Socio-ecological Vulnerability, Migration and Social Protection: An Examination of Fisheries-Based Livelihoods in Coastal Bangladesh

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Abstract

Bangladesh, a country situated in the Ganges-Brahmaputra-Meghna delta (GBM), is one of the most vulnerable countries to climatic stressors and changes. Low lying coastal region in the southern part of the country is highly vulnerable due to its exposure to frequent and intense cyclones, and other hydro-meteorological coastal hazards, such as projected sea-level rise, storm surges, monsoonal flooding and waterlogging, and saline water intrusion. In addition, there have been significant infrastructure development and land use change across Bangladesh's coastal regions since the 1960s that contributed to increase environmental risk and vulnerability of coastal communities. This dissertation examines the risks and vulnerabilities faced by the coastal communities, particularly small-scale fisheries and aquaculture-based communities, in Bangladesh and how the households and the government respond to manage these risks and vulnerabilities.

Three specific objectives of this dissertation are: a) to explore the risk and vulnerability that coastal households face in Bangladesh in conjunction with main climatic hazards and changes; b) to understand households' temporary internal migration decision-making in the context of climatic stressors and socio-ecological changes; and c) to explore the extent to which social protection programs in the coastal districts of Bangladesh are responsive to environmental and climatic changes facing coastal dwellers, with a focus on whether such programs help households build adaptive capacity. This research is primarily based on a fieldwork in three coastal districts of Bangladesh in 2017. During the fieldwork, the researcher conducted a household survey of 720 households, focus group discussions, and key informant interviews.

The three research objectives lead to three research papers. The first paper of this dissertation constructs household-level vulnerability and risk indices by applying the risk framework offered in the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC). With the help of these indices, this paper shows the levels of risk of hazards vary among geographical units, income levels and occupational groups. The indices also show that although vulnerability is well-correlated with poverty, risks of hazards are high for upper-income households as well. Applying the New Economics of Labour Migration (NELM) theory and the more recent environmental migration framework proposed by Black et al. (2011), the second paper shows that various types of environmental and climatic stressors impact households' decisions on temporary migration differently, and alongside environmental and climatic factors, traditional socioeconomic drivers of migration also play significant roles in households' temporary migration decisions. The third paper applies the adaptive social protection framework and finds poor targeting efficiency and the inability of the social protection system in scaling up when needed. However, the analysis does show poor households benefiting from social protection programs were less likely to use adverse coping strategies and were more likely to adopt productive livelihood strategies including production innovations and diversification.

This dissertation contributes to the methods of measuring and understanding risk and vulnerability specific to stressors, locations, income levels and occupations. It also sheds light on the importance of temporary migration as a risk management strategy that received less attention in the literature than permanent migration. Finally, it identifies areas to improve existing social protection programs to make them responsive to emerging risks and vulnerabilities. While addressing three separate but related topics, the papers are consistent in their implication on adaptation planning for coastal communities.

Format of the dissertation and contribution of co-authors

This dissertation follows an article-based format. There is some repetition in the text since all three papers are based on the same study districts, environmental and climatic contexts, and households.

I am the sole author of the chapter 1, chapter 2, chapter 3 and chapter 5. The chapter 4 is co-authored with my supervisors: Professor Melissa Marschke and Professor Gordon Betcherman. I am the lead author of this chapter. I developed the research idea in my thesis proposal, developed the analytical framework and conducted the fieldwork and statistical analysis, wrote the first draft of the main body of the chapter. My professors contributed to the writing and analysis of this paper.

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Chapter 1: Introduction

1.1 Overview

Coastal areas are one of the most vulnerable ecosystems exposed to climatic hazards and change (IPCC, 2014;2022; Toimil et al., 2020). Around 10% of the world's population lives in low elevation coastal areas, and about 40% lives within 100 kilometers of the coast (UN, 2017). Coastal natural resource-dependent communities are particularly vulnerable to such hazards and changes due to their dependence on ecosystem services, such as those provided by fisheries and mangrove forests, which are projected to be greatly hindered by climate change (Cinner et al., 2018). Along with the impacts of sea-level rise (SLR), coastal communities face multiple climatic hazards including frequent cyclones and storm surges, tsunamis, saline water intrusion, accelerated coastal erosion, and rising sea surface temperatures (IPCC, 2021; Touza et al., 2021). In addition, anthropogenic drivers involving demographic and settlement trends increase the impacts of climatic factors by further altering coastal ecosystems (IPCC, 2022).

Within coastal regions, deltas are especially vulnerable to climatic hazards and change due to their higher sensitivity to sea-level rise. The Ganges-Brahmaputra-Meghna (GBM) delta, for instance, ranks as one of three global deltas that are most impacted by sea-level rise (IPCC, 2014,2019; Tran et al., 2017). In terms of size, the GBM delta is the largest globally, constituting two-thirds of Bangladesh. The low-lying coastal zone in the southern part of the GBM delta is exposed to frequent and intense cyclones and other hydro-meteorological coastal disasters, such as sea-level rise, tidal surges, monsoonal flooding, rising temperatures, and saline water intrusions (IPCC, 2014; 2022; Rakib et al., 2019). The vulnerability to environmental and climatic changes among communities in this low-lying coastal area is far greater compared to inland communities of Bangladesh (Wilde, 2011). Human intervention and inaction, such as enacting rapid land-use changes in favour of brackish water shrimp aquaculture and neglecting to maintain coastal embankments, have intensified climatic impacts on local coastal communities (Mirza et al., 2012; Brammer, 2014; Parvin et al., 2017; Roy et al., 2017). These factors cause prolonged waterlogging and salinity intrusion in coastal districts, which have led to several environmental problems, including: declines to wild shrimp populations; losses to fish and non-fish aquatic biodiversity; disruptions to a natural environment home to diverse wild species; and decreases to the fertility of cultivable land.

Understanding the multiple risks and vulnerabilities facing coastal fisheries-based communities, as well as how different risk management strategies can address these risk and vulnerabilities, is crucial for designing effective policies and programs that promote adaptation to environmental change. This dissertation is structured within an overall frame of risk and vulnerability, investigating a range of strategies that might address these concepts, in the context of Bangladesh. One of the papers identifies households that face higher risks and vulnerabilities to major climatic hazards, along with the socio-economic, environmental, and climatic causes of these risks and vulnerabilities. The other two papers study two risk management strategies in the literature, namely social protection and temporary internal migration. The three papers, therefore, relate to questions concerning the risks and vulnerabilities faced by the coastal fisheries-based communities in Bangladesh, as well as the role of risk management strategies adopted by households and supported by the government. The three papers are also consistent in their theoretical approach, in that they do not draw on frameworks that single out climatic factors, but rather on those that situate climatic factors within broader socio-economic landscapes.

Overall, this dissertation contributes to the literature on coastal climatic risk and vulnerability by identifying sources of risk and vulnerability specific to climatic hazards and livelihoods. It also contributes to the adaptation literature by highlighting how migration and social protection interact with risk and vulnerability, as well as how these risk management strategies can be mobilized to build adaptive capacity among poor and vulnerable households and reduce their exposure and vulnerability to climate-related extreme events and changes. Another noteworthy contribution of this dissertation relates to the empirical frameworks it applies to understand risk and vulnerability and the roles that temporary internal migration and social protection play in managing them.

In this dissertation, I seek to answer three specific research questions:

1. To what extent are coastal fisheries-dependent communities in Bangladesh facing risks from climatic hazards and vulnerabilities, and how do risk and vulnerability levels vary by location, occupation, and income level?
2. How do coastal households in Bangladesh use temporary migration as a risk management strategy in the context of climatic hazards and socio-ecological changes?
3. Are government-run social protection programs in Bangladesh responding to the risks and vulnerabilities faced by coastal communities?

The three research questions stated above have guided three research papers. What follows in this section is the overview of the three papers:

The first paper (Chapter 2) aims to understand the risks and vulnerabilities of Bangladesh's coastal communities to major climatic stressors and changes and measure risks and vulnerability at household level. In doing so, this paper draws upon the risk and vulnerability framework offered in the fifth assessment report (AR5) of the Intergovernmental Panel on Climate Change (IPCC). This framework has not been applied in Bangladesh's coastal context before. To operationalize the AR5 framework, this paper develops a household vulnerability index and three household-level risk indices that correspond to three main climatic hazards: cyclones and storm surges; floods and waterlogging; and soil, surface water, and groundwater salinity intrusion. With the help of the vulnerability and risk indices, this paper identifies who is at risk of environmental hazards and changes and to what degree, while also exploring how coastal fishers and fish farmers, along with other agriculture-based occupation groups, are impacted by different types of hazards. The three indices can be replicated in other contexts as well to assess risks and vulnerabilities among different communities.

The second paper (Chapter 3) examines the role that temporary labour migration plays in managing environmental and climatic risks faced by coastal households in Bangladesh. Although temporary labour migration has been widely adopted by households facing seasonal hunger in other parts of the country, and while permanent migration and temporary displacement have been well-studied in Bangladesh's coastal context, temporary labour migration remains unexplored in relation to coastal risks and vulnerabilities. This paper makes a theoretical contribution by developing an analytical framework that combines the New Economics of Labour Migration (NELM) theory and more recent environmental migration frameworks proposed by Black et al. (2011). Supported by this analytical framework, this paper explores the differential impacts of various types of environmental and climatic stressors on households' migration decisions, as well as how traditional socio-economic drivers of migration and

households' risk management portfolios interact with environmental drivers in shaping households' temporary migration decisions.

The third paper (Chapter 4) seeks to understand how government-run social protection programs respond to environmental and climatic vulnerabilities and risks faced by coastal households. Although social protection is highlighted as one of the key climate change response strategies in relevant government documents, and despite academia and policy communities increasingly recognizing the role that social protection plays in managing climate change-related risk and vulnerability, there have been no investigations into the ways existing social protection programs address household risk and vulnerability in this coastal context. This paper applies the adaptive social protection framework (Davies et al., 2008; Béné et al., 2018) to examine whether social protection programs in the coastal districts of Bangladesh are responsive to environmental and climatic changes, as well as whether these programs help build adaptive capacity among coastal households. This paper quantitatively assesses how well social protection programs aid households in managing the social risks of environmental and climate-related shocks and disasters. Specifically, this study assesses social protection programs' effectiveness in terms of targeting efficiency, scalability, swiftness, and ability to foster adaptive capacity among affected households.

1.2 Background

Bangladesh's socio-economic trends and the significance of the fisheries sector

When Bangladesh emerged as an independent country in 1971, it was one of the poorest and least developed countries in the world (World Bank, 1972). In 1974, Bangladesh ranked as the second-lowest country in the world in terms of per capita income (Hossain et al., 2016). Acute food shortages coupled with multiple natural disasters and entitlement failure led the country into a famine in 1974 (Sen,1982; Alamgir and Salimullah, 1977). Despite the pessimism of these initial years, Bangladesh registered commendable progress in economic and social indicators over the last five decades (Sawada et al., 2018). The growth of per capita gross domestic product (GDP) increased from an annual average of 1.6% a year in the 1980s to 5.7% in 2010s. High and sustained economic growth over the last two decades helped Bangladesh attain remarkable progress in poverty reduction (World Bank, 2019). Bangladesh achieved lower-middle income status in 2015, and the country is also on track to graduate from the United Nations' Least Developed Countries (LDC) list by 2026 (World Bank, 2022). Based on the international extreme poverty line of $1.90 per person per day, Bangladesh's poverty declined from 33.7% in 2000 to 14.8% in 2016. Other development indicators also improved significantly alongside poverty reduction (World Bank, 2019; GoB, 2019). Between 1972 to 2020, life expectancy increased from 50 years to 72.6 years; the population growth rate decreased from 3% to 1%; the child mortality rate declined from 240 to 29 per 1000 live births; and the literacy rate increased from below 20% to almost 75% (World Bank, 1972; World Bank, 2022a).

Bangladesh's high economic growth is associated with significant structural changes in the economy over the last five decades (Raihan and Khan, 2020). Between 1974 and 2020, the share of the agricultural sector in the national GDP declined from over 60% to less than 15%; the share of the service sector increased from 35% to more than 50%; and the share of industry increased from 7% to 28% (Mujeri and Mujeri, 2021). Although agriculture's share in the GDP dropped considerably, the sector still employs 39.7% of the labour force almost equals to the service sector, which employs around 40% of the labour force (ILO, 2021). Although Bangladesh's exports are heavily reliant on its manufacturing

sector, specifically on readymade garments sector, the average growth rate of manufacturing's labour force has increased rather slowly, at only 0.35% over the past two decades (Moazzem and Arno, 2018).

Notably, the fisheries industry has emerged as a major driver of economic growth in Bangladesh, consistently comprising around 25% of the country's agricultural GDP over the last decade (DoF, 2020). The State of World Fisheries and Aquaculture-2020 report by the Food and Agricultural Organization (FAO) ranks Bangladesh third in inland open water capture production and fifth in world aquaculture production (FAO, 2020). Although fisheries contribute around 3.5% to the national GDP, the industry employs more than 20 million people (i.e., about 12% of Bangladesh's total population of 170 million people) (DoF, 2020). The sector also recorded higher growth rates than both livestock and crop industries. Fisheries are now the second largest export-earning industry in Bangladesh, after the readymade garment industry, and earn more than USD 600 million in export income every year (DoF, 2020).

Environmental changes and climatic hazards in Bangladesh's coastal region

Despite the achievements made in economic and social domains, Bangladesh's vulnerability to climatic hazards and change has the potential to reverse many of these gains (UNICEF, 2019). Consecutive reports of the Intergovernmental Panel on Climate Change (IPCC) consider Bangladesh as one of the most vulnerable countries to climate change and natural disasters (IPCC, 2001; 2007; 2014; 2021). Bangladesh's coastal districts are particularly vulnerable to a number of environmental and climatic hazards including cyclones and storm surges, floods and prolonged waterlogging, and salinity in soil, groundwater, and surface water. Projected climate change is likely to increase the intensity of these hazards.

Cyclones and cyclone-induced storm surges have affected the lives and livelihoods of millions living in Bangladesh's coastal regions. In meteorological terms, cyclones are circular depressions in atmospheric air pressure (Brammer, 2014). High sea surface temperatures in the Bay of Bengal constitute the main cause of frequent depressions and cyclones that affect the coastal regions of Bangladesh, India, Myanmar, and Sri Lanka (Nasher et al., 2022). The intensity of both cyclones and storm surges are predicted to increase due to rising sea surface temperatures and projected sea-level rise (GoB, 2018). Further, storm surges associated with cyclones inflict high numbers of cyclonic casualties in Bangladesh (Brammer, 2014; GoB, 2018). The funnel-shaped Meghna River estuary renders Bangladesh more susceptible to higher storm surges along the coastline (Brammer, 2014; DDM, 2018). Coastal embankments barely protect the coastal region from storm surges, since these structures were built to protect the hinterlands from saline water during normal high tide levels recorded from 1960-68, not to protect from the higher storm surges (Zaman and Mondal, 2020). Over the last six decades, a lack of financing for maintenance and several severe storm surges have caused significant damage to the embankments that has reduced their effectiveness (Rahman and Rahman, 2015; Thomas, 2020).

Coastal districts are also affected by regular flooding and waterlogging. Two climatic factors are responsible for causing floods in Bangladesh's coastal districts, namely heavy monsoonal rainfalls that occur between June and September and storm surges that occur in the exterior coastal regions (Buly, 2017; Gazi, 2019; Subhani and Ahmed, 2019). Notably, Bangladesh experiences more than 80% of its annual precipitation during the monsoon season alone (Ahmed et al., 2016). The hydro-meteorological characteristics of the delta regularly cause severe floods in the country during the monsoon months (Islam et al., 2010; Khan, 2020). Bangladesh's coastal districts, particularly the ones directly exposed to

the coastline, are especially susceptible to flooding due to storm surges. Some areas of the coastal region experience continuous waterlogging as flood water from excessive rainfall and storm surges becomes trapped and remains sedentary for several months (Awal and Islam, 2020).

A number of non-climatic or human-induced factors compound the causes of floods and waterlogging mentioned above (FSC, 2014; Kamal et al., 2018) . Sedimentation and the absence of well-designed tidal river management systems represent the main reasons for waterlogging in the southwestern part of Bangladesh's coast.[1] Additionally, the problem of high siltation is exacerbated by large-scale human interventions in the region's river systems. Inspired by the Dutch dike system, a large number of compartmentalized polders—low-lying tracts of land surrounded by embankments—were constructed in the 1960s in coastal zones to protect farmers from flooding and saline water intrusion. In total, 139 polders were built, covering half of the total coastal region of Bangladesh (Pukinskis, 2015). The polderization process disconnected the river system in the southwestern coastal region from closed water bodies, which acted as natural reservoirs during monsoons. In 1975, the completion of the Farakka Barrage, located in the upstream reaches of the Ganges River, significantly changed the hydrology of the river by diverting more than 50% of river discharge. Compromised water flows, in combination with polders that prevent silt from flowing into the Bay of Bengal, have led to high rates of sedimentation in this river system. This combination has created congestion in rivers and canal systems connected to the Ganges, causing severe waterlogging (Tareq et al., 2017; Noor, 2018). Poorly built road infrastructures with little or no coordination between government agencies also contributes to waterlogging (Rahman and Rahman, 2015). For example, government agencies have built numerous bridges and culverts in regions throughout the natural drainage system without considering the long-term hydrological implications.[2] Poorly designed bridges and culverts have also failed to maintain the required water flow and have contributed to narrowing the drainage channels on coastal districts.

Bangladesh's coastal districts suffer from increasing salinity levels in soil, groundwater, and surface water. Irregular rainfall, regular tidal flooding in unprotected areas, and storm surges during cyclones comprise the main climatic factors that have been increasing salinity levels here (Mahmuduzzaman et al., 2014, Salehin et al., 2018). Regular rainfall is required to flush out accumulated salts from the land. However, irregular or erratic rainfall in recent years has hindered this process (Iffat et al., 2021). Tidal surges and prolonged waterlogging of saline water, as discussed above, have also been important contributors to increasing salinity levels. After cyclone Aila in 2009, a significant portion of the southwest coastal belt was flooded by storm surges, and the saline water remained there for three years before being fully drained (Jakariya et al., 2016; Mainuddin and Kirby, 2021).

Several human-induced factors have also played a role in increasing salinity levels in the coastal districts. The withdrawal of fresh river water from upstream sections of the Ganges; the poor management of polders and sluicegates; the extraction of groundwater for irrigation near these polders; and the vast expansion of brackish water shrimp aquaculture have all served to increase soil salinity (Dasgupta et al., 2017; Rakib et al., 2019; Crowin, 2021). As noted above, the Farakka Barrage has reduced almost 50% of

[1] Tidal river management refers to "*temporary de-poldering in tidal rivers (rivers that do not receive upstream flow and are therefore under heavy influence of the tides), in order to prevent water logging caused by riverbed sedimentation*" (de Die, 2013)

[2] The Local Government Engineering Division (LGED) and the Roads and Highways Department (RHD) represent two government agencies involved in this construction.

the natural river flow in the Ganges River system (Hassan, 2019). While the ecology of the coastal regions in Bangladesh largely depend on the balance between fresh and saline water flows, severely reduced freshwater flow in the Ganges river system during dry seasons has caused a back water effect, thus, increasing salinity in the river system even further (Mirza, 1997; MoA, 2010; Gain and Giupponi, 2014; Rahman and Ahmed, 2018). The poor maintenance of coastal polders has presented additional complications (Nath et al., 2019). Limited by lengthy bureaucratic processes to allocate resources for infrastructure maintenance after cyclones and storm surges, government agencies have been unable to properly maintain polders (Afroz et al., 2016). Near these poorly maintained polders, groundwater extraction for irrigation has also contributed to increasing soil salinity, as the extracted groundwater already contains high concentrations of salt (Salehin et al., 2018). Brackish water shrimp farming represents another major factor of concern. Extensive shrimp enclosures require saline water to be brought in from nearby rivers connected to artificial canals. This practice has resulted in increasing soil, groundwater, and surface water salinity in the coastal region (Hossain et al., 2013).

Frequent climatic hazards and adverse ecological changes that have occurred over the past decades have rendered coastal fisheries-based households particularly vulnerable to livelihood and food insecurity. More than ecological factors are at play, however: government regulations on fisheries; human interventions in the coastal ecosystem; high interest rates among lenders in informal credit markets; water pollution by industry and agrochemicals used in shrimp farming; as well as weak law enforcement in the coastal region have together reduced the profitability of fishing as a livelihood strategy (Islam and Chuenpagdee, 2013; Henriksson et al., 2018; Mamun et al., 2016; Ahmed et al., 2021). Coastal fishers in Bangladesh are now facing fewer active fishing days (i.e., longer periods of unemployment) due to climatic hazards and regulatory reasons (Islam et al., 2021). The Sixth Assessment report of the IPCC (AR6) also recognizes that livelihoods based on coastal small-scale fisheries face the highest level of vulnerability from threats to marine resources and ecosystem services globally (IPCC, 2022). These communities are exceptionally vulnerable to climatic hazards and change due to their proximity to the coastline and direct exposure to multiple hazards and changes (Allison et al., 2009; Barange et al., 2018; Islam et al., 2019; Islam et al., 2021).

Crucial to designing effective policies and programs for fishers to adapt to environmental change is understanding the multiple risks and vulnerabilities facing this large sub-population. While a number of studies have recently captured the physical and/or socio-economic vulnerability of coastal communities, household-level, hazard-specific risk assessments are missing regarding Bangladesh's coastal context (Islam et al., 2014; Hoque et al., 2020; Miah et al., 2020; Mahmood et al., 2021). As a result, there remains a lack of knowledge in linking climatic hazards, household attributes, and people's livelihood activities.

Environment and migration

Bangladesh was predominantly rural in the 1970s (Islam and Islam, 2005). High population to land ratios in rural areas; rapid urbanization; and a wide gap between urban and rural wages were the early drivers of internal migration in Bangladesh (Nabi, 1992; Afsar, 1995; Alam and Mamun, 2022). The urban share of Bangladesh's population grew from 8% in the 1970s to 38% in 2018 (UN, 2018). Researchers have observed two major factors encouraging large-scale migration from Bangladesh's rural areas since the 1970s and 1980s. The first trend follows from Bangladeshi migration abroad to the gulf countries after the 1973 oil price boom, which created an enormous amount of development projects in those

countries (Rahman, 2012). According to the Bureau of Manpower, Employment & Training (BMET), around 80,000 workers migrated to Gulf countries up until 1980. This number increased to approximately 5 million by 2020 (Bhuiyan, 2020). The second migration trend has been propelled by the booming readymade garment (RMG) industries in Bangladesh, which mainly surround the national capital, Dhaka. The RMG sector mainly attracted women from rural areas in the early years, with the exponential growth of the RMG sector ultimately leading to a social transformation as young rural women started to migrate to Dhaka and Chittagong in greater numbers in pursuit of livelihood opportunities offered by this sector (Afsar, 1995). Alongside these two trends of migration, seasonal short-term internal labour migration represents another type of migration that has been widely practiced by many rural households attempting to cope with seasonal poverty, particularly in the northern districts of Bangladesh (Mubarak et al., 2016). Notably, this type of migration strategy is common among people affected by agricultural seasonality in various parts of the developing world (Khandker,2012). Studies have found positive impacts of seasonal migration regarding households' food security and consumption smoothing (Khandaker and Mahmud, 2012; Mubarak et al., 2016).

Since the 2000s, research on environment- or climate-induced migration has received significant momentum in migration literature. Several studies have examined the trends and patterns of environmental migration in Bangladesh (RMRRU, 2007; Poncelet, 2009; IOM, 2010; Black et al., 2011; Displacement Solutions, 2012; Martin et al., 2013). A number of studies estimate immediate displacements after disasters, such as cyclones or floods (Rayhan and Grote, 2007; RMRRU, 2007; IOM, 2010). Here, distress migration has been shown to act as a safety net for affected households during periods of considerable stress. Another group of studies broadly attempt to estimate the number of future climate refugees based on projected scenarios of future climate change. For example, a case study of the EACH-FOR project (Poncelet, 2009) predicted that massive movements due to the effects of climate change would be likely in Bangladesh in 20 to 30 years. Another IUCN study (Faruk, 2015) estimated that around 15 million people in Bangladesh alone could be on the move by 2050 due to climate change. The Bangladesh Climate Change Strategy and Action Plan-2009 (GoB, 2009) also predicted mass migration from coastal districts due to the future effects of climate change.

Two research gaps remain within the recent environmental migration literature in Bangladesh. The first gap arises from a lack of effort to contextualize environmental migration in wider socio-economic contexts. Although recent studies on environmental migration in Bangladesh have addressed temporary displacement and predicted the extent of future migration, there are very few empirical studies (Black et al., 2011; Martin et al., 2013) that have attempted to capture the complexity of environmentally induced migration (i.e., how emerging socio-ecological changes interact with traditional drivers of migration and shape households' migration decisions). Most studies have sought to single out environmental factors as the primary cause of migration, ignoring associated socio-economic factors (notable exceptions include Black et al., 2011). Another research gap relates to the lack of focus on temporary internal migration as a risk management strategy in the context of climatic and environmental vulnerability. While temporary internal migration as a livelihood risk management strategy has been thoroughly studied in terms of seasonal poverty in the northern districts of Bangladesh, migration research in the coastal districts has largely ignored the role that this type of migration plays as a risk management strategy.

