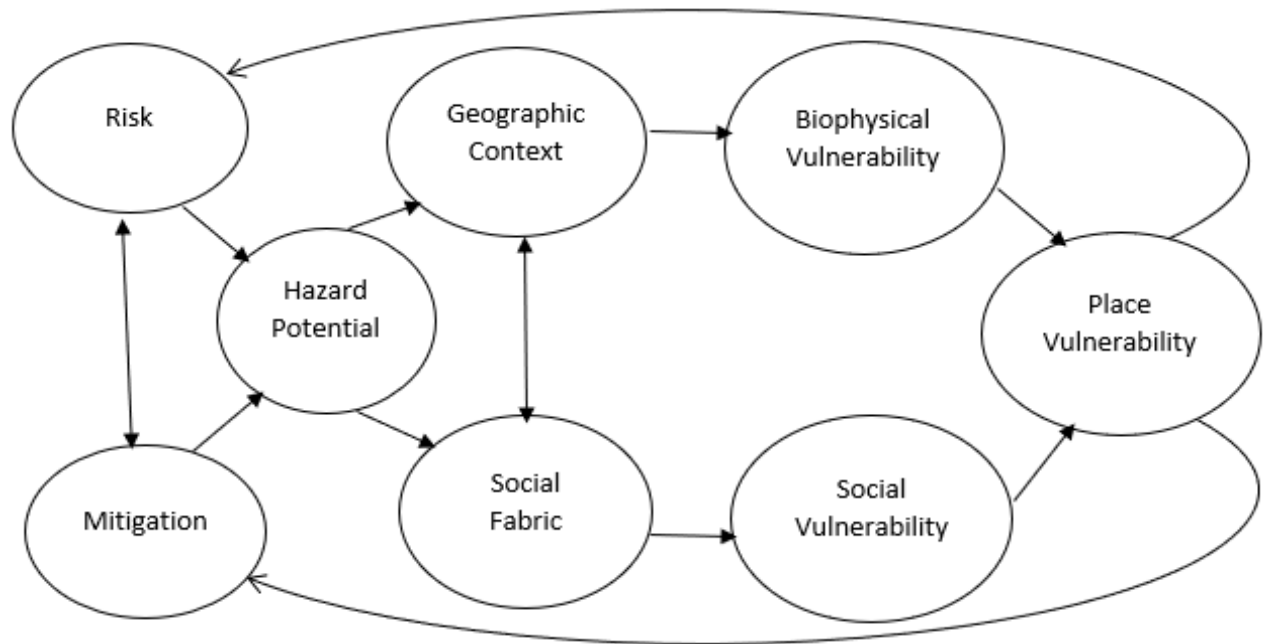


Figure 2.2 The Hazard of Place Model of Vulnerability (Cutter, 1996)

Mitigation practices are initiatives taken to reduce risk, and can reduce the hazard potential. Hazard potential is the combination of risk and mitigation. Hazard potential is filtered through the social context (socioeconomic conditions, cognition of risk, individual or societal ability to respond) and geographical context (site and situation, proximity) of a place or individual, and this determines the vulnerability of places. The vulnerability of places can amplify or reduce both risk and mitigation (Cutter, 1996).

Different research domains and disciplines define and use the term “vulnerability” in different ways. The conceptualization of vulnerability is complicated and has evolved over time (Adger, 2006; Fusel, 2007). But in the area of human-environment relationships, vulnerability has a common, though contested, meaning (Adger, 2006). The term “vulnerability” can be defined as the capacity or ability of individuals and groups to respond to external stress, which can impact the livelihoods, property and wellbeing of affected people (Kelly & Adger, 2000).

Assessing vulnerability is crucial to knowing the magnitude of a threat. In the context of natural disaster, the level of vulnerability can be determined by measuring the level of remedial actions and coping strategies that have been taken by the community or individual (Fussel, 2007; Greiving et al., 2006; Kelly & Adger, 2000).

For this reason, a natural disaster is not only a geophysical process. It is a complex mix of social, economic, political and geophysical processes. In the case of Bangladesh, geographical location (Parvin et al., 2008), high population density, and socio-economic conditions (Hutton & Haque, 2004) make the country highly vulnerable to disasters, including riverbank erosion. Hutton & Haque (2004), Rabbi et al. (2013), and Hoque (1988) have all found that low livelihood status, low income, and less accessibility to resources (such as electricity, drinking water, health care, and education) make riverside communities vulnerable to riverbank erosion in Bangladesh. Riverside communities depend on primary occupations such as agriculture and fishing. They often have few other skills with which to survive if they lose lands and houses. This makes it difficult to find employment if they are displaced by erosion. Many victims are forced to survive as a day laborer, rickshaw puller, or garment worker in a nearby city.

2.3 Risk Perception

Risk perception can be influenced by the type of disaster and characteristics of affected populations. For instance, financial loss is one of the main concerns of flood victims, and is something that cannot be reduced completely by taking mitigation measures. For landslide victims, on the other hand, casualty is the main concern, something that can generally be avoided by taking effective and timely evacuation measures (Ho et al., 2008). From this perspective, if the impact of a disaster can be prevented by effective responses, people will have a sense that it can be controlled. In Bangladesh, heavy rainfall and seasonal flooding are recurring annual riverine

hazards, and as a result these events are expected throughout the country. Some people have established mitigation practices to minimize their losses. However, Hutton & Haque (2003) found that a many victims do not anticipate riverbank erosion to be a dangerous problem prior to being displaced.

Age, education, income, gender, previous experience with a hazard, location of household, and other individual traits all have an influence on risk perception, behavior and response. Montz et al. (2017) categorized these characteristics into cognitive and situational factors. Cognitive factors include the psychological and attitudinal environment, while situational factors include the physical and socioeconomic environment. Both cognitive and situational factors can work individually, in combination, or even in sequence to influence the individual's perception and response (Montz et al., 2017).

In their discussion of coastal hazards, Parvin et al. (2008) found that it is important to understand the community's unique perceptions and assessments of their adaptive and proactive capacities for the establishment of successful hazard management programs. Cooperation and exchange of experiences between the affected community and local government can play a crucial role in the development of an effective coastal hazard reduction program (Parvin et al., 2008).

In the context of Bangladesh, gaps in perception among different stakeholders can hinder efforts to address the riverbank erosion problem. For example, Das (2011) found that the perceptions among victims, planners, engineers, and geomorphologist differ significantly, and so it is important that all perceptions be incorporated in the decision-making process (Das, 2011).

2.4 Adaptation

The consequences of climate change and other natural disasters severely affects rural people who basically depend on natural resources. Although they face many threats, most have successfully faced past hazardous events. Institutions play a crucial role in the success of historically developed adaptation systems. Both formal (local and national government) and informal (family, friends, and relatives) institutions shape social and individual behavior and influence livelihoods and adaptation systems. Institutions, adaptation, and livelihood are interconnected with one another. In the development of community adaptation practices, therefore, it is important to pay attention to institutions and livelihood systems (Agrawal & Perrin, 2009).

In the climate change context, some states are successfully implementing planning and interventions aimed at minimizing risk. But, the development and success of an adaptation practice depends not only on the state, but also the collective action of individuals and communities in the face of risks. This kind of collective action is the result of networking, bonding, and relationships between the individuals and communities, which is called social capital. The interdependence between state and social capital plays a vital role in resource management in developing countries where people are resource dependent (Adger, 2003).

Riverside communities In Bangladesh undertake a diverse range of adaptation and coping strategies (Haque, 1988). When a disaster strikes, poor people often survive by selling their lands, livestock, housing materials and personal belongings. Those who become landless often take shelter in nearby places that do not cost anything (someone's house, slums, or government owned lands). Some displacees migrate to towns or cities where lands and jobs are available (Hutton & Haque, 2004).

To enhance adaptive capacity, it is important to focus on strengthening the socio-economic status and social networks of riverside populations, and to promote the diversification of livelihood systems and the improvement of communication and transportation networks (Alam et al., 2017). Adaptive capability depends on different kinds of livelihood resources and strategies, including natural resources (trees, forests, crops, sands etc.), physical resources (livestock, irrigation equipment, boats etc.), social resources (networks and bonding among neighborhoods), financial resources, and human resources (including skills). Rahman et al. (2014) found that natural resources are not adequate to cope with hazards, so it is important to focus on other livelihood resources to establish long term adaptation strategies.

2.5 River Hazards and Initiatives

Bangladesh is situated within the active part of the “Bengal Delta” formed by the GBM river system (Brammer, 1990). As a result, two-thirds of the country is covered by low lying deltaic floodplain (Islam, 2001). This, combined with the seasonality of monsoon precipitation, the complex network of rivers and streams, and the concave shape of the coastline at the head of the Bay of Bengal, means that Bangladesh is highly vulnerable to natural disasters, specially river hazards such as floods, riverbank erosion, and saline water intrusion (Khatun, 2019; Rahman et al., 2014). These problems are further exacerbated by the country’s high population density, unplanned growth, and political and economic conditions (Khatun, 2019; Rahman, 2013).

The loss and impact of natural hazards can be mitigated and minimized by a coordinated program of preparedness. Bangladesh has undertaken a number of initiatives, both structural and non-structural, to minimize the impact of hazardous events. Structural measures include the hardening of embankments, building cyclone shelters, and river training. River training involves measures to modify the hydraulic flow and sediment response of a river, such as dredging or the construction

of spurs or guide bunds) (Khatun, 2019). Embankments can be concrete (non-erodible), earthen (erodible) and mixed type. In Bangladesh, concrete embankments are built to protect lands, households, and infrastructure from riverbank erosion (Sarker et al., 2011). Earthen embankments have traditionally been built to control flooding and saline water intrusion and can be constructed from clay, silt and sand. In the Southern coastal region of the country, a system of polders inspired by the Dutch dyke system has been constructed. Within a polder, earthen embankments serve as a perimeter barrier surrounding interior land (Dewan et al., 2015).

Non-structural mitigation measures include public awareness, flood forecasting, and early warning systems. Bangladesh has earned recognition for its disaster management capabilities and responses (Khatun, 2019). Over the past several decades, Bangladesh has spent about 20 percent of its annual budget on water development projects including both structural and nonstructural measures (Islam, 2001). Some of the major initiatives to control river hazards are the following:

- Building concrete embankments along the main rivers of Bangladesh to protect the riverbank from the erosion problem.
- Building polders within the secondary river system to control river flooding.
- Building submersible embankments to protect against flash flooding in the Haor area (in the northeastern part of Bangladesh)
- Building coastal polders to control tidal flooding as well as to protect against saline water intrusion (Thompson et al., 1996).

Bangladesh has also been improving warning systems for cyclone and flood forecasting. In all, hundreds of shelters and thousands of kilometers of embankment have been built. Still, these

measures are not adequate and Bangladesh still struggles to mitigate and minimize the impacts of natural hazards (Khatun, 2019).

2.6 History of Embankments in Bangladesh

In Bangladesh, the construction of embankments has a long history. Prior to 1947 (before the partition of India) the landlords (called “Zamindars” in Bangla) were responsible for the construction of earthen embankments to protect agricultural land from saline intrusion. During monsoons, these embankments were inundated by floodwater, and after the monsoon period, during the dry season, the embankments were rebuilt or repaired. Usually, the communities took part in the construction of these earthen embankments. This began to change after the partition of 1947. Disastrous floods in 1954, 1955 and 1956 led the United Nations to recommend government flood protection, and this resulted in the establishment of the East Pakistan Water and Power Development Authority (EP-WAPDA) in 1959, which became the Bangladesh Water Development Board (BWDB) after independence in 1971. The EP-WAPDA received considerable funding from international donors and constructed 4000 kilometers of earthen embankments to control flooding in coastal Bangladesh (Dewan, 2015).

The 1960s saw a shift to the construction of large scale polders and away from the local and traditional system of flood management that was built by the Zamindars before partition. The polders were constructed through the Coastal Embankment Project (CEP), which followed the Dutch dike system. Under the CEP, the EP-WAPDA created 136 polders in the coastal belt of Bangladesh (Food and Agriculture Organization, 1985). In addition, 1566 kilometers of embankments and 282 sluices were constructed in the southwest region of Bangladesh. The immediate impacts of the CEP project were positive: agricultural production increased in the entire coastal belt, and as a result the population increased in this region rapidly. Over time, however,

the polders started to prevent the deposition of silt on the floodplains, leading to high rates of sedimentation and the congestion of rivers and canals. The end result was the drying out of many of the rivers and canals over the period. The sedimentation and congestion also created a permanent waterlogging problem. By the 1980s and 1990s, this waterlogging problem covered more than 100,000 ha (Custers, 1993; FAO, 1985; Firoze, 2003) and began to negatively impact agricultural production. The large scale of the polders led to a change in regional hydro morphology which affected the ecosystem as well as biodiversity. Furthermore, the constant riverbank erosion on one side of the river and sedimentation on the other side became very common. The cost of protecting the polders from erosion was also high. All of these consequences neglected the earlier benefits of the polders (Alamgir, 2010; Craig et al., 2004; Rasul & Chowdhury, 2010; Sultana & Thompson, 1997).

During the 1970s, donors recommended that Bangladesh shift to the construction of small scale flood control projects, including drainage improvement and irrigation schemes, and focus more on non-structural flood control measures (World Bank, 1972). In response, the Bangladesh government collaborated with the Netherlands to implement the Early Implementation Project (EIP), which began in 1975 and continued until 1995 (Datta ,1997).

In the meantime Bangladesh experienced disastrous river floods in 1987 and 1988, events that captured worldwide attention and stimulated foreign countries and NGOs to help Bangladesh to improve its flood control system (Brammer, 1990). In June 1989 the World Bank agreed to help Bangladesh by coordinating international efforts (Boyce, 1990). The World Bank established a five-year action plan (1990-1995) for flood control and drainage in Bangladesh. One of the major issues identified was rapid shoreline change which has been addressed by building concrete embankments in floodplain areas such as Chandpur, Sirajganj, and Bhairab Bazar (WB, 1990).

Since the early 1990s, the Bangladesh government and donors (foreign countries and NGOs) have been responding to the riverbank erosion problem using structural engineering measures (Haque & Zaman, 1994). The Coastal Embankment Improvement Project Phase-1 (CEIP-I) is a mega-project focused on flood control and bank protection in coastal areas of Bangladesh. It has been running since 2013 and will continue until 2020. This project was funded by the International Development Association (IDA) and Climate Investment Funds (BWDB, 2013). The Flood and Riverbank Erosion Risk Management Investment Program (FRERMIP) is another active mega-project in Bangladesh focused on the repair of existing embankments and the construction of new embankments. The project has been ongoing since 2014 and will continue until 2023. It is funded by the Asian Development Bank (ADB) and the government of The Netherlands, and BWDB is responsible for implementing the project (ADB, 2013).

In Bangladesh, the common structural engineering measures to mitigate riverbank erosion are spurs, guide bunds, and revetments (Sarker et al., 2011). As described by Asawa (2006, p. 419), “spurs (also known as groynes, spur dikes, or transverse dikes) are structures constructed in a river transverse to the river flow, extending from the bank into the river”. They may be constructed with stone, gravel, rock, earth or pile structures. Guide bunds, also known as guide banks, “are artificial embankments meant for guiding the river flow past a bridge (or other hydraulic structures such as weirs or barrages) without causing damage to the bridge and its approaches” (Asawa, 2006, p. 423). These are built so that the flow path of the river doesn’t change. Revetments “are structures made to resist the erosive forces of moving water” (Pokrefke, 2012, p. 75). They may be constructed from a wide range of materials, including concrete blocks, boulders, mattresses, stone, riprap, or open asphalt concrete (Pokrefke, 2012). Figure 2.3, shows the design of a typical revetment.

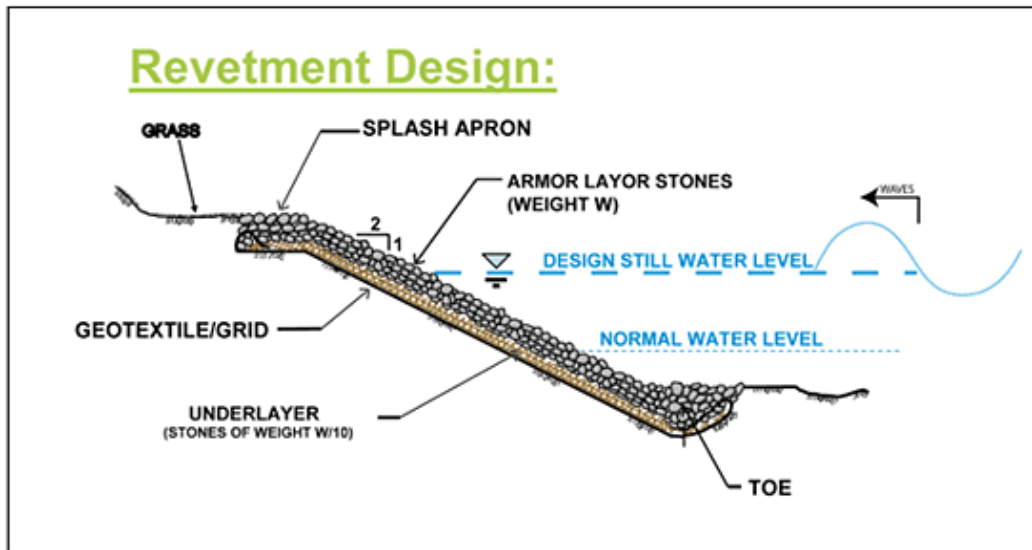


Figure 2.3 Design of Revetment Structure (source: www.fhwa.dot.gov)

Sarker et al. (2011) found that revetment type structures are more stable than any other types. The cost and stability of revetment structures depends on the methods and materials of revetment construction. A revetment constructed from boulders and extended deeper is costly but the most stable and effective (Sarker et al., 2011). The new embankment that was built in 2017 in Ramgati is a revetment type structural measure. Concrete blocks (CC blocks) were used in its construction. Figure 2.4 shows the revetment in Ramgati.



Figure 2.4 Revetment in Ramgati (Source: Author)

2.7 Previous Studies Related to Riverbank Erosion in Bangladesh

This study builds upon on existing studies on riverbank erosion in Bangladesh. Previous work has examined multiple dimensions of erosion, including vulnerability, hazard impact, and adaptations among communities and households.

A key aim of this study is to document the socio-economic and demographic conditions as well as livelihood practices of the residents of Ramgati Upazila. Previous studies, such as those by Hutton & Haque (2004), Haque (1988), Alam et al. (2017), and Bhuiyan et al. (2017) have demonstrated that such factors play a role in determining vulnerability to riverbank erosion. For example, in a survey of households from Sirajganj Sadar and Shariakandi Upazila along the Jamuna River, Hutton & Haque (2004) found that the demographic and socioeconomic conditions of people affect their capacity to respond to environmental threats. Similarly, in a 2017 study in Chauhali and Nagarpur Upazila (Jamuna River crosses both Upazilas), Alam et al. (2017) interviewed residents and found that the riverside communities are vulnerable due to their relative inaccessibility and

low livelihood status. Response capacity, coping capacity and resilience features have also been linked to the level of vulnerability. In a study focused on several communities in Harirampur Upazila along the Padma River, Bhuiyan and colleagues (2017) created a vulnerability index and showed that areas with more sensitivity and less adaptive capacity are more vulnerable to river hazards than areas with less sensitivity and more adaptive capacity.

Another objective of this study is to characterize the hazard of riverbank erosion in Ramgati, including its impacts, household adaptation strategies, and government responses. Previous studies, including Alam et al. (2017), Bhuiyan et al. (2017), Rabbi et al. (2013), and Rahman & Gain (2020) have highlighted the impacts of riverbank erosion. The primary impact is the loss of land, houses and infrastructure. Studies by Bhuiyan et al. (2017) and Rabbi et al. (2013) in Sirajganj District along the Jamuna River, found that riverside communities lose a large amount of fertile agricultural land and infrastructure to riverbank erosion, forcing changes to cropping patterns and forced resettlement (also Haque 1988). Alam et al. (2017) found that riverbank erosion decreases economic potential and pushes the victims towards poverty, and Rabbi et al. (2013) found that the erosion acts as a push factor for migration. In another study, Rahman & Gain (2020) interviewed residents in Kayra Upazila a coastal area in Bangladesh, and found that riverbank erosion hinders rural socio-economic, cultural, psychological and environmental development.

In response to the problem of riverbank erosion, households and communities have developed initiatives and coping measures. Existing adaptation strategies have been documented in previous research by Haque (1998), Rahman & Gain (2020) and Rahman et al. (2014). In one early study, Haque (1988) found that the most frequent adjustment strategy is simply “loss bearing” by victims. Other adaptations include taking financial loans (from the government, NGOs, Co-operatives or

relatives), and adjusting household resources. Households may be forced to reduce meals, and children may be taken out of school to do part time work (Rahman & Gain, 2020). In a study in Kazipur Upazila along the Jamuna River, Rahman et al. (2014) created an index of resources and showed that physical resources (livestock, irrigation equipment, a boat etc.) and financial resources (jewelry, cash, savings etc.) are the most effective means of coping with both flood and riverbank erosion hazards, while natural resources (productive lands, trees, crops etc.) do not provide sufficient support. Social resources (cooperative society and neighborhood and non-government organizations) are comparatively more effective in helping people cope with riverbank erosion. On the other hand, human resources (skills in agriculture, fishing, animal husbandry etc.) are more effective in helping people cope with floods. In some cases, concern about riverbank erosion has led to community mobilization. Zaber et al. (2017) describe how social media platforms such as Facebook have been used to raise awareness about riverbank erosion and press the government to take structural measures to control it.

| Studies | Study Areas |
|----------------------|--|
| Rahman and Gain 2020 | Koyra Upazila |
| Alam et al. 2017 | Chauhali and Nagarpur Upazila |
| Bhuiyan et al. 2017 | Harirampur Upazila |
| Rahman et al. 2014 | Kazipur Upazila |
| Rabbi et al. 2013 | Ullapara, Shahzadpur, Belkuchi, Kajipur and Sirajgonj sadar Upazila Shariakandi under the Sirajganj District. |
| Hutton & Haque 2004 | Sirajganj Sadar and Shariakandi Upazila |
| Haque 1988 | Kazipur Upazila |

Table 2.1 Study Areas of Previous Studies in Bangladesh

Table 2.1 lists previous studies, and Figure 2.5 shows their locations. As we can see, existing research has focused primarily on the upper region of Bangladesh. By contrast, the present research investigates riverbank erosion in the lower region or coastal area of Bangladesh. It is the first study to look at the problem of riverbank erosion in Ramgati.

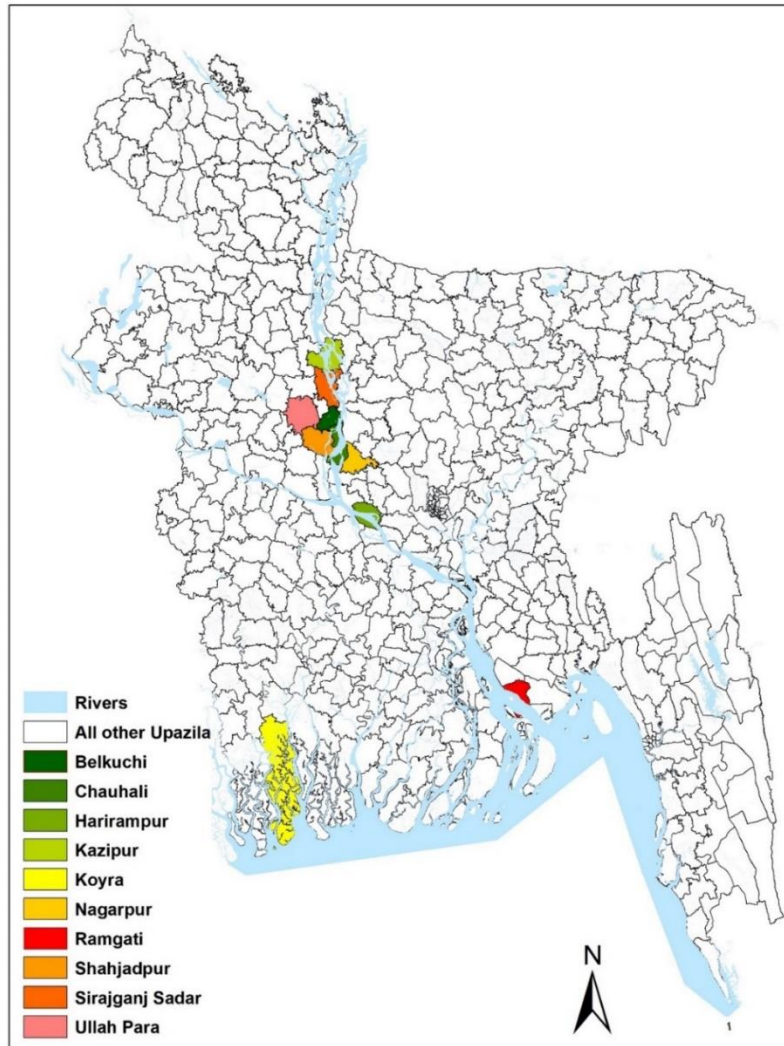


Figure 2.5 Study Areas of Previous Studies on Riverbank Erosion in Bangladesh

CHAPTER 3

Methodology

3.1 Study Area

The study area is Ramgati Upazila within the Lakshmipur District of Chittagong Division in Bangladesh (Figure 3.1). Bangladesh has four tiers of administration, ranging from Division to District, and then down to the Upazila and Union administration. Ramgti is one of 491 Upazilas in Bangladesh, and there are 8 Unions under the Ramgati Upazila administration (Wikipedia, 2013).