Social protection in managing risk and vulnerability

Bangladesh has a long history of social protection programs, which have evolved through multiple phases (Rahman and Ali, 2011; GoB, 2019). In the early 1970s, social protection programs in Bangladesh mainly revolved around food rations and post-disaster relief programs (Rahman et al., 2012). After the famine in 1974, the country underwent its first significant shift in social protection via a countrywide scaling up of a food for work program[3] to tackle seasonal food insecurity Rahman et al., 2012).

Traditional food rationing programs in Bangladesh were phased out in the 1980s due to their low impact on tackling poverty and food insecurity (Rahman and Ali, 2011). In the 1990s, the Government of Bangladesh introduced several conditional and non-conditional cash transfer programs aiming to improve girls' participation in education and to support special population groups, such as persons with disabilities, destitute women, and seniors. Another significant development in the 1990s was the introduction of a post-disaster food security program, called Vulnerable Group Feeding (VGF), in aftermath of the 1998 countrywide floods (Rahman and Ali, 2011).

In the 2000s, the Government of Bangladesh undertook several new social protection programs, and for the first time, sustainable graduation from poverty became the central focus of social protection policymaking. After 2010, the government attempted to overhaul the social protection system, having recognized the emerging vulnerabilities due to the impacts of increased natural hazards and the projected impacts of environmental and climatic changes (Islam et al., 2016). The environmental focus of social protection policy was reflected in the widely scaled-up social protection program for *hilsha* fishers, which provided payment for ecosystem services (PES) to eligible fishers during a temporary fishing ban each year. Additionally, the National Social Security Strategy (NSSS) of Bangladesh, developed in 2015, has aimed to implement a policy to integrate social protection programs with disaster risk reduction (GED, 2015). While the lifecycle approach is central to the new policy, strengthening resiliency for managing covariate shocks constitutes one of the main strategic approaches mentioned in the NSSS.

Social protection programs are now an integral part of Bangladesh's poverty reduction strategies. Major policy documents, including the recent seventh five-year plan, and previous poverty reduction strategy papers (PRSPs) have recognized the importance of social protection programs in supporting the livelihoods and food security of poor households (GoB, 2009; 2015). The Government of Bangladesh finances around 140 different types of social protection programs, allocating more than USD 8 billion annually to support these programs (MoF, 2019). More than one-third of the total allocated funds are used for financing livelihood support programs, such as Food for Work; general cash transfer programs; food security programs; as well as other social empowerment programs, including microcredit (MoF, 2019). Some of these programs—such as Vulnerable Group Feeding (VGF), Vulnerable Group Development (VGD), Test Relief, Gratuitous Relief, and Fund for Mitigation of Risk of Natural Disaster—are directly targeted toward households in regions affected by disasters.

In recent years, researchers and development practitioners have become increasingly concerned about the idea of using social protection programs as a mechanism for reducing poverty and vulnerability to climate change (Davies et al., 2008; Béné, 2011; Charles et al., 2019; Costella et al., 2021). Governments,

[3] Before 1974, the food for work program was a small component of social protection in Bangladesh (Rahman and Ali, 2011)

donor agencies, and non-government organizations (NGOs) have been using asset transfers, cash transfers, and other forms of social protection programs as strategies for managing social risk in the developing world since the 1980s (Barrientos and Hulme, 2008). While the effectiveness of social protection programs in reducing economic vulnerability has been well-evidenced in the development literature (Barrientos and Hulme, 2008), social protection as a strategy for reinforcing livelihoods and resilience before longer-term climatic changes remains poorly understood (Johnson et al., 2013). The Government of Bangladesh oversees several social protection programs across the country that address poverty, food insecurity, and vulnerability among low-income households. What is not understood is whether these social protection programs are effectively addressing emerging risks and vulnerabilities faced by Bangladesh's coastal communities.

1.3 Theoretical framework

In this thesis, risk and vulnerability are conceptualized as functions of both biophysical and socio-economic indicators. Based on this understanding, improving a household's socio-economic conditions would then contribute to reducing their risk and vulnerability to climatic hazards and change. This dissertation also incorporates views of migration and social protection as risk management mechanisms that can help to increase a household's adaptive capacity, and thus reduce the risks and vulnerabilities they face. What follows are brief overviews of the conceptual frameworks applied in this dissertation, as well as how these frameworks facilitate a deeper and more nuanced understanding of the overarching objective of this research. The individual papers present these frameworks in more detail.

The first paper of this dissertation applies the IPCC's most recent risk and vulnerability framework proposed in the Fifth Assessment Report (AR5) to quantitatively assess household-level risk and vulnerability among coastal communities in Bangladesh. The paper adopts definitions of risk and vulnerability from the AR5(IPCC, 2014). Chapter 2 of this dissertation elaborately discusses the AR5 framework and compares with the previous frameworks. The AR5 notably introduced the concept of risk within a climate context for the first time in an IPCC assessment report, whereas previous reports mainly concentrated on vulnerability assessment. The concepts of risk and vulnerability as defined in AR5 remain unchanged in the recently published Sixth Assessment Report (IPCC, 2022).

One noteworthy feature of the AR5 framework is that it adopts a contextual or starting-point approach to assess risk and vulnerability, as opposed to an outcome or end-point approach that was used in the previous IPCC frameworks. A contextual approach considers vulnerability as the present inability of a system to cope with changing climate conditions, which is determined by social, political, economic, institutional, ecological, and technological structures and processes (Adger, 2006; O'Brien et al., 2007; Meybeck et al., 2012; Murphy et al., 2015). Accordingly, this approach draws on both socio-economic and biophysical aspects of vulnerability (Turner et al., 2003; O'Brien et al., 2004; Fussel, 2007; Fellmann, 2012). Overall, the contextual vulnerability approach attempts to answer why some groups are more affected by climatic hazards than others (Fussel, 2007).

On the other hand, an outcome or end-point approach conceptualizes vulnerability as the net impact of climate change on a specific exposure unit after accounting for feasible adaptation options (Fussel, 2005; Fellmann, 2012). The central research question asked by this approach is: ''What are the expected net impacts of climate change in different regions?'' (Fussel, 2007).This approach typically focuses on biophysical elements of vulnerability, and although aspects of adaptive capacity pertain to this approach, it tends to emphasize technological solutions and marginalize socio-economic components of

vulnerability (O'Brien et al., 2004; Fussel, 2007; Fellmann, 2012). Instead of this outcome approach, the AR5 framework's contextual approach allows researchers to assess and compare the risks and vulnerabilities of different groups in relation to different climatic hazards and changes, as well as identify the socio-economic and biophysical causes of these risks and vulnerabilities.

The second and third papers respectively incorporate conceptual frameworks of migration and social protection that consider both of these strategies as risk management and adaptive capacity-enhancing mechanisms. The conceptual frameworks applied in this dissertation complement each other in helping to capture the roles that migration and social protection play in addressing the risks and vulnerabilities faced by households affected by climatic hazards and changes.

The second paper of this dissertation aims to understand the ways in which temporary internal migration manages households' risks regarding climatic hazards and changes. In doing so, this paper develops an analytical framework that draws upon the New Economics of Labour Migration (NELM) theory and a more recent environmental migration framework proposed by Black et al. (2011). NELM considers migration as a risk management strategy for households facing employment and/or income uncertainty (Mincer, 1978; Stark and Bloom, 1985; Stark and Lucas, 1988). NELM also views migration as an alternative to insurance, considering the absence of functional insurance markets in most low-income countries. This theory represents a significant departure from earlier neoclassical migration theories, which assumed that real or expected wage differentials between two places comprised the main reason behind migration. Alternatively, NELM assumes that migration is a household decision, in which informal contracts exist between migrants and their households to provide income insurance to one another.

Black et al.'s (2011) framework was developed in the context of environmental change, and it portrays migration not only as a response to environmental change, but also as an adaptive response to such change. The first generation of research on environmental migration tended to single out environmental factors, based on the understanding that environmental change is the direct cause of large-scale displacement. This view received momentum with Norman Myers' (1993) projection that 150 million people would become environmental refugees by 2050. Similar claims were made by others as well (Suliman, 1990; Russel et al., 1990). This view of environmental migration, known as the 'maximalist' view, is essentially rooted in neo-Malthusian arguments that link population growth with social and economic crises and migration (Morrissey, 2012). However, empirical evidence has afforded very weak support to the consequences of environmental change or climate change as depicted by the maximalist view. According to Black et al. (2011), it is very difficult, or even impossible, to distinguish environmental migrants from other migrants; instead, it might be more useful to examine all the key drivers of migration and then analyze how environmental change might interact with these drivers and influence households' migration decisions. Based on this argument, Black et al. (2011) have proposed a conceptual framework that incorporates both structural and behavioral drivers of existing migration processes, while accounting for and distinguishing between the environment and environmental change.

Black et al. (2011)'s framework is particularly applicable in regions or countries where migration trends already exist; where some of the drivers mentioned above are already in play; and where environmental change has already been observed or anticipated. This framework is well-suited for this research in Bangladesh, as the country has a long tradition of migration driven by various drivers other than

environmental ones, and as the country experiences a rapid socio-economic transition from a low-income, agrarian past to middle-income, industrial future (Marshall and Rahman, 2013). According to the latest Household Income and Expenditure Survey of Banglades-2016 (BBS, 2018), 13.7% of rural households reported migrating either within the country (e.g., from one district to another) or abroad. This dissertation develops an empirical model to apply Black et al.'s (2011) framework to understand the drivers of temporary internal labour migration from southern coastal fisheries- and aquaculture-based villages in Bangladesh. In doing so, I complement Black et al.'s (2011) framework with NELM's assumption that labour migration follows a household-level decision to manage livelihood risks faced by a household, with migrants and their respective households upholding an informal contract to support each other.

The third paper applies the Adaptive Social Protection (ASP) framework, coined by researchers at the Institute of Development Studies (IDS), Sussex (Davies et al., 2009). The ASP framework establishes a core conceptual link between research domains focusing on social protection, disaster risk reduction, and adaptive capacity (Davies et al., 2008; Davies et al., 2009; Arnall et al., 2010). Davies et al. (2009) have argued that while social protection, disaster risk reduction, and adaptive capacity-enhancing programs share common goals—including reducing vulnerability and increasing resilience in the context of poverty, disasters, or long-term changes in average climate conditions—these three communities of practitioners have tended to work in silos, ignoring their commonalities and overlapping agendas (Davies et al., 2013). The ASP framework maintains that social protection possesses the potential to reduce disaster risks among poor households, and that it can also help build adaptive capacity among these households to overcome future climatic hazards and changes, while ensuring that they do not fall further into poverty.

Figure 1.1 shows how the frameworks applied in this dissertation relate to each other. The environmental migration framework conceptualizes migration decisions as an outcome of the interaction between climate risk and other traditional socio-economic drivers of migration. NELM complements this environmental migration framework by considering migration as a household-level risk management strategy. Therefore, labour migration is likely to reduce a household's risks by increasing their adaptive capacity through income diversification. On another note, the ASP framework sits at the intersection of three disciplines: disaster risk reduction, social protection, and adaptive capacity. This framework envisions a social protection system that reduces household-level risk and vulnerability by decreasing their sensitivity and increasing their adaptive capacity to risks and vulnerabilities. In the first paper of this dissertation, the AR5's risk and vulnerability framework further helps identify groups of people who face high levels of risk and vulnerability to different types of hazards. The migration and social protection frameworks, respectively used in the second and third papers, facilitate a more nuanced investigation into whether these groups employ temporary migration as a risk management strategy and whether they are sufficiently supported by social protection programs.

While the migration and social protection frameworks are connected to the AR5's risk and vulnerability framework, these two concepts are also closely connected within the context of climatic hazards and change. As noted above, the migration framework used in this dissertation considers migration as a risk management mechanism for households who are coping with and/or adapting to adverse environmental conditions. Likewise, social protection also works as a risk management mechanism for vulnerable households (Holzmann et al., 2003). Migration and social protection may therefore represent

complements or substitutes as risk management strategies. Black et al.'s (2011) framework includes several obstacles and facilitators that may promote or prohibit the migration of individuals or households from areas affected by climatic hazards or changes. The cost of moving poses a significant barrier for many households hoping to send migrants elsewhere. Moreover, the uncertainty around finding employment at the destination, particularly in the absence of recruiters, makes this investment even riskier for households. Social protection can be a means of removing this cost-related barrier because it may free up resources among beneficiary households and allow them to invest in migration. In this way, social protection can play a complementary role with migration in managing households' risks regarding climatic hazards and changes. On the other hand, social protection can also offer households an alternative risk management strategy to migration, particularly distress-driven migration after rapid and extreme shock events like cyclones, landslides, flooding, or river erosion. Social protection can prevent such migration by offering support to the affected households (Mueller et al., 2014; Schwan and Yu, 2018). Similarly, social protection programs like cash for work can also provide employment opportunities during lean seasons or post-disaster recovery periods, which can reduce the need for migration to find employment opportunities elsewhere (Johnson and Krishnamurthy, 2010; Coirolo et al., 2013).

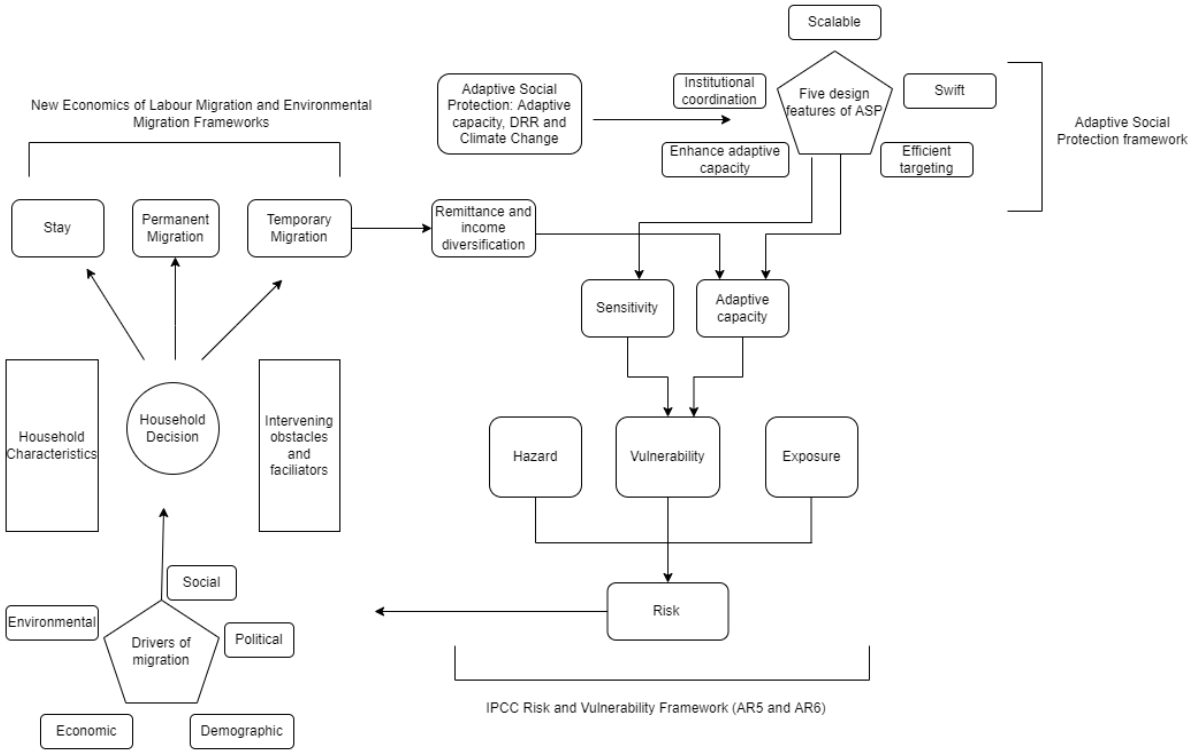


Figure 1.1: Conceptual frameworks used in the dissertation

1.4. Study area selection

Bangladesh's coastal zone comprises nineteen districts with a territory of 472001 sq. km., which is about 32% of the total area of Bangladesh. These nineteen coastal districts are divided into three administrative divisions: Khulna (southwest zone), Barisal (south central) and Chittagong (southeast

zone). Out of these nineteen districts, twelve are directly exposed to the Bay of Bengal, while the other seven districts are interior to coast. Despite their different proximities to the coast, all nineteen districts exhibit and experience similar environmental features and events, such as cyclones, salinity, tidal surges, and other forms of natural hazards (BBS, 2015). According to the population census of 2011,[4] around 25% of the population (or 35.5 million people) of Bangladesh live in the coastal region. The study area for this research covers three districts from three coastal divisions of Bangladesh: Satkhira district of Khulna division, Patuakhali district of Barisal division, and Noakhali district of Chittagong division. Six sub-districts, two from each of the three districts, were then selected to provide variation in terms of fishing and aquaculture activities, types of environmental stressors, and level of exposure to environmental and climate change. The selection was made based on discussions with informed government officials and subject matter experts. Finally, I randomly selected one union, which is the lowest administrative level in Bangladesh, from each sub-district. Thus, in total, six unions were selected from the three coastal districts. Figure 1 shows the location of the study districts on Bangladesh's map. The surveyed sub-districts are highlighted within circles in the district maps on the lower panel of Figure 1.2.

Each district exhibited a different livelihood profile. For example, livelihoods in Satkhira district are mainly based on shrimp and crab aquaculture and are reliant on the ecosystem services provided by the Sundarbans—the largest single-block mangrove forest in the world. Satkhira district is also the most vulnerable district in the region due to its high exposure to waterlogging, floods, tidal surges, salinity, and coastal erosion (BBS, 2015). For example, in 2009, Satkhira was one of the most affected districts by the Cyclone *Aila,* which inundated a large part of the district for about two years (Subhani and Ahmed, 2019) and displaced approximately fifty thousand people (Islam and Hasan, 2016). People living in this district are also affected by growing rates of piracy occurring in the Sundarbans (Chowdhury and Brahma, 2019). To the east of Satkhira, Patuakhali district features agricultural and both river and marine fisheries-based livelihoods. Patuakhali is also highly exposed to cyclones and tidal surges. Approximately 457 people were killed in this district by the super cyclone SIDR in 2007 (UNICEF, 2007). Farther east, Noakhali district in Chittagong division features a more diversified range of livelihood options than the other two districts. Along with small- and large-scale commercial fisheries, shrimp aquaculture, and salt beds, this region also offers various economic activities, including in tourism and heavy manufacturing industries. Regarding natural hazards, cyclones, tidal surges, and waterlogging are the main sources of environmental vulnerability in Noakhali district. Table A3.1 in Appendix 3 provides basic information on these selected districts.

[4] Population Census-2011 is the latest population census of Bangladesh, as the Bangladesh Bureau of Statistics postponed the Population Census-2021 until 2022.

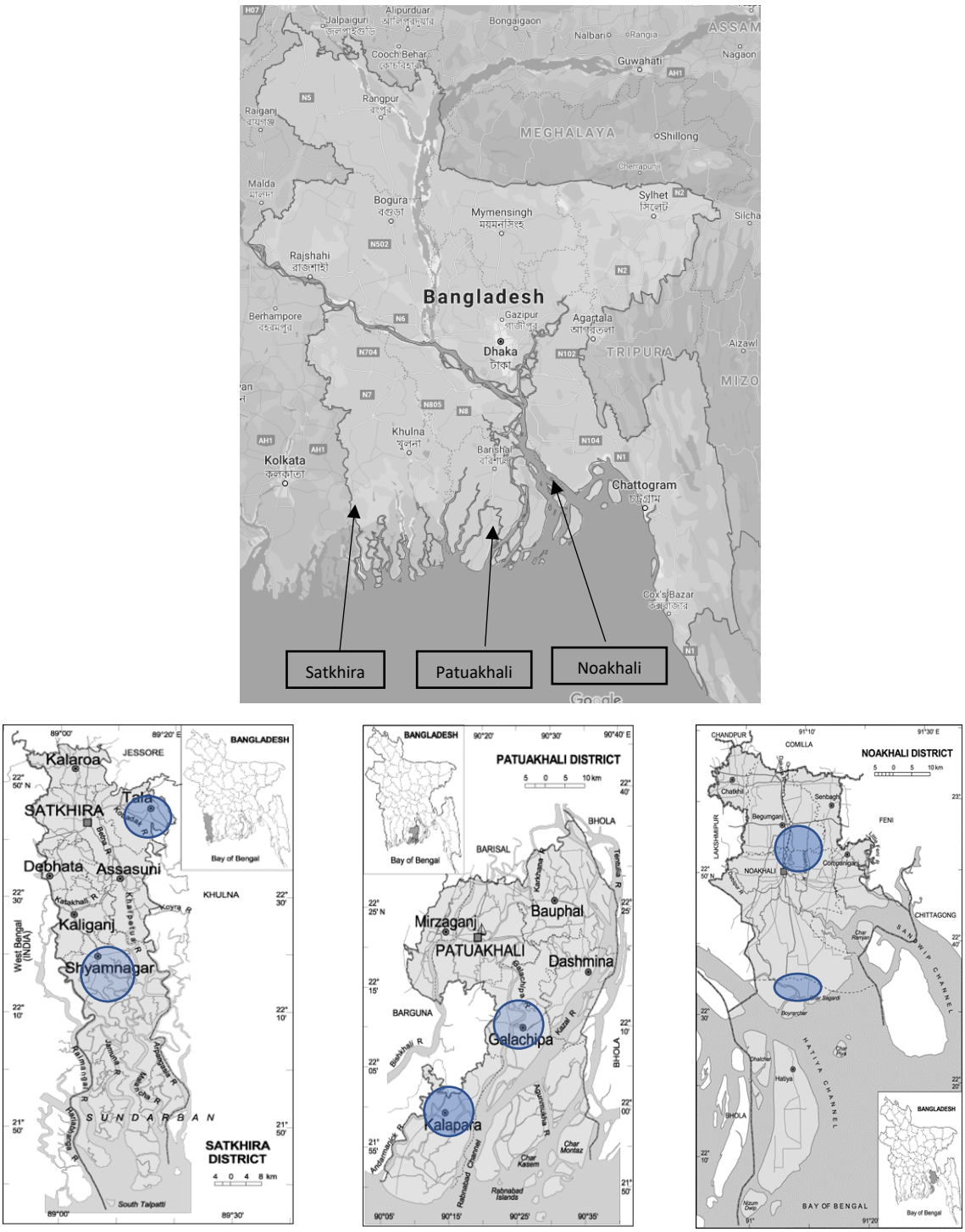


Figure 1.2: Map of Bangladesh and the study districts

Source: Google Maps and BDMAPS

1.5 Fieldwork methods

This research is primary based on fieldwork in Bangladesh that took place from December 2016 to October 2017. During the fieldwork, I collected data from both primary and secondary sources. To collect the primary data, I conducted a household survey, focus group discussions, and key informant interviews. This research was supported by the International Development Research Centre's International Doctoral Research Awards (IDRC-IDRA) and Joseph-Armand Bombardier Canada Graduate Scholarships from the Social Sciences and Humanities Research Council (SSHRC).

1.5.1 Household survey

The author designed the questionnaire[5] by drawing on Bangladesh's Household Income and Expenditure Survey-2016 (BBS, 2016), the Resilience Focused Baseline Survey: ECOFISH^{BD} Project[6] (Béné et al., 2017; Béné and Haque, 2021), and the fisheries and aquaculture modules used in the Vietnam Fisheries Transition Survey (Marschke and Betcherman, 2016). The questionnaire was peer-reviewed by researchers of the International Centre for Climate Change and Development (ICCCAD) and Development Research Initiative (DRI), which are two reputed research organizations in Bangladesh that possess vast experience in conducting survey-based research with households living in the country's coastal and rural districts. My academic supervisors also reviewed the questionnaire. Based on the comments received from the reviewers, I made necessary revisions to the questionnaire.

The questionnaire includes the following fifteen modules:

> Demographic information; household earning and employment; expenditures; fisheries; aquaculture; farming; detailed account of assets; landholdings; economic and environmental shocks; participation in social protection programs; perceptions of environmental and climate change; adaptive capacity; credit and savings information; temporary and permanent migration; and remittances.

The sampling strategy did not intend to generate a regionally or nationally representative estimate. The survey was administered face-to face with household heads (i.e., the main earning member of the household) and female co-heads, if the household head was not female. From each union, 120 households were surveyed. Depending on the unions, the survey covered up to nine villages to reach these 120 households. The total number of households in the survey sample was 720, with 120 households from each union. See Appendix 1 for detailed survey method.

1.5.2 Key informant interviews

I conducted 21 key informant interviews during the fieldwork period in Bangladesh. Key informants comprised subject matter experts, government officials (including fisheries and agricultural extension officers) and elected local government representatives. I conducted these interviews with experts to better understand the environmental and human-induced causes of the hazards. The information collected though these interviews enabled me to choose and validate indicators of hazards. Interviews with the government officials provided information on a range of topics, such as social protection targeting criteria and distribution mechanisms, the impacts of climatic stressors and changes to local agricultural and fisheries livelihoods, as well as government interventions in response to climatic and

[5] The questionnaire is provided in Appendix 7.
[6] This survey was conducted by Development Research Initiative (DRI), Bangladesh.

non-climatic changes. Interviews with elected local government representatives mainly focused on climatic stressors within their jurisdictions as well as household level social protection targeting and vulnerabilities faced by their constituents.

Key informant interviews provided me with an opportunity to understand the context of the coastal region and determine the districts where the fieldwork should be conducted. I completed most of these interviews prior to initiating the household survey.

1.5.3 Focus groups

I conducted the focus group discussions (FGDs) after first round of data analysis. The aim of the FGDs was to both validate and elicit complementary information regarding household survey. I reported the the findings from the focus groups to explain relevant quantitative findings in the discussion section of the three research papers of this dissertation. Additionally, I conducted focus groups to identify the livelihoods and assets that would be more exposed to different climatic stressors. I used this information in developing exposure indicators.

I intended to complete one focus group in each union (i.e., six focus groups in total). However, potential female participants in the study areas expressed that they were not comfortable speaking with me in the presence of male community members—particularly those who are not their family members—mainly for social and religious reasons. As a result, I conducted two sessions, one with male and another with female members of the communities, in each union. The focus groups were completed after initial analyses of the quantitative data. The focus groups were conducted after data analysis as a way to triangulate the main findings of the quantitative data analysis and ensure survey results were being properly interpreted. Regarding sampling approach, focus group participants represented the main occupational groups of the study areas. I tried to select participants from homogenous households so that the participants could express their views more freely. Discussion in the focus groups centred around climatic stressors and changes in the localities; the impacts of these stressors and changes on their livelihoods, adaptive practices, and migration patterns; as well as their experiences with social protection programs. One key topic during the focus groups was the extent to which major occupational groups had been exposed to different types of stressors and changes. The information collected through these focus groups has been incorporated into this dissertation alongside the quantitative survey findings. Focus groups were crucial in interpreting the quantitative data and gaining a deeper understanding of the findings.

I analysed the FGD data in three steps. First, I prepared and organized the data for analysis. I then typed and input my hand-written field notes and transcriptions into an Excel spreadsheet. Second, I arranged the data by emerging themes. Key themes included: impacts on livelihoods by types of hazards; labour migration decisions and reasons behind these decisions following different types of hazards; and social protection selection practices. Third, I reported the data as a part of the discussion sections and used them to select and validate indicators for the hazard and exposure index.

1.6 Research ethics

I received a certificate of approval (Ref. 10-16-14) from University of Ottawa's Social Sciences and Humanities Research Ethics Board (REB) on December 21, 2016 before initiating fieldwork. The research team provided each participant with an informed consent form and explained the purpose of the research. If a participant was unable to read or understand the consent form, I or the enumerator

explained the consent form to that participant. Participants were recruited voluntarily, and I informed participants that they could withdraw from the study at any stage. Survey and interview participants were ensured anonymity. However, focus group participants were made aware that other participants from the same focus group would know their opinions. After entering and cleaning the survey data in a master file, I assigned an identification number for each household and removed any identifiable attributes. To comply with confidentiality, the final data were only shared with my academic supervisors in an encrypted drive.

Chapter 2:
Climatic risk and vulnerability in coastal fisheries-based communities in Bangladesh

2.1 Introduction

Consecutive reports of the Intergovernmental Panel on Climate Change (IPCC) identify Bangladesh as one of the most vulnerable countries to climate change and natural disasters (IPCC, 2001; 2007; 2014; 2019; 2021). Bangladesh's southern coastal region is particularly vulnerable to multiple climatic stressors including frequent and intense cyclones and other hydro-meteorological coastal disasters, such as sea-level change, tidal surges, monsoonal flooding, rising temperature, and saline water intrusions (IPCC, 2014; 2019; Rakib et al., 2019). The adverse socio-ecological changes that Bangladesh's coastal region has experienced over the last few decades have increased the precarity of livelihoods and food security among the area's households (Lazar et al., 2015; Hossain et al., 2018; Dewan, 2021). The deterioration of drinking water sources, the scarcity of grazing land, changing crop patterns, and the reduction of active fishing days and fish stock all challenge the viability of secure and sustainable livelihoods for the region's population (Scoones, 2009; Hossain et al., 2017).

To implement effective policies and programs that reduce the impacts of climatic hazards at local levels, it is crucial to understand the likelihood of different types of climatic hazards and their potential impacts on households and communities (Adger, 2006; Füssel and Klein, 2006; Dudley, 2021). Risk and vulnerability assessments can identify current and potential hotspots, sources, and levels of risk and vulnerability, including the most vulnerable sectors and groups of people (Matteo et al., 2018; Zebisch et al., 2020). These assessments enable policymakers and practitioners to design mitigation and adaptation strategies. Based on the IPCC's most recent risk and vulnerability assessment framework (IPCC, 2014; 2022), this paper assesses the risk and vulnerability of coastal fisheries and aquaculture-based communities in Bangladesh. While risk and vulnerability are defined in different ways among different disciplines, this study adopts the IPCC's definitions of these two terms since the study area is a hotspot for multiple climatic stressors and changes. The IPCC's Fifth Assessment Report (AR5) defined vulnerability as the propensity of a system to be adversely affected, while risk represents the probability of occurrence of hazardous events or trends multiplied by the impacts of these events or trends that could occur (IPCC, 2014). The risk and vulnerability framework proposed in the AR5 report has also been adopted in the recently published Sixth Assessment Report of the IPCC (2022).

Researchers use diverse methodological approaches to systematically assess the climatic vulnerability of socio-ecological systems. These approaches can be broadly grouped into three categories: model-based approaches, qualitative approaches, and indicator-based approaches (Shah et al., 2013). These methods can also be used in combination. Earlier climate change vulnerability assessments widely relied on quantitative model-based assessments where researchers primarily concentrated on biophysical elements of vulnerability using ex-ante models (Smith, 1996; IPCC, 2001). On the other hand, qualitative vulnerability assessments mainly focus on the socio-economic elements of vulnerability and utilize interviews, focus groups, and cognitive mapping with the affected population (Cutter, 1996; Turner et al, 2003; Moran, 2006; Reed et al, 2013)). Finally, the index-based approaches to vulnerability assessment attempt to combine both biophysical and social aspects by constructing composite indices based on climatic indicators and data collected through household surveys.

Since 2001, the IPCC's conceptualization of vulnerability dominated vulnerability assessments and formulated vulnerability to be a function of exposure, sensitivity, and adaptive capacity (IPCC, 2001; 2007). The AR5 then reframed vulnerability as a function of sensitivity and adaptive capacity independent of any particular climatic or environmental stressors, and it also introduced the concept of risk, which is a function of climatic hazards, exposure, and vulnerability (IPCC, 2014). The AR5 also redefined the concept of exposure. In the previous AR4 framework, the exposure component was perceived as the occurrence of climatic hazards, while the AR5 framework conceptualized exposure as the presence of something of value that could be affected by climatic hazards. As a result, the risk assessments based on the AR5 framework became more likely to identify households and communities with higher asset endowments as more highly exposed than their counterparts with fewer assets. Whereas the vulnerability assessments based on the previous frameworks often reported the poorest households or communities as being the most exposed to climatic hazards and changes (Islam and Winkel, 2017; Hallegatte et al., 2018). Although the concept of vulnerability was revised by the IPCC in 2014, an overwhelming majority of the published research continued to use IPCC's earlier conceptualization of vulnerability for assessments and for calculating indices, with risk assessments often overlooked as well (FAO, 2015; Sahrma and Ravindranath, 2018). While some studies have applied the new frameworks to assess vulnerability and risk using qualitative methods, only a few have attempted to operationalize these concepts in a quantitative manner for geographic units but not at the household level (Dubois, 2021).

A recent systemic literature review by Gregor-Gaona et al. (2021) found that while some studies claimed to use the AR5 framework, they ultimately drew vulnerability indicators from the earlier AR4 framework. Prior to the publication of AR5, numerous vulnerability indices were constructed using the IPCC's Third (TAR) and Fourth Assessment Report (AR4) frameworks over the last two decades (Gregor-Gaona et al., 2021). As a result, there has been a reluctance to switch to the new framework because it may hinder the ability to compare new assessments with previous ones. Another possible reason for the low uptake of the AR5 framework is the lack of guidance from IPCC on operationalizing the framework (Ishtiaque et al., 2022).

Applying the IPCC's AR5 conceptual framework, this paper follows the index-based approach to construct risk and vulnerability indices at the household level in coastal fisheries and aquaculture-based communities in Bangladesh. This paper applies and proposes a replicable method to assess risk and vulnerability based on the AR5 framework, comprising indices that can be used for designing mitigation and adaptation programs, tracking changes over time, identifying target groups for interventions, and comparing the risk and vulnerability of different socio-ecological systems. This study draws on a household survey consisting of 720 participants, key informant interviews, and focus group interviews carried out between 2016 and 2017 across three coastal districts in Bangladesh. This paper measures the risk that coastal households face in Bangladesh in conjunction with three main climatic hazards, namely: (a) cyclones and storm surges; (b) floods and waterlogging; and (c) soil, surface water, and groundwater salinity.

This paper is organized in the following sections. Section 2.2 describes the IPCC's risk and vulnerability framework, which represents the theoretical lens used in this paper to operationalize the above concerns. Section 2.3 outlines the study area and data sources, and describes the method of index construction. Then this paper presents the vulnerability and risk indices across geographic location,

income level, and main occupation in Section 2.4, before discussing the findings along with several concluding remarks in Section 2.5.

2.2 IPCC's vulnerability and risk framework

The IPCC's AR5 risk assessment framework reflects a major shift from the earlier vulnerability assessment frameworks proposed in IPCC's TAR and AR4 (IPCC, 2001; 2007). In the AR5, the IPCC redefined the concept of vulnerability by moving to a risk-based conceptual framework (IPCC, 2012; 2014) and framed vulnerability as a component of risk. The AR5 risk-centric framework allows for greater consistency in approaches that address adaptation and risk reduction across climate and disaster risk management researchers. While the climate change researchers have mostly concentrated on vulnerability frameworks, the disaster risk management researchers have been using risk-centric assessments for a long time (Peduzzi et al., 2006; OECD, 2012; UNEP, 2013). Drawing upon the contextual vulnerability approach, the AR5 conceptualized vulnerability as a property of a system independent of exposure to hazards. Mathematically, the AR5 identified vulnerability as a function of sensitivity and adaptive capacity. Thus, exposure to hazards, considered as an element of vulnerability in the AR4 conceptual framework, was no longer an element of vulnerability in this new approach. Rather, risk in AR5 is a function of vulnerability, along with the probability of occurrence of hazardous events and exposure of the system to hazardous events. According to the new conceptualizations in AR5, equations (2.1) and (2.2) express the functional forms of vulnerability and risk, respectively. Table 2.1 presents AR5's definitions of the components of vulnerability and risk.

$$V = f(S, AC) \qquad (Eq.\ 2.1)$$

Where V=Vulnerability, S=Sensitivity and AC=Adaptive Capacity

$$R = f(H, E, V) \qquad (Eq.\ 2.2)$$

Where R=Risk, H=Hazards, E=Exposure and V=Vulnerability

Table 2.1: Definitions of risk and vulnerability components in AR5

Concept	IPCC's AR5 definition (2014)
Risk	The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard. In AR5, the term risk is used primarily to refer to the risks of climate change impacts.
Vulnerability	The propensity or predisposition to be adversely affected. Encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.
Sensitivity	Degree to which a system (i.e., fishery would be an example of a system) is directly or indirectly affected, either adversely or beneficially by climate variability or change.
Adaptive Capacity	The ability of a system/institution/humans/other organisms to adjust to potential damage and to take advantage of opportunities or respond to consequences.

Concept	IPCC's AR5 definition (2014)
Exposure	The presence of people, livelihoods, species, or ecosystems; environmental functions; services and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected.
Hazard	The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage to and loss of property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources.

Source: IPCC (2014)

2.3 Study area, data, and methods

2.3.1 Study area

This study was conducted in three coastal districts in Bangladesh: Satkhira (Khulna division), Patuakhali (Barisal division) and Noakhali (Chittagong division). Two sub-districts were chosen from each district: one directly exposed to the Bay of Bengal and the other from the interior coast. In total, six sub-districts were chosen for this study: Tala and Shyamnagar from Satkhira, Golachipa and Kolapara from Patuakhali, and Begumganj and Subarnachar from Noakhali. See section 1.4 of the Chapter 1 for details.

2.3.2 Data

The data for the risk and vulnerability assessments are derived from a combination of secondary and primary sources. The primary data originate from the Bangladesh Coastal Socioecological Vulnerability Survey (BCSEV)-2017, key informant interviews, and focus group discussions. The secondary data pertaining to environmental stressors are from the Department of Disaster Management and the Ministry of Agriculture of the Government of Bangladesh. See Section 1.5 of the Chapter 1 and Appendix 1 for detailed fieldwork methods.

2.3.4 Methods: Development of risk and vulnerability indices

This paper constructs three risk indices for three groups of hazards selected for this study: cyclone and storm surges, floods and waterlogging, and salinity (soil, surface water, and groundwater). These three groups of hazards were selected because surveyed households experienced these hazards most frequently within the three years preceding the survey.[7] Households also reported experiencing other shocks, such as riverbank erosion, drought, fish and livestock disease, and crop failure due to pest attack. However, none of these stressors was experienced by more than 4% of surveyed households.

To construct the risk index for each type of hazard group, this paper constructs the following three indices: a vulnerability index, a hazard-specific exposure index, and a hazard index. The vulnerability index, which is a combination of two sub-indices—the sensitivity index and adaptive capacity index—was first constructed. Next, the exposure index and hazard index were constructed for each of the three climatic hazards. Finally, three risk indices, one for each group of hazards, were calculated by integrating the vulnerability index and hazard-specific exposure index and hazard index (see Figure 2.1).

[7] 24.4%, 52.7%, and 23% of the sample households respectively experienced cyclones and storm surges, floods and waterlogging, and salinity.

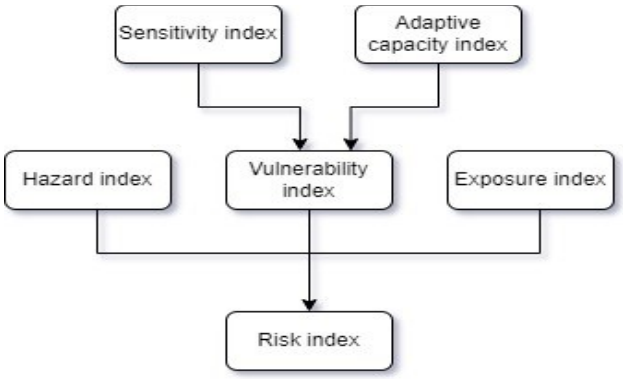


Figure 2.1: Risk index and its components

This section describes the indicators used in this study and how vulnerability, exposure, and hazard indices were combined to construct the three risk indices: cyclone and storm surges risk index, floods and waterlogging risk index, and salinity risk index.

Vulnerability indicators

Vulnerability indicators are comprised of indicators for sensitivity and adaptive capacity. While the hazard index attempts to indicate the future likelihood of hazards, the vulnerability and exposure components of the index together capture the potential impact of hazards on households. The vulnerability and exposure indicators are measured based on the present condition of the households, which could have been impacted by ongoing or past hazards. Sensitivity indicators capture the intrinsic attributes or conditions that determine the degree to which a household can be beneficially or adversely affected by a given hazard. To construct the vulnerability index, five sensitivity indicators that can worsen a hazard or trigger an impact were selected.

The first indicator, representing the *time it takes to get drinking water*, is an indicator of water insecurity and extreme conditions. The longer time required for collecting drinkable water reflects water insecurity and extreme conditions faced by households (Hahn, 2009; Hopewell and Graham, 2014). Climatic stressors can worsen the wellbeing of households that are already affected by existing water insecurity and extreme conditions. The second indicator of sensitivity is *compromised food security,* measured as the number of months in the past twelve months that the household had difficulty obtaining food. Food insecure households are more likely to fall into deeper food insecurity and poverty if affected by climatic stressors (FAO and WFP, 2020). The third indicator, *chronic disease of any household member,* is a dummy variable for households having at least one member who is chronically ill. Households with chronically ill members must allocate resources for the treatment of the household member. Therefore, such households are likely to have fewer human and financial resources to cope with climatic stressors (Paudel and Pant, 2020, CICC, 2021). The fourth indicator, *time required to reach a health facility*, denotes the remoteness of the household's location and the availability of basic services. Households located in remote areas are more sensitive to climatic stressors (DHS, 2018). The *dependency ratio,* measured as the ratio of persons in 'dependent' age groups (under 15 years and 65 years and above) to those in the 'economically productive' age group (15-64 years), is the fifth sensitivity indicator. Households with a high dependency ratio are likely to have less economically productive human resources to contribute to household income and disaster recovery efforts (Young and He, 2015).

The literature on adaptive capacity has frequently drawn indicators of adaptive capacity from the concept of capital assets developed by Chambers (1987) and further extended by Scoones (1997) into the Sustainable Livelihood Framework (Gbetibouo and Ringler, 2009; Choden et al., 2020; Mesfin et al., 2020). The conceptual overlaps between the concept of livelihoods and of adaptation led researchers to develop adaptive capacity indicators from capital assets (Reed et al., 2013; Clay, 2018). This approach is particularly relevant for measuring adaptive capacity at the level of communities or households instead of national or regional levels (Choden et al., 2020). This study also draws adaptive capacity indicators from capital assets (human, financial, physical, social, and natural).

Human capital is represented by two indicators: *level of education* and the *share of employed individuals among the working-age members of a household*. Education is crucial for strengthening human capital as it contributes to overall wellbeing (Howell and Howell, 2008). The adaptive capacity literature has also recognized that education can increase the cognitive aspects of adaptive capacity and contribute to better risk management, due to its direct effect on risk-reducing and risk-mitigating behaviour (Walker, 2021). A skilled population can exploit employment opportunities in sectors that are less exposed to climatic stressors, helping to protect them from income loss and other adverse effects of environmental and climate change. Employment is also an important aspect of adaptive capacity because a higher number of employed members in the household can distribute (and thereby decrease, on individual terms) livelihood risks linked to climatic stressors. However, if all employed members of a household were employed in the same sector, all of them would be exposed to the same climatic risk. This paper also includes a household livelihood diversity indicator to complement this indicator. Household livelihood diversification was calculated using Gibbs and Martin's index[8] (Gibbs and Martin, 1962):

$$LDI = 1 - \sum_{m=1}^{N} P_m^2$$

where p is the share of income from an individual source in the total income, and N is the number of the total income sources. Higher values of this index denote higher levels of livelihood diversification.

The index includes one financial capital indicator: *household savings (log)*. This indicator provides a general picture of the financial situation of the households. Households with higher savings are likely to respond better to adversity. Having higher savings also prevents households from asset-depleting negative coping strategies (Fenton et al., 2017).

Household physical capital is represented by four indicators: *type of housing*, *productive wealth index*, *consumption wealth index*, and *community infrastructure index*. While the first three indicators are measured at the household level, the fourth indicator is measured at the union[9] level. The type of housing indicator is essentially an index, too. The index was calculated based on the materials used for the floors, walls, and roof of the house.[10] Indices for productive and consumption wealth were constructed using the World Food Programme's *Creation of a Wealth Index* (WFP, 2017). The

[8] Gibbs and Martin's index is also known as Simpson's index.

[9] Unions are the lowest administrative units in Bangladesh's local government system.

[10] Households received scores for the materials comprising their homes, namely the floors, walls, and ceilings. Concrete materials received a score of 3, tin received 2, and straw or other weak materials received 1. For example, if a household's residence had concrete-built floors, walls, and ceilings, they would receive a full score of 9 on housing condition.

community infrastructure index is an important measure of the adaptive capacity of a community, since better infrastructure is more likely to reduce transactions costs and facilitate linkages between labour and product markets (Gbetibouo and Ringler, 2009). The community infrastructure index is calculated based on the availability of a number of crucial infrastructures in a locality, including daily and weekly village markets, paved roadways, cold storage, grain silos, veterinary clinics, etc. The full list of the amenities used to calculate the score can be found in the Appendix 2 in Table A 2.1. For each amenity, the union receives one point. The community infrastructure index is the sum of these points.

Social capital is composed of three indicators: household access to food or cash during hardship, household's membership with NGOs or community-based organizations, and household perception of community harmony in the village. While the first two indicators are dummy variables, the third is measured on a Likert scale between one to five 5 (where 1 denotes lowest level of harmony and 5 denotes a very high level of harmony).

Finally, household access to natural resources (e.g., open waterbodies, mangrove forests, etc.) was selected to capture household's natural capital. However, households were hesitant to provide this information since resource extraction from mangrove was often illegal in the study area. As a result, this indicator was dropped.

Hazard indicators

IPCC AR5's definition of hazard suggests using indicators to capture the potential occurrence of a natural or human-induced physical event, trend, or impact that may cause loss of life, injury, or other health effects, as well as damage to and loss of property, infrastructure, livelihoods, service provisions, ecosystems, and environmental resources. This paper includes potential occurrence, trend, and physical impact indicators of a hazard for each of the three groups of hazards selected for this study. This paper selects these hazard indicators based on expert interviews and literature. The majority of these indicators are measured at the district level because of data limitations at administrative units lower than the district. When available, sub-district or lower-level data were used.

Five indicators were included in calculating cyclone and storm surge hazard indices. The first two indicators represent the proportion of households affected by storm and storm surges between 2009 and 2015. These two indicators were drawn from Bangladesh's disaster-related statistics-2009-14 (BBS, 2015). This survey provides district-level representative data on the proportion of households affected by different types of climatic stressors. This proportion could be calculated from the BCSEV survey data as well. However, it is important to note that the last two super cyclones prior to the fieldwork happened in 2007 and 2009. These two years are out of the scope of this survey since the survey collected shock data for the five years preceding the survey (2012 to 2016). Between 2012 to 2016, the study districts experienced storms but not at the scale of those of 2007 and 2009. As a result, the author used the survey data of the Bangladesh Bureau of Statistics for these two indicators since it collected data from 2009 to 2015. Bangladesh's coastal districts experience such super cyclones once or twice a decade (Brammer, 2014).

A district-level storm surge score is also included in this index. The score is calculated from the secondary statistics drawn from the Department of Disaster Management, Government of Bangladesh. The score is a weighted index of the area inundated and the depth of inundation. Another indicator of this index is average elevation (measured in meters) at the sub-district level. Higher elevations are likely

to reduce the level of storm surges. The elevation data were drawn from Bangladesh's topographic map based on NASA's Shuttle Radar Topography Mission (STRM) data. Finally, a village-level indicator is included in the index: the proportion of households in a village that experienced storm or storm surges within the five years preceding the survey. The author acknowledges that some of these variables could be highly correlated to each other. However, the use of factor analysis is likely to reduce the risk of overweighting the correlated indicators.

For the salinity hazard index, four indicators were used: proportion of land area affected by soil salinity in the sub-district; surface water salinity level; groundwater salinity level; and the proportion of households in a village that experienced any type of salinity intrusion. The first three indicators were collected from secondary sources, and the fourth indicator was drawn from the household survey. The latest secondary data on soil salinity is from 2010, which was published by the Soil Resource Development Institute of the Ministry of Agriculture (MoA, 2010). This study provides sub-district level data on six different levels of salinity. The author calculated a weighted index based on the different levels of salinity and the proportion of land area under each level of salinity. The average surface and groundwater salinity levels were collected from the Bangladesh Water Development Board.

For floods and waterlogging, reliable sub-district level secondary data were not available. As a result, the author calculated the floods and waterlogging hazard index based on two indicators from the household survey: first, the proportion of households in a village that experienced flooding, and second, the proportion of households in a village that experienced floods followed by waterlogging.

Exposure indicators

The term 'exposure' has been redefined in the AR5 and has a completely new meaning. Instead of experiencing a climatic shock, exposure now refers to the presence of something of value in the system which can be negatively impacted by climatic hazards. The majority of the exposure indicators are captured at the household level. This research identifies household assets and occupations that can be damaged by a specific hazard and includes dummy variables of ownership of those of assets held by households and the proportion of household income from those livelihood indicators of exposure. This paper developed hazard-specific exposure indicators based on a review of the literature, expert interviews, and FGDs (Table 2.2). Vulnerability indices based on the AR4 conceptualization always considered all household assets as indicators of adaptive capacity. However, according to the new conceptualization, household assets that could be affected by a particular hazard should be considered as exposed assets to that hazard.