The location of this study area is between 22°52' and 22°90' north latitude and between 90°47' and 91°01' east longitude. The total area of Ramgati is 291.82 square kilometers and it has a total population of 229,153. The main source of income is agriculture, which accounts for 67% of total income. The second major source of income is commerce, which is 11% of total income (Banglapedia, 2019).

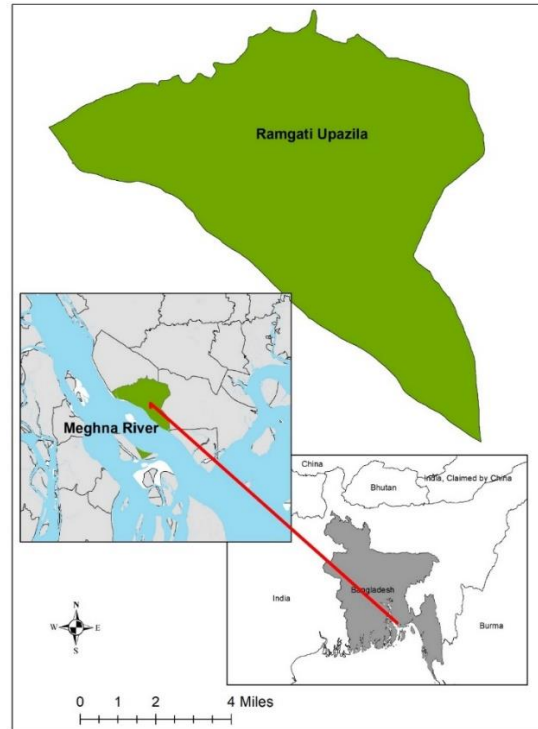


Figure 3.1 Study Area, Ramgati Upazila

Ramgati provides a good case study of riverbank erosion for a number of reasons, including the extent of riverbank erosion, its location in the coastal region, and the presence of a recently-built revetment. This study addressed the following objectives and research questions:

The first objective is to document the socio-economic and environmental conditions and livelihood practices of the residents of Ramgati Upazila. This addresses the following questions:

- a. What are the main occupations, and what challenges do residents face?
- b. What are the living conditions in Ramgati, and do these conditions differ across the Upazila?

The second objective is to characterize the hazard of riverbank erosion in Ramgati, including its impacts, household adaptation strategies, and government responses. This addresses the following questions:

- a. What are the main environmental challenges faced by households in Ramgati?
- b. What is the impact of riverbank erosion on households in Ramgati?
- c. How has riverbank erosion affected people's land, property, and livelihoods?
- d. What adaptation strategies have been taken by Ramgati households?
- e. What NGO or local government initiatives have been developed to deal with riverbank erosion?

The third objective is to describe the history and impact of the recently-built revetment in Ramgati.

This addresses the following questions:

- a. What is the history of the revetment, and why was it built where it was?
- b. Has the revetment had an impact on livelihood strategies, and if so, how?

And, the fourth objective is to identify factors that influence resident perceptions about riverbank erosion and the Ramgati revetment. This addresses the following questions:

- a. To what extent do socioeconomic factors influence resident perceptions about riverbank erosion and the new revetment?
- b. To what extent does previous erosion experience influence resident perceptions about riverbank erosion and the new revetment?
- c. To what extent does location (North-South or distance from the river) influence resident perceptions about riverbank erosion and the new revetment?

To answer these questions, this study draws upon two sources of data. The first is responses from a household survey administered for an existing project named “Coastal Erosion Vulnerabilities, Monsoon Dynamics, and Human Adaptive Response.” These data were supplemented by interviews with local residents and key informants.

A key component of the study is to identify the possible spatial variation in experience and perceptions of riverbank erosion. To do so, the study area was divided into different zones and distances. Three zones were delineated on the basis of the location of the revetment. The area protected by revetment has been categorized as the Center zone. The unprotected area extending from the revetment to the north is categorized as the North zone, and the unprotected area extending from the revetment to the South is categorized as the south zone. Figure 3.2 shows three zones of Ramgati.

The study area was also divided according to the distance of households from the river. Distance was measured using the “near tool” in ArcMap 10.6.1. Households located less than 600 meters from riverbank are categorized as the Near distance, households located between 600 meters and

1200 meters are categorized as Middle distance, and households located more than 1200 meters from the riverbank are categorized as the Far distance. There are 133 households located in the Near distance, 122 households in the Middle distance and 126 households in the Far distance.

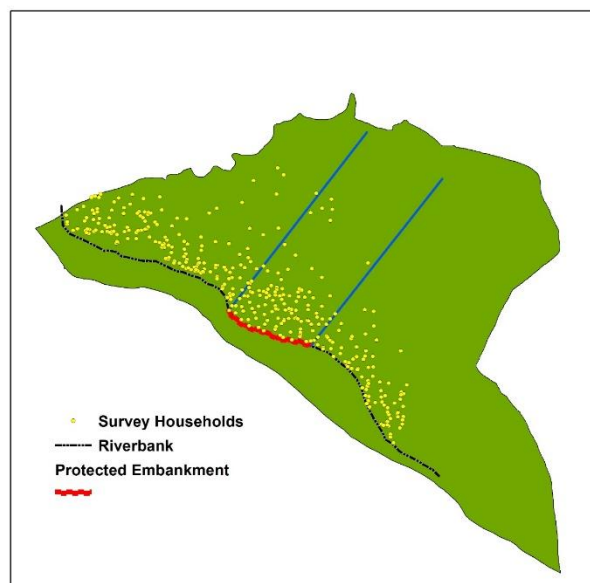


Figure 3.2 Three Zones and Survey Households Locations

3.2 Survey Data Analysis

In the context of human and environmental geography, the questionnaire survey is an essential tool when primary data are required to examine people's behavior, perception, or attitude about an issue (Flowerdew & Martin, 2013). Often the questionnaire is presumed to be a sample of a broader population and involves the collection of both quantitative and qualitative data (McGuirk & O'Neill, 2016). This study is an extension of an existing project that incorporated a questionnaire

survey of 420 randomly selected households in Ramgati and Kamalngar Upazilas. The goal of that research study is to develop improved understanding of the vulnerability, resilience and adaptive responses of the population in the Ganges-Brahmaputra-Meghna (GBM) delta in the face of riverbank erosion and monsoon dynamics. The survey had 97 closed ended questions that seek quantitative information about the respondents' attributes or behavior (McGuirk & O'Neill, 2016). The survey questionnaire is provided in Appendix A. It should be noted that in the final household survey, areas near the riverbank are overrepresented, and so the sample may not be representative of Ramgati Upazila overall.

After getting access to the survey responses, data were entered in SPSS for statistical analysis and to make tables and graphs. Out of 420 surveys conducted, 381 households were located in Ramgati Upazila, and data from those surveys were used in this study. The percentages and frequencies of responses were calculated, and Chi-Squared tests were performed to determine whether there is a significant difference between observed and expected frequencies and to report to what extent the socio-economic and demographic factors influence the perception of risk. P values are significant when 0.10 or less. If the results of Chi-Squared tests had cells with expected values of less than five, the test was not utilized.

3.3 Interviews and Analysis

Interviewing is a useful technique to probe an issue in depth. It can help to explore and understand an action in a specific setting. The purpose of an interview is to examine human relationships and discover as much as possible about why people feel or act in the ways they do. The aim of interview methodologies is to understand in depth and in detail rather than focusing on breadth and coverage (DeLyser, 2010). Interviews can bring people into a research process, incorporating their views of

life, behavior and experiences. Informants can share their experiences and perceptions by using their own words during the interviews (Dunn, 2016).

In this study, 6 key informant interviews and 18 household interviews were conducted. The interview guides were organized around ordered but flexible questioning for both the key informants and household interviews. The key informant interviews were conducted with local school and college teachers and local government officials. The interviews occurred in the office of the participants. The length of interviews was on average 40 to 50 minutes long. A list of interview subjects and the Interview Guide for Key Informant Interviews can be found in Appendix B.

The household interviewees were selected on the basis of the household's location and the occupation of the respondents. Six respondents were selected from each zone (North, Center and South zone) representing farmers, fishermen and business owners. The length of interviews was on average 30 to 40 minutes long. A list of respondents and the Interview Guide for the Household Interviews is in Appendix C.

During interviews, notes were taken and a digital audio recorder was used for recording. The recorded interviews were then converted to text and analyzed to detect patterns. Qualitative researchers recommend coding the texts of interviews into different categories or themes for analysis (Hay 2016). Coding the interview or survey data can be tedious work but it is a kind of detective work that is valuable in the research process. The purpose of coding is to eliminate unnecessary data, organize the data, facilitate searching and organization, and finally make the data available for analysis. Coding can bring out important themes or patterns suggested by the literature the project's research questions (Cope, 2016).

In this study, each recorded interview was transcribed word by word into a word document. Each transcript was read and re-read carefully, and quotes were copied and pasted under thematic headings into a word document. Themes were developed from existing literatures as well as the research objectives, and included the following:

- Livelihood Activities,
- Environmental Challenges,
- Risk Perceptions,
- Past Experience,
- Impacts on Livelihoods,
- Reparations and Adaptation Strategies,
- Interventions by the NGOs and the Government,
- Interventions by Local Community or Organizations,
- History and Impact of the New Embankment, and
- Future Demands of the People

The quotes were used in the study to support the quantitative data that were collected in both the interviews and the household survey. Figure 3.3 shows the data collection and analysis flow chart for this study. The following chapters discuss the results that have been revealed through the mixed methods approach used in the study.

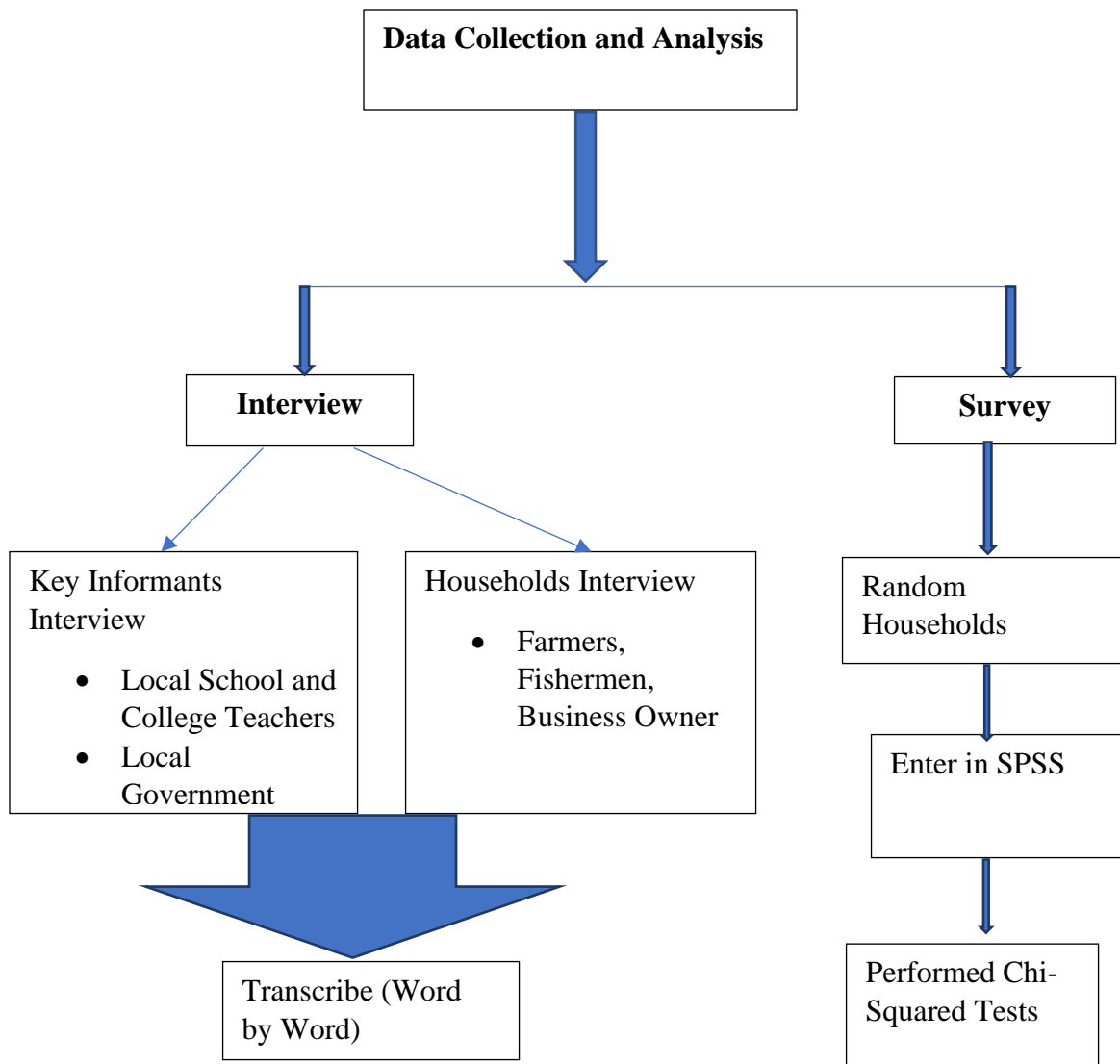


Figure 3.3 Flow Chart of Data Collection and Analysis

CHAPTER 4

Socio-economic Status and Livelihood Practices

This chapter addresses the first research objective, and describes the demographic characteristics, socioeconomic conditions, and livelihood practices of Ramgati Upazila. Drawing on data from both the household survey and ethnographic interviews, the chapter has two aims. The first is to examine how Ramgati compares to national averages for Bangladesh using data from the 2016 *Final Report on Household Income and Expenditure Survey* published by the Bangladesh Bureau of Statistics (BBS). This comparison provides context for the investigation of riverbank erosion in Chapters 5, 6, and 7. The second aim is to assess spatial differences in key variables related to socio-economic status and livelihood practices. Chi-Squared tests were performed to identify significant differences across the three zones and the three distances. Results from this analysis assists in interpreting variations in perceptions, impacts, and adaptation strategies related to riverbank erosion across the Upazila. Throughout the chapter, survey data generally reflect the responses of the head of household, but in some cases, data incorporate information provided about all household members. Sample sizes are indicated in the figures and tables below.

4.1 Population Characteristics

As shown in Table 4.1, 50.9% of the members of households surveyed are male, while 49.1% are female. These figures are in line with national averages in Bangladesh.

| Region | Male | Female |
|------------------|-------------|---------------|
| Bangladesh | 49.6 | 50.4 |
| Urban | 49.1 | 50.9 |
| Rural | 49.8 | 50.2 |
| Ramgati (n=2369) | 50.9 | 49.1 |

Table 4.1 Percentage of Male and Female in Bangladesh and Ramgati.

Table 4.2 shows the percentage of household members in different age groups compared to rural Bangladesh overall. We can see that Ramgati has a lower percentage of young children (0-9), but a higher share of teenagers and young adults (10-24).

| Age Groups | Rural | Ramgati (n=2375) |
|-------------------|--------------|-------------------------|
| 0-4 | 9.9 | 4.9 |
| 5-9 | 11.0 | 9.0 |
| 10-14 | 12.0 | 13.9 |
| 15-19 | 9.7 | 13.1 |
| 20-24 | 7.5 | 9.0 |
| 25-29 | 8.5 | 8.2 |
| 30-34 | 7.4 | 7.1 |
| 35-39 | 7.1 | 9.1 |
| 40-44 | 5.4 | 5.6 |
| 45-49 | 5.3 | 4.7 |
| 50-54 | 4.0 | 3.4 |
| 55-59 | 3.5 | 3.8 |
| 60 and Above | 8.5 | 8.3 |

Table 4.2 Percentage of Different Age Groups in Bangladesh and Ramgati

4.2 Education

Education is a form of human capital, and contributes to the welfare of individuals, households and society (BBS, 2016). In the Bangladesh context, those who finish at least high school have more employment opportunities, and education can also play a role in adaptation strategies in response to disasters. Figure 4.1 shows the highest level of education attained by survey respondents. More than two-thirds of respondents did not complete more than elementary school.

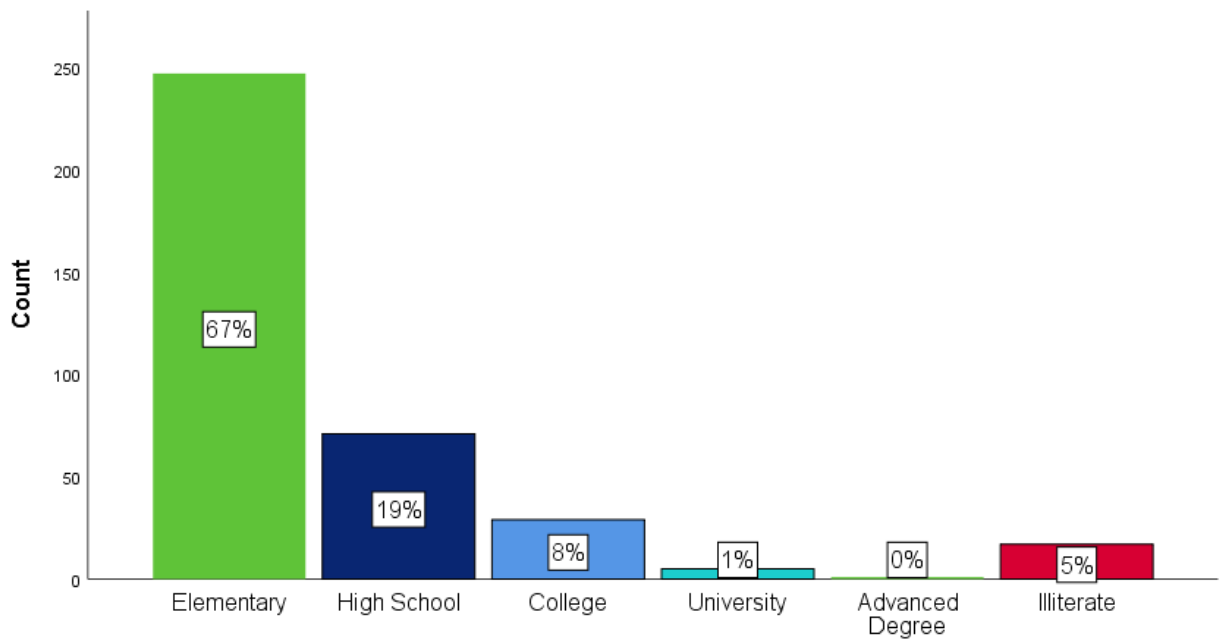


Figure 4.1 Education Qualification of the Survey Respondents in Ramgati

To determine whether there are differences in educational attainment across the three zones of the Upazila, households were placed into three categories and a Chi-squared test was performed. The test found significant differences in educational composition in Ramgati. As shown in Figure 4.2, respondents in the North are less likely to have completed high school or college than those in the Center and South (20% versus 41% and 30% respectively).

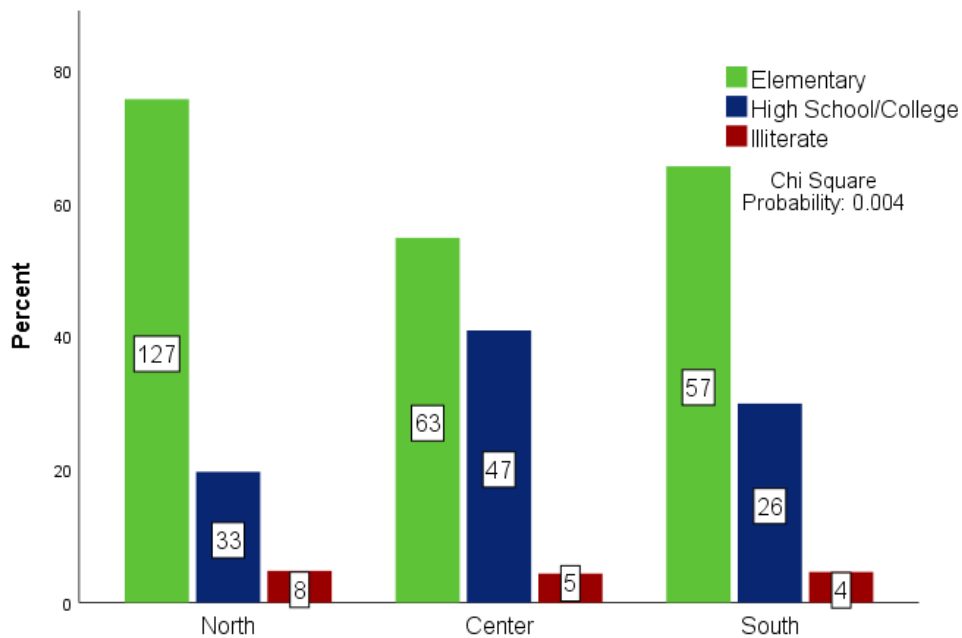


Figure 4.2 Education in Different Zones of Ramgati

4.3 Occupations and livelihoods

Riverside communities in Bangladesh are usually dependent, either directly or indirectly, on fishing and farming. The setting provides access to the river for fishing and for irrigation, and lands near the river are fertile from frequent inundation and sedimentation. Ramgati Upazila is no exception to this pattern. Figure 4.3 shows the prevalence of common occupations in Ramgati as indicated by survey respondents. We can see that the majority (54%) are dependent on farming and/or fishing, with a significant number of household heads also engaged in salaried employment or running small businesses. When compared with all rural areas of Bangladesh (Table 4.3), Ramgati is somewhat more dependent than average on agriculture and fishing.

| Bangladesh(%) ¹ | | Ramgati (n=381)(%) | | |
|----------------------------|-------|--------------------|--------|-------|
| 37.8 | | 54.0 | | |
| Rural | Urban | North | Center | South |
| 49.0 | 10.3 | 54.3 | 38.9 | 52.8 |

Table 4.3 Prevalence of Agriculture and Fishing in Bangladesh and Ramgati

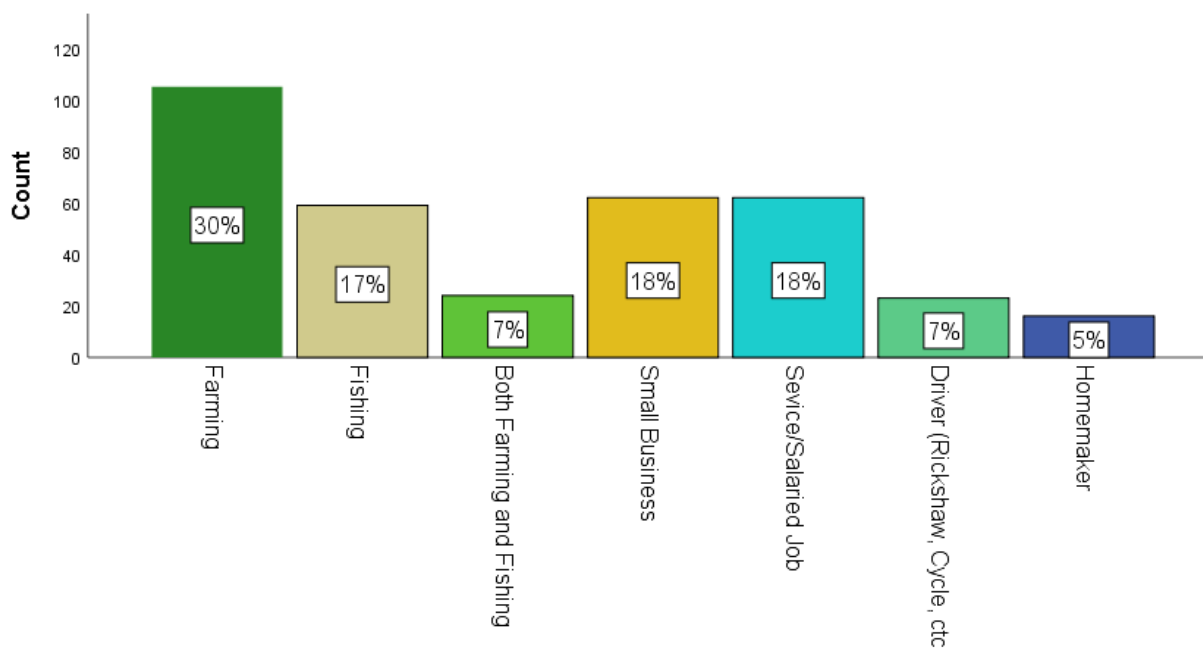


Figure 4.3 Household Head's occupation

During household interviews, many respondents mentioned Ramgati's dependence on farming and fishing livelihoods. As a local government official said,

As this upazila beside is the river, I want to say more than 60 percent of the people are directly or indirectly dependent on the river...There are also lot of farmers. Most of the people are connected with either fishing or farming. (11)

¹ The census category includes farming, fishing, forestry and animal husbandry.

Farming in Ramgati is focused around rice cultivation in flooded paddies (see Figure 4.4), supplemented by selected cash crops, including lentils, green beans, peanuts, and soybeans, a particular specialty of Southeastern Bangladesh. One key informant commented that,

A large amount of soybeans are cultivated here. I do not see this much soybean elsewhere in Bangladesh. This area is also renowned for cultivating other kinds of green beans. Production of coconuts and betel nuts are very good in this area as well. (12)

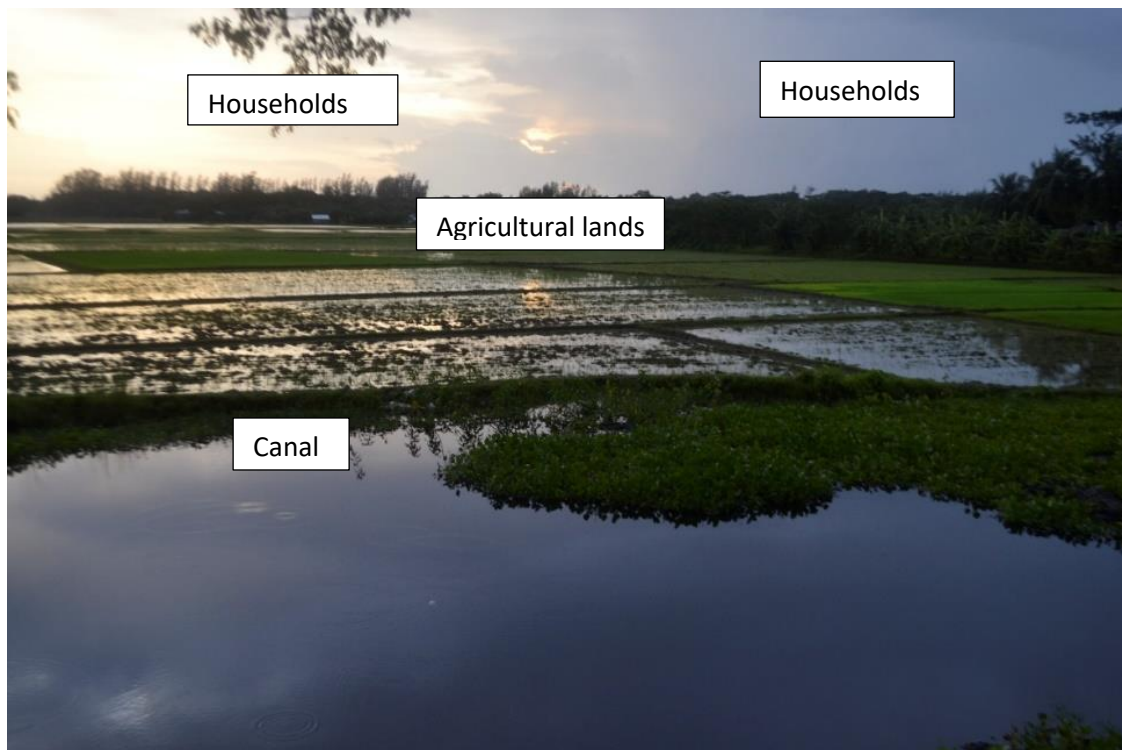


Figure 4.4 Typical Land Use in Ramgati (Source: Author)

In Ramgati, farmers work fairly small plots and either cultivate their own land or lease from neighbors and relatives. If someone leases land, he or she typically must give the land owner between one third and one half of the harvest. The cultivator is responsible for all raw materials such as fertilizers, seeds, and equipment, and is liable for any losses. The five farmers interviewed reflect a range of situations: 2 farmers own their land, 1 usually leases from others, and 2 farmers

own land and also lease from others. All have a farm size ranging from 1.5 to 2 acres. One farmer from the South zone mentioned that,

I own and cultivate 1 acre of land, and sometimes I also lease from my neighbor. (24)

In Bangladesh, individuals who make a livelihood from fishing usually live in communities close to a river or other water body (a typical community is shown in Figure 4.5). People can be engaged in a range of different activities in support of fishing. Some fish with their own fishing equipment, some lease fishing equipment to others, some make and sell fishing equipment, and still others only do the physical labor of fishing. About a quarter of respondents in Ramgati identified fishing as a livelihood.



Figure 4.5 Main Fish Market in Ramgati (Source: Author)

Although farming and fishing are important activities in Ramgati, there are other important sources of livelihood. In the household survey, 18% of household heads indicated that they run small

businesses, such as grocery stores, super shops, garment stores, pharmacies, furniture stores, tea stalls, and fishing equipment businesses. Figure 4.6 shows a typical grocery store and super shop in a market place. Usually the size of the businesses in rural areas is small, and the owner generally lives close to the store. Figure 4.7 shows a typical tea stall in rural area, where people usually have snacks and teas.



Figure 4.6 Typical Grocery Store and Super Shop in Rural Area of Bangladesh (Source: Author)



Figure 4.7 Typical Tea Stall in Rural Area of Bangladesh (Source: Author)

About 20% of households surveyed are dependent upon employment in the service sector or have a salaried job, for example working for a company or in local government. These jobs often require a higher degree of education and provide greater economic well-being. Figure 4.8 shows the relationship between highest earned education and occupation in Ramgati. As can be seen, most of those who are high school or college graduates own businesses or have service or salaried jobs, whereas those with only elementary school education are concentrated in farming and fishing activities.

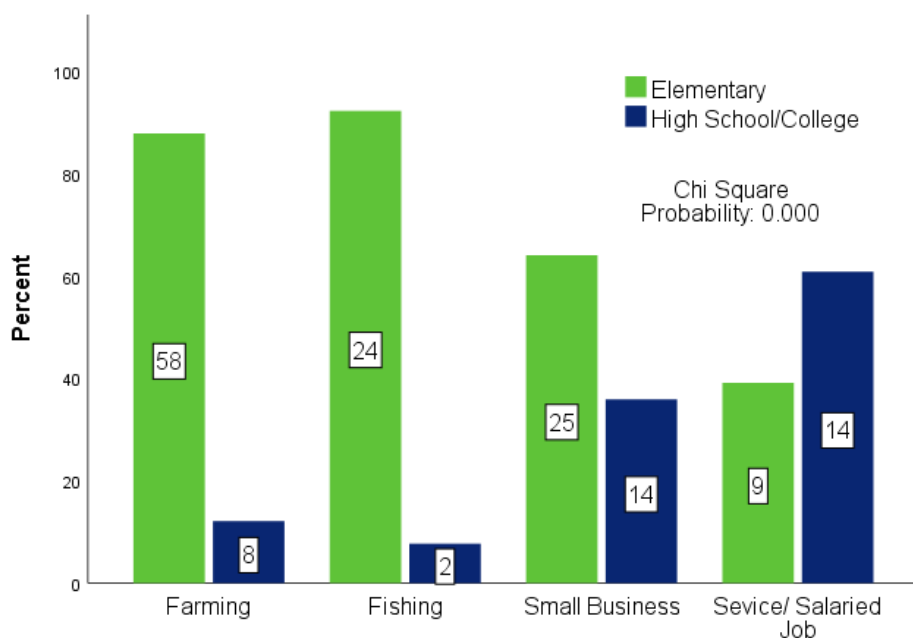


Figure 4.8 Education Qualifications in Different Occupations

Although only a small number of survey respondents (5%) indicated ‘homemaker’ as a primary occupation, it is common for women in Ramgati to engage in household activities and childcare. Some women contribute to household income through activities like tailoring or making handicrafts such as textiles, metal works, jewelry, wood works, cane and bamboo works, or clay and pottery. Women also assist their husbands with fishing or farm work. As one key informant stated:

[Some] women help their husbands if they work as fishermen. Some women, for instance, make fishing nets, either for household use or to sell to others. In farming households, the wife typically helps their husband during the cultivation of crops. (14)

Regardless of occupation, households in Ramgati usually supplement household food and income by raising fish or livestock, activities that are often undertaken by women. Household fish ponds are common within the Upazila; 11 of the 17 interview respondents indicated that they raise fish, either for subsistence or commercial purposes. One respondent, for example, noted that:

Yes we have a pond. Usually we raise the fish for our household consumption, but sometimes we also sell the fish. Last year we earned 50 thousand taka [a little less than \$600]. (17)

Many households also raise ducks or chickens, primarily for household consumption, including 13 of the interviewees. Three of the interviewees indicated that they have cows, with numbers ranging from 2 to 5.

4.3.1 Spatial Variation of Livelihoods:

To examine the spatial variation of livelihoods, Chi-squared tests were performed to identify differences in occupation across zones and sectors in Ramgati. Results show a statically significant difference in occupational structure by both zone and distance. As shown in Figure 4.9, farming is more prevalent in the South zone. Indeed, 36% of all farmers in the study sample are located in the South. Fishing, by contrast, is concentrated in the North zone, which is home to 75% of all fishers. The Center has a slightly higher proportion of small business, which reflects that fact that the municipality and a large market are located in the Center.

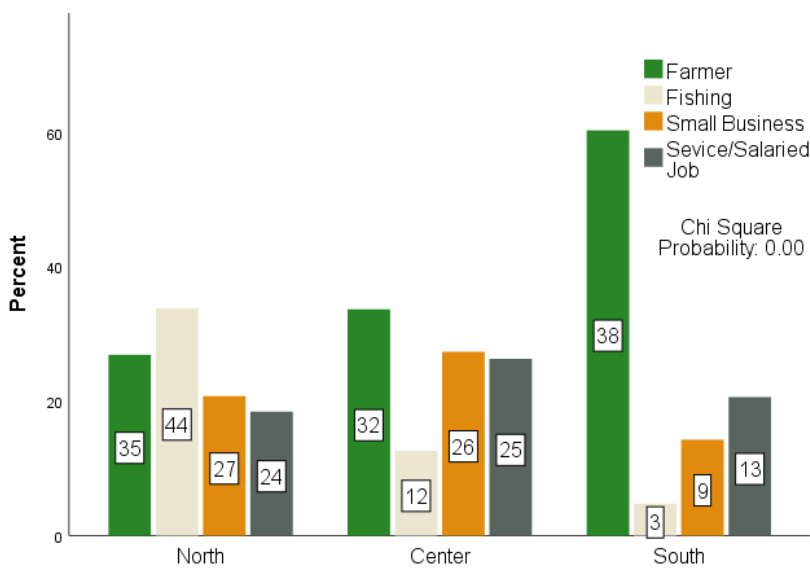


Figure 4.9 Household head's Occupation in Different Zones of Ramgati

When examining occupation and distance from the river (Figure 4.10), we can see that a higher proportion of fishers live close to the river, and about 45% of all fishers live within 600 meters of the river. This obviously places them at greater risk for riverbank erosion. By contrast, farming is more likely to occur at a greater distance from the river, with 45% of all farmers living beyond 1200 meters.

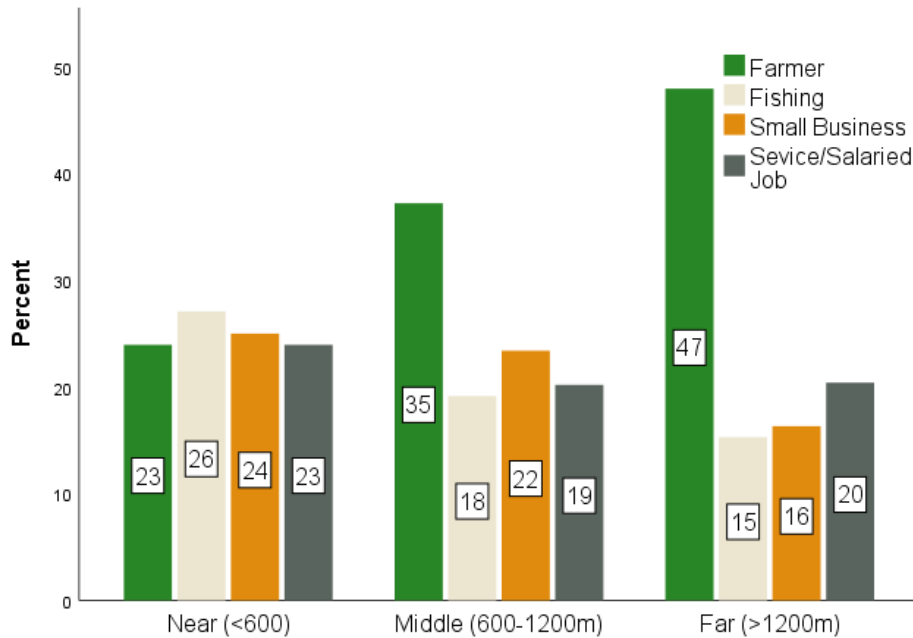


Figure 4.10 Household head's Occupation in Different Distances from River

4.4 Socioeconomic Status

Socioeconomic status reflects the living conditions and general economic well-being of households in Ramgati. In the remainder of this chapter, socio-economic status is examined through a consideration of household income, household size, housing conditions, access to infrastructure, and household assets.

4.4.1 Households Income

Household income has a significant impact on the ability of households to plan for and respond to natural hazards. Household income was calculated by combining contributions from all household members identified in the project survey. Results are shown in Table 4.4 and compared with national averages for Bangladesh. We can see that average monthly incomes in Ramgati, while quite low, are about 30% higher than the rural average for Bangladesh. There are evident geographical differences in income across the three zones, with incomes higher in the North and lower in the South. Although incomes in Ramgati are higher than average, few households have significant wealth and many would have a difficult time coping with a natural disaster. Of 14 interviewees who responded to a question about savings, 13 indicated that they have no savings from one year to the next, which leaves no buffer if they are unable to work for an extended period of time.

| Bangladesh (Tk) | | Ramgati (n=381) (Tk) | | |
|-----------------|---------------|----------------------|---------------|---------------|
| 15988 (\$190) | | 20119 (\$240) | | |
| Rural | Urban | North | Center | South |
| 13998 (\$165) | 22600 (\$270) | 22715 (\$270) | 18118 (\$230) | 17701 (\$200) |

Table 4.4 The Average Monthly Income of Households in Bangladesh and Ramgati

To examine the relationship between income and occupation in Ramgati, household income was divided into three categories, and a Chi-squared test for independence was performed. As shown in Figure 4.11, significant differences were found across occupational categories. In particular, it can be seen that the majority (53%) of households in the lowest income category are headed by farmers. By contrast, households headed by fishers make up only 10% of the lowest income category and are the most likely to be in the highest category.

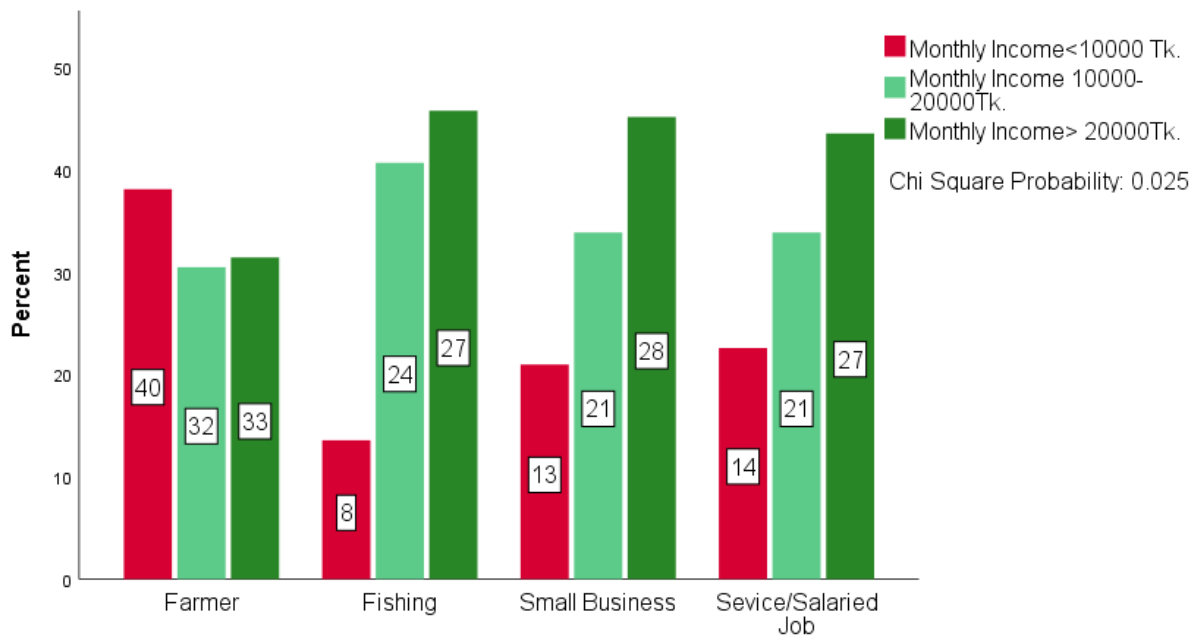


Figure 4.11 Households Total Monthly Income by Occupations of Household Head

Looking at the spatial variability of income (Figure 4.12), a Chi-Squared test found statistically significant differences across the three zones in Ramgati. Consistent with the data in Table 5, we can see that households in the North are most likely to be in the highest income category, while those in the South are most likely to be in the lowest. Figure 4.13 shows the three income categories in relation to distance from the river. A Chi-Squared test for independence found no significant difference in the income categories across the three distances.

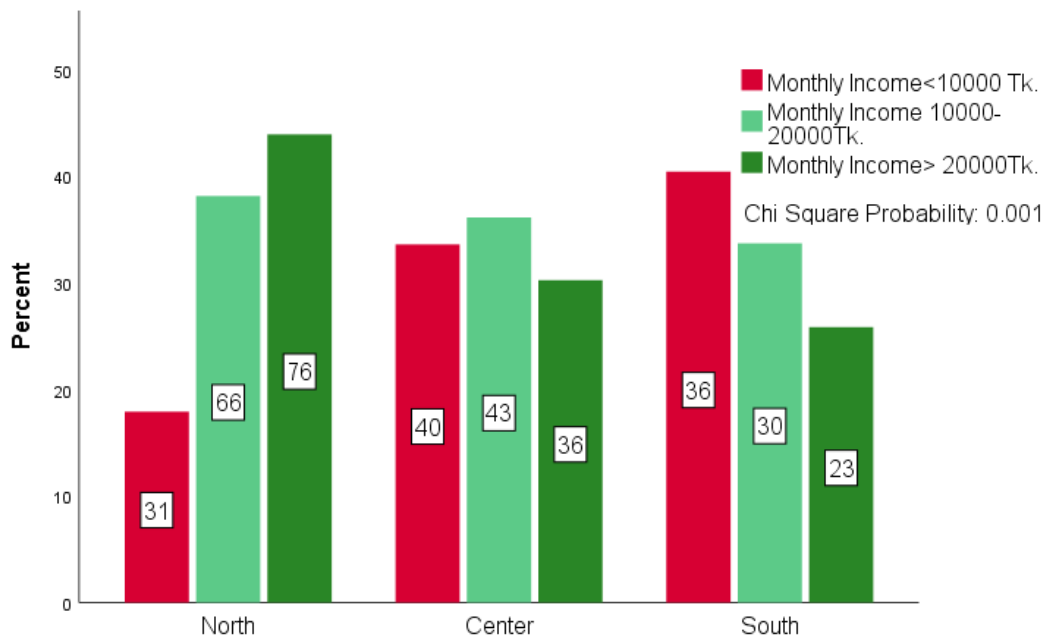


Figure 4.12 Households Total Monthly Income in Different Zones of Ramgati

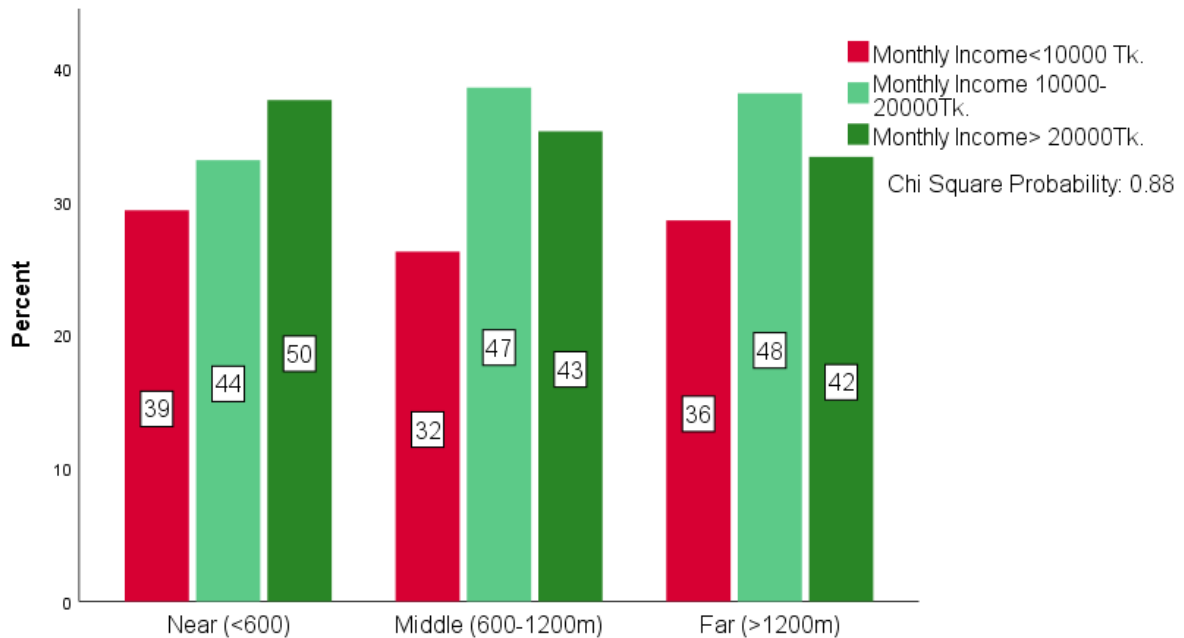


Figure 4.13 Households Total Monthly Income in Different Distances From River

4.4.2 Household Size

As shown in Table 4.5, the average household size in rural areas of Bangladesh is 4.06. In Ramgati, it is higher, at 5.69, with size ranging from 5.36 in the Center to nearly 6 in the North. To examine regional differences, households were divided into three size categories, and a Chi-squared test for independence was performed. As Figure 4.14 shows, there is a statistically significant relationship between household size and zone, with 53% of all large size households located in the North. A separate Chi-squared test to assess household size in Ramgati in relation to distance from the river found no significant difference (Figure 4.15).

| Bangladesh | | Ramgati (n=381) | | |
|------------|-------|-----------------|--------|-------|
| 4.06 | | 5.69 | | |
| Rural | Urban | North | Center | South |
| 4.11 | 3.93 | 5.99 | 5.36 | 5.53 |

Table 4.5 The Average Households Size in Bangladesh and Ramgati

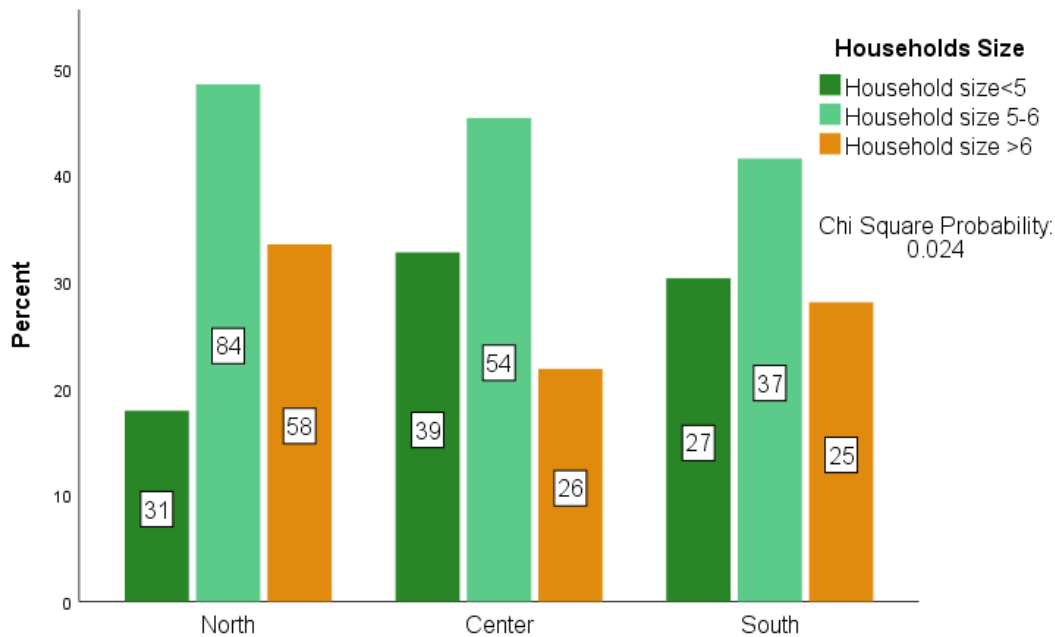


Figure 4.14 Average Households Size in Different Zones of Ramgati

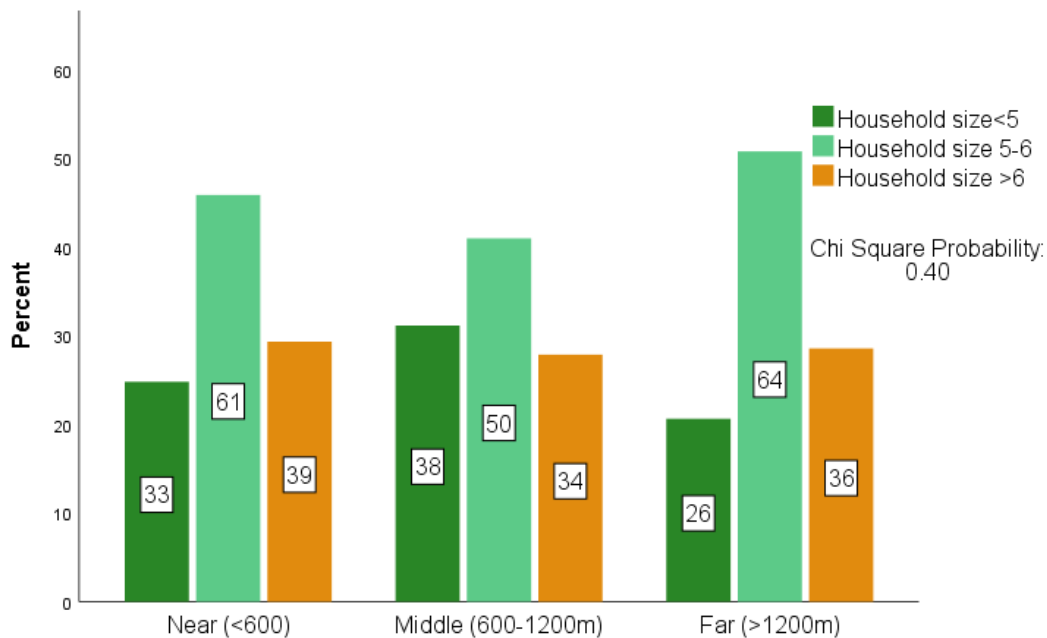


Figure 4.15 Average Households Size in Different Distances From River

Household size was also examined in relation to average monthly household income, as displayed in Figure 4.16. A Chi-squared test found a statistically significant relationship, with the larger-sized households earning more money than small sized households. Nearly half (49%) of all households earning more than twenty thousand taka monthly have a household size of 6 or larger. Sometimes a larger households size can mean that there are income sources from multiple household members, and this might be a reason for this finding.