Table 2.2: Exposure indicators

Hazards	Indicators
Exposure to storm and storm surge	Household's ownership of fishing boat
	Household's ownership of farmland
	Household's ownership of fish farm (both shrimp and non-shrimp)
	Household's ownership of livestock
	Exposure of livelihood to cyclone: Proportions of household income from: fishing, shrimp aquaculture, non-shrimp aquaculture, farming and livestock
	Household's ownership of (both shrimp and non-shrimp)
	Household's ownership of farmland

Hazards	Indicators
Exposure to floods and waterlogging	Household's ownership of livestock
	Exposure of livelihood to waterlogging: Proportions of household income from: river fishing, shrimp aquaculture, non-shrimp aquaculture, farming and livestock
Exposure to salinity	Household's ownership of farmland
	Household's ownership of fish farm (non-shrimp)
	Household's ownership of livestock
	Exposure of livelihood to salinity: Proportions of income from river fishing, non-shrimp aquaculture, farming, livestock and wage labour

Index construction

Selected indicators for the vulnerability, exposure, and hazard indices were measured at different scales and units. As a result, these variables could not be aggregated into one index without normalization (this refers to transforming indicator values measured in different scales and units into unitless values on a common scale). Before normalization, the author first treated the outliers by trimming values outside the 2.5 and 97.5 percentile of the distribution of the non-categorical variables. That is, any observed value greater than the 97.5 percentile was lowered to match the 97.5 percentile, and any observed value lower than the 2.5 percentile was raised to the 2.5 percentile. In the case of categorical indicators (dummy variables), an indicator would not qualify for inclusion in the index if the indicator took a value of 1 for more than 95% or less than 5% of the sample; in such cases, the indicator would not represent any variability across households.

After treating the outliers, the variables were normalized using the following min-max method:

$$x_{i,0\ to\ 1} = \frac{x_i - x_{min}}{x_{max} - x_{min}} \qquad (Eq.\ 2.3)$$

where x_i represents the indicator value, x_{min} is the lowest value for that indicator, x_{max} is the highest value for that indicator, and $x_{i,0\ to\ 1}$ is the normalized value of the indicator within the range of 0 to 1.

The normalization transformed the indicator values to a standardized value range of 0 to 1. Next, the author checked whether the indicator values increased in the right direction, i.e., lower values should denote positive conditions in terms of risk while higher values should reflect more negative conditions. For example, indicators of sensitivity and adaptive capacity would contribute to vulnerability in opposite directions. Higher values of adaptive capacity indicators would represent a higher adaptive capacity and consequently lower vulnerability. Therefore, the direction of the adaptive capacity indicator value range would be negatively related to vulnerability, i.e., vulnerability would increase as the adaptive capacity indicator value decreases, and vice versa. To construct the vulnerability index, this paper inverted the value of adaptive capacity indicators by subtracting the standardized value from 1. Therefore, an index of lack of adaptive capacity was calculated. This operation can also be expressed as:

$$x_{i,0\ to\ 1} = \frac{x_{max} - x_i}{x_{max} - x_{min}} \qquad (Eq.\ 2.4)$$

After standardizing the indicators, a factor analysis was performed to construct each of the three indices: vulnerability index, hazard index, and exposure index. Factor analyses group together individual

indicators that are collinear to form a composite indicator, which captures the information common to each individual indicator as much as possible. Alternatively, equal weights could be used to calculate the indices. However, using equal weights risks imposing higher weights on dimensions when there is a high degree of collinearity between indicators. The author acknowledges that the weight derived from a factor analysis is not a measure of the theoretical importance of the associated indicator; rather, the method adjusts for overlapping information between two or more correlated indicators.

Before performing the factor analysis, the correlation structure of the indicators was observed. In cases of very high correlation between two variables, one of the variables was excluded since the two variables are likely measuring the same phenomenon. This paper incorporated both quantitative and qualitative indicators (categorical indicators) to construct the indices since both types of indicators are important features of vulnerability assessments. However, a traditional factor analysis should not be applied to categorical variables. To accommodate both quantitative and qualitative indicators, this paper applied a non-linear factor analysis method that can analyze a mixed-scale data set. While this approach is predominantly used in psychological assessments, it has been used in constructing socio-economic indices in recent years (Rajesh et al., 2018).

The non-linear factor analysis tool, *Polychoric*, in the statistical package Stata was used to conduct the factor analysis. The next step was the identification of a certain number of latent factors (fewer than the number of individual indicators) representing the data. Each factor depends on a set of coefficients (loadings) and each coefficient measures the correlation between the individual indicator and the latent factor. This study applied the standard practice of choosing factors that have associated eigenvalues larger than one (the Kaiser Criterion)[11]. After selecting the factors, factor scores were calculated. The indices were calculated by aggregating the score of the factors. While aggregating the factors, weights were assigned to each factor depending on the proportion of variability that the factor explained. That is, the percent of variability explained by the individual factor was divided by the total variability explained by the factors retained. Of note, factor analyses have not been used for calculating floods and waterlogging hazard indices due to the very low number of indicators for these phenomena.[12] See Appendix 7 for the factor analysis related statistics.

After calculating the sensitivity and lack of adaptive capacity indices, the vulnerability index for each household was calculated by taking the geometric mean of these two indices (Eq. 2.6):

$$\textit{Vulnerability Index} = \sqrt[2]{Lack\ of\ Adaptive\ Capacity\ index\ X\ Sensitivity\ index} \qquad \textit{(Eq. 2.5)}$$

After calculating the vulnerability, exposure, and hazard indices, the risk index was calculated by taking the geometric mean of the three components using equation 4 (Eq. 2.7). While the hazard and exposure indices are different for each group of hazards, the vulnerability index is common in all three risk indices:

$$\textit{Risk Index} = \sqrt[3]{Vulnerability\ Index * Exposure\ Index\ *\ Hazard\ Index} \qquad \textit{(Eq. 2.6)}$$

[11] Verimax rotation was used to further clarify the relationship among factors. It intends to maximize the variance shared among items. This process simplifies the factor structure and makes its interpretation easier and more reliable (Abdi, 2003).

[12] The geometric mean of the two indicators was used to calculate the index value.

Alternatively, the additive index could be constructed by taking an average of the vulnerability, exposure, and hazard indices. Although additive indices are very simple to calculate, they suffer from substitutability problems, i.e., low achievement in one dimension can be compensated for by high achievement in another. Since 2010, the United Nations' Human Development Index (HDI) switched from the arithmetic mean to the geometric mean (UNDP, 2020). The advantage of using a geometric mean is that it reflects poor performance in any dimension or component of the index since low achievement in one dimension is not compensated for by high achievement in another dimension. In the results section, the average risk score for households is reported at the sub-district-level for each group of hazards.

2.4 Results

The result section first reports the vulnerability index by main occupation group and income level. What follows are the three risk indices for cyclones and storm surges, floods and waterlogging, and salinity by sub-district. Then, all three risk indices are compared across main occupation groups and income levels. The results also draw on qualitative information collected during the fieldwork to help explain the risk levels experienced by the main occupation groups.

Vulnerability by location, occupation group, and income level

Table 2.3 reports the average vulnerability index scores of households by sub-district and income level. The author categorized the households into three groups according to their income level following the criteria used by the Bangladesh Bureau of Statistics:[13] extreme poor, moderate poor, and non-poor. The table shows that the average vulnerability score was the highest for the extreme poor (0.47) and the lowest for non-poor households (0.35). The correlation coefficient between households' per capita income (log) and vulnerability index score was also negatively correlated, and the correlation coefficient (-0.275) was significant at a 1% level. Among the sub-districts, households of Subarnachar had the highest average vulnerability index score (0.52), followed by Shyamnagar (0.43) and Tala (0.40) sub-districts. Average vulnerability index scores for Kolapara, Golachipa, and Begumganj sub-districts were very similar and ranged between 0.33 and 0.37.

Table 2.3: Vulnerability index score by sub-district and poverty level

Sub-district	Extreme poor	Moderate poor	Non-poor	All income groups
Tala	0.43	0.41	0.34	0.4
Shyamnagar	0.47	0.42	0.38	0.43
Kolapara	0.36	0.38	0.34	0.37
Golachipa	0.28	0.28	0.32	0.33
Begumganj	0.42	0.34	0.3	0.35
Subarnachar	0.54	0.49	0.47	0.52
All sub-districts	0.47	0.41	0.35	0.4

[13] District-level income cut-offs suggested by the Bangladesh Bureau of Statistics were used to determine income levels.

Note: The colour continuum ranges from green to red. Green and red, respectively, denote the lowest and the highest vulnerability levels.

Table 2.4 shows the average vulnerability index scores for the main occupation groups in the study areas. The researcher determined the main occupation of a household based on the occupation which accounted for the largest share of a household's income.[14] Households were divided into seven main occupational groups: marine fishing, river fishing, aquaculture, farming, livestock rearing, wage labour, and 'other'. The table reports that the average vulnerability index score was the highest for river fishers (0.46), followed by wage labourers (0.44). Households dependent on farming and aquaculture were among the occupation groups with lower vulnerability index scores, with 0.31 and 0.34, respectively. One noteworthy point is that the extent of vulnerability of occupational groups varied across the sub districts. For example, river fishers of Tala, Shyamnagar, and Subarnachar sub-districts faced higher levels of vulnerability than in other sub-districts.

Table 2.4: Vulnerability index score by sub-district and main occupation group

Main occupation	Tala	Shyamnagar	Kolapara	Golachipa	Begumganj	Subarnachar	All sub-districts
Marine fishing			0.35	0.36			0.35
River fishing	0.50	0.52	0.33	0.33	0.46	0.53	0.46
Aquaculture	0.35	0.33	0.39	0.30	0.29	0.49	0.34
Farming	0.33		0.21	0.26	0.46	0.49	0.31
Livestock	0.36		0.33	0.38	0.40		0.36
Wage labourer	0.48	0.46	0.40	0.36	0.38	0.51	0.44
Other	0.31	0.42	0.38	0.28	0.37	0.51	0.38
All occupations	0.40	0.43	0.37	0.33	0.35	0.52	0.40

Note: The colour continuum ranges from green to red. Green and red, respectively, denote the lowest and the highest vulnerability levels. Some cells do not present any value due to the lower number of households falling into the intersections of those sub-districts and main occupations.

Risk indices

Table 2.5 presents households' average risk index scores for three types of hazards by sub-district. The table shows that households in different sub-districts faced different levels of risk from each hazard. The table also shows that households from the sub-districts of Patuakhali district—Golachipa and Kolapara—faced the highest risk of cyclones and storm surges, followed by Shyamnagar of Satkhira district and Subarnachar of Noakhali district. Three of these four sub-districts are directly exposed to the coastline.

Floods and waterlogging were the highest reported hazards in the household survey. The survey showed that 59% of households experienced either floods or waterlogging, or a combination of both. The majority of the households in Tala and Kolapara experienced waterlogging, whereas households in Begumganj, Golachipa, and Kolapara experienced floods. Table 2.5 shows that households in Tala, Golachipa, and Shymanagar sub-districts faced higher levels of waterlogging and flood risks than households in other sub-districts.

Among the three districts, Satkhira, particularly the Shyamnagar sub-district of Satkhira, was the most impacted by all three salinity types. Around 95%of households in Shyamnagar sub-district reported

[14] Surveyed households were asked to provide their income breakdown by different occupation categories.

having experienced at least one type of salinity. In the other two districts, sub-districts that are directly exposed to the coastline (such as Kolapara and Subarnachar) faced a higher level of salinity risk than interior sub-districts.

Table 2.5: Risk indices by sub-district

Sub-district	Cyclone and storm surge risk index	Floods and waterlogging risk index	Salinity risk index
Tala	0.11	0.54	0.22
Shyamnagar	0.49	0.44	0.51
Kolapara	0.56	0.35	0.23
Golachipa	0.55	0.52	0.12
Begumganj	0.36	0.39	0.07
Subarnachar	0.42	0.31	0.19

Risk indices by occupation group

Tables 2.6, 2.7, and 2.8 report the risk indices and present a heat map of risks by main occupation group for cyclones and storm surges, floods and waterlogging, and salinity, respectively. For cyclones and storm surges, the average risk index was the highest for marine fishers. River fishers, farmers, and fish farmers also faced a high level of risk. Many marine and river fishers from all three districts reported that they had survived cyclonic catastrophes and severe weather depressions in the sea. In recent years, fishers lost valuable fishing days during each month of the cyclone season, occurring from March to June and September to December. Marine fishers often found themselves having to shorten or abandon their fishing trips because of intense weather, which led to capital losses. Many had also lost their boats and fishing gear during episodes of violent sea weather. Most marine fishers did not have their own boats, and instead borrowed money from local moneylenders to rent boats for their fishing voyages. Shortened and abandoned fishing trips resulted in marine fishers being unable to repay moneylenders on time, while also leading them to deplete their household's assets in order to repay these high-interest loans.

Storm surges accompanied by cyclones affected fish farmers considerably because their ponds and shrimp enclosures were washed away. FGD participants shared their experience of the aftermath of the super cyclones Sidr in 2007 and Ayla in 2009, whose tidal surges destroyed their fish farms. These households not only lost their fish and shrimp stock, but the earthen dykes surrounding their ponds and enclosures were also weakened. A significant amount of expenditure had to be deployed to rebuild the aquaculture farms. Despite losing significant aquaculture investments, households dependent on aquaculture reported that they barely received any assistance from governmental and non-governmental sources because the majority of them were not considered 'poor' by these agencies' standards. Viral infections also spread in coastal fish farms caused by storm surge-induced flooding, which compromised the productivity of these fish farms.

Along with fishers and fish farmers, farmers were also heavily affected by cyclones and storm surges. Although a large proportion of farmers in Satkhira district changed occupations due to environmental change, farming remains a significant livelihood strategy for the inhabitants of Patuakhali and Noakhali districts. The cyclone seasons in Bangladesh coincide with the pre-harvest period of two major rice crops

in the year. The pre-monsoon cyclone season begins before the harvest of the *Boro* crop, while the post-monsoon cyclone season starts right after sowing the *Aman* crop. Farmers of Patuakhali and Noakhali suffered severe damages to their standing crops caused by recent cyclones and coastal tidal surges.

Table 2.6: Cyclone and storm surge risk index

Main occupation	Tala	Shyamnagar	Kolapara	Golachipa	Begumganj	Subarnachar	All sub-districts
Marine fishing			0.60	0.60			0.60
River fishing	0.11	0.49	0.56	0.60	0.47	0.47	0.50
Aquaculture	0.13	0.59	0.69	0.65	0.43	0.55	0.41
Farming	0.12		0.53	0.58	0.53	0.51	0.51
Livestock	0.11		0.59	0.63		0.47	0.35
Wage labourer	0.09	0.45	0.47	0.46	0.24	0.27	0.31
Other	0.10	0.43	0.56	0.47	0.32	0.31	0.39
All occupations	0.11	0.49	0.56	0.55	0.36	0.42	0.42

Note: The colour continuum ranges from green to red. Green and red, respectively, denote the lowest and the highest risk levels. Some cells do not present any value due to the lower number of households falling into the intersections of those sub-districts and main occupations.

Table 2.7 shows that households dependent on livestock, aquaculture, marine fishing, and farming faced a high risk of waterlogging and floods in the affected sub-districts. Large aquaculture farmers were heavily impacted by flooding and waterlogging as floodwaters inundated and broke dykes and ponds, causing farmed fish to escape their controlled habitat. Farmers lost their standing crops often due to untimely flooding and prolonged waterlogging, making it impossible to cultivate more than one crop per year, whereas they used to cultivate three rice crops per year. Households dependent on livestock rearing were affected by damaged grazing grounds caused by floods and waterlogging. As a result of these fields remaining under water for months, the food produced to feed their cattle became increasingly scarce. They also faced complications in relocating their livestock to safer places since their shelters remained unusable for months due to waterlogging. Floods and waterlogging did not have a direct impact on marine fishers' livelihoods, but their homes and assets were at high risk of these two stressors as they live close to the shoreline.

Table 2.7: Waterlogging and floods risk index

Main occupation	Tala	Shyamnagar	Kolapara	Golachipa	Begumganj	Subarnachar	All sub-districts
Marine fishing			0.61	0.41			0.58
River fishing	0.63	0.55	0.57	0.42	0.50	0.37	0.44
Aquaculture	0.65	0.55	0.73	0.48	0.46	0.46	0.56
Farming	0.71		0.58	0.40	0.55	0.37	0.50
Livestock	0.62		0.68	0.53		0.41	0.61
Wage labourer	0.63	0.49	0.60	0.37	0.38	0.32	0.49
Other	0.59	0.49	0.63	0.39	0.46	0.36	0.49
All occupations	0.63	0.52	0.62	0.41	0.45	0.36	0.50

Note: The colour continuum ranges from green to red. Green and red, respectively, denote the lowest and the highest risk levels. Some cells do not present any value due to the lower number of households falling in the intersections of those sub-districts and main occupations.

For salinity, households dependent on aquaculture faced the highest risk (Table 2.8). Although saline water can create opportunities for shrimp farming, it can also impose detrimental impacts on freshwater fish farming and reduce the availability of drinkable water for everyone. It is noteworthy that salinity degraded vast areas of cultivable land in the salinity-affected regions. The survey found that due to increasing salinity, many farmers had to switch their occupation from farming to other livelihood activities or switched to saline-tolerant farming activities. In Shyamnagar, the survey found that no households were primarily dependent on farming or livestock due to the scarcity of cultivable and grazing land. Wage labourers in this sub-district also faced high levels of risk. The FGDs found that work opportunities in the farming sector decreased significantly in Shyamnagar.

Table 2.8: Salinity risk index

Main occupation	Tala	Shyamnagar	Kolapara	Golachipa	Begumganj	Subarnachar	All sub-districts
Marine fishing	-	-	0.23	0.15	-	-	0.22
River fishing	0.13	0.36	0.16	0.10	0.04	0.13	0.15
Aquaculture	0.26	0.66	0.34	0.24	0.08	0.46	0.32
Farming	0.28	-	0.22	0.13	0.07	0.27	0.17
Livestock	0.20	-	0.20	0.15	-	0.25	0.20
Wage labourer	0.21	0.48	0.21	0.13	0.06	0.23	0.22
Other	0.21	0.50	0.24	0.14	0.07	0.29	0.25
All occupations	0.22	0.51	0.23	0.12	0.07	0.19	0.22

Note: The colour continuum ranges from green to red. Green and red, respectively, denote the lowest and the highest risk levels. Some cells do not present any value due to the lower number of households falling into the intersections of those sub-districts and main occupations.

Risk and poverty

Figure 2.2 compares the average risk indices for extreme poor, moderate poor and non-poor households. Unlike the vulnerability index, non-poor households' risk score for each type of hazard was slightly higher than extreme and moderate poor households. However, the risk scores of the three income groups do not vary much although their vulnerability scores vary significantly. While the average vulnerability score was higher for poorer households, the exposure scores took the opposite direction as for all three types of hazards, the exposure index scores were considerably higher for non-poor households than they were for extreme and moderate poor households (Figure 2.3). In other words, households' poverty is strongly correlated with households' vulnerability score but negatively correlated with exposure score. As a result, the poverty relationship with vulnerability and with exposure more or less cancel each other which explains less variation of risk scores across different income groups. The higher exposure of the non-poor households is explained by the new framing of exposure in the AR5 framework. In the previous vulnerability frameworks, all assets were assumed to contribute to the adaptive capacity of households. However, according to the AR5 conceptualization of risk, an asset that can be negatively impacted by hazards is considered a part of a household's exposure to those hazards. As a result, non-poor households' higher asset endowment contributed to their higher exposure scores since these households have more to lose due to climatic hazards and changes.

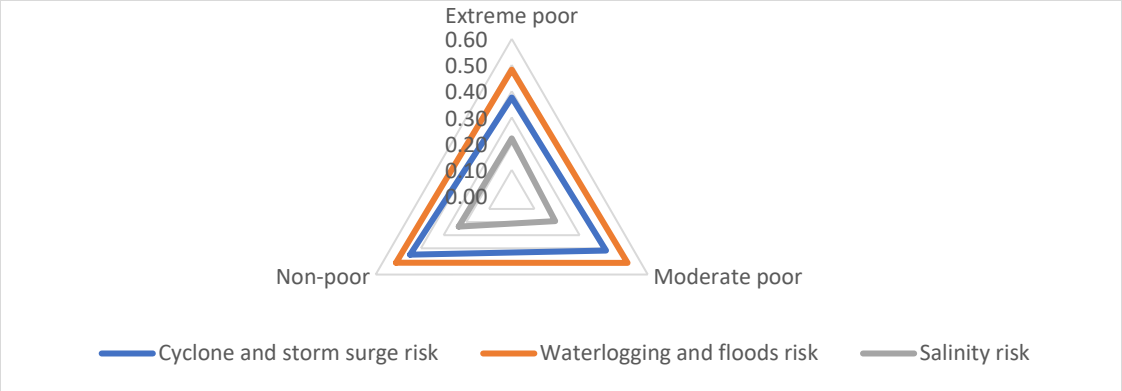


Figure 2.2: Risk indices by income level

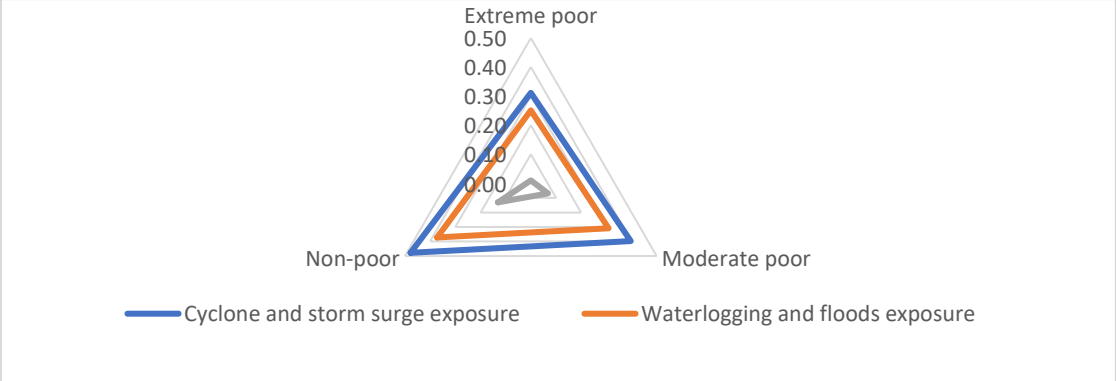


Figure 2.3: Exposure indices by income level

Implications of switching from AR4 to AR5 Framework

This section compares the AR5 risk indices constructed in this paper with the AR4 vulnerability indices. To make the comparison, this paper constructs three vulnerability indices following the AR4 framework for cyclones and storm surges, waterlogging and floods, and salinity. The AR4 vulnerability indices were constructed following AR4 definitions of components and by combining three components of the AR4 vulnerability framework: adaptive capacity, sensitivity, and exposure. Figures 2.4, 2.5, and 2.6 compare the AR4 vulnerability indices with AR5 risk indices across income groups for cyclones and storm surges, floods and waterlogging, and salinity, respectively. All three figures show that AR4 vulnerability index scores decrease as income levels increase, meaning that poorer households were more vulnerable to climatic hazards. On the other hand, AR5 risk index scores show the opposite trend, as higher income groups faced higher risks of climatic hazards. The main reason of this difference is the difference between the definitions of exposure in the two frameworks. Since richer households had higher asset holdings that could be impacted by climatic hazards, their exposure indices to hazards were much higher than poorer households.

Switching from the AR4 to AR5 framework may have significant policy implications if the results are not interpreted carefully. On one hand, the higher risk score of non-poor households can be attributed to their higher exposure according to the new definition exposure in AR5. On the other hand, poorer households also faced significant risks of climatic hazards, but mainly due to their high sensitivity and low adaptive capacity. While designing interventions for high-risk households, it is therefore important

to keep the different sources of risks in mind. For example, poorer households require immediate support to increase their adaptive capacity and reduce their sensitivity. Moreover, such interventions may not be equally meaningful for non-poor households since they already have a high adaptive capacity and low sensitivity. Non-poor households need interventions to reduce their exposure to climatic hazards and changes.