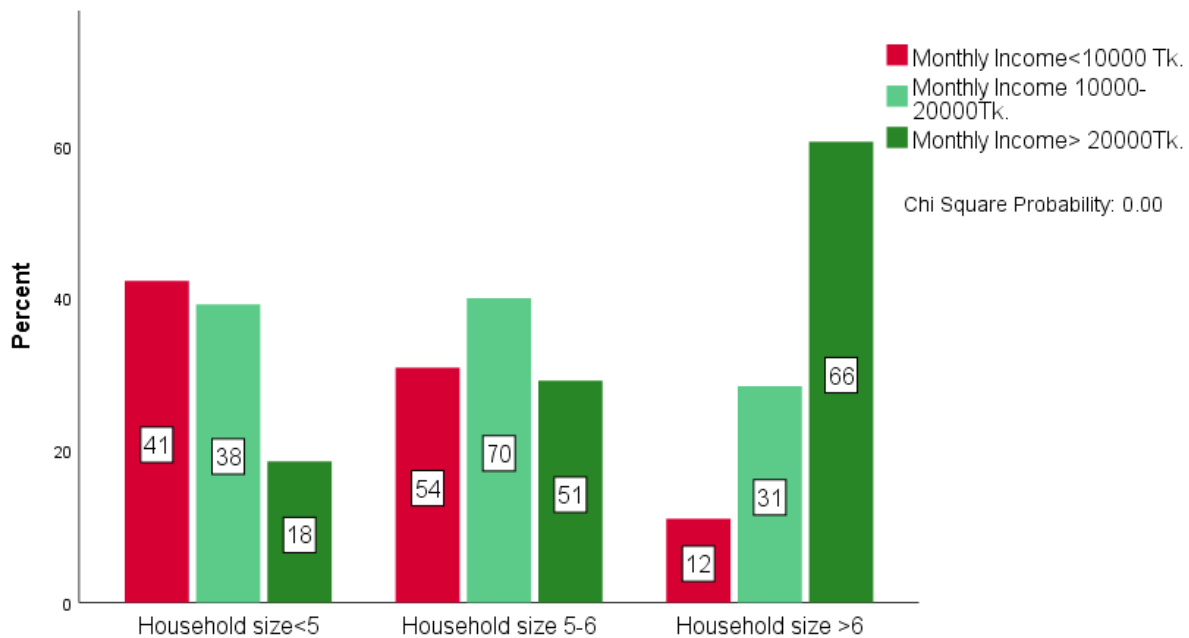


Figure 4.16 Households Monthly Income VS Household Size

4.4.3 Housing Structure

Housing structure is one important indicator of the standard of living (BBS, 2016). In rural areas of Bangladesh, three types of houses are common: full concrete houses, half concrete and half tin sheet houses, and houses made entirely of tin sheets. In general, economically well-off households tend to build homes with concrete walls and/or roofs. Table 4.6 shows the materials used in housing construction among household survey respondents. We can see that some 90% of houses in Ramgati use tin sheets for both the walls and roof (see Figure 4.17), which is significantly higher than rural areas of Bangladesh in general, especially when it comes to the walls. One possible reason for this is that wealthy households in Ramgati may not feel confident to invest in concrete houses due to the threat of riverbank erosion. One key informant suggested as much:

If you see the houses, most of the houses are built with tin...compared to other upazilas, we are behind. People do not have the confidence to spend more money to build concrete houses due to the risk of erosion. (11)

| Roof (n=380) | | | |
|--------------------------|--------------------|--------------|----------------------------|
| Materials | Corrugated tin (%) | Concrete (%) | Leaves/Straw/Tile (%) |
| Rural area of Bangladesh | 89.4 | 5.3 | 5.3 |
| Ramgati | 96.6 | 1.3 | 2.1 |
| Walls (n=380) | | | |
| Materials | Corrugated tin (%) | Concrete (%) | Without corrugated tin (%) |
| Rural area of Bangladesh | 55.7 | 20.3 | 24.0 |
| Ramgati | 89.2 | 7.4 | 3.4 |

Table 4.6 The Materials of Housing Structures in Bangladesh and Ramgati



Figure 4.17 Typical Household and Tin Sheet Houses (Source: Author)

4.4.4 Source of Energy

In Ramgati the main sources of energy are electricity, solar power and kerosene. The sources of energy in Ramgati are shown in Table 4.7. Less than half of homes (44.5%) have access to electricity, which is a lower proportion than the average of the rural areas of Bangladesh (Table 4.8).

| Energy sources | Number | Percent of cases |
|---------------------|--------|------------------|
| Electricity (n=381) | 169 | 44.5 |
| Solar power (n=380) | 190 | 50.0 |
| Kerosene (n=380) | 155 | 40.8 |

Table 4.7 The Percentage of Energy Sources in Ramgati

| Bangladesh (%) | | Ramgati (n=381)(%) | | |
|----------------|-------|--------------------|--------|-------|
| 75.9 | | 44.5 | | |
| Rural | Urban | North | Center | South |
| 68.9 | 94.0 | 36.4 | 47.0 | 56.2 |

Table 4.8 The Average Access to Electricity for Households in Bangladesh and Ramgati

Electricity is the most reliable source of energy and is desired by most households. Kerosene and solar power are used by households when electricity is not available. Solar power is common across the Upazila. Table 4.7 shows that 50% of households have access to energy through solar power. It is a renewable source of energy and a viable alternative to electricity for households that do not have a connection. Kerosene is used in lamps for lighting, but is not as valuable as electricity and solar power because kerosene cannot be used to power and recharge electronic devices.

A Chi-squared test for the spatial variation of energy sources in Ramgati (Figure 4.18) found that the North zone has less access to electricity. No statistically significant relationship was found between access to electricity and distance of households from the river (Figure 4.19).

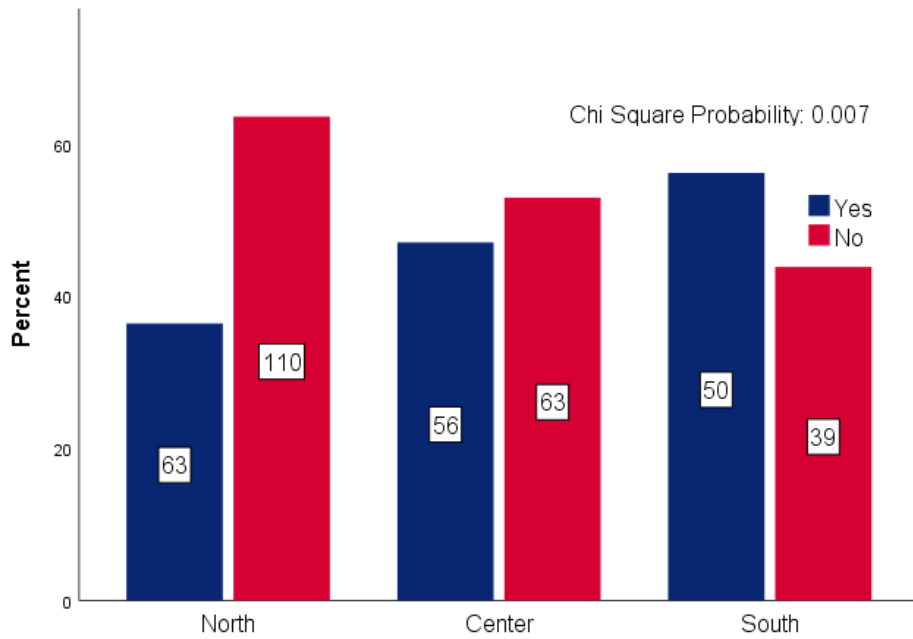


Figure 4.18 Access to Electricity by Households in Different Zones of Ramgati

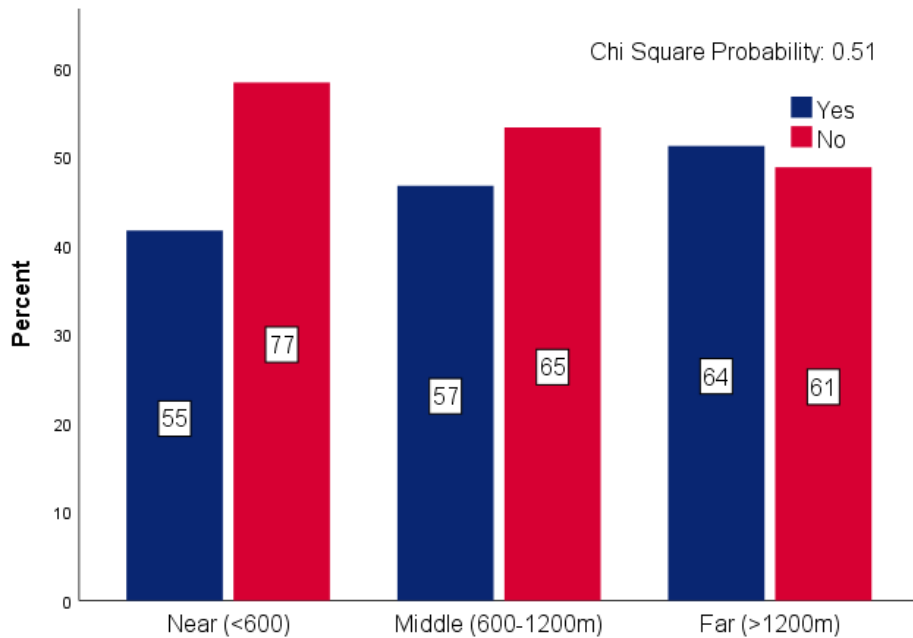


Figure 4.19 Access to Electricity by Households in Different Distances From River

4.4.5 Source of Drinking Water

In rural areas of Bangladesh, tube wells are the main source of drinking water. Households either have a tube well installed in their homestead or have to walk every day to other households in the neighborhood to acquire their daily required drinking water. In times of stress, such as a natural disaster, households lacking access to a tube well can suffer from a lack of drinking water. Overall, 60% of Ramgati households surveyed have access to a tube well (see Table 4.9 below).

Chi-squared tests were performed to assess the spatial variation of drinking water sources. Results (shown in Figures 4.20 and 4.21) found significant differences across both zone and distance. Specifically, the North zone has less access to drinking water at the homestead as compared to the Center and the South, and households nearest the river have less access to drinking water at the homestead than households in the near and far categories.

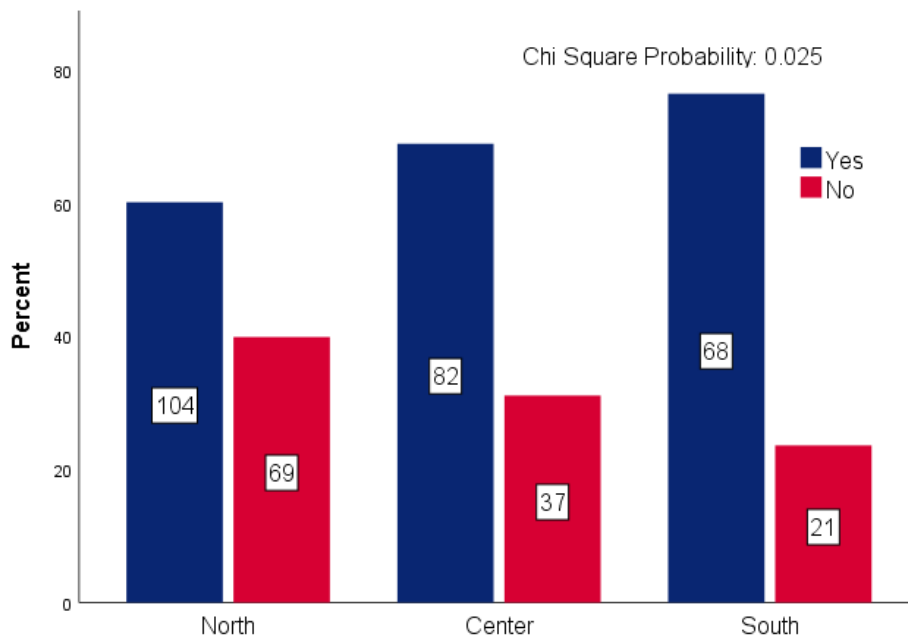


Figure 4.20 Source of Drinking Water at Homestead in Different Zone of Ramgati

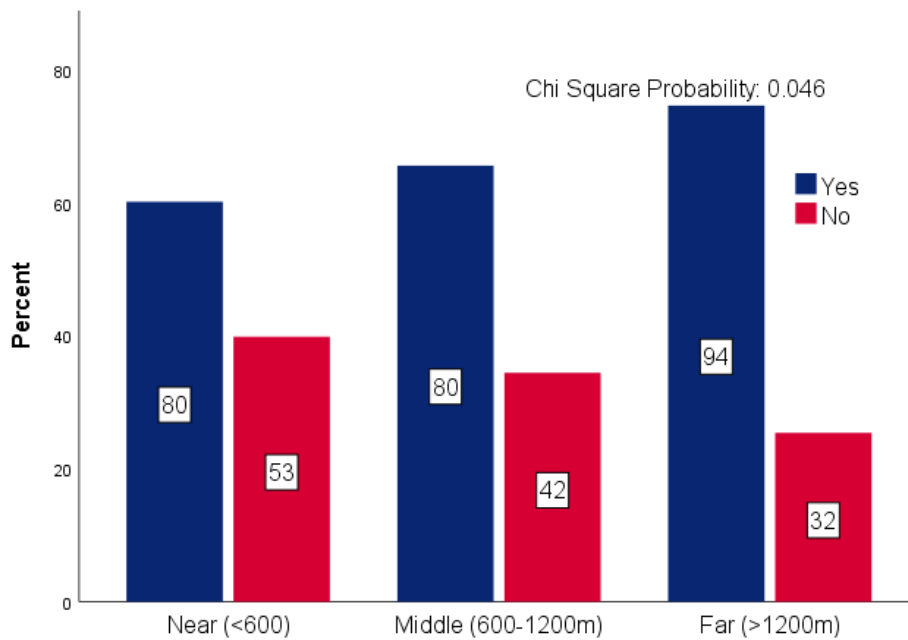


Figure 4.21 Source of Drinking Water at Homestead in Different Distances From River

4.4.6 Household Assets

Respondents in the household survey were asked to identify a wide range of household assets, including basic infrastructure, communication devices, household amenities, and livelihood assets, all of which can be viewed as indicative of socio-economic status. These assets can help households during or after disasters. Chi-squared tests were performed to test for significant differences in these household assets across both zone and distance. The only significant differences were found in the availability of refrigerators and LPG connections, which are both more common in the Center. No significant differences were found in relation to distance from the river.

| Assets | Number (n=381) | Percent |
|---------------------------------|-----------------------|----------------|
| Household Infrastructure | | |
| Sanitary latrine | 325 | 85.3 |
| Tube well | 232 | 60.9 |
| Solar light | 186 | 48.8 |
| LPG connection | 18 | 4.7 |
| Communication Devices | | |
| Mobile phone | 362 | 95 |
| Smart phone | 116 | 30.4 |
| TV | 96 | 25.2 |
| Dish network | 32 | 8.4 |
| Radio | 20 | 5.2 |
| Internet services | 18 | 4.7 |
| Computer | 4 | 1 |
| Households Amenities | | |
| Refrigerator | 43 | 11.3 |
| Sewing machine | 29 | 7.6 |
| Livelihood Assets | | |
| Livestock | 104 | 27.3 |
| Other fishing equipment | 79 | 20.7 |
| Fishing boat | 26 | 6.8 |
| Farming tractor | 2 | 0.5 |
| Transportation | | |
| Bicycle | 46 | 12.1 |
| Motorbike | 20 | 5.2 |

Table 4.9 Households Assets In Ramgati

4.5 Summary

The population characteristics of Ramgati are similar to other rural areas of Bangladesh, except that there is a higher percentage of residents in the 10 to 24 age groups. Most of the households of Ramgati are dependent on agriculture and fishing, activities that are dependent on proximity to the river. Farming and fishing households may have increased vulnerability to riverbank erosion. Many do not have other employment skills and lack the education that might help them to cope if they lose their house or land, and it would thus not be easy for them to get a job in city or town (Hutton & Haque, 2004; Rabbi et al., 2013). The average monthly income of households in

Ramgati is higher compared to the average of the rural areas of Bangladesh, but this may not always result in better living conditions. Because residents are under the threat of erosion, they may feel hesitant to build concrete houses. As we have seen, in Ramgati the percentage of tin sheet roofed and walled house is higher than in other rural areas of Bangladesh. Ramgati also has less access to electricity compared to other rural areas of Bangladesh.

The results discussed in this chapter show that there are some notable spatial differences across Ramgati Upazila. We have seen that residents tend to have more education in the Center and South zones. The south is more of a farming area, while the north is more oriented around fishing. Across the upazila, fishers tend to live near the river and farmers live far from the river. The Center zone has a higher concentration of small business and salaried employment due to the location of a large market in the Center. The households of the North have a higher average monthly income than the South or Center. The North also has a higher average household size, and across the study area large households tends to earn more money than small size households. Despite a higher income, the North zone has less access to both electricity and drinking water at the homestead. The households nearest to the river have less access to drinking water at the homestead than households far from the riverbank. Although the North has higher household income, other factors—such as lower levels of education, more fishers, and less access to electricity and drinking water—suggest that the North may be more vulnerable than the south and center to natural hazards such as riverbank erosion (Bhuiyan et al., 2017; Hutton & Haque, 2004; Rahman & Gain, 2020).

Overall, the results of this chapter show that in Ramgati there is spatial variation in the socio economic and demographic conditions of households. These geographical patterns may have an impact on the experiences and perceptions related to riverbank erosion. Chapters 5, 6, and 7 assess the extent of this impact.

CHAPTER 5

Environmental Challenges, Impacts of Riverbank Erosion, Household Adaptation Strategies, and Government Responses

Because of its geographical location within the massive GBM hydrologic system, Bangladesh experiences riverbank erosion on a continual basis. Adaptation strategies, preparedness programs and management plans can help to mitigate and minimize the impact of such events. This chapter is focused around Research Objective 2 and has three key aims. First, the chapter describes the prevalence of riverbank erosion in Ramgati and its impacts on local residents. Second, the chapter discusses some of the adaptation strategies that have been adopted by the local people, including patterns of resettlement forced by the loss of home and property. Finally, the chapter describes initiatives taken by the local and national government as well as NGOs to deal with the issue of riverbank erosion. Chi-Squared tests were performed to identify the association or statistical relationship of different variables—such as household location, socio economic condition, occupation and past experience—on the impact of riverbank erosion, adaptation strategy, and perception of NGOs and government initiative.

5.1 Environmental challenges

Ramgati is one of the Upazilas within the coastal Laksmipur District. Due to its location along the lower left bank of the Meghna River, households experience a number of different hazards related to the river and other natural phenomena (Fussel, 2007; Khatun, 2019; Rahman et al., 2014; Parvin et al., 2008). Floods and riverbank erosion are the most common hazards. Respondents in the household survey were asked to identify hazards that have caused the most serious negative impacts to their household. As Figure 5.1 shows, 210 out of 381 (55%) respondents mentioned

flood, and 126 (33%) respondents mentioned riverbank erosion as the most damaging hazard in Ramgati Upazila. Other natural hazards, such as cyclones, tornadoes, thunderstorms, nor westers, and lightning are less damaging events in Ramgati.

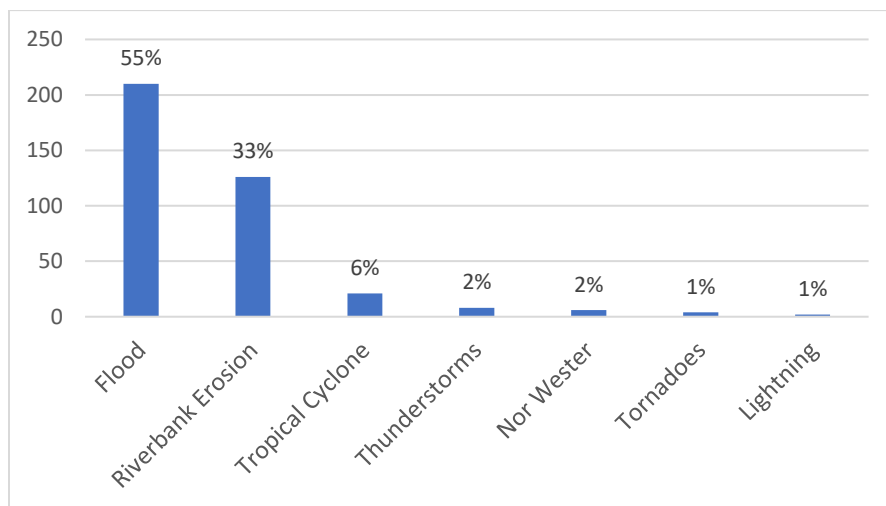


Figure 5.1 Most Damaging Hazard Since 2008 in Ramgati

Flooding is an annual phenomenon in Bangladesh, and is a common hazard across the country. It can result from high tides, excessive rainfall and snowmelt from upriver. In addition to being the most common response in the survey, flooding was also mentioned by interview respondents. All five of the respondents from the South zone mentioned that flooding is very common. One interviewee from the South said that,

During high tide in the river, water can inundate lands and houses. Flooding usually happens in the rainy season. (7)

The respondents from the Central zone, which is now protected by the new revetment, expressed that they no longer have problems with flooding. One respondent from the Center said that,

Now, flooding is not a problem here. Before building this revetment flooding was ... a problem. (1)

Usually, the Meghna River carries fresh water from upriver, but occasionally saline water enters Ramgati from the Bay of Bengal. This can have a detrimental impact on crops. All of the interview

respondents from the North and South zones reported that they are suffering from occasional problems with salinization. One respondent from the South shared that,

During high tide, river water flows inland and there is also an occasional problem with salinization ... Saline water...is not good for agriculture. (15)

Other natural hazards, such as tropical cyclones, thunderstorms, nor westers, tornadoes and lightning occur infrequently. Tropical cyclones, while rare, can have a significant impact. One fisherman from the South recalled that,

Recently we experienced a cyclone. Most of the houses were severely damaged. We left our house and took shelter in my grandparents' house. (5)

5.2 Extent of Riverbank Erosion

Riverbank erosion is a significant problem in Ramgati. Thousands of households have lost homes and land to the river and thousands more are at risk from erosion. Figure 5.2 depicts shoreline change from 1984 to 2016 based on imagery from Google Earth. We can see that the west border of Ramgati has been eroded almost 3 miles. Key informant interviews provide further evidence for this trend. A number of interviewees described huge loss of lands and houses due to riverbank erosion in Ramgati. One, for example, said that,

We have already lost half of this Upazila due to the erosion...we lost one whole union that was Char Abdullah.(12)

An assistant teacher of an elementary school mentioned that,

In my childhood...this riverbank was 10-15 kilometers away...But now you see this river is very near to my house. (14)

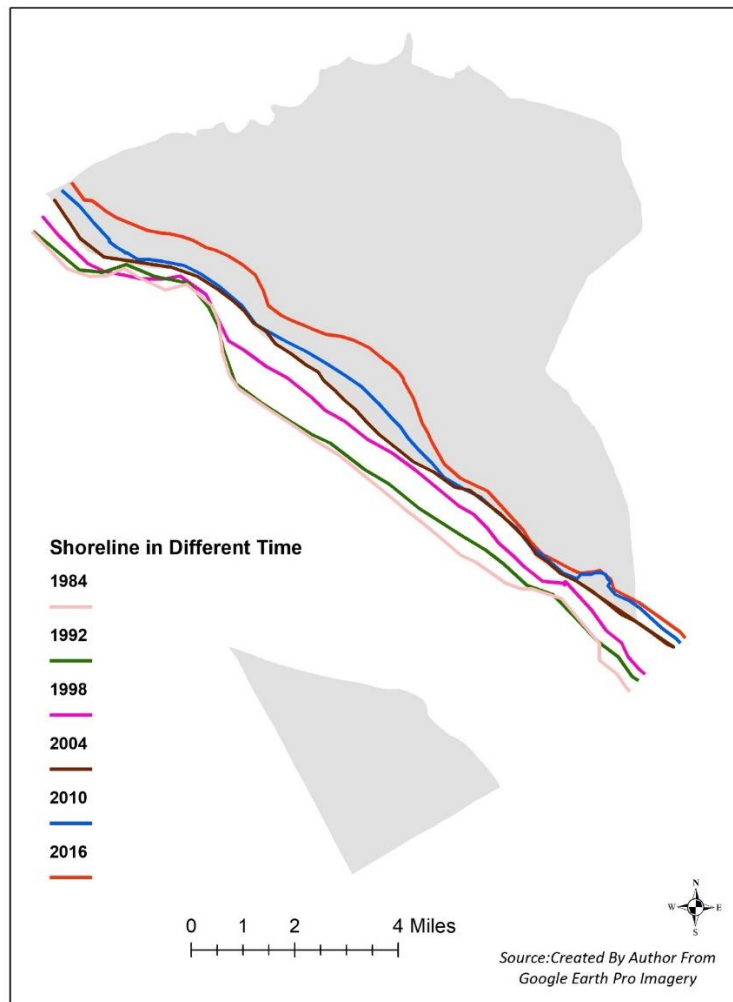


Figure 5.2 Change of Shoreline Along Ramgati Upazila

With such a significant amount of shoreline change, it is not surprising that many households report being affected. Looking at survey respondents, 167 out of 341 (or 49%) said that riverbank erosion had previously forced their household to move. Of those interviewed, 45% indicated that they had previously lost their homes as a result of riverbank erosion, and an additional 22% mentioned that their father had lost his house (see Figure 5.3). The impacts have been felt across all zones of Ramgati. Figure 5.4 shows the riverbank erosion in the North zone.

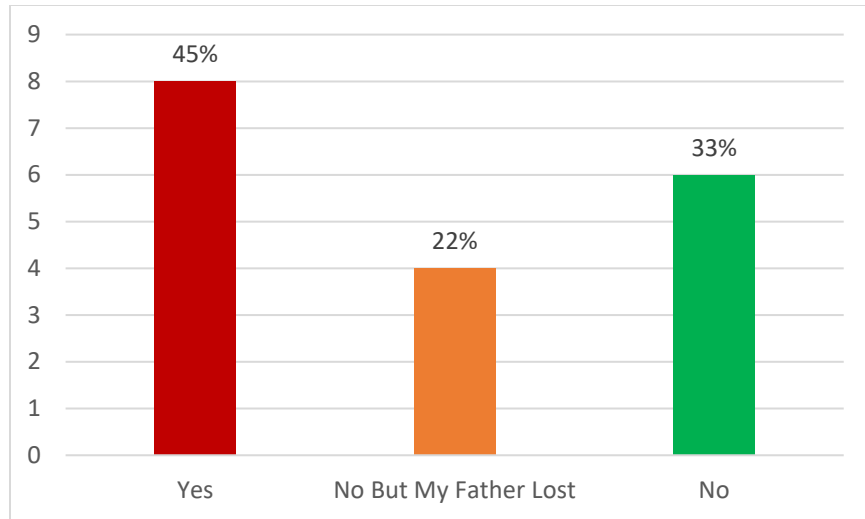


Figure 5.3 Victims of Erosion



Figure 5.4 Riverbank Erosion In Ramgati (Source: Author)

During the interviews, respondents with different occupations shared their experiences with the erosion problem. One fisherman from the Center zone said that,

My father had a house at Bhola district. Before my birth he lost that house and moved here to Ramgati. Again he lost his house here and...the lost house was very near to this embankment. (20)

A fisherman from the North zone mentioned that,

I lost almost 2 acres of land in the river. My father also lost his house, which is why we moved here about 40 years ago. We were in the same Upazila at 7 number char alexander union and then we moved here to 4 number char alexander union. (16)

One of the business owner from the South zone said that,

We lost our house 12 years ago and we also lost almost 30 acres land. After that we moved here. There was nothing we could do. You cannot do anything against this disaster. (15)

The interviews suggest that people of all occupations are directly or indirectly affected by riverbank erosion. To assess whether the experience of losing one's house to erosion varies depending on the occupation of the household head a Chi-Squared test was performed. Figure 5.5 shows that there is a statistically significant relationship between the victims and occupations, with fishers being more likely to have experienced losing their house or land to the river. One possible explanation for this result is that fishers tend to live near to the river and are therefore more likely to experience riverbank erosion.

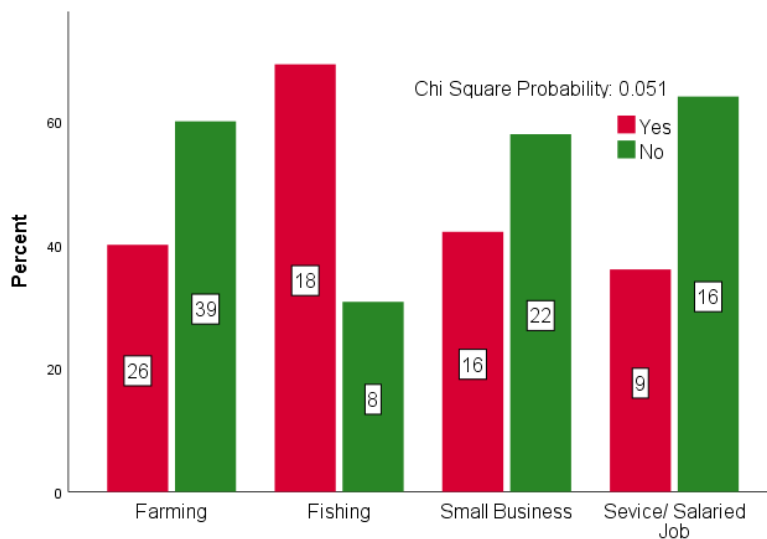


Figure 5.5 Occupation Vs Past Experience of Erosion

5.3 Impact of Riverbank Erosion

The major consequences of riverbank erosion are loss of homestead and agricultural land, forced migration, and the resulting negative impacts on the livelihoods of victims. Riverbank erosion also has social and economic impacts on other community residents. Table 5.1 shows responses to the following question on the household survey: “For your most recent relocation due to riverbank erosion, please identify negative impacts that this erosion event and relocation had on your household.” As we can see, households report losing agricultural lands, assets, crops, and livestock. Waterborne diseases can occur in displaced communities because a large number of people may be forced to share a small dwelling where there is a lack of fresh water and sanitation facilities.

| Impact | Number of Households | Percentage of Households (%) |
|---|-----------------------------|-------------------------------------|
| Loss of assets (household items) | 149 | 39 |
| Loss of income | 143 | 38 |
| Shortage of drinking water | 140 | 37 |
| Loss of crops | 130 | 34 |
| Inconvenience | 130 | 34 |
| Loss of land used by household | 129 | 34 |
| Incidence of waterborne diseases | 99 | 26 |
| General despair, feeling of much stress | 99 | 26 |
| Loss of livestock | 79 | 21 |

Table 5.1 Negative Impacts of Riverbank Erosion

When people lose their homes, they often are forced to move to a new area and find a new job. It often takes time to cope in a new community. One farmer from the Center mentioned that,

[Households who have been forced to relocate] are surviving badly. You know after losing their house they usually live in someone else’s place. The new locality often doesn’t accept them, and they can be treated badly. We used to call them “refugees” which is kind of a bad word. (18)

5.3.1 Migration Dynamics

Losing and rebuilding houses is a common occurrence in Ramgati. We can examine the prevalence of household resettlement using results from the household survey, which asked respondents whether they had been forced to relocate because of riverbank erosion. Figure 5.6 shows the relationship between relocation and length of time in current residence. The results, which are statistically significant, show that 93% of respondents who have been in their homes less than 10 years report being the victims of riverbank erosion. By contrast, only 8 percent of those who have lived at their current residence more than 10 years reported a previous relocation due to erosion. Based on this finding, it could be said that in recent years, Ramgati households have experienced greater incidence of erosion than in previous years.

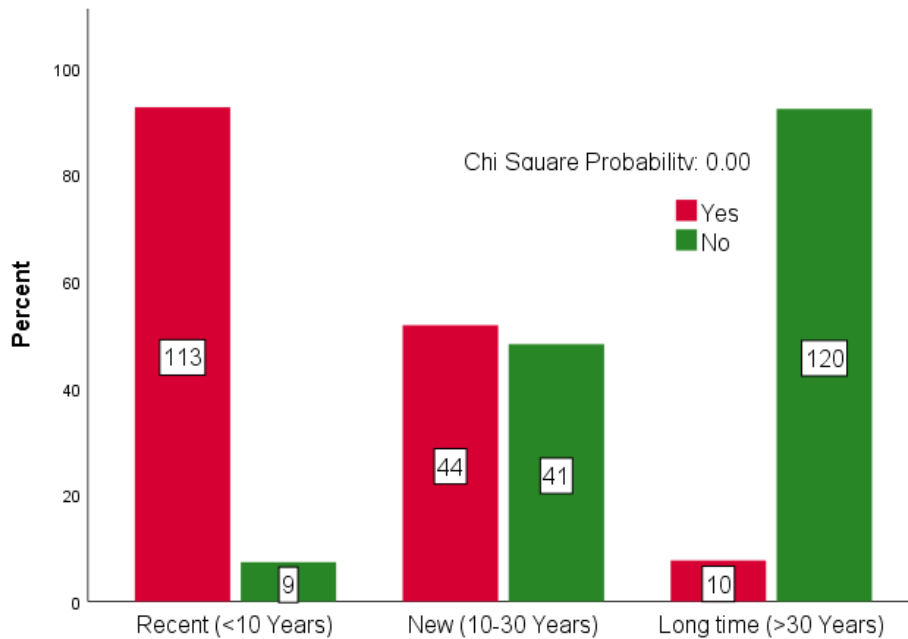


Figure 5.6 Past Experience Vs Length of Stay in Current Home

Results from the household survey can be used to examine the settlement patterns of those who have fallen victim to riverbank erosion. Chi-Squared tests were performed to assess the spatial location of respondents who have past experience of erosion in Ramgati. Figure 5.7 shows that there is no statistically significant relationship when examining the zone of victims. Households with previous experience of migration are almost evenly distributed across the three zones. Figure 5.8 shows that a statistically significant relationship was found between the distance of households from the river and their past experience of relocating. In particular, households near to the river have more previous experience with riverbank erosion. Of those now living within 600 meters of the riverbank, 63% reported being previous victims of erosion compared with only 33% of those living 1200 meters or more from the river.

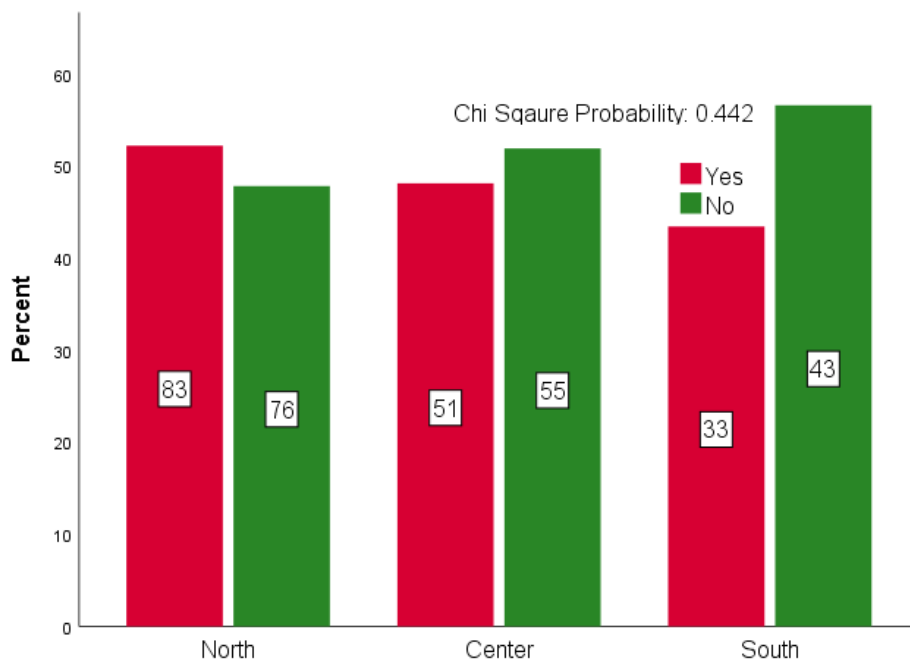


Figure 5.7 Victims of Erosion in Different Zones

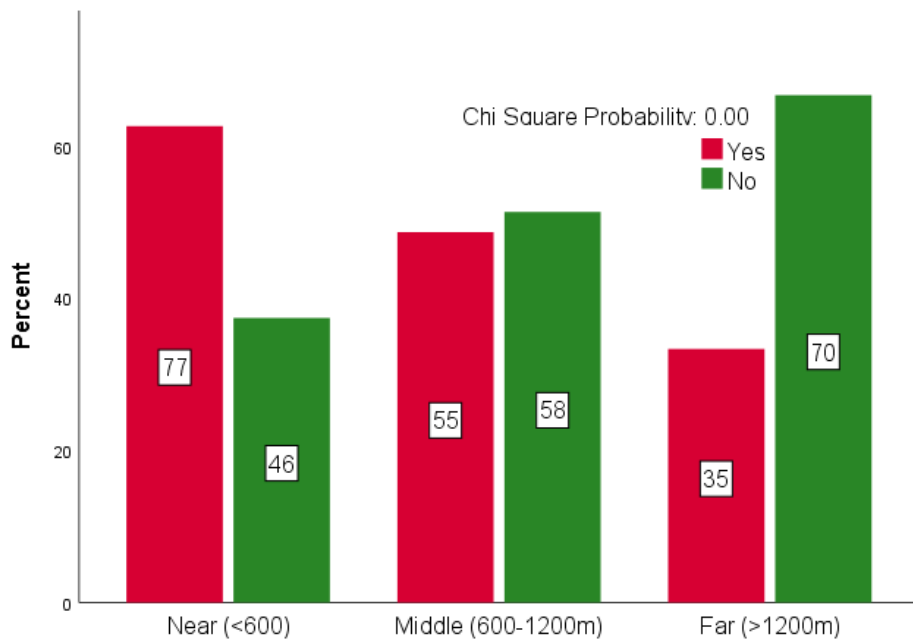


Figure 5.8 Victims of Erosion in Different Distances

5.3.2 Household Income

Riverbank erosion can have many direct and indirect impacts on the livelihoods of victims. One important impact can be the loss of household income as a result of livelihood disruption or forced relocation. Using data from the household survey, a Chi-squared test found a statistical relationship between households' past experience of erosion and average monthly income. Figure 5.9 shows that 62% of low income households have previously experienced erosion, suggesting that riverbank erosion has a negative impact on household income.

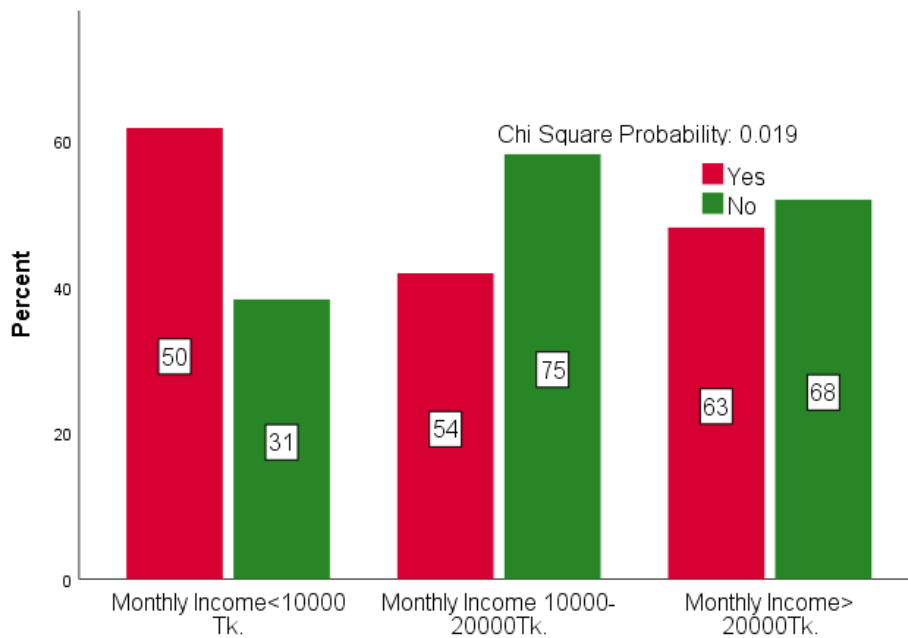


Figure 5.9 Monthly Income Vs Past Experience

5.3.3 Impacts on Riverside Communities

Residents who have not lost their house can still be affected by the phenomenon of riverbank erosion. Many feel they are under the threat of erosion, which can cause anxiety and indirectly impacts their livelihood. Farmers fear losing lands, businessmen are losing customers, and fishing boats are losing labor.

During interviews, farmers and fishers stated that they constantly worry under the threat of losing their livelihoods due to erosion. One farmer shared that,

Our major problem is erosion - I always think that anytime I could lose my lands in the river. (23)

Fishers also face the threat of losing their households, which would require moving somewhere else and perhaps changing their occupation. One fisherman said that,

The river still has fish even though the bank is eroding, but, if I lost my house I would have to move and it would be depressing. That would impact on my occupation and livelihood. Fire or any other hazard can affect your livelihood but riverbank erosion affects your house as well as your livelihood.(20)

Similar to the fishers, those who own businesses worry that they are at risk of losing their household or livelihood. A tea stall owner said that,

Yes I know I am in risk now. I am doing well in my business now, but if I lose my house I don't know how I can survive. I would need to ask my neighbor for a place to stay. Otherwise I would have no option. And if I move from here I will lose my business which is the main source of my income. (22)

Even business owners who are not directly impacted can feel the effects of riverbank erosion on their customer base. As one business owner stated,

Due to riverbank erosion, a lot of people moved away from from here, so eventually I lost my customers. As a result, now my daily sales are very low and my income is not sufficient to support my family. One customer who took a loan from me never paid me back, and has now lost his house and moved away from here. (7)

Another business owner mentioned that,

When my customers lose their house, they move away from here. Sometimes they cannot pay me, and ultimately that affects my business. Even so, I cannot ask or force them to pay me back. How can I ask them? I see they are in very bad situation, they are living hand to mouth. (18)

Because of the threat of erosion, people are reluctant to invest money in businesses in Ramgati, and this is an obstacle to the region's development. A college teacher said that,

This is an underprivileged area. If you go through all of this area you will not see any banks here. People have no money. The area faces constant risk of erosion, so investors are not interested to do development work here. People do not want to buy land here. (12)

Overall riverbank erosion is a key reason why a community may be underprivileged. It keeps the residents under stress and it has a negative impact on the socio-economic development of riverside communities.

5.4 Adaptation Strategies

Adaptation practices can play an important role in mitigating the impact of extreme events like riverbank erosion. Although local residents in Ramgati must find ways of responding to the threat of riverbank erosion, many also express a sense of hopelessness, and often individuals have no choice but to accept their situation. A fisher from the South shared that,

Riverbank erosion is a big problem. Individually I can't do anything against this problem.
(3)

When considering coping mechanisms in Ramgati, there are two types of activities: one is to take measures beforehand to protect against erosion (mitigation), and the other is to respond after losing land or houses (adaptation). In general, mitigation initiatives are taken by the community or local government, and include placing geo bags along the shoreline and making bamboo fences to temporarily control the severity of the erosion. A teacher said that,

General people cannot take any action. The government only can take initiatives to control this erosion problem. People are fully dependent on government. Because they can do nothing. They cannot fight with the Meghna. (13)

This study documented a variety of adaptation responses among the victims of erosion in Ramgati. Well-off households are able to move in order to escape the hazard. When people are displaced, some families can get help from friends or relatives, often moving into their house until they are able build or buy their own. But the poor and those who have no help from others often suffer more. They often end up living near their lost household or on khash lands (lands owned by the government), or moving to a slum. A respondent replied that,

I know many family who lost their houses like us. Rich people who had land and money they built new house, but the poor people still living here near to the river bank. Poor have no option to go somewhere. (5)

A college teacher said that,

I also lost my house but still I am in a good position because I am doing a good government job as well as government is paying a sophisticated salary to me. All of my brothers and sisters are highly educated and established. (12)

Figure 5.10 shows, how households respond to riverbank erosion. In Ramgati, the common adaptation strategies to survive after losing one’s house or land in the river are to take a financial loan, get help from the relatives and friends, and sell livestock. No significant differences were seen among in adaptations strategies across zones and distances within the Upazila.

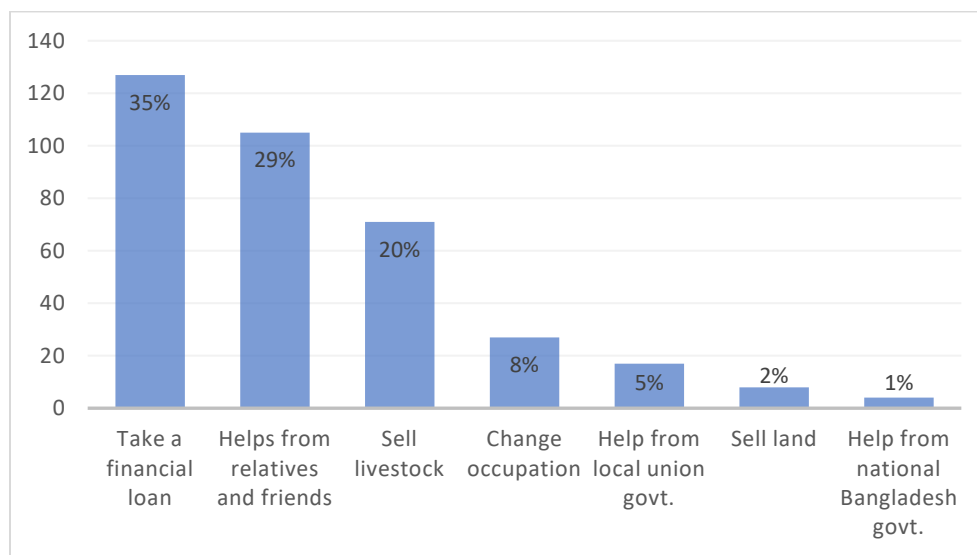


Figure 5.10 List of Adaptation Strategies

5.5 Government and NGOs initiatives

The Bangladeshi government and NGOs have taken a number of initiatives to mitigate the impact of riverbank erosion problems in riverside communities. Those initiatives are discussed below.

5.5.1 Government Initiatives

When confronted by the enormous challenge of riverbank erosion, riverside communities expect assistance from the national government. The government’s primary mitigation initiatives are to protect the riverbank using geo-bags or a concrete revetment. Government programs can also help the victims to resettle and rebuild the house. In Ramgati, interview respondents noted that their

local government provides land to the victims who becomes landless due to riverbank erosion. A local government official said that,

When they lose their house, they come to my office and they ask for a piece of land to live on. Then we provide land to them. The government has khash land and we give it to them free of cost...But the government needs a lot of funding for this. (13)

Despite this, 53% of Ramgati residents report being unhappy with the activities of the national and local government except for the new revetment (see Figure 5.11). Their main demand to the government is to protect all of Ramgati by extending the revetment.