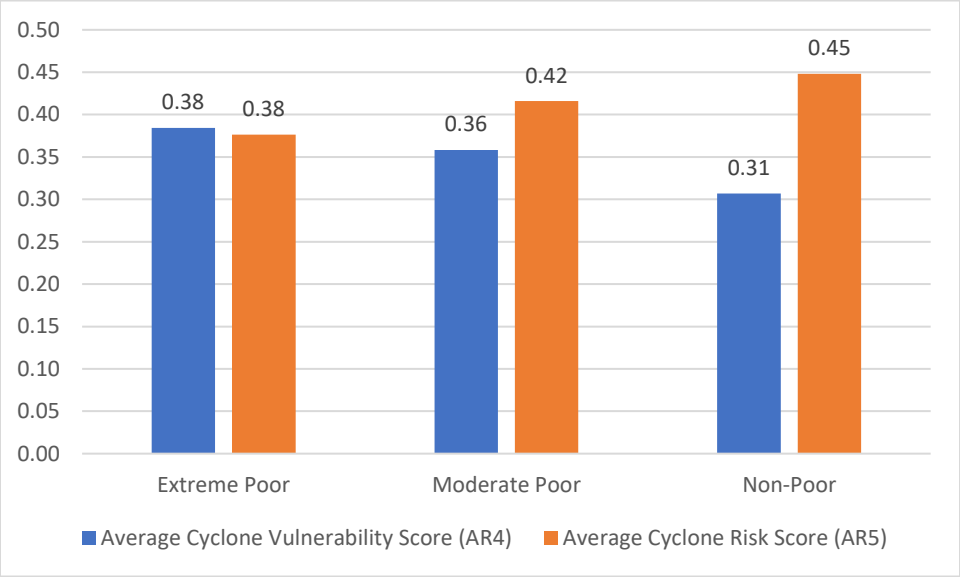


Figure 2.4: AR4 cyclone Vulnerability Index and AR5 cyclone risk index across poverty groups

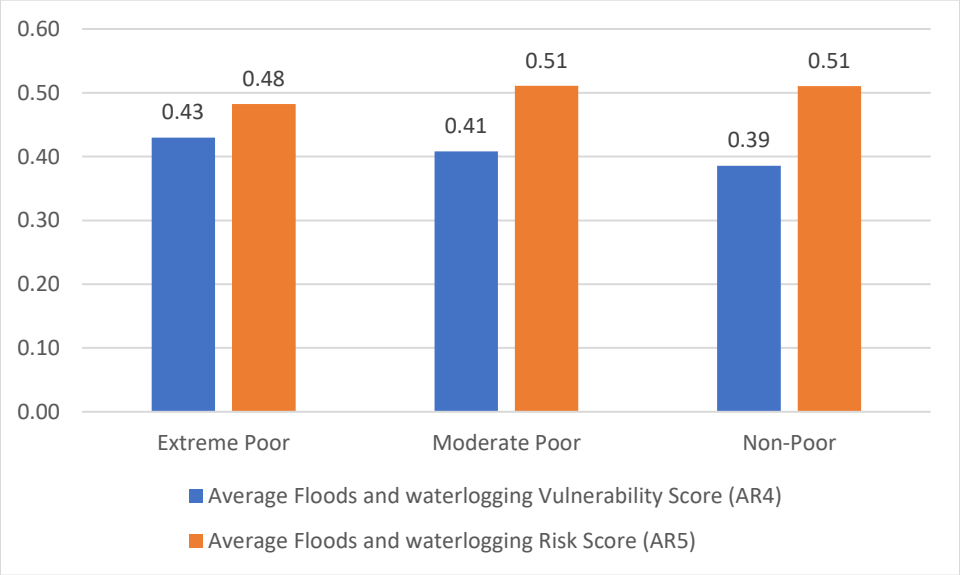


Figure 2.5: AR4 floods and waterlogging vulnerability Index and AR5 floods and waterlogging risk index across poverty groups

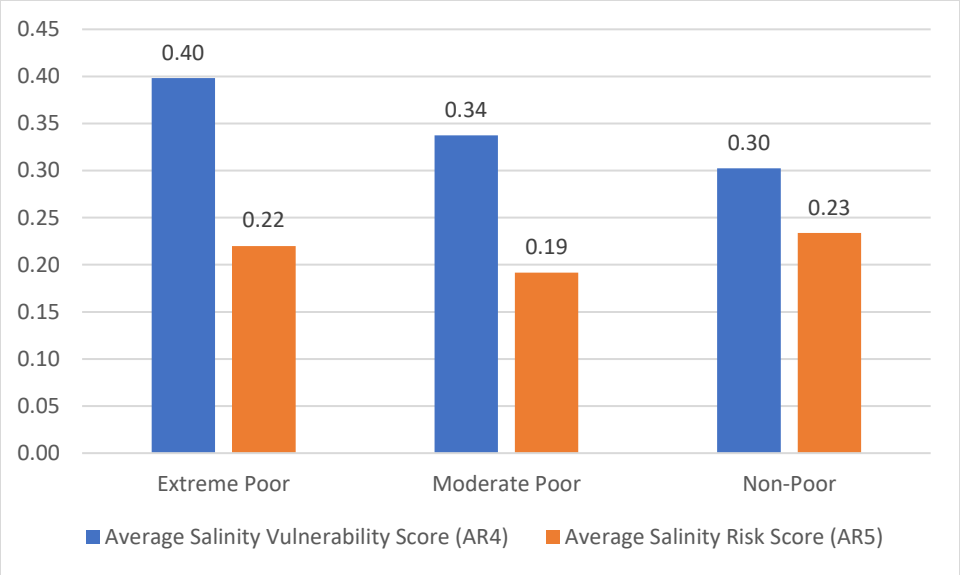


Figure 2.6: AR4 salinity vulnerability index and AR5 salinity risk index across poverty groups

Comparison between weighted and equally weighted indices

Although this paper used factor analyses to derive the weights of indicators, I carefully checked the correlation between indicators and dropped indicators in cases of high correlation (see section 2.3.4). I also developed risk indices with equal weights and compared equally weighted indices with the weighed risk indices reported in the results section. Table 2.9 shows a high degree of correlation between weighted and equally weighted indices, implying low sensitivity between weighting methods. Considering the correlation between indicators, the careful selection of indicators mitigated the risk of high sensitivity.

Table 2.9: Correlation between weighted and equally weighted risk indices

Indices	**Correlation coefficient**
Weighted and equally weighted cyclone risk index	0.79
Weighted and equally weighted waterlogging and flood risk index	0.69
Weighted and equally weighted risk index	0.76

2.5 Discussion and conclusion

Climate change and vulnerability is a major challenge in the Ganges-Brahmaputra-Meghna (GBM) delta regions of coastal Bangladesh. This paper makes a methodological contribution by constructing a household-level risk index using the AR5 framework. To date, only a handful of published papers have applied this framework to construct a risk index for geographic units (Dubois et al., 2021, Malakar et al., 2021), and none have done so at the household level. Although several studies have mentioned the risk framework of the AR5, the AR4 framework was used for index construction (see Gregor-Gaona et al., 2021). The risk and vulnerability indices constructed in this paper can serve three purposes: mapping hazard and vulnerability risks with the support of replicable indices based on IPCC's AR5 framework; providing a baseline to track risk and vulnerability in the future; and informing policy and program development with important household-level risk and vulnerability information; What follows is a discussion on how the indices developed in this study could serve these purposes.

First, one of the main contributions of this paper is developing a replicable method for applying the AR5 risk and vulnerability framework to quantitatively assess socio-ecological systems. Frequent climatic hazards coupled with human interventions into the coastal ecosystem have caused significant environmental changes in the study area. These changes have posed significant challenges to the lives and livelihoods of Bangladesh's coastal population. The indices map the risk of hazards and vulnerability across geographical locations, income groups, and main occupations. These household-level risk indices have illustrated how risk can be highly differentiated across income level, livelihoods, and micro-regions. This study found that although vulnerability was well-correlated with poverty, risks of hazards were high for high-income households as well. However, the sources of risk differed between these two groups. While the low-income households' main source of risk was their vulnerability—exemplified by a lack of adaptive capacity and a higher level of sensitivity—upper-income groups faced high risks of hazards due to their higher level of exposure, as they possessed more assets exposed to climatic hazards.

The indices also demonstrated that households depending on some livelihood activities possessed higher risks to specific hazards than other households. The level of risk for each livelihood activity varied depending on the climatic hazard. For example, households depending on marine fishing, river fishing, and farming faced a high risk of cyclones and storm surges. Risk of waterlogging and floods were higher for marine fishers, farmers, fish farmers, and livestock farmers. The risk of salinity has been increasing gradually over the last four decades. The quantitative data could not capture the risk level of salinity for farmers and livestock farmers in the most salinity-prone sub-district because households depending on these two occupations switched to other professions over time. Households depending on non-shrimp aquaculture and wage labour also faced a higher livelihood risk due to salinity. In some areas, even shrimp farmers found it difficult to continue shrimp aquaculture due to very high levels of salinity. Many of those farmers have been switching to crab farming.

The indices also showed that different parts of coastal regions did not face the same levels of risk for all types of climatic hazards. In fact, the level of risk from a particular hazard also varied across the sub-districts of the same district. Communities that were directly exposed to the shoreline faced higher levels of risk from cyclones, storm surges, and saline water intrusion, while communities living in the interior sub-districts were more prone to hazards like river flooding and waterlogging.

This paper also compares the AR5 risk indices with the AR4 vulnerability indices and highlights the possible policy implications of the differences between them, mainly due to the revised definition of exposure in AR5. It highlights the importance of decision-making based on the components of the risk indices because households in different income groups faced higher risks due for different reasons. To

make effective policies, it is important to understand the root causes of the risks faced by different types of households.

Second, the indices provide baseline metrics that can be used as a reference point to track the trajectory of risk and vulnerability of socio-ecological systems, and they can also be used to evaluate the impacts of interventions aiming to reduce risk and vulnerability. Since 2007, several vulnerability indices have been developed based on the IPCC AR4 framework. Concerns over the potential discontinuation of trajectory analyses after moving to a new framework has comprised one of the reasons for the low uptake of the AR5 framework. However, previously constructed AR4 vulnerability indices can be transformed into AR5 risk indices. Adaptive capacity and sensitivity indicators are common in both frameworks. Using previous secondary data on geographic location, one can construct a hazard index. From the asset and income data collected for adaptive capacity, the newly conceptualized exposure index can be calculated following the method used in this study. That is, keeping the adaptive capacity and sensitivity indicators unchanged, researchers can integrate hazard and exposure indices to transform a previously calculated AR4 vulnerability index into an AR5 risk index. In this way, a trend analysis of risk can be conducted.

Third, the findings of this study have implications for climate change-related intervention programs in Bangladesh's coastal districts. The components of the risk indices suggest that households with different characteristics have different types of needs for dealing with hazard risks. For example, poorer households might require immediate interventions to decrease sensitivity and improve adaptive capacity, while richer households might require interventions to protect their assets from climatic hazards. These findings can be taken into consideration for designing programs targeting coastal communities. The social protection paper (chapter 4) shows that government-run social protection programs provide the same types of support to households from different income groups. This 'one-size-fits-all' approach to social protection is unlikely to address the needs of households with different characteristics who face climatic risk and vulnerability. The chapter 4 also reports a significant targeting failure in government-run social protection programs in Bangladesh. Indices like the ones developed in this paper can be useful for identifying households eligible for these programs.

Chapter 3:
Environmental vulnerability, temporary labour migration decisions, and households' risk management: Evidence from Bangladesh's coastal fisheries-based communities

3.1 Introduction

Bangladesh's coastal zone, spanning over 19 districts and 47000 sq. km., is going through significant socio-ecological transitions due to rapid change in land use and increased climatic stressors (Lázár et al., 2015; Hoque et al., 2018; Ahmed et al., 2019; Aravindakshan et al., 2020). While headcount poverty in this zone decreased from 32.2% to 22.2% between 2010 and 2016 (BBS, 2018), more than 37 million people living in Bangladesh's coastal districts experience multiple environmental and climate-induced vulnerabilities, including cyclones, tidal surges, waterlogging, saline water intrusion, riverbank erosion, droughts, and land subsidence (IPCC, 2014;2018; Lázár et al., 2015; Huda et al., 2020). Projected sea-level rise, higher cyclone frequency, erratic rainfall, and other extreme events are likely to further intensify the vulnerability of Bangladesh's coastal population (Dasgupta et al., 2017; Brown et al., 2018; Oppenheimer, 2019; Bell et al., 2021). The Intergovernmental Panel on Climate Change (IPCC) projects a loss of 17% of land surface and 30% of food production by 2050 in Bangladesh due to rising sea levels and coastal erosion (IPCC, 2014; 2018).

In addition to environmental and climate change-induced stressors, human-induced factors also contribute to the vulnerability of the country's coastal population. Over the last five decades, coastal districts in Bangladesh experienced significant infrastructural development including the construction of embankments. While these embankments initially reduced flooding and increased agricultural productivity, these initiatives have also jeopardized coastal ecosystems by contributing to rapid sedimentation and waterlogging that has caused substantial damage to the livelihoods of many (Warner et al., 2018; Nath et al., 2019; Hanlon, 2020). The majority of the coastal districts have also undergone rapid changes in land use from rice farming to shrimp aquaculture. Despite the significant contribution of shrimp aquaculture to the local and national economy, the growth of shrimp farming in the coastal region has inequitably benefited higher-income households (Abdullah et al., 2016; Johnson et al., 2016; Hossain and Hasan, 2017). Moreover, this practice has caused negative impacts on local ecosystems (Barange et al., 2018; Hossain et al., 2018). These climatic and socio-ecological changes have affected coastal people's life and livelihood patterns by deteriorating the quality of drinking water, increasing the scarcity of grazing land, changing cropping patterns, and reducing active fishing days and fish capture. Smallholder farmers, small-scale fishers, and landless wage labourers have been among the most affected occupation groups (Hossain and Hasan, 2017).

On the other hand, new economic opportunities have been opening up elsewhere, primarily in urban areas where Bangladesh has experienced substantial job growth in both the formal and informal sectors (ADB and ILO, 2016; World Bank, 2017; Rahman et al., 2018; Gutierrez et al., 2019). Following economic liberalization reforms in the 1990s, Bangladesh's economy grew more than six percent on average over the last two decades, and remarkably reduced poverty from 48.9% in 2000 to 24.5% in 2016, lifting nearly 25 million people out of poverty (World Bank, 2019). With this sustained economic growth, the country has created more than 1.15 million new jobs per year on average since 2003. However, it is worth noting that this rise in employment has been increasingly concentrated in the country's large

urban centers, which has attracted large-scale internal migration from rural areas (Farole et al., 2017). Growing urban employment opportunities have also provided income diversification opportunities for coastal households impacted by ongoing environmental changes and increased livelihood risks (Bernzen et al., 2019). Consequently, there has been a growing understanding in academic and policy communities that migration can be a critical risk management and adaptive strategy for households facing increasing or intensifying climatic risks, with migration offering opportunities for income diversification, skill transfer, and trans-local connections (McLeman and Smit, 2006; Bardsley and Hugo, 2010; Black et al., 2011; Afifi et al., 2016; Adger et al., 2018; Maharjan et al., 2020).

Studies on internal labour migration in Bangladesh have examined several processes, including the role of labour migration in tackling seasonal hunger and poverty in the country's northern districts (Khandker et al., 2011; Bryan et al., 2014; Mobarak, 2020); the flow of female migrants to major cities to participate in the ready-made garments (RMG) sector (Afsar, 2003; Siddiqui, 2003; Sikder et al., 2014; Qayyum, 2019); as well as the general migration trends of individuals hoping to take advantage of urban labour opportunities (Ishtiaque, 2013; Lagakos et al., 2018; Hossain and Huggins, 2021). Migration research in the context of Bangladesh's southern coastal region has mainly focused on the trends and patterns of environmental and climate change-induced migration (RMRRU, 2007; Poncelet, 2010; IOM, 2010; Black et al., 2011; Displacement Solutions, 2012; Martin et al., 2013). This body of research can be divided into two broad categories. The first attempts to estimate the magnitude of immediate displacement after disasters, such as cyclones and floods (Rayhan and Grote, 2007; RMRRU, 2007; IOM, 2010; Mallick and Vogt, 2014; Islam and Shamsuddoha, 2017; Alam et al., 2020; Hossain et al., 2020). The second category estimates the number of future climate refugees based on the projected scenarios of climate change (Poncelet, 2010; Davis et al., 2018).

Although migration as a risk management or adaptation strategy has received much attention in the literature (Bardsley and Hugo, 2010; Black et al., 2011; McLeman and Smit, 2006; McLeman and Hunter, 2010), there remains a lack of empirical research on coastal communities in Bangladesh. In particular, few investigations have probed how emerging socio-ecological changes interact with traditional drivers of migration and shape households' labour migration decisions. Most studies sought to single out environmental factors as the primary cause of migration, ignoring the associated socioeconomic factors (notable exceptions include Black et al., 2011).

Drawing upon a survey of 720 households carried out in 2017 across three coastal districts in Bangladesh, this paper explores how environmental stressors and change interact with traditional socio-economic variables in determining household labour migration decisions in the context of emerging socio-ecological changes. Combining the new economics of labour migration (NELM) approach (Stark and Bloom, 1985; Stark and Lucas, 1988) with a more recent environmental migration model (Black et al., 2011), this paper presents an analytical framework to understand households' migration decision-making in the context of climatic stressors and socio-ecological change. A number of key findings emerge from this study. First, various types of environmental and climatic stressors have different effects on households' decisions regarding temporary migration. Second, alongside environmental and climatic factors, traditional socioeconomic drivers of migration also play significant roles in households' temporary migration decisions. Third, households use temporary migration as a livelihood risk management strategy, while the use of this strategy depends on other risk management mechanisms available to them.

The paper is set out as follows: Section 3.2 discusses the theories to explain labour migration decision-making and develops a conceptual framework for this study. Section 3.3 describes the empirical strategy, methods of data collection, and the variables used in this study. Section 3.4 presents the results of the econometric analysis, and Section 3.5 provides a discussion and conclusion regarding these results.

3.2 Theories to explain labour migration decision-making

Early neoclassical migration theories and environmental migration theories largely ignored each other in explaining the drivers of migration. The first generation of economic migration theories (Lewis, 1954; Ranis and Fei, 1961), developed in the realm of neo-classical economics, does not consider environmental factors as determinants of migration. These theories conceptualized migration as an income-maximizing choice of an individual, and they were built on the concept of dual economic sectors and the push and pull factors that arise from this dualism. In its original formulation, migration was seen as stemming from wage differences between regions in rural ('traditional') economies and labour shortages in urban ('modern') economies (see for example Lewis, 1954; Ranis and Fei, 1961). In an extension of this theory, Harris & Todaro (1970) argued that this 'push-pull' arose not from wage differentials, but rather from the probability of obtaining a job with *expected* wage differentials.

The first generation of environmental migration theories tended to single out environmental factors as the direct cause of large-scale displacement, without considering other socioeconomic drivers of migration. This view received momentum with Norman Myers' (1993) projection that 150 million people would become environmental refugees by 2050. Similar claims were made by others as well (Suliman, 1990; Russel et al., 1990). This view of environmental migration, known as the maximalist view, is essentially rooted in the neo-Malthusian tradition of arguments that link population growth with social and economic crises and migration (Morrissey, 2012).

Later in the 1980s, the New Economics of Labour Migration (NELM) theory (Mincer, 1978; Stark and Bloom, 1985; Stark and Lucas, 1988) extended the neoclassical approach by shifting agency from individuals to households and introducing a number of new considerations in terms of why people migrate. This extension includes the idea of risk management to complement income maximization. By positing that migration decisions are made by households, the NELM model assumes that a social contract exists between household members, whereby migrants are expected to send remittances and, in turn, can continue to access their household's pooled resources (Williams & Baláž, 2012). In its emphasis on the risk management function of migration, NELM frames migration as an alternative to insurance, particularly given the absence of functional insurance markets and formal social protection in developing countries. Although NELM does not explicitly mention uncertainties from environmental factors, it allows researchers to model labour migration through incorporating risks induced by environmental hazards and change. Newer environmental migration theories view migration as a complex process and have sought to develop frameworks that go beyond the simplistic narrative that environmental change results in migration (c.f., McLeman and Smit, 2006; Obokata et al., 2014; Warner et al., 2010). This body of literature argues that by concentrating only on environmental hazards, environmental migration frameworks underemphasize the fact that migration is already a significant phenomenon in many countries and regions. Thus, both economic and environmental migration theorists broadened their scope and created opportunities to establish linkages with each other.

Black et al. (2011) offer a particularly nuanced analysis of migration, arguing that it is difficult to distinguish environmental migrants from other types of migrants. They outline five drivers of migration: social, political, demographic, economic, and environmental, which form part of a broader conceptual framework. Notably, their proposed framework incorporates environmental change as an external

factor that directly influences migration decisions through changes to environmental drivers and indirectly through interactions with the other four drivers of migration (social, political, demographic, and economic). The Black et al. (2011) model focuses on how the broader drivers of migration, including risk management as found in the NELM model, may be interconnected with environmental change.

The conceptual framework presented by Black et al. (2011) is particularly relevant for this research since it incorporates the environment and environmental change into understanding the drivers of migration. Although Black et al. (2011) predominantly discuss these drivers in terms of permanent migration, they note that the environment can factor into decisions for short-term migration as well, specifically where environmental conditions or stressors reduce productivity (and presumably income), thus prompting the need to seek alternative income sources. In this way, Black et al. (2011) adopt a perspective based on risk management and livelihood diversification.

This paper develops an empirical model to apply Black et al.'s (2011) framework to understand the drivers of temporary labour migration from southern coastal fisheries and aquaculture-based villages in Bangladesh. In doing so, this paper complements Black et al.'s (2011) framework with two fundamental assumptions in NELM: one, that labour migration represents a household-level decision to manage livelihood risks faced by households; and two, that migrants and their households form an informal contract to support each other. In addition, this paper also intends to recognize the role that different types of climatic and environmental stressors play regarding households' labour migration decisions.

Along with environmental change, Black et al.'s (2011) framework includes environmental hazards as drivers of migration. Different types of hazards may have varying impacts on households' migration decisions (Gray and Mueller, 2012; Mbaye and Zimmermann, 2015). Environmental hazards are frequently categorized into two groups, namely rapid-onset and slow-onset events (Renaud, 2011; Randall, 2015; Koubi et al., 2016). Rapid-onset events, such as floods, cyclones, tidal surges, nor'westers, hailstorms, landslides, and river erosion, unfold almost instantly and tend to create immediate physical impacts on the affected population. On the other hand, slow-onset events develop gradually from incremental changes occurring over many years (IDMC, 2018). Examples of slow-onset events are salinity intrusion and desertification. Aside from rapid- and slow-onset events, this paper further considers recurring events. Recurring events are similar to rapid-onset disasters but occur every year, such as waterlogging during the monsoon season or flash floods. This paper distinguishes such recurring events from rapid-onset events because this type of event is likely to impact households differently than rapid-onset events (Anwar, 2008; Gunderson, 2010; Ferries et al., 2013; Baytiyeh, 2017). Perhaps unsurprisingly, households are more likely to have risk management strategies for these recurring events since they are aware of the event’s annual recurrence.

3.3 Empirical strategy

3.3.1 Data and study area

The empirical analysis of this paper is based on data from an original household survey, the Bangladesh Coastal Socio-ecological Vulnerability Survey (BCSEV)-2017, key informant interviews, and focus groups. See Section 1.5 of chapter 1 and Appendix 1 for detailed fieldwork methods.

The survey sample covered three districts from the three coastal administrative divisions of Bangladesh: Satkhira district in Khulna division; Patuakhali district in Barisal division; and Noakhali district in Chittagong division. Two sub-districts from each district were selected. See Section 1.4 of Chapter 1 for details on selection of districts.

During the survey, households were asked to identify any migrants from their households and classify them into two categories: one, migrants from the household who were no longer considered to be household members, and two, migrants who were still considered to be household members. Out of the 720 households, 126 reported that previous members of their households had migrated permanently over the last ten years. Among these 126 households, only 31 received remittances from permanent migrants on occasion, which was usually during periods of hardship. On the other hand, 157 households reported that migrants from their households were away during some or most of 2016 to work, who were still considered household members since these migrants either depended on the households or contributed significantly to the households' income and decisions. In total, 183 such individuals migrated for employment from these 157 households.

Within the surveyed households, 70% of the respondents were male with a median age of 38, while women headed only 5% of households. The average size of the households was 4.42 members. The average number of years of education among household heads was 3.5, indicating a very low level of educational attainment. However, the average number of years of schooling attained by the highest educated member of the household was 7.4, indicating a considerable increase of educational attainment in the next generation. An overwhelming majority of the surveyed households (94%) were involved in more than one livelihood activity, while 73.6% received income from more than two livelihood activities. Around three-quarters of surveyed households were engaged in at least one of three primary livelihood activities: fishing (33.3%), wage labour (23.8%), and aquaculture (17.2%). Other primary activities included self-employment (5.2%), livestock rearing (3.6%), farming (3%), and others (9.3%). Unemployment was very high in the sample, with 75% of surveyed households reporting at least one unemployed male adult in the household, while 55% also reported having at least one unemployed female member. The proportion of households with at least one unemployed male adult was higher in Patuakhali and Noakhali districts (84% and 85%, respectively) than in Satkhira district (55%). Regarding female unemployment, 82% of households in Noakhali, 67% in Satkhira, and 19% in Patukahli had at least one female member who was not involved in any economic activity.

The majority of labour migrants hailed from Satkhira district (40% of surveyed households), followed by Patuakhali (15%) and Noakhali districts (9.6%). While most individuals (64%) migrated for up to six months, 27.4% stayed away for more than nine months. The length of migration also varied depending on who was migrating from the household. Among migrant household heads, 94% migrated for less than six months, while 51% of the adult sons or daughters of the household head migrated for more than six months. This suggests that the household heads tend to migrate for short-term employment, while their adult children, who might represent surplus household labourers, look for longer-term employment elsewhere. The majority of migrants' (73.2%) expenses were paid from their respective household's common fund, while 14% of migrants paid their expenses themselves and a further 8.6% borrowed funds from external sources.

Table 3.1 reports the occupations of migrants at their points of origin and their destinations. Overall, it shows that migrants tended to be employed in sectors where they could apply the skills they gained through the occupations they held at their points of origin. For example, 38% of fishers found employment in fishing boats at their destinations, 62.5% of shrimp post-larvae collectors did the same at their destinations, 37.5% of the aquaculture workers gained employment in fish farms, and 64.3% of wage labourers were involved in wage employment in their destinations. Notably, 45 individuals who

were unemployed at their point of origin during most of the year before they migrated became employed at their destination.

The survey collected households' migration histories for the three years preceding the survey (2014, 2015, and 2016). These data indicated that the majority of migrants (94 individuals, or 57% of these surveyed households) migrated in all three years, 40 (24%) migrated in two of the three years, while only 31 migrants (19%) migrated in one of the three years.

Paper 1 (Chapter 2) constructed three respective risk indices for cyclones and storm surges, waterlogging and floods, and salinity. This paper divides these risk indices into three terciles (with 3 being the highest level of risk) and reports the percentage of households that sent temporary migrants, by tercile, for each of the risk indices (Table 3.2). Table 3.2 shows that households facing higher levels of salinity risk (i.e., a slow-onset stressor), migrated more often than those facing lower levels of salinity risk. In contrast, households that faced lower levels of cyclone and storm surge risk (i.e., a rapid-onset stressor) migrated more often than households that faced higher levels of risk from cyclone and storm surge.

Table 3.1: Occupations of migrants at their point of origin and destination

		Occupation at destination (%)										
Occupation at origin	Number of migrants	Fishing boat crew	Post-larvae collector	Aquaculture worker	Farming	Wage labour	Industrial worker	Small business	Office Job	Other	Unemployed	Total
Fishing	26	38.5	0.0	0.0	0.0	19.2	15.4	0.0	3.8	19.2	3.8	100
Post-larvae collector	16	0.0	62.5	0.0	0.0	31.3	0.0	0.0	0.0	6.3	0.0	100
Aquaculture	16	6.3	0.0	37.5	6.3	37.5	0.0	6.3	0.0	6.3	0.0	100
Farming	8	0.0	0.0	0.0	25.0	25.0	0.0	0.0	37.5	12.5	0.0	100
Wage	56	3.6	0.0	1.8	0.0	64.3	16.1	0.0	3.6	3.6	7.1	100
Small business	6	0.0	0.0	0.0	16.7	16.7	0.0	16.7	16.7	33.3	0.0	
Other	10	0.0	0.0	0.0	0.0	20.0	10.0	0.0	10.0	40.0	20.0	100
Unemployed	45	6.7	0.0	0.0	0.0	28.9	28.9	2.2	17.8	15.6	0.0	100
Total	183	8.8	5.5	3.8	2.2	38.3	14.8	1.6	8.7	12.6	3.8	100

Table 3.2: Migration and risk

	% of households who sent temporary migrants		
Risk tercile	Cyclone and storm surge risk	Waterlogging and floods risk	Salinity risk
Tercile 1	30.4	29.5	9.7
Tercile 2	20.7	15.2	22.8
Tercile 3	14.0	20.3	32.6

3.3.2. Logistic models to understand the drivers of migration

The paper applies binary logistic regression modelling to capture how environmental risks interact with social, political, demographic, economic, and environmental drivers in determining households' labour migration decisions. Following NELM (see Section 3.2 above), the decision to migrate is conceptualized as a household decision, not a decision made by an individual. The logistic regression model can be expressed as:

$$\log\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \mathrm{x}_i.\beta \qquad (1)$$

where

P_i is the probability of household *i* having a member migrating for work temporarily;

β_0 is the intercept;

β is a vector of parameters for the effects of the independent variables;

x_i is a vector of independent variables, which include social, political, demographic, economic, and environmental drivers of migration, along with environmental change and risk management variables.

Note that the models were estimated at the household level.

This paper draws on three logistic regression models that offer progressively more comprehensive explanations for household migration decisions. The first model includes only environmental drivers and environmental change variables. The second model adds demographic, social, economic, and political drivers to the first model. This second model is an empirical application of Black et al. (2011)'s environmental migration framework. The third model adds a number of risk management variables to the second model and thus, combines the NELM framework with Black et al. (2011)'s framework. By progressively adding variables to these models, the incremental importance of adding Black et al.'s (2011) and NELM frameworks to environmental variables becomes clear.

3.4. Operationalization of variables

Dependent Variable

For the empirical models, the dependent variable is a dummy variable that identifies households who reported at least one temporary labour migrant within the twelve months preceding the survey, i.e., in the year of 2016. Since this paper focuses on understanding migration as a livelihood strategy, work-based reasons for migration were necessary to distinguish migration as a livelihood strategy from its other motivations, such as study, travel, family reasons, and long-term medical treatment. Note that

following the NELM theory, this paper conceptualizes labour migration as the result of a household decision. This paper recognizes, however, that some of the literature (for example, Abreu, 2012b; Hagen-Zanker, 2008) points out that decision-making in neoclassical models is individual-based and that one of the innovations of the NELM is that households are seen as the decision-making unit.

Environmental change and environmental drivers

All three regression models include two main groups of independent variables: environmental change and environmental drivers (Black et al., 2011). Environmental change variables include two dummy variables: fish catch decline and perceptions of rainfall pattern change. The dummy variables for the fish catch decline and rainfall change take the value of one (1) if a household reported fish stock decline and perceived a change in rainfall patterns, respectively. Both variables are expected to be positively associated with a household's temporary labour migration decisions.

The environmental drivers group of independent variables includes the time needed to access safe drinking water and dummy variables that reflect households' experiences regarding different types of disasters. The time required for accessing drinking water indicates water scarcity and level of difficulty for securing drinkable water. It is also an indicator of the overall living conditions in the study area. The model also includes dummy variables that indicate the types of shocks experienced by the households within the three years prior to the survey, i.e.; between 2014 and 2016. Sample households are divided into five groups: (1) households that experienced only rapid shocks; (2) households that experienced only recurring shocks; (3) households that experienced only slow-onset disasters[15]; (4) households that experienced multiple types of shocks; and (5) households that experienced no environmental shocks. Keeping the dummy variable for households that experienced no shocks as the reference, the model includes four dummy variables: rapid, recurring, slow-onset, and multiple shocks. Households' experiences of environmental shocks are expected to be positively associated with a household's temporary labour migration decisions.

The paper also presents the results of alternative regression models (see Appendix table 3.4 in Appendix 3), replacing the dummy variables indicating types of shocks between 2014 and 2016 with dummy variables that indicate the types of shocks experienced by the households between 2013 and 2015, i.e., between the fourth and the second year preceding the survey. These alternative models are presented because one of the years of experiencing the shock (2016) in the original model overlaps with the migration year of the dependent variable. For households that experienced shocks only in 2016, migrants from those households could have migrated before experiencing the shock in the same year. This is not a problem for slow onset and recurring disaster because slow onset disaster has been happening over the years (e.g., salinity), and recurring disasters occurs almost every year (e.g., Waterlogging). However, if a household is impacted by rapid disaster in 2016 only, the causal effect of that shock on migration is difficult to establish because the household might not have experienced any rapid shock in the previous years. To tackle this problem, alternative models were run. That said, the data shows that the overwhelming majority (75%) of the households that experienced a rapid shock in 2016 also experienced another rapid shock (same or different rapid shock) in the previous years.

Demographic, social, economic, and political drivers

Both Model 2 and Model 3 include demographic, social, economic, and political drivers as independent variables. The demographic drivers represent how households are structured, which may play an important role in migration decisions. In particular, demographic variables in the regression model

[15] slow-onset disasters can also qualify as environmental change indicators.

include: the age and the squared age of the household head; the sex of the household head; and the dependency ratio measured as the ratio of the sum of the number of children (0-14 years old) and older persons (65 years or over) to the working-age population (15-64 years old) of the household. Demographic variables are expected to have varying effects on a household's temporary labour migration decisions. A household head's age and squared age are likely to have a positive effect on migration decisions, since households with older heads are expected to have more adult children who can migrate. The dependency ratio is expected to be negatively associated with a household's labour migration decisions, as children and elderly people tend to be unable to migrate and might require caregiving from other family members, which would constrain their migration options. To see the effect of demographic shocks on migration decisions, the model includes a dummy variable for households who experienced any demographic shock in the past five years. Demographic shocks include death, disability, and chronic illness of an earning member.

The models include economic drivers as explanatory variables, namely: human capital and dummies for household land ownership. A household's human capital has the potential to play an important role in migration decisions, although the relationship between human capital and migration may not be linear, as both high and low levels of human capital can spur migration. On one hand, households with higher human capital are more likely to take advantage of external labour markets (Chen and Liu, 2016; Betcherman et al., 2019). On the other hand, households with lower human capital may need to supplement their low income by exploring opportunities elsewhere. The models also include the number of years of education attained by the highest educated member of a household. As this study concentrates on temporary labour migration only, and as the descriptive statistics show that most migrants gain employment in destinations that require very low skill levels, a negative association between education level and labour migration is expected. For land ownership, households are categorized into four groups: (1) functionally landless and marginal landowners (up to 1 acre); (2) small landowners (1.01 acres to 2.5 acres); and (3) medium and large landowners (2.5 acres and above). Keeping functionally landless and marginal landowners as the reference, the model includes dummy variables for these other three land ownership categories.

Political drivers, including insecurity of life and government policies, may impact migration decisions (Moore and Shellman, 2004; Davenport et al., 2003). The regression model includes two variables related to human security: a dummy variable for conflict over water and a dummy variable for households that reported feeling insecure due to sea and river pirates. These variables are expected to positively impact a household's labour migration decisions. The model also includes one policy variable: a dummy variable for households affected by a two-month fishing ban during the *hilsha* breeding season. Notably, while almost half of surveyed households reported income from fishing activities, not all were impacted by the temporary fishing ban, since these bans were specific to certain species. For example, *hilsha* fishers were the main group of fishers impacted by the fishing ban.

Social connections and the presence of histories and cultures of migration can be critical social drivers in shaping a household's migration decisions (Massey, 1990; Kandel and Massey, 2002; Black et al., 2011). The regression model includes three dummy variables representing social drivers: (1) whether the household has previous migration history; (2) whether the household members are religious minorities; and (3) whether at least one of the members of the household is a member of community-based groups or cooperatives. The migration history of the household is captured by dummy variables for households that reported at least one migrant from the household who migrated for work, permanently or temporarily, in the past. The previous migration experience of a household is expected to encourage future migration because of their increased likelihood to benefit from established networks in the destination. This paper considers the religious minority dummy variable as a network variable because it

is also a proxy for a household's social network. Since 91% of the population of Bangladesh belongs to a religious majority group, Muslim (BBS,2022), it is likely that a household belonging to a religious minority has fewer networks outside their community, as compared with a household of majority group, and are thus less likely to migrate. Group membership is expected to be positively associated with labour migration since households that have members in such groups are more likely to receive information regarding livelihood strategies and opportunities elsewhere.

Model 2 also includes dummy variables for the main occupations, which could be considered as proxies for a household's dependence on ecosystem services, their tied-up capital in specific natural resource-based livelihood activities, and their livelihood preferences. The occupations comprise fishing, aquaculture, farming, livestock rearing, wage work, office job, self-employment, among others. Surveyed households were asked to provide their income breakdown based on these categories. This paper determined the primary livelihood activity of a household according to the activity that accounted for the largest share of a household's income in the year preceding the survey.

Risk management variables

Model 3 adds four risk management dummy variables to Model 2:

The first dummy variable represents whether households had received support from social protection programs run by the government. In the study districts, households reported receiving social protection support from a number of such programs, including vulnerable group feeding (VGF), vulnerable group development (VGD), test relief (TR), food for work (FFW), and work for money (WFM)[16]. Social protection programs are likely to enhance households' risk managing abilities by ensuring more predictable sources of income during hardship (Holzmann and Jorgensen, 1999; Andersson et al., 2011; Weldegebriel and Prowse, 2013). Therefore, a household's inclusion in these programs is likely to negatively impact a household's temporary labour migration decisions.[17] To capture how access to social protection interacts with different types of shocks, the models include three interaction variables: rapid-onset disaster*access to social protection; recurring disaster*access to social protection; and slow-onset disaster*social protection.

The second dummy variable represents whether households accessed microfinance. Access to microfinance is likely to protect households against risks by promoting productive employment (Cohen and Sebstad, 1999). Therefore, microfinance can serve as an alternative to migration for households attempting to manage risks.

The third dummy variable represents whether households can access informal credit, cash, or in-kind support from relatives or friends during hardship. In the absence of formal insurance and the inability to access social protection, informal risk management channels may play an important role for households coping with adverse shocks (Cohen and Sebstad, 1999; Vo, 2018), and prevent migration.

The fourth dummy variable represents whether households received support from local, national, or international non-government organizations (NGOs) operating in the study area. Many NGOs were active in the study area to support households in various ways, such as transferring livelihood supporting assets and adaptive technologies like rainwater harvesters, promoting saline-tolerant agriculture, transferring assets through the distribution of livestock, and constructing flood-proof

[16] Chapter 4 provides more detailed account of social protection programs in the study districts.

[17] This model could suffer from endogeneity due to inclusion of this variable, since households who are included in social protection programs are more likely have lower incomes. However, the descriptive statistics show that social protection recipients are distributed across all income groups (See the Appendix of Paper 3 in this thesis).

houses. This dummy variable is expected to be negatively associated with migration. Since the NGOS also primarily target poor households, this variable is likely to be correlated with dummy variable representing households who received support from social protection programs run by the government. However, the correlation coefficient for these two variables is very low (0.08).

3.5 Results

Table 3.3 presents the results of the three logistic regression models. The descriptive statistics for the variables included in the regression are shown in Appendix Table A 3.2.

Environmental drivers

Coefficient estimates suggest that the dummy variable for perceived rainfall change is positive and significant in all three models, implying that a household's perception of climatic change plays an important role in temporary labour migration decisions. The variable reflecting the time required to access drinkable water—as an indicator of overall livability—also yields a positive and significant coefficient at the 1% level in all three models, indicating that migration becomes more likely when households face a scarcity of drinking water. The dummy variable for perceived fish catch decline is not significant in any of the models.

Among the environmental shock variables, the dummy variables for recurring disasters are positive and significant in all three models, while the dummy variables for slow-onset disasters and multiple types of disasters are positive and significant in Model 1 and Model 3 only. The dummy variable for rapid-onset disasters is not significant in any of the models.

Significances of coefficient estimates remain unchanged in the alternative models (Appendix table 3.4) with different shock years (2013 to 2015).

Demographic, social, economic, and political drivers

Among the demographic drivers, the age of the household head is positive and significant in Model 3, implying that the age of the household head increases the likelihood of temporary labour migration among members of the household. However, the squared age of the household head is not significant in any model, meaning that the effect of age on labour migration decisions does not diminish. The dummy variables representing other demographic drivers, namely those for female-headed households and a household's dependency ratio, are not significant in any of the models.

Both Model 2 and Model 3 confirm that social drivers are significant determinants of a household's temporary labour migration decisions. On one hand, previous migration experience and membership in community-based groups make households more likely to send labour migrants. On the other hand, members of religious minority households are less likely to migrate for work.

Dummy variables representing the highest level of education are not significant in any of the models. The dummy variables for land ownership confirm that households with higher land ownership are less likely to send out labour migrants.

Model 2 and Model 3 show that political drivers also play a significant role in households' temporary labour migration decisions. The dummy variables for two political drivers—whether households were affected by piracy and whether households were affected by conflicts over land and water—are positive and significant in both Model 2 and Model 3. However, the dummy variable for the third political driver,

representing whether households were affected by the two-month ban on fishing, is not significant in any of the models.

Among the primary occupation dummies, only the dummy representing wage labourers yields positive and significant coefficients, implying that households who are primarily dependent on wage labour income are more likely to send migrants for work.

Risk management strategy variables

Risk management strategy variables are only included in Model 3. While the dummy variable for households' access to social protection programs is not significant, the interaction variables showing the association between access to social protection programs and all three types of disasters are negative and significant, indicating that households who experienced different types of disasters and received social protection assistance are less likely to send out labour migrants. However, the interaction dummy variable representing the fishing ban and inclusion into social protection programs is not significant.

Among the other alternative risk management variables, the dummy variable for households receiving assistance from NGOs is negative and significant, implying that households that received support from NGOs are less likely to migrate. Dummy variables for access to microfinance and access to informal assistance from family and friends are not significant.

Importantly, the explanatory power of the models increased from Model 1 through Model 3, with the Pseudo R-Square[18] jumping from 0.13 in Model 1 to 0.34 and 0.39 in Models 2 and 3, respectively. The increased explanatory power in the successive models justifies the inclusion of other traditional drivers and risk management strategy variables in addition to environmental drivers and environmental change variables.

[18] While pseudo R-squares cannot be interpreted independently or compared across datasets, they are valid and can be useful in evaluating multiple models that predict the same outcome on the same dataset (Jeremy and Long, 2006).

Table 3.3: Determinants of migration: Results of the logistic regression

	Model 1	Model 2	Model 3
Household perceived change to rainfall patterns	0.511**	0.495*	0.628**
	(0.218)	(0.277)	(0.286)
Household perceived fish catch decline	-0.0755	0.495	0.407
	(0.288)	(0.361)	(0.406)
Household affected by rapid-onset disasters only	-0.598	-0.703	0.277
	(0.422)	(0.487)	(0.620)
Household affected by recurring disasters only	1.632***	1.320**	2.446***
	(0.309)	(0.563)	(0.768)
Household affected by slow-onset disasters only	1.810***	0.749	2.587***
	(0.320)	(0.679)	(0.988)
Household affected by multiple types of disasters	0.792**	0.400	2.287***
	(0.328)	(0.526)	(0.764)
Time in minutes required to obtain drinkable water	0.0391***	0.0385***	0.0471***
	(0.0129)	(0.0145)	(0.0144)
Household affected by demographic shocks		0.127	0.207
		(0.325)	(0.339)
Household head's age in years		0.105	0.120*
		(0.0747)	(0.0672)
Household head's age squared		-0.000848	-0.000958
		(0.000821)	(0.000725)
Female household head		0.0110	0.0755
		(0.596)	(0.702)
Dependency ratio		0.145	0.109
		(0.154)	(0.157)
Household's previous experience of migration		1.994***	2.315***
		(0.258)	(0.299)
Religious minority household		-1.065***	-1.204***
		(0.310)	(0.318)
Group membership		0.634**	0.831***
		(0.296)	(0.304)
Household affected by economic shocks		-0.368	-0.304
		(0.330)	(0.339)
Years of education of highest educated individual		0.0471	0.0359
		(0.0415)	(0.0408)
Household's land ownership: marginal		-0.180	-0.520
		(0.470)	(0.488)
Household's land ownership: small		-0.178	-0.600
		(0.458)	(0.467)
Household's land ownership: medium and large		-1.100	-2.017**
		(0.775)	(0.893)
Household had dispute/conflict over land or water		0.479	0.676*
		(0.335)	(0.375)
Household affected by fishing ban		-0.341	-0.428
		(0.409)	(0.673)
Household affected by pirates		1.617***	1.638***

	Model 1	Model 2	Model 3
		(0.475)	(0.479)
Household received social protection program benefits			0.638
			(0.832)
Interaction variable: rapid-onset disaster and social protection			-2.455**
			(1.032)
Interaction variable: recurring disaster and social protection			-1.613*
			(0.962)
Interaction variable: slow-onset disaster and social protection			-1.670*
			(0.979)
Interaction variable: multiple shocks and social protection			-3.044***
			(0.909)
Interaction variable: fishing ban and social protection			0.437
			(0.879)
Household had access to microfinance			-0.357
			(0.357)
Household had access to informal support			-0.250
			(0.296)
Households received support from NGOs			-0.840*
			(0.464)
Primary occupation: aquaculture		-0.126	-0.103
		(0.410)	(0.435)
Primary occupation: farming		0.783	0.764
		(0.666)	(0.692)
Primary occupation: small business		0.184	0.191
		(0.675)	(0.646)
Primary occupation: livestock rearing		-0.497	-0.441
		(0.549)	(0.583)
Primary occupation: wage labour		0.800**	0.759**
		(0.342)	(0.367)
Primary occupation: formal employment		0.325	0.369
		(0.705)	(0.698)
Primary occupation: other		-0.548	-0.645
		(0.627)	(0.660)
District dummy: Satkhira		0.209	-0.423
		(0.590)	(0.654)
District dummy: Patuakhali		0.0478	0.383
		(0.499)	(0.656)
Constant	-2.698***	-6.763***	-7.528***
	(0.311)	(1.605)	(1.568)
Observations	720	719	719
Pseudo R2	0.1381	0.3396	0.3826
Prob > chi2	0.000	0.000	0.000

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

3.6. Discussion and conclusion

This paper focuses on the role that temporary labour migration plays as a risk management strategy for coastal households impacted by different types of environmental stressors, while also illustrating how environmental factors interact with other socio-economic drivers of migration and shape households'

labour migration decisions. Traditional fisheries-, aquaculture-, and farming-based livelihoods in coastal Bangladesh have been threatened by frequent, rapid, and recurring disasters and slow-onset environmental changes. Simultaneously, new employment opportunities have been opening up elsewhere. Until recently, permanent migration and temporary displacement from rural coastal regions due to environmental stressors and climate change comprised a large proportion of the migration research concerning Bangladesh's vulnerable coastal communities. However, households have also responded to these forces of change by using temporary labour migration as a livelihood diversification or risk management strategy to cope or adapt to the environmental changes they face. This paper contributes to the understanding of the determinants of temporary labour migration by applying an analytical framework that combines NELM theory and Black et al.'s (2011) framework.

To identify the determinants of temporary labour migration, this paper tested three models that consider progressively wider sets of possible factors. While the first model included only environmental stressors and other environmental variables, the second and third models added variables drawn from Black et al.'s (2011) framework and NELM theory respectively. The first model illustrates that different types of environmental stressors (i.e., rapid, recurring, and slow-onset stressors) had varying effects on households' temporary labour migration decisions. This finding also holds in the more extended models and help validate the main propositions of both Black et al. (2011) and NELM's frameworks. The results of Model 2 support Black et al.'s (2011) proposition that the relationship between environmental change, stressors, and migration is not straightforward, but is rather influenced by various other traditional drivers of migration, such as social, political, and economic drivers that play an important role in shaping households' migration decisions. Model 3 demonstrates that households' migration decisions were also dependent on the risk management strategies available to households.

A key finding of this study is that different environmental stressors did not impact households' migration decisions in the same way. The three regression models illustrate that households affected by recurring stressors and long-term environmental changes were more likely to send temporary labour migrants; in contrast, rapid-onset disasters did not have a significant impact on households' temporary labour migration decisions. The predictable nature of recurring shocks and observed long-term environmental changes afforded households the opportunity to plan, and the affected households could predict the need for risk management strategies. Households, particularly from Satkhira district, reported that the recurrence of disasters made them think about livelihood strategies to mitigate the income effects of such disasters. In Satkhira, households experienced prolonged annual waterlogging due to malfunctioning embankments and raised riverbeds during the monsoon. Most of the waterlogging-affected households had to take shelter in raised school buildings for at least three months, without the availability of local work opportunities during this period. Predictions on the timing of recurring disasters encouraged many households to send migrants elsewhere and find employment for a particular period. For slow-onset events, such as salinity, households tended to adapt to the changes locally and diversify their livelihood portfolios. Labour migration was essentially a component of the livelihood diversification efforts of these households.

Rapid-onset disasters did not have a significant impact on households' temporary labour migration decisions—a result that contradicts a number of other studies (Poncelet et al., 2010; Walter, 2015; Koubi et al., 2016). For example, Koubi et al. (2016) found that sudden and short-term extreme weather events such as floods or typhoons significantly increased the likelihood of migration. This difference in findings is linked to how migration is defined. In the wider literature, voluntary migration and

involuntary displacement have often been expressed under the umbrella term of 'migration' (Foresight, 2011). Temporary displacement immediately after rapid-onset disasters was involuntary and very common in the study area, but people often returned to their origin within a short period of time, typically within one to four weeks. In this paper, involuntary temporary displacement was not conceptualized as migration; rather, the focus of this paper is temporary labour migration, which is considered as a household-level strategy to manage livelihood risks. While rapid-onset disasters like cyclones and storm surges often leave affected communities unlivable immediately and induce short-term involuntary displacement, temporary labour migration requires planning, networking, and the use of household resources to finance migration expenses. As households observed, relief activities implemented by the government and international and local NGOs after a rapid-onset disaster encouraged them to return immediately to take advantage of funds and support for rebuilding their damaged residences and other assets. Increased food distribution in these affected communities further helped households cope with food insecurity after rapid-onset disasters.

The results illustrate that environmental condition variables, such as households' perceived change to weather patterns (rainfall) and the scarcity of drinkable water, were also significant determinants of temporary labour migration decisions. Previous studies have found that the scarcity of drinkable water represents an important determinant of permanent migration (Black et al., 2011; Kabir et al., 2017). While acknowledging its relation to permanent migration, this measure also reflects the poor environmental conditions of a locality that could trigger temporary migration as well. Among the study districts, Satkhira has experienced severe scarcities of drinkable water due to high levels of salinity and arsenic contamination. Households reported that female members spend a significant amount of time on labour-intensive ways of collecting drinkable water for their households. Regression results also show that households facing challenges in collecting drinkable water were more likely to send temporarily migrate for labour.

Alongside environmental drivers and environmental change variables, traditional drivers of migration also had a significant effect on households' temporary labour migration decisions. The regression results indicate that although households' demographic status variables did not have a significant effect, social, economic, and political drivers significantly impacted households' temporary labour migration decisions. For example, the regression models highlight that households with strong social networks had a higher likelihood of sending temporary labour migrants.