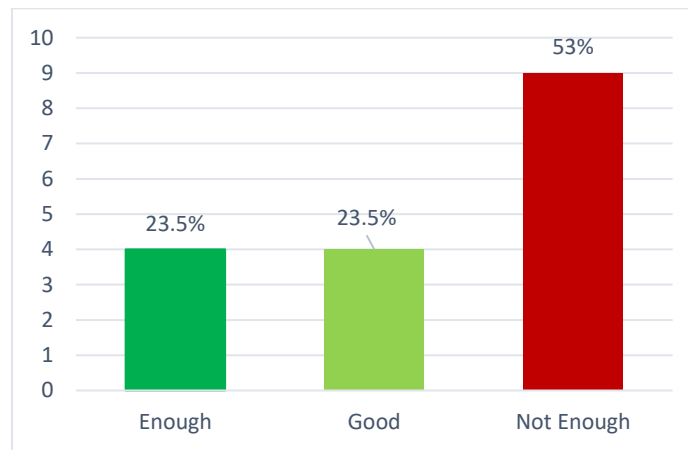


Figure 5.11 Level of Help From the National Government

5.5.2 NGOs Initiatives

In Bangladesh, adaptation and mitigation activities are also undertaken by NGOs. NGOs such as ASHA, BRAC, and Grameen Bank are working in Ramgati. They assist people by giving them loans, livestock, seeds, and fertilizer, and by providing occupational training. Some NGOs work to empower women by teaching them activities such as tailoring and handicrafts. One respondent mentioned that,

There are some NGOs who are helping people by giving loans for doing business. For example, I am totally dependent on ASHA and BRAC to run my business. I have 300,000 taka in loans from them. (4)

In Bangladesh NGOs are working to help people adapt and to mitigate the impact of natural disasters. To identify the activities of NGOs in Ramgati, the household survey asked the question: “In the past five years, have you taken a loan from an NGO?”

In Chapter 4 it was concluded that the North zone is more vulnerable to riverbank erosion. It can be hypothesized that this area would therefore have more experience working with NGOs. A Chi-Squared test found a statistically significant relationship between household location and the activities of NGOs. Figure 5.12 shows that the majority (55%) of people who took a loan from an NGOs are located in the North.

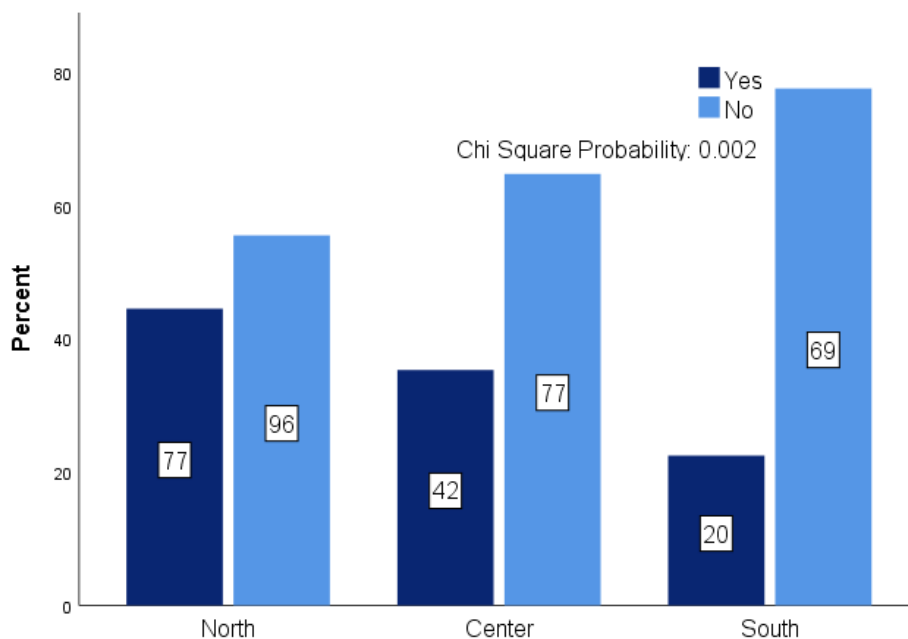


Figure 5.12 Distribution of Loan Holder From NGOs in Different Zones

As noted above, one of the major adaptations strategies in Ramgati is to take a financial loan from NGOs. So it could be hypothesized that the victims of riverbank erosion will have more connection with NGOs. To examine the relationship between previous experience of erosion and relationship with the NGOs a Chi-Squared test was performed and found a statistically significant relationship

between holding a loan from an NGOs and previous experience of erosion. People who have been forced to move are more likely to have taken a loan from an NGOs (see Figure 5.13).

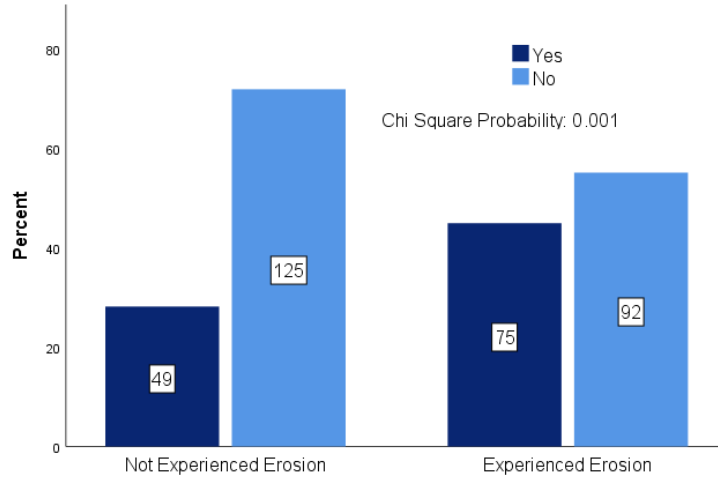


Figure 5.13 Past Experience Vs Loan from NGOs

Figure 5.5 showed that fishers are more likely to have experienced losing their house or lands in the river. Accordingly, it can be hypothesized that the fishers will have a greater connection with NGOs. As Figure 5.14 shows, a Chi-Squared test found a statistically significant relationship between occupation and holding a loan from an NGOs, with the fishing community being more likely to have taken an NGO loan.

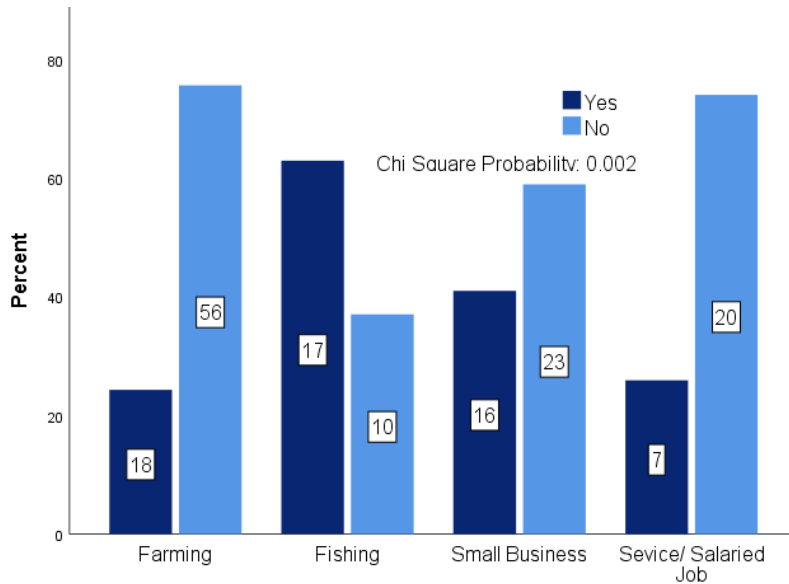


Figure 5.14 Occupation Vs Loan from NGOs

Overall, NGOs in Ramgati are working with the vulnerable community to mitigate the impact of riverbank erosion as well as other natural disasters. One of their main activities is to provide financial loans to affected households.

5.6 Summary

In Ramgati, the more frequent hazards are flooding and riverbank erosion, although other natural hazards such as tropical cyclones, salinization, tornadoes, thunderstorms, and lighting are occasionally experienced as well. Results from both the household survey and interviews show that riverbank erosion is a significant problem in Ramgati. Thousands of households have already been affected and thousands more are at risk of erosion. Previous studies by Bhuiyan et al. (2017) and Rabbi et al. (2013) both showed that the major impacts of riverbank erosion are the loss of houses and forced migration. The findings of this study show that this is also true for the coastal zone of Bangladesh. Losing and rebuilding houses is very common in Ramgati, and even people who have not yet lost their house feel that they are under the constant threat of erosion. Riverbank

erosion not only has a negative impact on livelihood of victims, it also affects other residents of the riverside communities.

Rahman and Gain (2020) showed that riverbank erosion has a negative impact on the socio-economic, cultural, psychological and environmental development of riverside communities. These findings are also true for the present study. Riverbank erosion makes people nervous and indirectly affects their livelihoods. People are reluctant to invest money in businesses in Ramgati due to the constant threat of losing their households and lands by erosion. Results from this chapter show that erosion affects some Ramgati residents more than others, with fishers more likely to have experienced losing their homes or lands. The Near distance and low income households have more experience with riverbank erosion in Ramgati.

Often individuals have no choice but to accept their situation. In Ramgati, most of the victims take financial loans from NGOs, banks or friends and relatives. Other common adaptation strategies are to seek help from friends and relatives, change occupations, or sell livestock or other or household assets. Haque (1998), Rahman & Gain (2020) and Rahman et al. (2014) found similar findings for other riverside communities in Bangladesh.

In addition, this chapter identified some of the initiatives that have been taken by the Bangladesh government and by NGOs. Prior to building the revetment (the history and impact of riverbank erosion is discussed in following chapters), the government placed geo-bags several times, but this was not effective. The government also has been resettling some displaced people. Several NGOs are also working in Ramgati. They help residents by providing loans, livestock, seeds, fertilizers, and occupational training. Households in the North are more connected with NGOs as are fishers and those who have past experience with riverbank erosion.

CHAPTER 6

History and Impact of the Revetment on Livelihoods

This chapter addresses the third research objective. As described in Chapter 5, riverbank erosion has been a recurring hazard for the people of Ramgati, and a constant source of deprivation and stress. The construction of a concrete embankment is a common response in Bangladesh to protect riverside communities from erosion. In Ramgati, after pressure by local residents, a 3.5 kilometer revetment was built in the Center zone of the study area as a means to control the riverbank erosion. This chapter discusses the history and impact of this revetment. First, it describes the community activism that influenced the building of the embankment. Next, the chapter assesses how the revetment influences local livelihoods.

6.1 History and Reason for Building the Revetment

Interview respondents and Google Earth Pro imagery suggest that riverbank erosion has been a continuous problem along the entire left bank of the lower Meghna River, including the entire 16 km shoreline of Ramgati. Concrete embankments have been built in several places along the lower left bank of the Meghna river, but most of this shoreline has remained unprotected. Because the construction of embankments requires a significant amount of funding, the government of Bangladesh has built them only on an emergency and priority basis.

Prior to the building of the embankment in Ramgati, the riverbank was continuously eroding. People became increasingly desperate, and eventually organized a protest in Ramgati and neighboring Kamalnagar to draw the attention of the national government (see Figure 6.1). One of the interview participants was directly involved with the protests at that time. He said that,

When this river started coming very near to us, I thought a lot about the local communities. It seemed that we had no government. I thought, if we have a government, then why are people suffering? I even saw people who were landlords become homeless due to erosion ... So we staged protests and made human chains, movements to get attention from the government. Our demand was to build an embankment to protect us from erosion.



Figure 6.1 Human Chain at the Riverbank of Ramgati (Source: Facebook)

As Zaber et al. (2017) describe, the movement to stop riverbank erosion in Ramgati made extensive use of social media and represents an innovative approach to protest in the context of hazards. The younger generation of Ramgati, many of whom reside in cities such as Dhaka or Chittagong or live abroad, started to post photos, videos and commentary on Facebook related to riverbank erosion. The online activists posted on their individual Facebook wall as well as Facebook groups or pages, with the aim of highlighting the situation to the rest of the country, and to gain the attention of the national government and ultimately convince them to build a protective embankment. The activists promoted the use of specific hashtags when posting something related to the riverbank erosion problem in Ramgati and Kamalnagar. Figure 6.2 shows some of the

Facebook posts that were collected from Facebook by searching for the hashtags #SaveRamgati, #SaveRamgoti and #SaveKamalnagar.

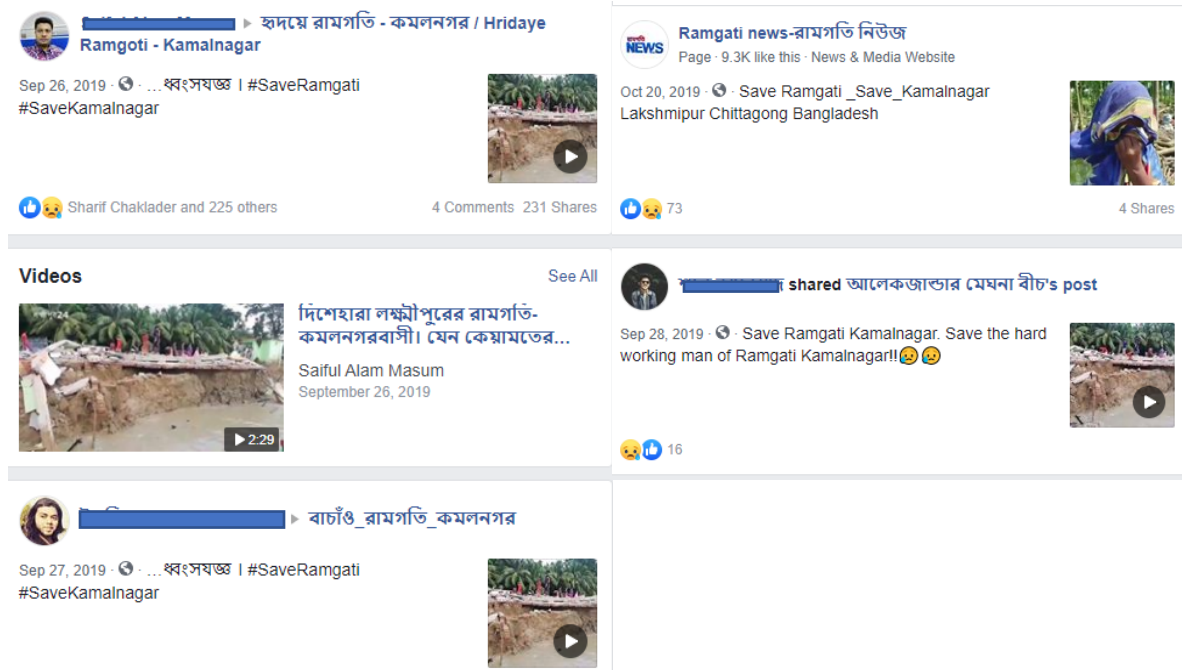


Figure 6.2 Different Posts in Facebook Related to Riverbank Erosion in Ramgati

It is worth noting that most of the activists were living outside of Ramgati, in areas that have good internet access. Survey data (see Table 4.9 in Chapter 4) indicate that social media access is not widespread in Ramgati; 30% of households have a smartphone and only 4.7 % have internet access.

Eventually, the local Member of Parliament (MP), Abdullah Al Mamun, visited Ramgati and told local residents that the Bangladesh government would build an embankment in Ramgati. One online activist posted on Facebook that:

“This Monday (11-07-16) at 6.20 pm in the afternoon, our honorable MP Mr. Al Mamun and a team of officials came to Ramgoti to visit erosion-affected areas. The MP had the

opportunity to talk to people who were affected by erosion recently. He assured to initiate bank protection measurement as soon as possible” (Zaber et al., 2017, p. 5).

The MP helped to secure funding from the Bangladesh national government, and in 2015, the engineering division of the Bangladesh Army started the embankment construction work. In 2017, they completed the revetment.

A key question for this study is why the revetment was built only in the center of the Upazila. Based upon interviews with local residents and key informants, it is clear that the center was chosen because it is the location of the Upazila administrative offices as well as government schools, colleges, a hospital, and the largest marketplace. In the images below (Figure 6.3), the geo-location of the revetment has been drawn manually in relation to some of the Upazila’s important administrative and commercial activities. It would obviously be more costly to rebuild this infrastructure than to protect the riverbank with a concrete embankment. As one key informant mentioned:

You know, the upazila headquarters is here, and the municipality is also here. This is the heart of Ramgati - all of the government institutions are here. That was the reason to build the revetment in the center. (13)

Another stated that:

You see, the revetment is very near to the municipal center where we have all of the government offices, institutions, schools, colleges and market place. To save all of these institutions, the government decided to build the revetment as soon as possible. (10)



Figure 6.3 Locations of the Revetment and Government Institutions

6.2 Impact of the Revetment on Livelihoods

Interviews with local residents addressed their perceptions of the revetment. Overall, respondents expressed a high degree of satisfaction, with many suggesting that it is one of the best initiatives undertaken by the government. Key informants were in agreement that the revetment protects the government from big losses. Local business owners, many of whom had suffered as riverbank erosion affected their customers, stated that they are doing well again. One business owner said that,

We never lost any lands or any other properties [because of erosion,] but it affected on our business. Before, we would sell around 600,000 taka per day [\$7500]. But due to the erosion we could sell only 200,000 taka per day [\$2500]. After the building this revetment, our business is doing well again. Actually, this revetment brought lot of changes in our daily life. Everything is going well now. But before building this revetment, for 5 to 6 years we had to suffer the erosion problem. (17)

Farmers living in the Center zone are also benefitting from the revetment, which has eliminated problems of river flooding and salinization. One farmer from the Center said that,

We don't have a flood problem, (19)

and another stated,

There is no salinization problem after building this revetment. (18)

Another benefit for the Upazila is that the revetment has become a place for recreation. Many people now visit the revetment to see the natural beauty of the mighty Meghna river. Many enjoy swimming or sitting at the edge of the river. During festivals, it is crowded with tourists, and some local residents have taken advantage of new business opportunities because of the revetment. Tourists, for example, buy fish from the local fish market or other traditional foods from the Upazila marketplace. One respondent said that,

During different festivals lot of tourists come to enjoy the natural beauty of the Meghna river. Local people are benefiting financially because of the tourists. Some new shops have been established near the revetment. (17)

The local government has recently made an effort to make the area around the revetment more aesthetically pleasing to attract tourists (Figure 6.4). They have planted trees along the revetment, built chairs and covering, added lighting to the revetment, and added security. One local government official said that,

Yes, we are trying to attract more tourists by establishing some opportunities and facilities. We added some seats and sheds. We also planted trees there. You know, during festivals a lot of people visit here...We have a plan to build public toilets for the visitors. Local businesses have benefitted due to the visitors. (13)



Figure 6.4 The Revetment in Ramgati (Source: Author)

6.3 Summary

As we have seen in Chapter 5, riverbank erosion has a huge negative impact in Ramgati. To help mitigate the impact of erosion, the national government of Bangladesh built a revetment in the Center zone of Ramgati. Based upon the discussion in this chapter, it is clear that the Center was chosen because that is where the Upazila administrative offices, government schools, colleges, hospital, and largest marketplace are located. Otherwise the government would risk losing all of these institutions and infrastructure in the river.

This study found that the revetment has had positive impacts on the livelihoods of residents in the Center. People of all occupations are doing well due to the presence of the protective embankment. Business owners are doing better in their businesses and farmers have fewer problems with flooding and salinization.

The revetment has also become a tourist spot, and people now visit the revetment to enjoy the natural beauty of the riverbank. Local businesses have benefited from tourist visits, and the local government is working to make the revetment more aesthetic and secure in an effort to attract more tourists.

CHAPTER 7

Factors Influencing Risk Perception

This chapter focuses on the fourth research objective and is aimed at identifying key factors associated with resident perceptions about riverbank erosion now that the revetment has been completed. Risk perception can be influenced by the type of hazard as well as the socioeconomic conditions and demographic characteristics of the respondents. Differences in perception among different stakeholders can affect efforts to solve the riverbank erosion problem. To address this issue properly, a comprehensive approach is essential, where the perceptions of all stakeholders, including local residents, are incorporated in policy or decision making.

Respondents to the household survey were asked a number of questions designed to document local perceptions regarding riverbank erosion and measures to protect against it. To assess differences in this perception, Chi-Squared tests were performed to identify the association between location (zone and distance) and socioeconomic and demographic variables and perceptions of erosion risk and attitudes toward the new revetment.

7.1 Magnitude of Riverbank Erosion

As described in Chapter 5, the bank of the lower Meghna river basin has been eroding steadily over the past several decades. To judge whether local residents perceive this to be the case, they were asked to evaluate the statement that “riverbank erosion has increased since 1990”. In Ramgati, 97% of respondents think that riverbank erosion has increased since 1990. Interview respondents mentioned that in recent years they have seen increased shoreline change along Ramgati Upazila. One interview respondent said,

In 2003, I can remember that this riverbank was 15 kilometers away where it is now.

Due to the strong consensus among survey respondents, no differences could be detected in perception of erosion increase by location, socioeconomic status, or demographic characteristics.

7.2 Concern of Losing Home

Montz, et al. (2017) showed that location of household, education, income, previous experience with a hazard, occupation, age, gender, and other individual traits have an influence on risk perception. These factors can work individually, in combination, or even in sequence to influence an individual's perception and response. The association or statistical relationship of those factors on people's perception in Ramgati is described below. The Ramgati household survey asked residents to respond the following question: "For this current year of 2018, how worried or concerned are you that your home will fall into the Meghna River due to riverbank erosion?" Responses to this question are used as a measure of risk perception in the analysis below.

7.2.1 Zone

To begin with, it can be hypothesized that the existence of a revetment will influence the level of concern about erosion. In the Ramgati example, the revetment was built in the Center zone, while the north and south remain unprotected. A Chi-Squared test was performed to identify the relationship between the existence of a revetment and the level of concern about erosion. The test found a statistically significant difference in perception across the three zones. As can be seen in Figure 7.1, the households located in the North and the South are more concerned than the households that are located in the Center.

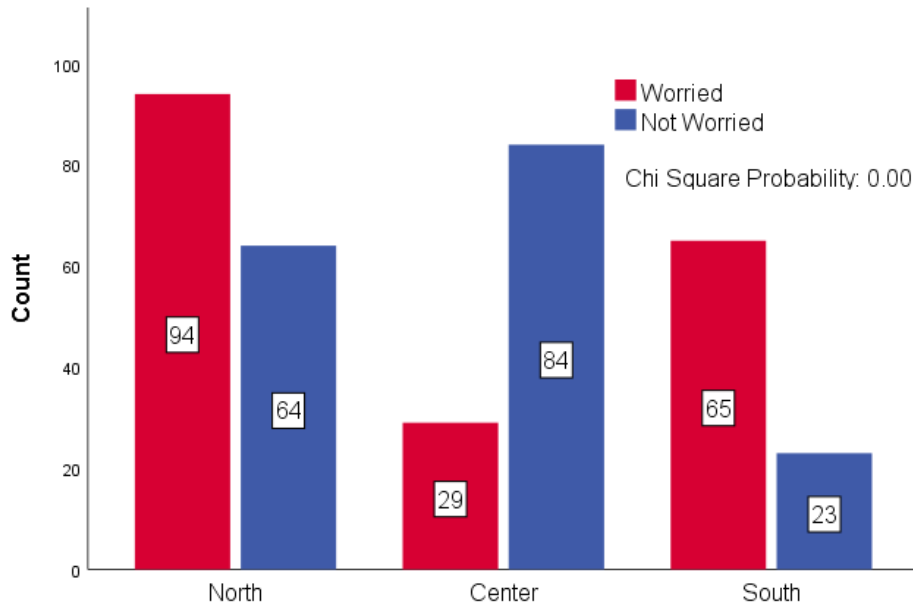


Figure 7.1 Concern of Losing House in Different Zones

Data from both the survey and local interviews indicate that the main reason for this variation in perception is the presence of the new embankment. For example, the Ramgati household survey asked residents to respond the following question: “How strongly do you agree with the statement ‘My home is protected from riverbank erosion due to the presence of the embankment?’” Figure 7.2 shows responses for people living in the Center zone. We can see that 80% of respondents from the Center said that they now feel that their home is protected from erosion due to the presence of the revetment.

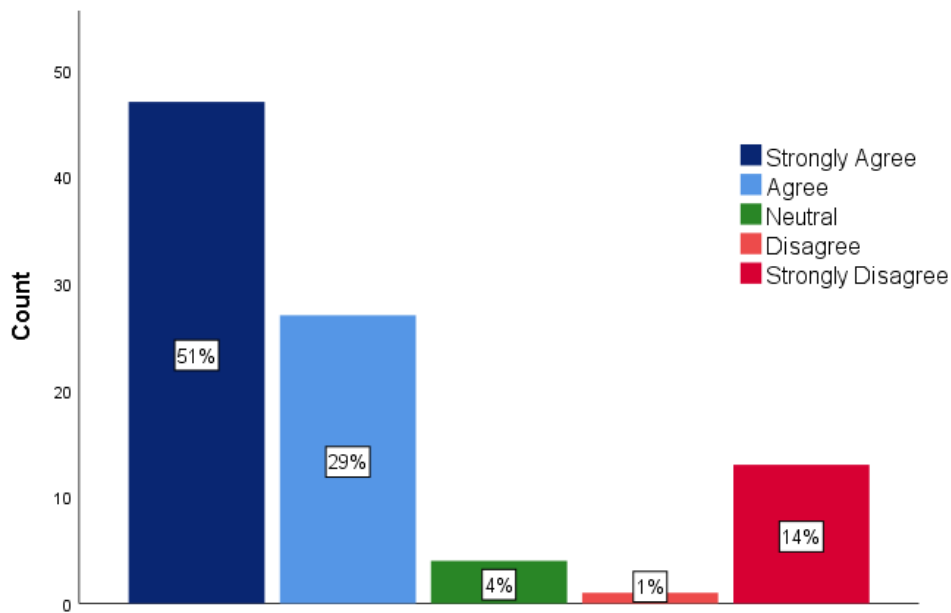


Figure 7.2 Concern of Losing House for People in the Center Zone

These results can be compared to another common form of flood control protection. In some communities, an elevated road or path has been constructed to provide some protection from flooding and erosion. Respondents to the household survey were asked to identify this kind of protection, and then asked the following question: “How strongly you agree with the statement, My home is protected from riverbank erosion due to the presence of an elevated road or path?” As can be seen in Figure 7.3, only 13% respondents who have an elevated road between their house and riverbank said that they feel protected from erosion. This shows that the concrete barrier has a much stronger influence on risk perception than other kinds of protection.

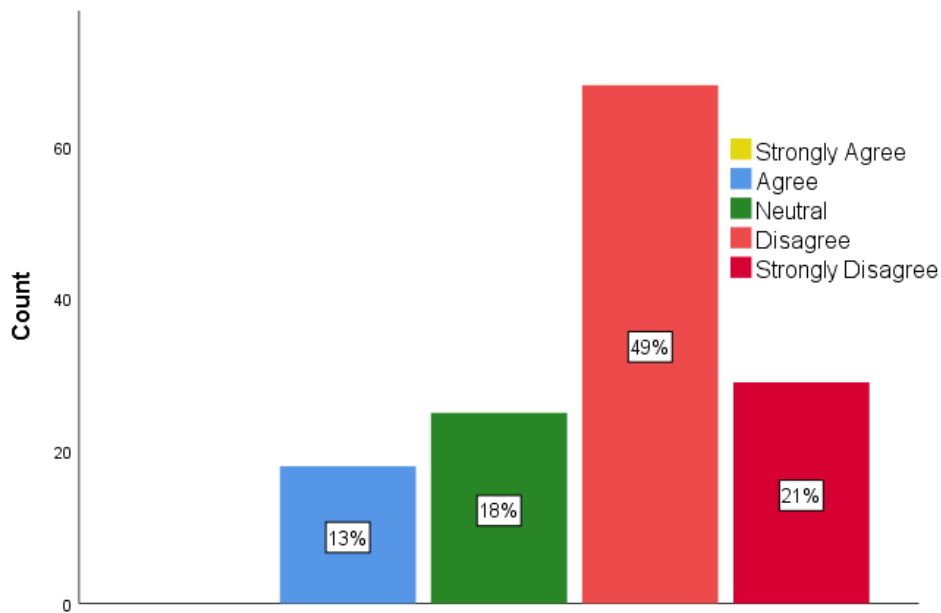


Figure 7.3 Concern of Losing House for People Who Are Living Behind Elevated Path

The importance of the revetment to risk perception is backed up by data from interviews. Each of the 6 interviewees from the Center zone said the revetment makes them feel safer now. One of the respondents from the Center said that,

Before they built this revetment, my house was very near to the riverbank and I was very worried...I prayed to Allah to save my house. During that time, most of the night I could not sleep. Now by the grace of Allah I feel very good and safe. (4)

7.2.2 Distance of Households

It can be hypothesized that those who reside in communities closer to the riverside will have greater concern about river hazards. A Chi-Squared test was performed to test for variation in perception based on the distance of households from the river and found a significant difference. As shown in Figure 7.4, the households within 1200 meters are much more worried than households far from the river. In Chapter 4, we saw that residents near to the river have tended to resettle there recently

and most of them have previous experience with erosion. Those characteristics might influence their risk perceptions. One interviewee whose house was located very close to the river said that,

You see, the riverbank is very near my house. So I am always worried. I feel that very soon I will lose my house. (22)

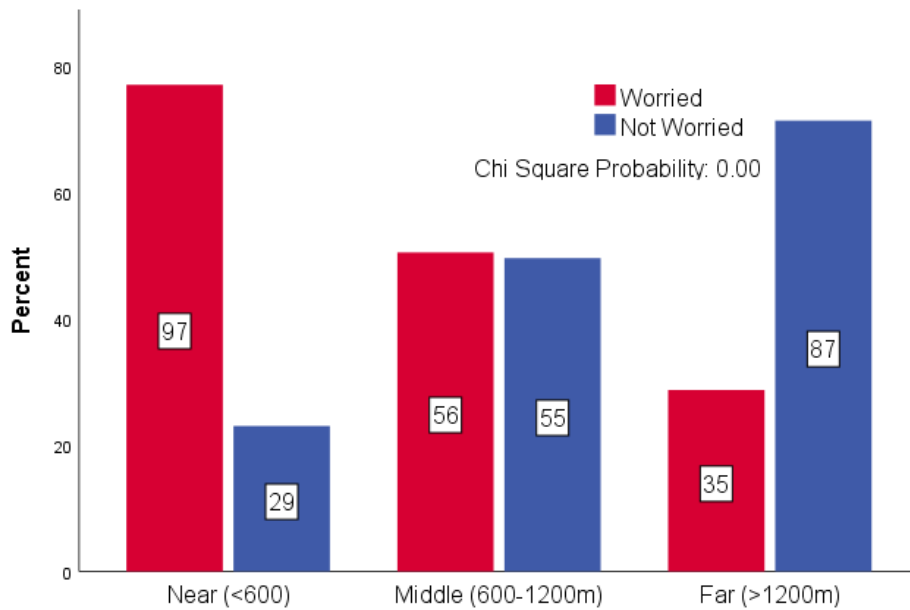


Figure 7.4 Concern of Losing House in Different Distances

7.2.3 Average Monthly Income of Households

In general, poor households have fewer resources and are therefore more vulnerable to natural hazards than those who are wealthy (Rahman et al., 2014). It can be hypothesized that households with a lower average monthly income will have greater concern about river hazards. A Chi-Squared test was performed to identify the statistical relationship between household monthly income and fear of losing one's house. As Figure 7.5 shows, households with less average monthly income are more worried about losing their house in the river. An interview respondent reflected this relationship, stating that,

[I know I am at risk], but I don't know what should I do. I have no money, and don't even have any land. Where will I go? For now, there is nothing I can do against this disaster.
(22)

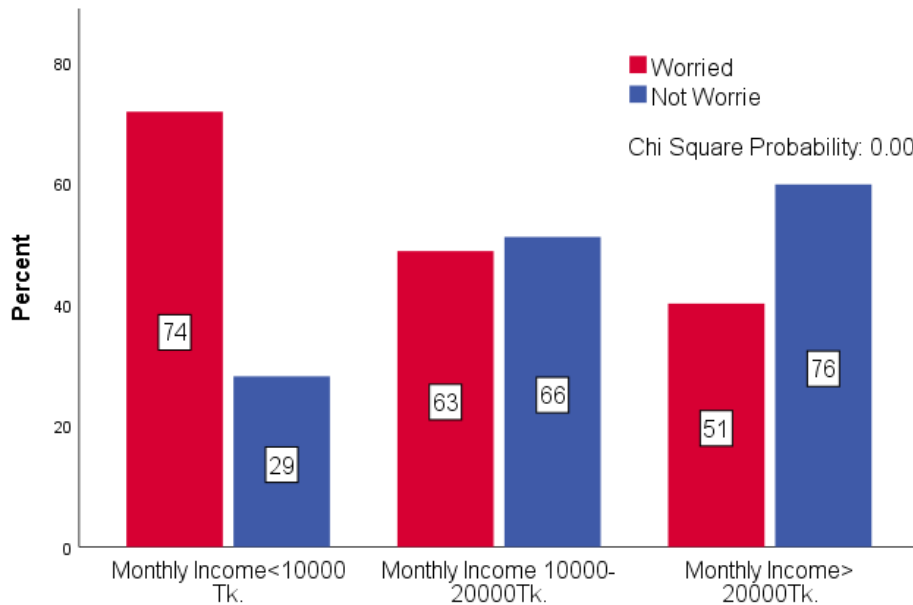


Figure 7.5 Concern of Losing House by Income Category

7.2.4 Past Experience

In Chapter 5, this study found that in Ramgati the people who have experienced losing their houses in the river tend to be less well-off and also to live near to the river. In the present chapter, we found that the households with less income, and those who are closer to the river, express greater concern about riverbank erosion. These factors are likely to be related. So, it could be assumed that the previous experience with a hazard might be associated with risk perception. To examine this in Ramgati, a Chi-Squared test was performed and found a statistically significant relationship between past experience with erosion and concern of losing one's house again in the river. Figure 7.6 shows that the respondents who had previous experience of losing their house are more worried that they will lose their home.

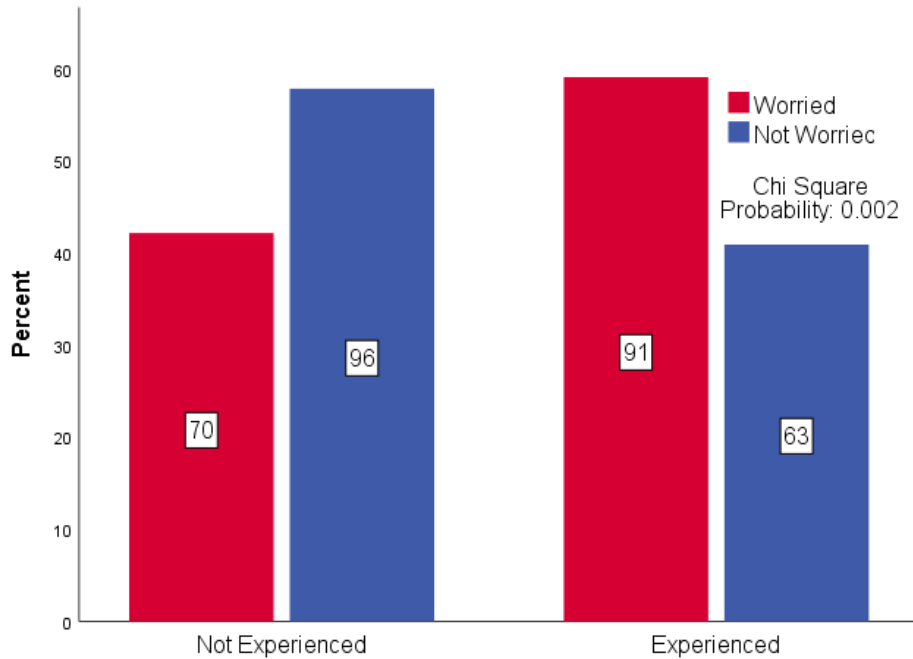


Figure 7.6 Concern of Losing House Compared with Previous Experience of Erosion

7.2.5 Education

Education can be an influence on people’s knowledge and awareness of disasters. Montz, et.al, (2017) showed that an individual’s level of education has an influence on risk perception. It can be hypothesized that educated people are less worried about river hazards because, as shown in Chapter 4, those with more education tends to have a salaried job or own a business and therefore better off. This means that they may have more resources to cope with the impacts of riverbank erosion. To examine the relationship between education and fear of losing one’s home, respondents were grouped into two categories, those who have only an elementary education and those who have a high school, college or university degree. Figure 7.7 shows that there is a statistically significant relationship between education level and concern of losing one’s house. Specifically, less educated people are more worried that their home will fall into the river due to riverbank

erosion. This could be explained by the fact that less educated people might live near the river and lead a more precarious livelihood, which could have an influence on their risk perception.

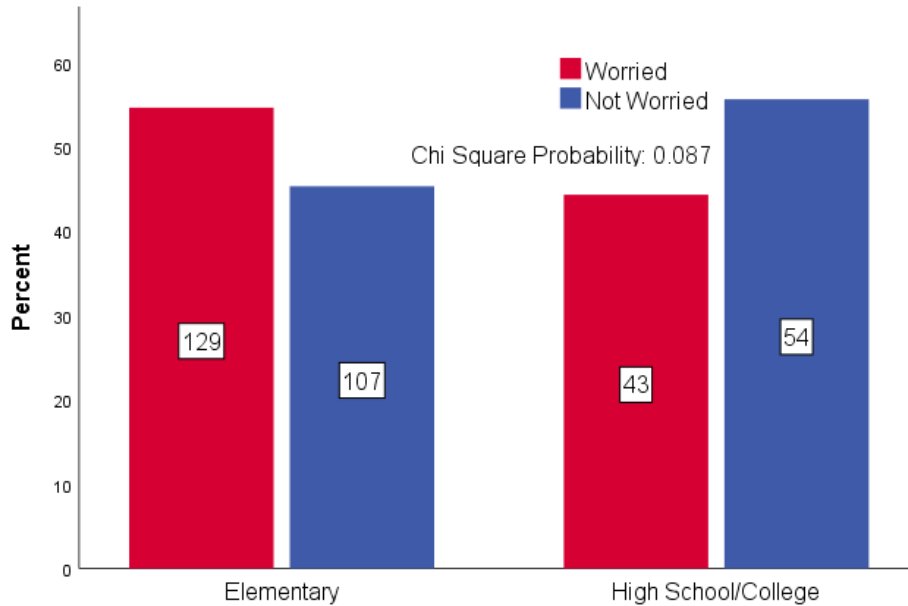


Figure 7.7 Concern of Losing House by Education Level

7.2.6 Occupation

The impact of hazards is different for different kinds of occupations. For example, in this study farmers said that riverbank erosion has a direct impact on their agricultural activities, whereas business owners said they are not directly losing their lands or houses but are indirectly affected through the financial impact and displacement of their customers. It can be hypothesized that farmers and fishers will be more worried about river hazards because they are more directly dependent on the river. A Chi-Squared test was performed to identify any statistical relationship between occupations and concerns of losing one's house. Figure 7.8 shows that there is no statistically significant relationship between this measure of risk perception and occupations.

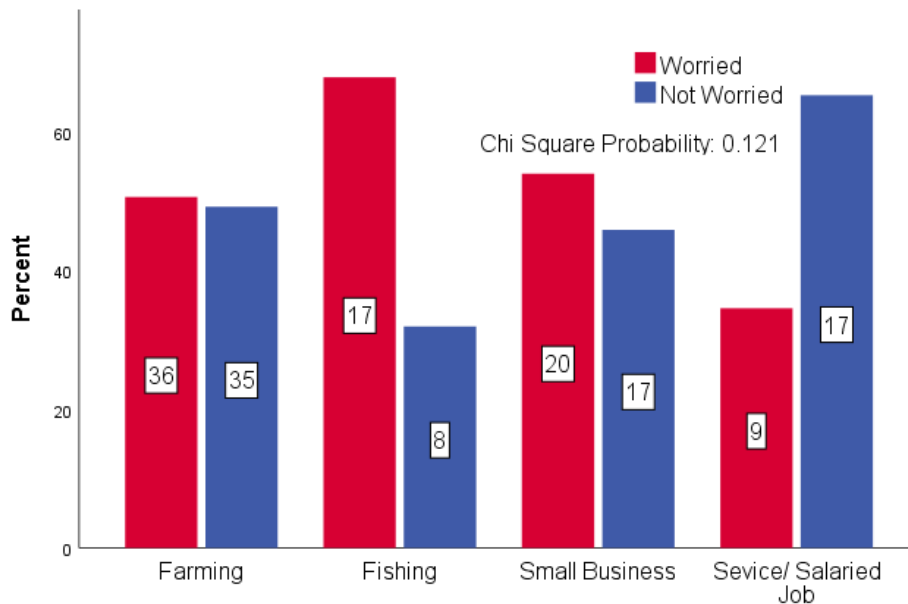


Figure 7.8 Concern of Losing House in Different Occupations

7.2.7 Age

Age is another factor that can influence people's perception of risk. Different age groups might have different perceptions of risk and disaster. Old people, for example, may be more worried about riverbank erosion because they are more vulnerable and they may also have more experience with natural disasters. To identify whether age has an association or not, a Chi-Squared test was performed. The respondents were categorized into three age groups: one group under 35 years old, a second group between ages 35 to 50, and a third group more than 50 years or age. Figure 7.9 shows that there is no statistically significant relationship between the age of respondents and concern about losing one's house in the river.

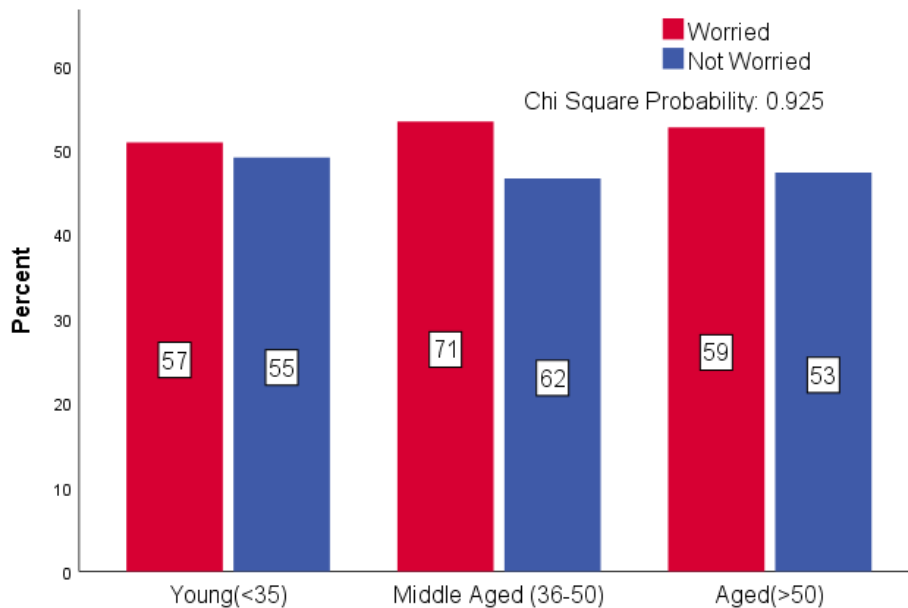


Figure 7.9 Concern of Losing House in Different Age Groups

7.3 Impact of the Revetment

We have seen in this chapter that residents express a high degree of satisfaction with the recently-built revetment. But some studies suggest that hardening the shoreline in one area can increase erosion in other areas. For example, Dewidar and Frihy (2007) conducted a study in Egypt and Selvan et al. (2016) conducted a study in India to see whether a revetment influences erosion in areas nearerby. Both studies used remote sensing techniques to analyze shoreline change and found that the revetment has increased the erosion in other areas. To see whether local residents in Ramgati perceive something similar, respondents to the household survey were asked how much they agree with the following statement: “I think the new embankment acts to protect areas near the embankment but acts to make riverbank erosion worse for other areas that are not immediately near and protected by the embankment”? Overall, 63% of respondents believe that the revetment

has made the erosion problem worse in the areas that remain unprotected. To see whether this perception varies according to the location of households, Chi-Squared tests were performed to see whether responses to this question vary by zone or distance.

7.3.1 Zone

Figure 7.10 shows that a majority of survey respondents in all three zones believe that the revetment is increasing erosion in unprotected areas. This perception is highest in the North, though it is not a statistically significant difference. Some indication that the erosion problem may be worse in the North is also evident in the interview data. During interviews, residents were asked “Is the problem of riverbank erosion worse in some parts of the Upazila than others?” and also “Are some sections of the river changing more rapidly?” Many respondents indicated that the areas that are not protected by the revetment are at risk of erosion. They believe this is true for both the North and South, but particularly the North zone. Of the 15 interviewees who offered an opinion, 11 said that the North is at a high risk of erosion. An interviewee from Center zone mentioned that,

The North and South part are at risk, as neither has a revetment. But I think the North is now at higher risk of erosion.

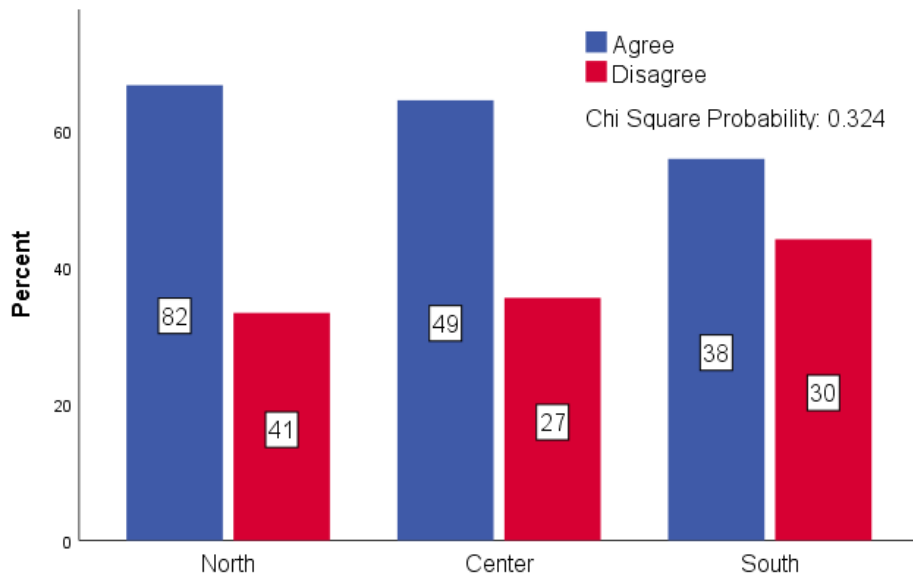


Figure 7.10 Perception about the Revetment in Different Zones

7.3.2 Distance of Households

In this study we have seen that people who live close to the river are more worried about losing houses immediately, and they may have more first-hand knowledge about riverbank erosion. It can therefore be hypothesized that the distance of households from the river could influence perceptions of erosion. A Chi-Squared test was performed to see if there is a statistically significant relationship between distance and the perception that hardening the shoreline makes nearby unprotected areas more vulnerable to erosion. Figure 7.11 shows that a Chi-squared test found a statistically significant relationship. People who live near the river are more likely to agree that “the new embankment acts to protect areas near the embankment but acts to make riverbank erosion worse for other areas that are not immediately near and protected by the embankment”.

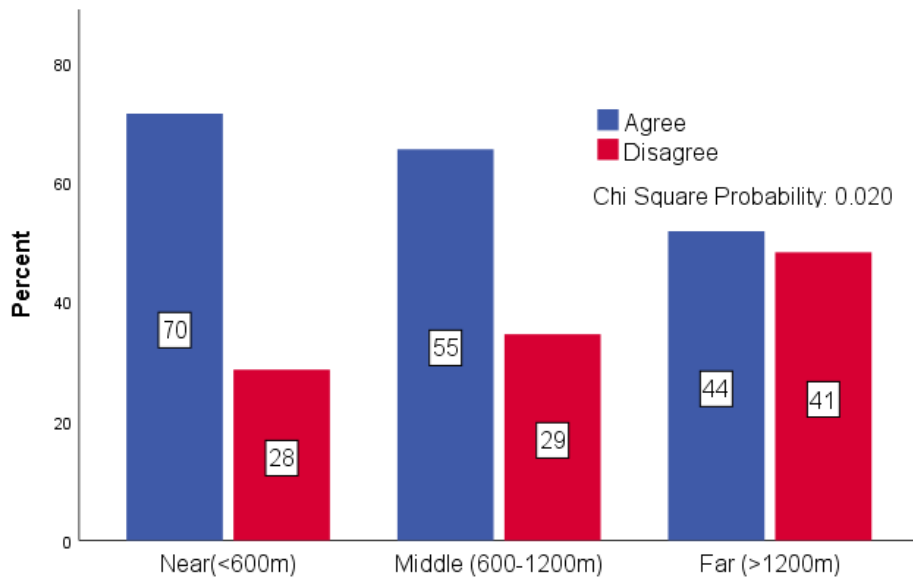


Figure 7.11 Perception about the Revetment in Different Distances

7.3.3 Future Concern

A key perception question in the household survey asked respondents “How strongly to you believe that your house will be fall into the Meghna River at some date in the future?” This question allows for an assessment of residents’ perception of future risk. Nearly all respondents (97%) agreed that their house will fall into the river at some date in the future. This can be explained in part by the fact that the revetment only covers 3.5 km of the 16 km Ramgati shoreline. But even those now protected by the embankment express concern that their house will eventually fall into the river. This may reflect a belief that the revetment will eventually be destroyed by riverbank erosion. But it also speaks to a sense of fatalism that is expressed by local residents, and a belief that individuals have very little control over riverbank erosion. During interviews, a number of respondents stated that the control of riverbank erosion in the hand of Allah (God), so, it is not a

matter of whether the bank is protected or not. For example, one respondent from the Center zone said that,

By the grace of the Almighty we are protected now due to this revetment. If Allah wants he can destroy this protection. I know there was a strong embankment in Bhola district but it was destroyed. So it depends on the Almighty. If Allah wants he can save all of us. But we also need to try ourselves to protect against erosion. (4)

A business owner mentioned that,

No, we are not safe yet. You see, We have a 30 kilometeter-long riverbank including Ramgati and Kamalnagar but only 3.5 kilometers is protected now. How can we say we are safe now? If the government does not extend this embankment protection we will lose huge amount of land and houses in the future. (17)

Because almost everyone agrees that their house will fall into the river at some date in the future, differences in responses to this question are not evident according to socio-economic conditions, previous experience with erosion, or the location of households of the respondents.