Piracy in the sea and mangroves were prevalent in the study area during this research period (Pandey, 2015; Kibria et al., 2018). The results show that households who were affected by piracy in the sea or mangroves were more likely to send temporary migrants for work. While piracy in the mangroves decreased significantly as the Government of Bangladesh offered amnesty to the pirates in 2018,piracy in the sea is still affecting the lives and livelihoods of fishers (Rahman, 2021). Piracy at sea poses a major threat for fishing households: interviewees spoke of being abducted, paying a very high ransom for their freedom, and losing boats and fishing gear. Piracy created significant fear as well: households spoke of those who were killed by pirates when failing to find the cash for ransom payments. Households who experienced abduction were hesitant to continue their work as fishers, whether in the sea or inside mangrove estuaries, expressing their intent to shift livelihood strategies or look for work in other places.

The government policy of a two-month fishing ban during the *hilsha* breeding season had an impact on the employment of the fishers. However, the regression results show that this policy did not have a

significant effect on households' temporary labour migration decisions. While unemployment is likely to work as a push factor for migration, the government's policy to support affected households through a special food security program might have helped these households manage the impacts of unemployment. During the FGDs, fishers also reported that their lack of skills beyond fishing further influenced their decisions to not migrate during the fishing ban period.

The results of this study support NELM's proposition that temporary labour migration constitutes a risk management strategy for households (Stark and Bloom, 1985; Stark and Lucas, 1988). The descriptive statistics show that migrants mainly depended on their households' resources to bear the expenses of migration, while most of the temporary migrants also sent remittances to their households. These findings clearly justify the NELM framework's assumptions that migration is a household's decision, rather than an individual's, and that an informal contract exists between the migrants and the household to support each other. The regression results indicate that households who foresaw risks from recurring and slow-onset disasters were more prone to migrate, while households who had access to resources to manage risks, such as government social protection and NGO support, were less likely to temporarily migrate for work. This finding highlights the role that social protection plays in managing environmental risks faced by coastal households. Another paper in this thesis (Paper 3: Chapter 4) also found that social protection can adeptly manage environmental risks, as households receiving social protection were less likely to adopt adverse adaptive behaviours, such as reducing consumption and selling assets, following environmental shock events.

One limitation of this study is that it could not capture the impact of macro-level political and economic trends on households' temporary labour migration decisions, as suggested in Black et al.'s (2011) framework. Another limitation of this study is it did not shed light on the impact of temporary labour migration on households' risk management abilities, namely how well migrant-sending households could manage livelihood risks induced by different types of shocks. Longitudinal data would be required for such nuanced analyses in order to draw causal linkages between labour migration and adaptive capacity or resilience.

In sum, the findings of this paper confirm that complex relationships exist between environmental change and stressors, other drivers of migration, households' risk management strategies, and decisions regarding temporary labour migration. A greater number of household members migrated annually for work: such migration can be considered temporary in response to recurring disasters, and as part of a multi-local livelihood portfolio (Rigg, 2006; Peth and Bertel, 2014; Sakadopolrak et al., 2016; Tappe and Nguyen, 2019).

Chapter 4:
Do Bangladesh's social protection programs promote adaptive capacity in fisheries-based coastal communities?[19]

4.1 Introduction

Social protection programs have been used by governments, donors, and non-governmental organizations to reduce vulnerability throughout the Global South since the 1990s (Barrientos, 2011; Merrien, 2013). A central assumption of social protection thinking is that environmental, economic, and other stressors can deplete an affected households' skills, assets, and income, leading to a failure of meeting their basic needs and/or to an adoption of negative coping strategies. This can include reducing food consumption, selling off assets, or taking children out of school (FAO, 2016; Bowen et al., 2020). Furthermore, social protection can be 'productive' by supporting households to make investments and to diversify in ways that will increase future livelihoods (Solórzano, 2016; OECD, 2019). The general effectiveness of social protection programs in reducing economic vulnerability is known (Holzmann, 2009; OECD, 2018). However, as greater concern over the vulnerabilities induced by environmental hazards and climate change emerges, the idea of using social protection to address household vulnerability to climate and environmental change has gained momentum among researchers and policy-makers (Davies et al., 2008; Béné, 2011; Charles et al., 2019).

Social protection frameworks are forever evolving (Holzmann and Jørgensen, 2001; Sabates-Wheeler and Devereux,2008; Davies et al., 2008). Building on past frameworks, the adaptive social protection (ASP) framework establishes a core conceptual link between social protection, disaster risk reduction, and climate change adaptation literatures (Davies et al., 2009; Solórzano, 2016; Béné et al., 2018; Bowen et al., 2020). These three research and policy communities share common goals including vulnerability reduction and increasing resilience in the context of poverty, disasters, or long-term changes in climate conditions. The thinking behind the ASP framework is that well-designed social protection systems can effectively complement agricultural and rural policies in enhancing local people's adaptive capacity to respond to the effects of actual or anticipated climatic stimuli, as well as to moderate negative consequences or exploit beneficial opportunities (Davies et al., 2009).

Bangladesh has been at the forefront of recognizing the potential role of social protection for addressing the climate-related vulnerabilities facing households. Although a number of studies (Mannan and Ahmed, 2012; Mujeri et al., 2013; GoB, 2018; World Bank and KWPF, 2019) found some positive impacts of social protection programs in tackling poverty and ensuring food security in Bangladesh, a gap remains regarding our understanding of the effectiveness of existing social protection programs in addressing emerging risks and vulnerabilities induced by environmental and climatic factors and building adaptive capacity. Moreover, no studies have paid attention to how social protection policies unfold among coastal communities in Bangladesh. The Intergovernmental Panel on Climate Change (IPCC, 2007; 2014) and the Climate Risk Index -1999-2018 (Germanwatch, 2019) consider Bangladesh to be one of the most vulnerable countries globally to climate change and natural disasters. Bangladesh's low-lying coastal region is particularly vulnerable with exposure to frequent, intense cyclones and other

[19] This chapter is co-authored with my supervisors: Professor Melissa Marschke and Professor Gordon Betcherman.

hydro-meteorological coastal disasters, including tidal surges, monsoonal flooding, rising temperatures, saline water intrusion, and projected sea-level rise (IPCC, 2007; 2014; Rakib et al., 2019).

In this study, we apply the adaptive social protection framework to explore the extent to which social protection programs in the coastal districts of Bangladesh are responsive to environmental and climatic changes facing coastal dwellers. We particularly focus on whether such programs help households build adaptive capacity. The study draws primarily on a household survey in three coastal districts to quantitatively assess how well food security, cash transfer, and development sector programs help households manage the social risks of environmental and climate-related shocks and disasters. Drawing on the ASP framework, the analysis considers four important features of these programs in terms of how well they perform: scalability, response swiftness, targeting, and fostering adaptive capacity among affected households.

A number of key findings emerged from our analysis of programs implemented in the coastal districts we studied. Food security programs were often not scaled up when needed. Furthermore, in most cases, households did not receive social protection benefits quickly after climatic and livelihood shocks. Targeting was often not efficient in the sense that a large share of households benefiting from social protection programs were non-poor and did not meet the eligibility criteria for these programs. However, our analysis shows that food security programs, in particular, did foster adaptive capacity in the event of shocks. Poor households benefiting from these programs were less likely to use adverse coping strategies such as reducing food consumption and selling assets, and they were more likely to adopt productive livelihood strategies including production innovations and diversification. These findings provide new empirical evidence on ASP in an understudied context. These results are also of interest to policy-makers working to refine social protection programming, especially in environmentally challenging settings.

The paper begins with a brief overview of social protection programs in Bangladesh, particularly those focusing on food security, before turning to the analytical framework and design. Here we unpack how we apply the ASP framework. We then highlight our main results, before turning to the analysis and conclusion.

4.2 Social protection programs in Bangladesh

Sustained economic growth over the past two decades has helped Bangladesh make remarkable progress in reducing poverty. Other development indicators, such as life expectancy and literacy rate, have also significantly improved (GoB, 2019; World Bank, 2019). Even so, Bangladesh's vulnerability to climate change is significant and has the potential to reverse many of these gains (UNICEF, 2019). Although social protection programs have a long history in Bangladesh, beginning with food security programs introduced in the 1970s (Rahman et al., 2012; Rahman et al., 2014), earlier programs did not focus on risk reduction for natural disasters.

As an example, a number of conditional and non-conditional cash transfer programs in the 1990s were designed to address the vulnerabilities of disadvantaged groups including the elderly, destitute women, and persons with disabilities (Rahman et al., 2012). After 2010, social protection programs were overhauled, recognizing newer vulnerabilities facing households that were linked to the impacts of increased natural hazards and projected climate change. This shift was seen in policy documents: the main strategic approach found in Bangladesh's National Social Security Strategy (NSSS) has been to strengthen resilience to manage covariate shocks, i.e., shocks that have a community-wide impact (GED, 2015). Currently, the Government of Bangladesh finances around 140 social protection programs,

allocating over USD 8 billion annually to these programs (MoF, 2019). According to the classification system of the Ministry of Finance, social protection programs fall under three broad categories: food security, cash transfers, and development sector programs.

Among these three categories, food security programs are our main interest in this study, as they aim to reduce the vulnerability of households affected by natural disasters, risks related to seasonality, as well as poverty. These programs are further classified by the government into four groups: public works, conditional food and cash transfers to address food insecurity, unconditional food assistance, and food price subsidies. Public works, which includes food for work (FFW), work for money (WFM), and test relief (TR), aim to provide income support during the agricultural lean season and during post-disaster recovery periods. Vulnerable Group Development (VGD) represents an example of a conditional food security program; it is the largest conditional food security program in Bangladesh exclusively targeted toward destitute women, and it is conditional upon recipients' enrolment into two years of training on health and nutrition and income-generation activities. Under this program, recipients receive a ration of 25 to 30 kg of wheat or rice for a period of 24 months (World Bank, 2016).

Vulnerable Group Feeding (VGF), an unconditional food assistance program, is the largest food security program in Bangladesh. It was initiated in the 1990s and then scaled up in 2008 to address acute food insecurity following natural disasters. This program was later extended to poor and unemployed households. The government also runs a special VGF for fishers to support their livelihoods when fishing bans are enforced. However, it mainly targets fishers who catch one specific fish species, *hilsha*[20], while largely ignoring other fishers who are also frequently affected by fishing bans. Finally, a large number of people are supported through a food price subsidy program called Open Market Sale (OMS). The OMS sells rice and wheat at a subsidized price to address seasonal poverty and post-disaster food insecurity. The duration of food security program support varies by program and the beneficiary households targeted. Under the VGF program, extremely poor households are supposed to receive the assistance throughout the year while other households receive the assistance during agricultural slack seasons or after climatic shocks. On the other hand, the special VGF for fishers or OMS programs are run for a specific period.

Cash transfer programs in Bangladesh are unconditional safety nets or humanitarian assistance interventions targeted toward individuals facing vulnerability because of old age, disability, maternity, widowhood, or other relevant family circumstances. The government of Bangladesh runs around 15 cash transfer programs. Among these programs, the Old Age Allowance program receives the highest level of allocations followed by Allowances for the Widow; Deserted and Destitute Women Program; Allowances for the Financially Insolvent Disabled Program; and Maternity Allowance Program for the Poor Lactating Mothers program.

The third type of social protection, the development sector programs, strives to empower vulnerable people by providing stipends for education at different levels, offering a number of health care services for the poor and vulnerable,[21] and building infrastructure such as irrigation systems and affordable housing, as well as relocating households affected by disasters to a safer place. Each of these social protection programs contains a number of targeting criteria for selecting eligible households. However,

[20] *Tenualosa ilisha*.

[21] These health care services include maternal, neonatal, and child and adolescent health care; tuberculosis, leprosy, and other communicable and noncommunicable disease control.

the absence of a household-level poverty database makes it impossible to apply scientific or rigorous targeting mechanisms based on household characteristics and poverty status (World Bank, 2016).

Responsibility for social protection in Bangladesh is remarkably diffuse. At least 24 government ministries are involved in designing and delivering social protection programs (GoB, 2019). Various ministries and agencies run very similar programs with duplicate objectives and coverage, and with little coordination (Rahman et al., 2014; World Bank, 2016). Most of the programs are delivered at the union level, the lowest administrative level in Bangladesh. In the unions, the elected local council distributes program benefits to households or individuals. Although there is little or no coordination at the national level, all social protection programs are eventually funnelled through a single committee in each union. In theory, then, the union council can avoid duplication in distributing benefits.

4.3 Analytical framework and research design

The fifth report of the IPCC (AR5) defines adaptive capacity as 'the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences' (IPCC, 2014). When applied to social protection, adaptive capacity calls for interventions that foster the capacity of households to reduce the impacts of disasters and climate change-related hazards on households. These interventions can help vulnerable households acquire context- and place-specific capacities to address climate-related risks (e.g., technologies and traditional and innovative strategies[22]), as well as generic capacities (e.g., assets, income, knowledge, health, political power), to address the structural deficits that shape vulnerability and, to increase adaptive capacity (Béné et al., 2012; Eakin et al., 2014; Lemos et al., 2016).

Béné et al. (2018) identified five criteria necessary for a social protection system to be adaptive in the context of environmental and climate-related shocks: institutional coordination, scalability, targeting households that are vulnerable to shocks and disasters, swiftness of the programs in responding to shocks, and fostering adaptive capacity. Our empirical analysis focuses on how well social protection programs perform in the coastal regions of Bangladesh in terms of four of these criteria: scalability, swiftness of response, targeting efficiency, and fostering adaptive capacity. Although institutional coordination is important for effectiveness, unlike the others it does not directly describe outcomes for households, which is the unit of analysis for our empirical analysis. The research design for assessing each of the four criteria we consider is outlined below. We then describe our primary data source, which is a household survey conducted in three coastal divisions in Bangladesh.

Scalability

Scalability refers to a program's ability to expand both horizontally and vertically in the face of adverse events. Horizontal expansion involves increasing the number of beneficiary households, while vertical expansion concerns increasing the value or duration of an intervention to match beneficiaries' additional needs from adverse events.

Scalability is assessed by comparing the number of households who experienced shocks during the year preceding the survey with the number of households who received social protection benefits from food security programs, which are the primary means of supporting households impacted by environmental shocks. We only tested horizontal scalability with the survey data, that is whether the number of beneficiaries increased with the number of households experiencing shocks. While we could not test

[22] These strategies include saline tolerant agriculture and aquaculture in salinity prone areas as well as floating gardens in waterlogged areas.

vertical scalability, the secondary data collected from government circulars and interviews with union council members confirmed that the allocation per person remained unchanged after disaster events (GoB, 2016; 2017).

Swiftness

Swiftness refers to a social protection program's ability to disburse resources in a relatively short period of time so that affected households can be supported soon after the occurrence of shock events. This is critical since evidence suggests that a quick response after adverse events generally yields better results than the same response delivered later (Pelham et al., 2011; McCord, 2013; Bastagli, 2014; O'Brien et al., 2018).

To assess the swiftness of response, we used survey data on environmental shocks experienced by households during the three years preceding the survey, as well as data on whether households received social protection benefits or humanitarian assistance within four weeks after the shock. The survey data distinguished between rapid shock events and slow-onset events. We only included rapid shock events in the swiftness analysis since it proved difficult for households to determine when slow-onset events first started; moreover, the government would be unlikely to respond to such events quickly. We considered swiftness of response with respect to two types of rapid shock events: recurring shocks and unexpected rapid shocks. Recurring shocks are those events that are likely to happen every year, such as monsoonal flooding and waterlogging, while unexpected rapid shocks are those that cannot be predicted or are difficult to predict, such as cyclone storms. We also included the two-month fishing ban in the swiftness analysis, although this represents a non-climatic event. However, it encompasses a covariate livelihood shock experienced by many fishing households in the study area every year.

Targeting efficiency

Targeting efficiency refers to how well interventions direct benefits to both chronically poor or vulnerable households and those that are likely to experience transitory poverty because of disasters or climate change-related shocks. The effective targeting of adaptive social protection programs requires more rigorous information on contextual risks and vulnerabilities than conventional social protection programs, which mainly reference household information related to income and food security (Schnitzer, 2019; WFP, 2019; Bowen et al., 2020). Vulnerability mapping at both the household and community level can be useful for identifying potential beneficiaries of adaptive social protection programs (Béné et al., 2018).

Since poverty is central to the targeting criteria mentioned in all the social protection programs present in the study area, it would be expected that program beneficiary households would represent low-income groups. To verify this pro-poor targeting following World Bank's approach (Gautam and Faruquee, 2016), the sampled households were divided into five income groups based on their poverty status: extreme poor, poor, near-poor, vulnerable to poverty, and upper-income group. We used the district level lower and upper poverty lines suggested by the Bangladesh Bureau of Statistics to identify the groups (BBS, 2018). Appendix Table A 4.1 defines the groups and shows the share of the sampled population in each group. For the different social protection programs, we assessed targeting efficiency by comparing the distribution of beneficiaries by income group with the distribution of the overall survey sample.

Fostering adaptive capacity

Social protection interventions can not only help households cope with the adverse consequences of shocks, but they can also support them in adjusting their livelihood strategies and creating productive opportunities for the future. This is what is meant by fostering adaptive capacity. Social protection programs can foster the adaptive capacity of households through four channels. First, these programs can help households avoid adverse coping measures following livelihood shocks, such as selling productive assets and reducing food consumption. Second, receiving support from social protection programs can free up poor households' resources and have a positive impact on their asset profile, thus allowing them to invest in innovative strategies that may increase their adaptive capacity (Solórzano, 2016; OECD, 2019). Third, programs can directly or indirectly encourage households to diversify their livelihoods, which can enhance their adaptive capacity (Devereux and Guenther, 2009; Weldegebriel and Prowse, 2013). Fourth, social protection programs can encourage households to invest in their future, allowing them to invest in their human capital and other assets that will enhance future livelihoods (Chapman, 2006; UNESCO, 2010; Bowen et al., 2020).

It is important to note that building adaptive capacity is not an immediate process. Accordingly, our objective in this study is to examine whether a household's inclusion into social protection programs promotes factors that serve to build their adaptive capacity in the long run. Four regression models were specified and estimated for the assessment.

Two of these models analyzed whether a household's inclusion into social protection programs was associated with avoiding adverse coping activities following climatic shock events. The adverse coping activities we analyzed comprised reducing food consumption (model 1) and selling productive assets (model 2). In both cases, the regressions were specified as probit models. The estimation samples were restricted to the households who reported that they had experienced at least one climatic shock within the year preceding the survey.

The other two models estimated the impact of social protection programs on whether households adopted innovative adaptation strategies (model 3) and whether they were associated with livelihood diversification (model 4). Both models were estimated using the full sample. Model 3 is a probit specification with the dependent variable indicating whether the household adopted any innovative adaptive technologies or strategies within one year preceding the survey. Surveyed households reported using a range of adaptive technologies and innovative strategies and the frequency of these strategies is shown in Appendix Table A 4.2.

Model 4 estimated an OLS regression to observe the association of social protection programs with households' livelihood diversity. The dependent variable is the livelihood diversity index, LDI, computed using Gibbs and Martin's index[23] (Gibbs and Martin, 1962) expressed as:

$$LDI = 1 - \sum_{m=1}^{N} P_m^2$$

[23] There are a number of ways to compute livelihood or income diversification, including ones that account for the number of income sources and those that compute an index, such as Herfindahl's index. Gibbs and Martin's index is essentially a modified form of Herfindahl's index, as the latter is subtracted from 1 to calculate the former. A low value from Herfindahl's index denotes higher levels of diversification, while a high value from Gibbs and Martin's index denotes higher levels of diversification. Gibbs and Martin's index is also known as Simpson's index.

where p is the share of income from an individual source in the total income, and N is the number of the total income sources. Higher values of this index denote higher levels of livelihood diversification.

We included a range of explanatory variables in the models. Our main explanatory variable of concern is the dummy variable (*d_spfoodsec*), which identifies households who received support from food security programs within one year preceding the survey. We also included dummy variables for two other types of social protection programs present in the study area: identifying households with at least one cash transfer program beneficiary (*d_spcashtrans*) and identifying households that have received support from development sector programs (*d_spdev*), which mainly comprise school stipends and school feeding programs.

The models also included a variable indicating a household's frequency of experiencing environmental and climatic shocks. Following Hahn et al. (2009), this index was calculated as:

$$Frequency\ of\ shocks = \frac{ShockHi - Shock\_min}{Shock\_max - Shock\_min}$$

where *ShockHi* is the number of climatic shock events experienced by the household *I,* and $Shock\_min$ and $Shock\_max$ are the minimum and maximum number of shock events, respectively, experienced by all sampled households within the three years preceding the survey.

The models also included a number of control variables for demographic characteristics, economic well-being, and livelihood categories. Table A 4.3 in Appendix 4 defines these variables and reports their summary statistics.

Study area and data

The study area covers three districts from three coastal divisions of Bangladesh: Sathkhira district of Khulna division, Patuakhali district of Barisal division, and Noakhali district of Chittagong division. Six sub-districts, two from each of the three districts, were then selected to provide variation in terms of fishing and aquaculture activities, types of environmental stressors, and level of exposure to environmental and climatic change. See section 1.4 for more details on study area selection.

The main source of data for our empirical analysis was the Bangladesh Coastal Socio-ecological Vulnerability Survey (BCSEV)-2017, which was conducted in January 2017, focus group discussions and 21 key informant interviews.[24] See Section 1.5 of Chapter 1 and Appendix

4.4 Results

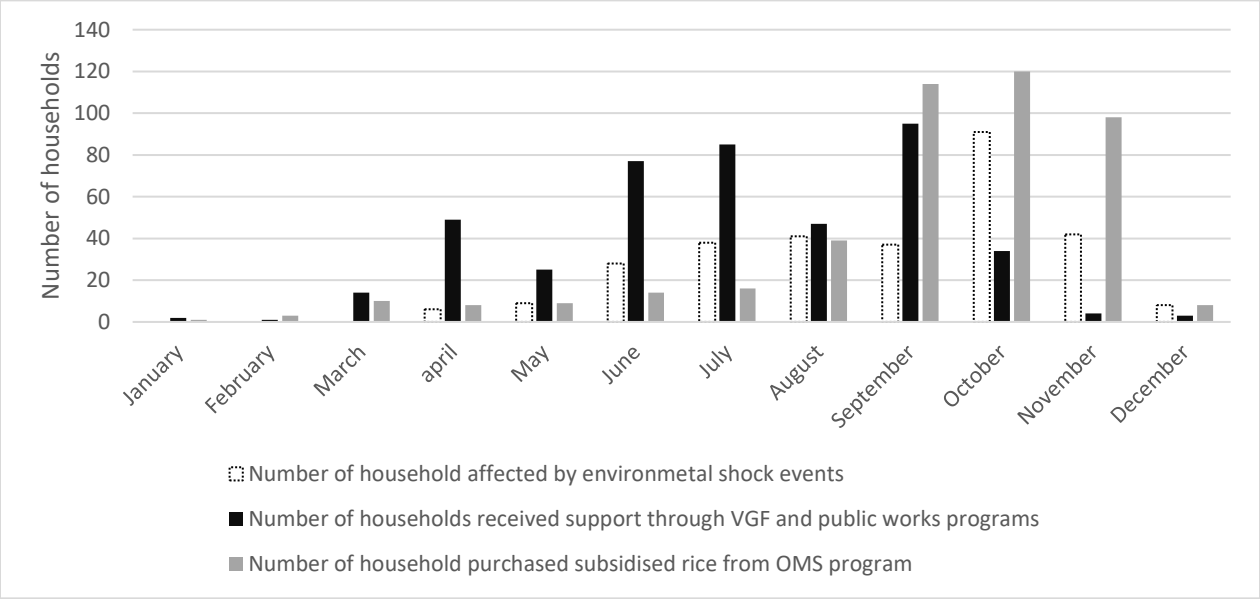
Survey respondents received assistance from 15 different social protection programs in the 12 months preceding the survey. The survey identified four cash transfer programs, nine food security programs, and two development sector programs present in the study area. In total, 293 sampled households received assistance from these programs. Appendix Table A 4.4 provides the detailed distribution of participation in each program among the surveyed households study sample.

[24] The survey was designed by one of the authors (Haque), who also directed the implementation of the survey. The survey was carried out by a team of 12 enumerators.

Scalability

Based on the survey data, Figure 4.1 depicts the monthly incidence of households who experienced shocks and benefited from food security programs, including VGF and public works. Figure 1 shows that the distribution of VGF and public work program benefits remained high in June, July, and September, but were then scaled back, despite household shocks peaking in October. The reason why VGF distributions peaked in June-July and September relates to those months coinciding with the months of two Eids,[25] which are the major VGF distribution events throughout the country. For example, in the survey year 2016-17, 10 million people were provided with VGF assistance during two Eids (GoB, 2016). The OMS program, in contrast, was scaled up between September to November, which corresponds more closely to the timing of environmental shock events. However, it should be noted that respondents generally indicated that they preferred VGF programs to OMS during months of hardship, since VGF programs provide food at no cost while OMS only subsidizes food prices.