7.4 Extension and Building of Concrete Embankment

The analysis in this chapter has identified significant differences in the attitudes and perceptions of Ramgati residents depending upon whether or not they reside in areas protected by the revetment. As noted above, only about 25% of the Ramgati shoreline is protected. Several questions on the household survey asked respondents about the possibility of extending this protection. One question asked residents how strongly they agree with the statement that “An engineered concrete embankment should be constructed to protect the entire Meghna shoreline of my union.” Of those responding, 99% support the extension of concrete embankment. An interviewee from the South zone mentioned that,

This is our demand to the government, to extend this revetment. We always hope that the revetment will be extended. Otherwise we will lose our houses very soon. (6)

The household survey sought to identify the actors that residents feel can play a vital role in the building or extension of the protective embankment. Respondents were asked: “If you desire that more embankment be constructed in Laximpur, who do you think are the most important actors necessary to actually gain the resources to actually construct new embankment?” Table 7.1 shows that the majority of people think that the prime minister or the national government of Bangladesh can play the most important role in this kind of initiative. Local government officials also feel that the national government should build the embankment to protect Ramgati, but at the same time, they are also concerned about limitations in funding. Generally, it is not easy for the government to fund the construction of embankments. A local government official said that,

Yes we have a proposal to build 37 kilometers, the whole of Ramgati and Kamalnagar upazilas. But we need 16 kilometers immediately. Unfortunately, we have funding only for 800 meters of this 16 kilometers. (13)

| Actors of a New Embankment | Frequency (Responses) | Percentage |
|--|------------------------------|-------------------|
| Prime Minister or Govt of Bd | 320 | 84 |
| Local politician (member of parliament) | 30 | 7.9 |
| Donor countries or agencies | 26 | 6.8 |
| Individual voices and upswell from the village (non-officials) | 5 | 1.3 |

Table 7.1 Actors of a New Embankment

7.5 Summary

Montz et al. (2017) suggested that the characteristics of an individual, such as age, education, income, gender, previous experience with a hazard, and location of household, might have an influence on his or her risk perception. Similarly, this study found that in Ramgati, people who

live in areas unprotected by the revetment, people who live near the river, residents with low income and less education, and those who have had a previous experience of losing their house are more worried of losing their home due to riverbank erosion. Those characteristics often combine to influence respondents' risk perceptions. For example, in Chapter 5 we have seen in Ramgati who live near the river often have previous erosion experience and also have lower average monthly income. These variables together have an influence on their risk perception.

The presence of the revetment also has an influence on the risk perceptions of residents. People who are living near the river think that the revetment protects areas near the revetment, but acts to make riverbank erosion worse for nearby areas that are not protected. In general, the residents of Ramgati demand the extension of the revetment, and they believe the prime minister or government of Bangladesh are in the best position to take this initiative to protect them from the riverbank erosion problem.

CHAPTER 8

Conclusions

The purpose of this chapter is to summarize the results of this study, discuss its contributions to the literature, and point to future considerations. on risk perceptions of riverbank erosion and attitudes toward the new revetment.

8.1 Findings

This thesis focused on a new revetment that was built by the Bangladesh national government to control the riverbank erosion problem in Ramgati Upazila. The study used interview and survey data and performed Chi-squared tests to identify the association and statistical relationship among different variables.

The first research objective focused on understanding the characteristics of Ramgati that are associated with vulnerability to riverbank erosion. The magnitude of vulnerability depends on both physical and social factors. In that context, occupations and livelihood strategies can have an impact on vulnerability to a particular disaster. This study found that residents of riverside communities are mostly dependent on primary occupations, especially farming and fishing. This places their livelihoods at risk from riverbank erosion. This study also found spatial variations in the socio-economic and demographic conditions in Ramgati and identified the North as a more vulnerable zone to riverbank erosion.

The second research objective focused on the extent of riverbank erosion in Ramgati and the responses by residents to mitigate and adapt to its impacts. This study found that the major impacts of riverbank erosion are the loss of lands, houses and other infrastructure. It forces victims to relocate and causes psychological stress. Overall, riverbank erosion hinders the socio-economic

development of the affected communities. This study also found patterns in those who are the victims of riverbank erosion. They are more likely to be fishers, live close to the river, and they have a lower average monthly income.

There is often little that residents can do individually to stop riverbank erosion, but social capital can enhance the ability to cope with its effects. The networking, bonding and relationships among individuals and the communities can play a vital role in adaptation strategies and hazard mitigation. This study found that social capital has a positive impact in riverside communities. For example, after losing lands and houses, victims often survive by taking loans and by taking temporary shelter in the homes of friends or relatives.

Other coping strategies taken by affected households include selling household assets and changing occupations in order to survive. The local government often assists the victims by providing lands and/or houses to displaced people. NGOs are also active in the region, helping people by providing loans and training to improve the employment skills of affected residents.

The third research objective focused on the history and impact of the revetment. In Ramgati, the revetment can be seen as an emergency measure to protect government institutions and the main marketplace. This initiative was pushed by the local residents, who staged protests to demand that the government control riverbank erosion. This study found that the protective embankment has had an impact on residents' livelihood strategies. Households and businesses that are now protected by the revetment are doing well. Residents in the Center zone report feeling safe and are now relieved from the psychological stress caused by erosion. The protective embankment has now become a place for recreation, and the gathering of tourists has benefited local business.

The fourth research objective focused on the residents' attitudes towards the revetment. It also identified the variables that have a statistical relationship with risk perceptions. This study found that unprotected households in the North and South are more worried about losing their houses in the short term. In addition, people who live near the river think that the hardening of the shoreline in the Center is increasing erosion in unprotected areas. The study identified a number of characteristics that have a statistically significant association with the perception of erosion risk, including low income, previous experience, and less education.

8.2 Contributions to the Literature

The discipline of geography emphasizes interdisciplinary studies to solve contemporary problems. This study ties together the social and environmental vulnerabilities to riverbank erosion under the tradition of human-environmental research. The study was initiated to examine the rationale for building a revetment and its impact on livelihood strategies and risk perceptions. No prior studies of riverbank erosion in Bangladesh have focused on a protective embankment. By using both quantitative and qualitative data, this study revealed that the protective embankment has had a positive impact on local livelihoods and also has influenced the risk perceptions of riverside communities. People who are living behind the protective embankment think that they are protected from riverbank erosion, while those who are not protected are more concerned about losing their houses and are suffering from other river hazards such as floods and salinization.

This study showed that both social and environmental factors have an influence on vulnerability to hazards. For instance, the study found that the dependency of locals on primary occupations can increase vulnerability to riverbank erosion. At the same time, the environment has an impact on the social factors. For example, the study found that the problem of riverbank erosion hinders the socio economic development of riverside communities.

This study contributes to the existing literature on riverbank erosion in Bangladesh. Although most previous studies were conducted in the upper region of the country, this study focused on the riverbank erosion problem in the coastal area of Bangladesh. In some cases, the findings of this study confirm the results of research from other regions of Bangladesh. For example, the study found similar impacts of riverbank erosion as studies by Bhuiyan et al. (2017), Rabbi et al. (2013), Alam et al. (2017), and Rahman & Gain (2020). These include the loss of homesteads and agricultural lands, push migration, negative impacts on socio-economic development, and psychological stress. This study also found similar adaptation strategies in response to riverbank erosion as those found by Haque (1998), Rahman & Gain (2020), and Rahman et al. (2014). The adaptation strategies of the riverbank erosion problem are to get help from friends, relatives, neighbors, NGOs, banks and government and to sell households assets.

Overall, this research represents one of the first studies of riverbank erosion focused on the role of a protective embankment. In recent years, the number of embankments has been increasing in Bangladesh. Results from this study can help address the impact of protected embankment in other areas of the country.

8.3 Limitations of the Research

Because of time and monetary constraints, the interview portion of study had a modest sample size and focused on a limited range of occupations in Ramgati. In particular, no household interviews were conducted with women, in part because the three main occupations investigated (farmer, fisher, and business owner) are predominantly male activities in Bangladesh. Future studies would benefit from including a wider range of occupations and a more concerted effort to incorporate the perceptions of women.

Although, this study used a large sample size survey (381 households), the relative clustering of survey responses close to the river suggest caution in attributing results to the entire Upazila. Future research should validate the findings of this study incorporating a larger and more geographically distributed sample.

Finally, this study looked separately at the associations and statistical differences of demographic and geographical variables. Additional insight might be gained by looking at the interactions and combined impacts of these variable, perhaps by using a MANOVA analysis.

8.4 Future Considerations

Future studies can build on this research is a number of ways to better understand the riverbank erosion problem in Bangladesh. This study found that the people who are living near the river believe that the revetment has increased erosion in areas near the revetment. To assess this, remote sensing and GIS techniques could be used to accurately detect the shoreline change and measure erosion rates over time to see whether the protective embankment increases the intensity of erosion.

This study focused on the role of one revetment in the coastal area of Bangladesh. Future studies could compare the role and impacts of revetments in the upper region of Bangladesh for comparison.

This study found that the revetment has become a place of recreation, and this kind of tourism has an impact on local businesses. This study did not investigate this further. So a future study could focus on the role of revetment in recreation and their impact on local business across the country.

8.5 Summary

Riverbank erosion is one of the major environmental challenges in Ramgati. The Upazila is vulnerable to riverbank erosion due to its location along the left bank of the Meghna river, one of the major rivers in GBM river system. Riverbank erosion has a negative impact on local livelihoods as well as socio-economic development in Ramgati. The Government of Bangladesh, NGOs, and individuals have all responded to riverbank erosion to try to mitigate its impact. The building of the revetment is the most notable response, and one that has made a positive impact on the livelihoods and risk perceptions of the residents of Ramgati.

Overall, this study makes a contribution to existing riverbank erosion studies in Bangladesh. In particular, this work helps to provide a better understanding of the erosion problem in the coastal area of Bangladesh and it places a new focus on better understanding the role of a revetment in how people perceive and respond to riverbank erosion. This research can contribute to policy to solve the riverbank erosion problem. Results from the study suggest that the national government of Bangladesh should extend the revetment to help control riverbank erosion in Ramgati.

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APPENDICES

Appendix A: Questions for Survey Analysis

(with the number of original questionnaire)

1. GPS location of respondent household:
2. 1. Are you head of this household: Yes ____ No: _____
3. 2. Gender, age and education of the respondent:
4. 3. If respondent is not head of this household, what is gender age and education of head of household?
5. 4. How long has this household/family been living in this current home? in months or years
6. 5. How many years have you lived in this union even if not in your current home? Years
7. 6. What is the occupation of the main household head of this household?
8. 8. Is there a concrete constructed embankment (e.g. with blocks, etc.) at the Meghna riverbank that is located between your home and the riverbank?
9. 9. If yes to Q8, then how strongly do you agree with the statement, “My home is protected from riverbank erosion due to the presence of the embankment”?
10. 10. If the answer is no to Q8, then is there any elevated road/path between the Meghna riverbank and your home?
11. 11. If the answer is yes to Q10, then how strongly you agree with the statement, “My home is protected from riverbank erosion due to the presence of an elevated road or path”?

12. 62. How do you agree or disagree with the following statement, “I think the embankment construction in recent years near my areas is a positive thing”.
13. 63. How do you agree or disagree with the following statement, “I think the embankment acts to protect areas near the embankment but acts to make riverbank erosion worse for other areas that are not immediately near and protected by the embankment”.
14. 64. If you desire that more embankment be constructed in Laximpur, who do you think are the most important actors necessary to actually gain the resources to actually construct new embankment?
15. 35. For this current year of 2018, how worried or concerned are you that your home will fall into the Meghna River due to riverbank erosion?
16. 36. How likely is it that you will have to move your household due to riverbank erosion over the following time periods?
17. 37. Regardless of specific future dates and years, how strongly to you believe that your house will be fall into the Meghna River at some date in the future?
18. 38. We are in 2018. If you believe that your house will fall into the Meghna River, in what year is your best guess that it will fall into the Meghna River?
19. 39. If you think your house will fall into the Meghna River, what is your the number of years that you think it will be until your house falls into to river? (0 is 2018, 1 is 2019, etc. and 9999 = never)
20. 40. When you think of the impacts of riverbank erosion, please rank the most important issue that you consider when making a decision about relocating due to riverbank erosion:

21. 53. What do you think are some causes of riverbank erosion in this area of your village and union?

Socio-Economic Status Related Questions from survey:

1. 15. What are building materials of your main dwelling structure?
2. 16. How old is your main dwelling structure?
3. 17. Specify for current and past residence locations, the year you moved to that location and the reason for moving to the location. (multiple moves in year can occur).
4. 20. For your most recent relocation due to riverbank erosion, please identify negative impacts that this erosion event and relocation had on your household.
5. 23. During your move due to your most recent relocation due to riverbank erosion, did you have friends or family in the union that you relied on to help you to help you during your relocation?
6. 24. If yes to Q23, to what degree to you agree with the statement, “Assistance from relatives or friends helped me to cope with the event of having to relocate due to riverbank erosion”.
7. 25. For your three (if that many) most recent household relocation moves due to riverbank erosion, what were the primary and secondary occupations of the main household head:
8. 57. If you needed to move in the future due to riverbank erosion, what things would you do to help cope with the negative impact of having to move due to riverbank erosion? (check yes or no)

9. 58. When considering the possible need to move in the future due to riverbank erosion, how strongly do you agree or disagree with the statement, “I have thought about and have plans on how to move and survive in the event of having to move because of riverbank erosion”.
10. 59. If you had to move for some reason due to riverbank erosion, how much assistance do you think you would be able to receive from the following people or organizations providing assistance?
11. 86. What energy sources do you use for your household, please rank the top source?
12. 87. Please tell us if you possess the following household assets that you own:
13. 88. For the last year of 2017, please estimate using percentages that add up to 100% the amount that you perceive your household relies to provide food and other needed things during the year from these general activities
14. 89. Does this household have electricity?
15. 90. In the past five years, have you taken a loan from a bank?
16. 91. In the past five years, have you taken a loan from an NGO?
17. 92. In the past five years, have you taken a loan from an individual that is not a bank or an NGO?
18. 93. How much financial debt you have in Taka owed to any source?
19. 94. In general and thinking about your household’s ability to take a loan, how strongly do you agree or disagree with the following statement, “In general, I am confident I would be able to take a loan if I need to for some reason”.
20. 95. Thinking about your household’s ability to take a loan if you needed a loan to help during a future riverbank erosion disaster, how strongly do you agree or disagree

with the following statement, “I am confident I would be able to take a loan if I need to because I was impacted by riverbank erosion”.

21. 96. Does this household allow female members to work to support the household in activities outside of the household?
22. 97. Household Roster (fill in for all family members living in this household who regularly eat and sleep here.)

Appendix B: List of Interview Subjects Interview and

Interview Guide for Key Informant Interviews

| Interview No. | Gender | Position or Designation |
|---------------|--------|--|
| 10 | Male | Head of the Alexander Pilot High School |
| 11 | Male | Secretary, Union Administration |
| 12 | Male | Principal, A.S.M Abdur Rob Govt. College |
| 13 | Male | UNO, Ragati Upazila. |
| 14 | Female | Asst. Teacher, Govt. Primary School |
| 21 | Female | Asst. Teacher, Govt. Primary School |

Interview #: _____

Date: _____

Name: _____

Position or Designation: _____

Read Informed Consent and get signature.

I. Background and Livelihoods

I am a geography student interested in rural development, hazards, and climate change. I'd like to start with a few general questions about the people and livelihoods in this area.

Are you originally from this area? How long have you lived here?

Can you provide some background about this region? How would you describe some of the main development challenges?

What are the major occupations or sources of household income? What income-earning opportunities exist for women?

Are there regional differences among the different Unions within the Upazila? If so, what are some of the differences?

How important is farming in this area? What are some of the major crops? Are farmers using high-yielding varieties of rice? Has this been successful?

What would you say are the main challenges faced by farmers in trying to be successful? Do you think that climate change is impacting agriculture here? How so?

Some of the land in this area is in polders, is that correct? When were they established? Are there problems within the polders related to waterlogging or other environmental problems?

Have there been problems with salinization of water? How about arsenic contamination? Please explain.

II. Changes and Development Interventions

OK, next I am interested in learning about some of the development projects that have affected this area.

What changes have you seen in this area compared to 10 or 20 years ago? Do you think things have improved for the typical household, or gotten worse? Why do you think so?

I have read a lot about the Char Development and Settlement Program. What can you tell me about this? Has it helped many people from this Upazila? In general, do you think it has been successful?

Have there been any other development projects in the area, either by the government or NGOs?

What has been the focus of these projects? Do you feel they have been successful?

Have any groups been formed to promote community participation – such as Water User Groups or Social Forestry projects? How have these worked?

Is there anything else that is distinctive about this district that I should know about?

III. Riverbank Erosion

As I mentioned to you, my project focuses specifically on riverbank erosion, especially how people are coping with it and government programs to deal with it. So, the next set of questions focus on this issue.

How big an issue is riverbank erosion in this district? What areas are most affected?

Has there been a lot of shoreline change over the years? How so? Have there been any significant erosion events that you can recall?

Do you think that climate change is making the problem of riverbank erosion worse? How so?

Do households lose a lot of homes and property because of riverbank erosion? Have many people been displaced? Have you personally experienced any losses?

What kind of coping strategies do households use when faced with riverbank erosion? How do people prepare, and what do they do when they suffer losses?

IV. Risk Mitigation Initiatives

Now I want to ask some questions about government programs related to hazards.

What kind of programs have been implemented over the years to deal with hazards from flooding or riverbank erosion? Who has been involved in these projects (government, NGOs)?

Have these been successful in your opinion? Why or why not?

Do you think a local leader or member of parliament can play vital role for having funding to mitigate the erosion and other disaster?

V. The Revetment in Ramgati

Finally, I want to focus on the revetment that was recently built in the center of Ramgati.

How did the initiative to build a revetment arise? What were the factors that influenced the decision to build the revetment?

Was there influence of local leader or member of parliament to build this revetment? Was there any pressure from residents or local community groups to add protections to the riverbank?

Why was new embankment built where it is? Was this part of the river subject to greater erosion? Or were there other factors involved in the location?

Where did the funding for the revetment come from? How much did it cost?

How do you think people feel about the new embankment? Do you think some people now feel more protected? How about people north and south of the revetment?

Would you say that people in the center are now more protected than households in the north or south?

Is there any plan to extend the embankment in the south and north region? If you desire that more embankment be constructed in Laximpur, who do you think are the most important actors necessary to actually gain the resources to actually construct new embankment?

So people use the embankment for recreation? How has this affected the area?

What kind of initiative should the government take in the future?

V. Final Thoughts

Is there anything else you would like me to know about riverbank erosion in Laximpur or Ramgati?

Who else would be good for me to speak to for my research?

Thank you very much for your time!

Appendix C: List of Interview Subjects and

Interview Guide for Household Interviews

| Interview No. | Age | Education | Occupation | Location |
|---------------|----------|------------------------|---------------------------------|----------|
| 17 | 35 | MA | Businessman | Center |
| 4 | 35 | 8 th Grade | Businessman | Center |
| 1 | 66 | Uneducated | Fisherman | Center |
| 20 | 37 | Elementary | Fisherman | Center |
| 18 | 65 | 5 th Grade | Farmer | Center |
| 19 | 61 | Literate (TLM) | Farmer | Center |
| | | | | |
| 22 | 35 | 8 th Grade | Businessman | North |
| 6 | 40 | Elementary | Businessman | North |
| 8 | 45 | Uneducated | Fisherman | North |
| 9 | 49 | 3 rd Grade | Fisherman | North |
| 16 | 55 | BA | Fisherman | North |
| 2 | 40 | 10 th Grade | Farmer | North |
| | | | | |
| 7 | 32 | 8 th Grade | Businessman | South |
| 15 | 25 or 26 | Diploma in Agriculture | Businessman | South |
| | | | | |
| 3 | 68 | 10 th Grade | Fisherman | South |
| 5 | 18 | 10 th Grade | Student (father is a fisherman) | South |
| 23 | 57 | 5 th Grade | Farmer | South |
| 24 | 48 | Uneducated | Farmer | South |

Interview #: _____

Date: _____

Name: _____

Location: _____

Read Informed Consent and get signature.

I. Background and Livelihood

I am a geography student studying hazards related to the river and impacts on local communities. I'd like to start by getting some information about you and your household.

What is your age?

How many years did you attend school?

Who else lives in this house (ages and relationship)?

What income-generating activities support your household?

How much you earn monthly? Do you have any savings after month or year? Does your household receive money from someone living in town or abroad?

What are the building materials of your main dwelling structure?

How long have you lived here? Are you originally from this area? If not, where?

How much land do you have? Do you own the land? If not, who does own it, and what is your relationship?

Do you do any farming? What are your major crops? Do you plant high-yielding varieties of rice? Has this been successful? What would you say are the main challenges faced by farmers in trying to be successful?

Do you raise fish for household consumption? Do you have any other livestock?

Does your land have any environmental problems? Waterlogging? Salinization? Other problems?

II. Changes and Development Interventions

OK, next I am interested in learning about some of the projects that have affected this area.

Have there been any projects in this area to help families like yours? Please explain.

Have you heard of the Char Development and Settlement Program? What is your opinion about this project?

In general, do you feel that the government has done enough to help the people of Ramgati? Why or why not?

Are there local organizations (other than the government) that provide assistance to families like yours? What are they, and what do they do?

Are you a member of any groups? – such as a Water User Group or Social Forestry project? How have these worked?

If there was one thing that could be done to help the people of Ramgati, what would that be, and why?

III. Risk Perception

Now I want to ask some questions about hazards related to the river.

How big is the problem of riverbank erosion in Ramgati? How big of a problem is flooding?

Have you ever personally lost land or any properties due to erosion? If so, what did you do in response?

Have you ever been displaced due to riverbank erosion? If so, what did you and your family do to survive?

In general, do you feel that your household is at risk because of riverbank erosion? Do you do anything to prepare?

Is there any impact of riverbank erosion on your occupation and livelihood activities? Please explain.

Do you know other people who have been affected by riverbank erosion? If so, what did they do to respond? How many people overall have been displaced?

Is the problem of riverbank erosion worse in some parts of the Upazila than others? Please explain. Are some sections of the river changing more rapidly?

IV. The Revetment in Ramgati

Finally, I want to focus on the revetment that was recently built in the center of Ramgati.

Are you aware of the revetment? When do you first recall hearing about it?

Why do you think the revetment was built? Is it something that the community wanted? Where do you think the money came from?

Was there influence of a local leader or member of permanent to build this revetment?

Why do you think the revetment was built where it was? Would you like to see it extended to cover more of the riverbank? If so, who do you think should be most responsible for getting this done?

Do you personally feel safer now that the revetment is there? Does it affect the way you use your land or property? How so?

Do you think the revetment makes some houses safer than others? Explain?

Do you use the revetment for recreation? Overall, do you think it has been good for the community? Do you think other people feel that way?

V. Final Thoughts

Is there anything else you would like to say about riverbank erosion in Laximpur or Ramgati?

Who else would be good for me to speak to for my research?

Thank you very much for your time!

Appendix D: IRB Approval



EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board
4N-64 Brody Medical Sciences Building · Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office 252-744-2914 · Fax 252-744-
2284 · www.ecu.edu/ORIC/irb

Notification of Initial Approval: Expedited

From: Social/Behavioral IRB

To: Mizanur Rahman

CC:

Jeff Popke

Date: 7/15/2019

Re: UMCIRB 19-001413

Vulnerability, Risk Perception, and Livelihood Strategies Among Riverside
Communities of Ramghati Upazila In Bangladesh: The Role of Embankments

I am pleased to inform you that your Expedited Application was approved. Approval of the study and any consent form(s) occurred on 7/15/2019. The research study is eligible for review under expedited category # 6, 7. The Chairperson (or designee) deemed this study no more than minimal risk.

Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a Final Report application to the UMCIRB prior to the Expected End Date provided in the IRB application. If the study is not completed by this date, an Amendment will need to be submitted to extend the Expected End Date. The Investigator must adhere to all reporting requirements for this study.

Approved consent documents with the IRB approval date stamped on the document should be used to consent participants (consent documents with the IRB approval date stamp are found under the Documents tab in the study workspace).

The approval includes the following items:

| Name | Description |
|--|--|
| Bangla Consent Form | Translated Consent Document |
| Interview Guide.docx | Interview/Focus Group Scripts/Questions |
| Interview Guide.docx | Surveys and Questionnaires |
| Rahman Informed-Consent-Documents-Template-No-More-Than-Minimal-Risk-1-21-19.doc | Consent Forms |
| Thesis Proposal_Mizanur.pdf | Study Protocol or Grant Application |