Figure 4.1: Shocks and food security program distributions by month



Swiftness

The survey data indicate that social protection assistance reached recipient households within two weeks of a shock event in only 28% of the cases. However, the swiftness varied depending on the type of shock. Table 4.1 shows that households who were affected by recurring events, such as flooding and waterlogging or the two-month fishing ban, received social protection assistance faster than households who were affected by unexpected rapid events like cyclones and storms. Interviews with the chairperson and members of the union councils suggested that the remoteness of coastal villages, a lack of infrastructure to store food items for food security programs at the union level, and the bureaucratic procedure of releasing funds represented the main reasons for slow responses after unpredictable rapid shocks. Key informants further suggested that, in the case of rapid disasters, it would be crucial to have

[25] Eids are main religious festivals for Muslims. Bangladesh is a Muslim majority country, where 91% of the population are Muslims (BBS, 2022)

funding readily available at the district level for quick response. Otherwise, it would be time consuming to receive funding from the ministries and then channel it toward local levels.

Table 4.1: Shocks and social protection response

	Number of affected households	Number of households who received social protection assistance within four weeks of a shock	Percentage of households who received social protection assistance among the affected
Flooding and waterlogging	360	130	36.1
Cyclone, storm, and tidal surge	196	21	10.7
Two-month fishing ban	163	39	23.9
River erosion	22	4	18.2

Source: BCSEV-2017 survey
Note: Households might have been affected by multiple shock events.

Targeting efficiency

Table 4.2 shows the distribution of beneficiaries for the three types of social protection programs across the income groups defined in the section 3.3. This table indicates that the majority of beneficiaries for all three types of programs were from non-poor groups. However, our data show that while more than 50% of social protection beneficiaries were non-poor, a large proportion of extremely and moderately poor households remained uncovered by social protection programs (see Table 4.3). For example, 61.5% of recipients of food security programs were non-poor, though 80% of extremely poor and 75.9% of moderately poor households did not receive support through these programs.

Table 4.2: Distribution of social protection programs among beneficiary households by income groups (%)

	Extreme poor	Moderate poor	Near-poor	Vulnerable to poverty	Upper-income group	Total
Food security programs	9.3	6.1	9.3	13.8	61.5	100
Cash transfer programs	24.1	12.1	10.3	15.5	37.9	100
Development sector programs	18.1	9.2	12.6	13.7	46.4	100
All social protection programs	15.7	8.5	10.5	13.6	51.7	100
All households (Full sample)	20.2	11.3	11.3	13.8	43.8	100

Source: Authors' analysis of BCSEV-2017 survey data.
Note: Definitions of income groups are provided in Appendix Table A 4.1.

Table 4.3: Household-level benefit incidence of social protection programs by income group (%)

	Extreme poor	Moderate poor	Near-poor	Vulnerable to poverty	Upper-income group	Full sample
Food security programs	20	24.1	35.8	43.4	55.7	43.4
Cash transfer programs	9.7	8.9	7.4	9.1	7	8.07
School-based programs	57.6	34.2	45.7	40.4	43.2	40.8
All social protection Programs	48.3	48.1	58	61.6	67	62.1

Source: Authors' analysis of BCSEV-2017 survey data.

The paper 1 (Chapter 2) of this dissertation constructs risk indices for three major climatic stressors experienced in the study area: cyclones and storm surges; floods and waterlogging; and soil, groundwater, and surface water salinity. Table 4.4 reports the benefit incidence of recipients of food security programs[26] based on the intersection of poverty and risk level. Here, households are divided into three terciles for each risk index with 1 having lowest risk and 3 highest. The table shows that for cyclones and salinity, the incidence of social protection recipients was higher for households that faced higher levels of risk. However, among the households who faced the highest levels of risk, the benefit incidence of food security programs was higher for upper-income groups than for lower-income households. For floods and waterlogging, the benefit incidence of food security programs was lower for households facing higher levels of risk.

Table 4.4: Benefit incidence among recipients of food security programs by poverty and risk level (%)

	Cyclone and storm surge risk			Floods and waterlogging risk			Salinity risk		
Poverty level	Risk tercile 1	Risk tercile 2	Risk tercile 3	Risk tercile 1	Risk tercile 2	Risk tercile 3	Risk tercile 1	Risk tercile 2	Risk tercile 3
Extreme poor	10.3	20.0	55.6	29.5	20.5	7.3	5.4	20.9	38.3
Moderate Poor	12.9	19.4	60.0	36.0	23.3	13.6	15.6	10.5	46.2
Near-poor	11.5	34.4	71.4	48.5	45.0	15.4	12.0	34.8	58.1
Vulnerable to poverty	18.4	45.5	78.8	57.7	50.0	36.6	15.0	54.3	55.3
Upper-income group	30.1	51.9	84.5	72.5	61.2	52.4	56.3	62.1	66.7
Full sample	19.1	35.2	78.7	52.5	46.2	34.0	30.5	46.6	55.7

Source: Authors' analysis of BCSEV-2017 survey data.

The vulnerability index is one of the components of the risk index developed in chapter 2. This index is not hazard-specific. Table 4.5 reports the distribution of social protection programs across five vulnerability quantiles. Here, households are divided into five vulnerability quantiles, with quantile 1 being the lowest vulnerable group and quantile 5 the highest. Similar to the distribution across poverty groups, this distribution also shows that majority of the beneficiaries of social protection programs belonged to bottom three vulnerability quantiles. For food security programs, only 36.5% recipients households were from the top two vulnerability quantiles. Table 4.6 shows the benefit incidence of

[26] Only food security programmes are reported in this table because these programmes were the main social protection instruments to address vulnerability caused by climatic stressors.

recipients of food security programs across vulnerability quantiles and poverty levels. The table reports that the benefit incidence of food security support is the lowest for the highest vulnerable quantile. Further, within this quantile benefit incidence of each non-poor group is considerable higher than extreme poor and moderate poor groups.

Table 4.5: Distribution of social protection programs among beneficiary households by vulnerability quantiles (%)

	Vulnerability Quantile 1	Vulnerability Quantile 2	Vulnerability Quantile 3	Vulnerability Quantile 4	Vulnerability Quantile 5	Total
Food security programs	19.6	21.5	22.4	21.2	15.4	100
Cash transfer programs	22.4	17.2	20.7	20.7	19.0	100
School-based programs	17.2	22.0	21.6	17.2	22.0	100
All social protection Programs	18.9	21.1	20.7	19.8	19.6	100

Table 4.6: Benefit incidence among recipients of food security programs by poverty and vulnerability level (%)

	Vulnerability Quantile 1	Vulnerability Quantile 2	Vulnerability Quantile 3	Vulnerability Quantile 4	Vulnerability Quantile 5
Extreme poor	28.6	16.7	27.3	21.1	14.9
Moderate Poor	31.3	23.1	17.6	41.7	15.8
Near-poor	22.2	35.7	46.7	42.9	38.9
Vulnerable to poverty	42.9	42.1	52.9	38.5	52.6
Upper-income group	52.5	65.3	63.4	71.2	55.3
Total	43.0	47.2	49.3	46.5	34.0

Adaptive Capacity

Table 4.7 presents the results of the probit and OLS models that were estimated to investigate whether social protection programs were associated with greater adaptive capacity among recipient households. Models 1 to 4 were run on the poverty sample that includes households under the poverty line. Ideally, the estimation sample for the regressions would be households that are eligible for social protection programs. However, each program has its own eligibility criteria, so households eligible for one program might not necessarily be eligible for another. To avoid complexity, we ran the regressions on the poverty sample since poverty is the common eligibility criteria for all food security programs.

The estimation of Model 1 indicates that the exposure index was significant at the 1% level, implying that households who were exposed to multiple climatic shocks were more likely to reduce their food consumption to cope with shocks. However, poor households that were recipients of food security programs were less likely to adopt negative coping strategies after being affected by a shock. On the other hand, the estimated coefficients for cash transfer and school-based programs were not significant. Households who had no adult male member, as well as households who had a higher dependency ratio, were likely to reduce food consumption after a disaster.

Model 2 addresses another adverse response to shocks, namely whether poor households had sold productive assets. The estimation found that households in food security programs were less likely to sell such assets following a disaster event, with the coefficient significant at the 10% level. Similar to Model 1, inclusion in the other two social protection programs did not yield a significant coefficient. It is interesting to note that variables which represent proxies for households' economic well-being—whether households are landless and whether they do not possess any productive asset—had negative and statistically significant coefficients, implying that these households were less likely to sell assets to cope with climate shocks. We would interpret these results as indicating that these households did not possess enough assets to sell to cope with shocks.

Just as food security programs, but not cash transfer or development sector programs, were correlated with avoiding adverse coping actions, the same pattern occurred when we examined positive adaptation strategies. As shown in Model 3, the coefficient for inclusion in a food security program was positively correlated (significant at the 1% level) with whether a household adopted at least one innovative technology or strategy, while the other two types of programs did not yield significant coefficients. In terms of primary livelihoods, households who were engaged in river fishing, aquaculture, and livestock rearing were more likely to adopt innovative technologies or strategies than the reference group (farmers). These technologies and strategies include using long-range radios during fishing trips, storing rainwater, switching to saline tolerant varieties of rice or vegetables, diversifying crops, building floating gardens, among others (see Appendix Table A 4.3 for the full list). Model 4 indicates that recipients of food security benefits were more likely than non-recipients to diversify their income, with the result significant at a 1% level.

These regressions were also estimated for the full sample (Models 1A-4A in Table 4.5). While social protection programs are meant to primarily target households under the poverty line, we have seen that a large proportion of recipients were non-poor and from the top two income groups (Table 4.3). We would expect that, since non-poor households possess more resources enabling them to adopt adaptive technologies and strategies, social protection might play a less significant role in enhancing their adaptive capacity, compared to poor households.

The estimations for the full sample also show that food security programs had a stronger effect than cash transfer or development programs on adaptive capacity. Nonetheless, as expected, the associations were not as strong as they were when the sample was restricted to poor households. The estimated coefficients for participation in food security programs were negative and significant in terms of households' reducing their food consumption (Model 1A) and positive and significant regarding whether households adopted at least one innovative and adaptive strategy (Model 3A). However, the effects on selling assets and income diversification disappeared. As was the case with the sample of poor households, the other program types had no significant association with any of the outcomes we estimated.

Table 4.7: Social protection and adaptive behavior: Results of the Probit and OLS regression

	Poverty Sample				Full Sample			
	Model 1: Probit	Model 2: Probit	Model 3: Probit	Model 4: OLS	Model 1A: Probit	Model 2A: Probit	Model 3A: Probit	Model 4A: OLS
	Food consumption reduction	Selling of assets	Adaptive technology and innovative strategy	Income diversification	Food consumption reduction	Selling of assets	Adaptive technology and innovative strategy	Income diversification
d_spfoodsec	-0.543*	-0.614*	0.827***	0.0817**	-0.427***	0.0290	0.357**	0.0286
	(0.286)	(0.342)	(0.242)	(0.0341)	(0.160)	(0.193)	(0.147)	(0.0216)
d_spcashtrans	-0.0838	-0.182	0.131	0.118***	-0.400	-0.198	0.0302	0.0839***
	(0.409)	(0.466)	(0.322)	(0.0410)	(0.249)	(0.323)	(0.219)	(0.0303)
d_spdev	-0.324	0.0522	-0.0485	0.0257	-0.131	-0.115	-0.0356	0.0146
	(0.263)	(0.316)	(0.208)	(0.0277)	(0.151)	(0.185)	(0.130)	(0.0190)
Frequency of shocks	7.789***	6.175***	2.856***	0.0183	7.417***	5.356***	2.689***	0.00367
	(1.165)	(1.240)	(0.739)	(0.0931)	(0.673)	(0.721)	(0.484)	(0.0674)
head_age	-0.0261	0.0463	-0.0185	0.00122	0.0168	0.0229	-0.0120	0.00809*
	(0.0602)	(0.0848)	(0.0523)	(0.00635)	(0.0367)	(0.0488)	(0.0339)	(0.00454)
hhh_agesq	0.000214	-0.00019	0.000218	6.53e-06	-0.000250	-0.000164	0.000127	-6.28e-05
	(0.000617)	(0.0008)	(0.000557)	(6.60e-05)	(0.000384)	(0.000510)	(0.000362)	(4.77e-05)
hhh_edu	-0.0400	0.0370	-0.0278	-0.00649*	-0.0135	-0.00347	-0.000546	-0.00496**
	(0.0355)	(0.0424)	(0.0295)	(0.00378)	(0.0197)	(0.0253)	(0.0174)	(0.00250)
d_nomale	1.216**	0.608	-0.529	0.0381	0.534*	0.429	-0.395	0.0272
	(0.523)	(0.543)	(0.463)	(0.0509)	(0.321)	(0.386)	(0.320)	(0.0393)
dependency_ratio	0.117*	0.0736	0.0363	-0.00142	0.0184	0.0524	-0.0224	-0.00169
	(0.0703)	(0.0749)	(0.0542)	(0.00746)	(0.0395)	(0.0473)	(0.0351)	(0.00505)
d_landless	-0.0166	-0.672**	0.430**	-0.00756	0.102	-0.431**	-0.0435	-0.0296
	(0.258)	(0.313)	(0.206)	(0.0264)	(0.147)	(0.187)	(0.126)	(0.0182)
d_nomfi	0.179	-0.602*	-0.179	-0.0259	0.0887	-0.210	-0.210	-0.0318
	(0.232)	(0.310)	(0.196)	(0.0250)	(0.175)	(0.229)	(0.160)	(0.0220)

d_noprodasset	-0.194	-0.417	-0.598**	-0.0294	0.0980	-0.609*	-0.360*	-0.0569**
	(0.277)	(0.462)	(0.265)	(0.0302)	(0.194)	(0.320)	(0.187)	(0.0242)
log_pcexp	0.0400	0.0272	0.116	-0.0131	-0.247**	-0.207	0.122	-0.0356**
	(0.212)	(0.295)	(0.180)	(0.0245)	(0.119)	(0.155)	(0.101)	(0.0146)
d_mainriverfish	0.619	-0.386	0.807**	-0.0915**	0.245	-0.165	0.605***	-0.0972***
	(0.401)	(0.524)	(0.330)	(0.0414)	(0.226)	(0.281)	(0.186)	(0.0274)
d_mainseafish	0.0226		1.767***	-0.0817	-0.448	-0.261	0.238	-0.128***
	(0.785)		(0.570)	(0.0689)	(0.278)	(0.345)	(0.232)	(0.0336)
d_mainaqua16	0.00507	-0.562	0.820**	0.0292	-0.137	-0.0222	0.457**	0.0276
	(0.429)	(0.515)	(0.377)	(0.0456)	(0.227)	(0.271)	(0.202)	(0.0299)
d_mainlvstock16	0.277	-0.223	1.112***	-0.0191	-0.0776	0.0345	0.635**	0.0375
	(0.486)	(0.578)	(0.430)	(0.0583)	(0.347)	(0.397)	(0.311)	(0.0477)
d_mainwage16	0.136	0.155	0.124	-0.0954**	0.0590	0.163	-0.0605	-0.0484*
	(0.354)	(0.398)	(0.314)	(0.0372)	(0.209)	(0.253)	(0.193)	(0.0269)
d_mainjob16	-0.358		1.208*	-0.0420	-0.136		0.0664	0.00642
	(0.800)		(0.634)	(0.0836)	(0.469)		(0.424)	(0.0580)
d_mainothers16	0.972*	-0.660	0.409	-0.0756	0.430	-0.398	0.00635	-0.0303
	(0.507)	(0.698)	(0.425)	(0.0481)	(0.289)	(0.459)	(0.268)	(0.0350)
d_patuakhali	-2.422***	-0.0458	-1.408***	0.0627	-1.537***	-0.480	-1.199***	0.0672**
	(0.541)	(0.575)	(0.423)	(0.0502)	(0.300)	(0.366)	(0.249)	(0.0330)
d_sathkhira	-0.282	1.200***	0.874***	0.0631**	0.136	0.953***	0.994***	0.116***
	(0.320)	(0.437)	(0.243)	(0.0319)	(0.198)	(0.300)	(0.160)	(0.0233)
Constant	-0.366	-4.471	-2.926	0.363	0.646	-1.741	-2.285**	0.398**
	(2.250)	(3.128)	(1.851)	(0.237)	(1.280)	(1.608)	(1.096)	(0.154)
Observations	227	216	348	345	522	510	719	712
R-squared	0.339	0.343	0.285	0.218	0.279	0.244	0.236	0.218

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.5 Discussion and conclusions

This study applied the ASP framework to understand the responsiveness of existing social protection programs in the context of climatic shocks and disasters in a region that has not been studied—coastal Bangladesh. Specifically, we examined how these programs address the vulnerabilities facing fisheries and aquaculture-based communities. We offered empirical evidence that illustrates how the social protection system could be more effective in addressing these pressing vulnerabilities. The system, as is, has faced a number of challenges, including: an inability to scale-up when needed; a slow response to climatic and livelihood shocks; and a poor performance in targeting beneficiaries. Notwithstanding these challenges, we found evidence that, in the wake of shocks, beneficiaries of food security programs were less likely to adopt adverse strategies and were more likely to adopt productive responses than households who did not participate in these programs. We examine each in turn.

First, with regards to an inability to scale-up, our analysis suggested that the horizontal scaling-up of social protection—increasing the number of beneficiaries—is motivated by political factors rather than the needs of those affected by climatic and livelihood shocks. For example, we showed how food security programs were scaled up during religious holidays and festivals, namely in the months of Ramadan and Eid, but not when climatic or livelihood shocks emerged (e.g., typhoons). Furthermore, vertical scaling-up—increasing the amount of support per household after shock events—is not currently practised in Bangladesh, perhaps linked to capacity challenges, such as, failure to anticipate climatic shocks and financial constraints. Future social protection programs should incorporate ways to scale-up both horizontally and vertically by considering region-specific seasonality of climatic events. Horizontal and vertical scaling-up will also require the creation of fiscal space, i.e., the budgetary room that allows a government to provide resources for public purposes without undermining fiscal sustainability (Heller,2005, Khondker and Datta, 2014, Oritz et al, 2017). The creation or expansion of fiscal space can be achieved through external financing, tax administration and reforming existing programs with better coordination and higher efficiency. However, strong political will be required to use fiscal space in favour of scaling-up social protection (Khondker and Datta, 2014).

Second, the majority of social protection programs demonstrated poor performance in terms of being delivered in a timely manner, particularly in the case of climatic shocks. Social protection programs were relatively swifter in responding to recurring shock events that tend to happen around the same time every year. This includes monsoonal flooding and waterlogging. In such cases, the government is somewhat prepared for these events and, hence, can respond more quickly. However, a lack of emergency funds to respond to urgent needs at lower tiers of government means social protection programs are delayed after less predictable climatic events such as cyclones or intense storms. Coastal regions are not as easy to access as those around the capital, and local units do not have the space to store food reserves for such moments. Moreover, funds allocated by the government for emergency management have been modest, and foreign financing has been mobilized through bi- and multi-lateral development partners after major disasters (Ozaki, 2016); nonetheless, such funds take time to transfer to local governmental units. Given that a quick response after adverse events generally yields better results in terms of helping households (Béné et al., 2018), and that climatic shocks will continue (IPCC, 2022), ensuring swift program delivery represents another important area for improvement.

Third, effective targeting remains a challenge across the social programs operating in coastal areas. Our analysis demonstrated that many recipients of social protection programs were not poor; moreover, a considerable proportion of poor, vulnerable households were not covered by many programs. This is linked to unclear or inappropriate targeting criteria, the discretion of local leaders in arbitrary targeting, and the absence of appropriate databases to base targeting on

concrete indicators of hardship. Improvement in these areas by establishing measurable targeting criteria, a single database for all programs, proxy mean test scores for selecting beneficiaries would greatly enhance the ability of social protection programs to meet their intended beneficiaries and, thus, their overall effectiveness.

Examples of unclear or inappropriate targeting criteria include households being unable to eat two meals a day, which is difficult to verify, or an annual income cut-off for beneficiaries (in one program USD 50 was used, and only four of our sampled households had incomes less than this threshold). Another program required households to meet four of twelve targeting criteria for selection: only 14% of households in our sample met the minimum four criteria threshold, and 75.5% of poor households were not eligible. In fishing households, for the specific VGF targeting fishers, two-thirds (66%) of recipient fishers were large-scale fishers belonging to the highest income group in our study sample. Many low-income group fishers, who work as labourers on fishing boats, were left out of the program because they did not have the appropriate documentation (a fisher identity card in this case). The result was that fish workers were not able to access assistance from this fisheries-specific program meant to help such workers.

In the absence of realistic and systematic targeting criteria, the targeting process relies on the arbitrary decisions and perceptions of union council members, who, in turn, are relieved of any accountability since it is difficult to find households that meet the criteria of inclusion into social protection programs. In our study sample, 73% of the food security program beneficiaries who were non-poor reported that they had a personal connection to one or more members of local union councils. A recent study by the Bangladesh Planning Commission (GED, 2020) also found discretionary selection of program beneficiaries by local government representatives and business elites perpetuating nepotism and corrupt practices. The absence of a database on household-level income, consumption, vulnerability, and other indicators of well-being exacerbates this targeting challenge. Although Bangladesh agreed to a World Bank project in 2013 aiming to establish a National Household Database to calculate a poverty score per household, the project was never completed.

That said, our analysis found that poor households receiving food security benefits—though not cash transfers or development sector program benefits—were more likely to avoid adverse coping and adaptive strategies, such as cutting back on food consumption or selling assets, while also being more likely to diversify their incomes and adopt innovative livelihood strategies. This illustrates how food security programs can foster adaptive capacity among poorer households. This evidence becomes weak, however, when we ran regressions on our entire sample including non-poor households. This finding suggests that food security programs work best for the population they are intended for. Notably, the majority of these programs as presently operated do not directly aim to increase households' adaptive capacity; the impacts captured in the regression results essentially reflect indirect impacts created by these programs. This suggests that far more can be done to create social protection programs that help build adaptive capacity. Moreover, if targeting can be made more efficient, resources would be used more efficiently, and there would be potential to increase the adaptive capacities of a far larger number of poor households.

For future analysis, a greater number of dimensions related to the adaptive capacity of social protection programs could be tested. This was a study limitation: we could not test the impact of social protection programs on other dimensions of adaptive capacity, such as asset accumulation or human capital development (Béné et al., 2012; Lemos et al., 2016; Rosengren et al., 2021). It would also be very instructive to undertake a longitudinal analysis, building a panel database to better understand how households fare in the medium- and long-term based on their participation in social

protection programs. This is important since adaptive capacity is something that is built up over time.

Bangladesh's sustained rates of economic growth and poverty reduction have kept the country on track to graduate from the UN's Least Developed Countries (LDC) list by 2026 However, the increased frequency of natural disasters and projected climate-induced vulnerabilities threaten a large portion of the population, including in the coastal region. Even though Bangladesh has undertaken several initiatives to improve disaster management on its coast, most projects have been infrastructure-related. Among the 301 projects developed between 2014 and 2018 within the government-financed Bangladesh Climate Change Trust Fund (BCTF), only 30 projects target household-level adaptive capacity through social assistance and asset transfers (BCTF, 2019). While infrastructure development is critical for disaster management, increasing households' adaptive capacities is also essential for bolstering resilience to climate change. Social protection programs that are scalable, respond in a timely manner, well-targeted have the potential to play an important role in building household-level adaptive capacity and reducing vulnerability.

Chapter 5: Conclusion

This dissertation has presented three research papers on climatic risk and vulnerability, temporary migration, and social protection in the context of coastal fisheries and aquaculture-based communities in Bangladesh. Drawing on the IPCC's (2014) Fifth Assessment Report (AR5) risk and vulnerability framework, Chapter 2 develops a methodological contribution to the risk and vulnerability assessment literature by applying this framework to quantitatively calculate household-level risk and vulnerability assessments. Chapter 3 explores the role that temporary internal migration plays as a risk management strategy for households affected by climatic hazards. This chapter provides a theoretical contribution to environmental and labour migration literature by combining the recent environment migration framework with the New Economics of Labour Migration (NELM) theory in order to understand the motivations of migration among Bangladesh's coastal communities. The fourth chapter investigates whether government-run social protection programs are properly addressing the risks and vulnerabilities faced by coastal communities. What follows is a summary of the key findings of the papers, application of theories, methodological contribution, policy implications of the findings, and future research agendas.

Summary of findings

The first research question of this dissertation asks: To what extent have coastal fisheries-dependent communities in Bangladesh faced risks from climatic hazards and vulnerabilities, and how have these risk and vulnerability levels varied by location, occupation, and income level? In general, I found that high levels of vulnerability affected coastal fishers in Bangladesh. In particular, the findings of the first paper suggest that households dependent on river fishing were the most vulnerable among all occupation groups considered in this study. Another finding is that households' vulnerability and poverty were well-correlated, meaning poorer households also faced higher levels of vulnerability in terms of lack of adaptive capacity and high levels of sensitivity. This result echoes the findings of numerous recent studies on poverty and vulnerability (Deressa et al., 2009; Hallegatte and Rozeberg, 2017; Winsemius et al., 2018; Sinha et al., 2022).

Alongside the vulnerability index, the first paper also constructs three risk indices for cyclones and storm surges, flooding and waterlogging, and salinity. The risk indices show that not all coastal regions were equally impacted by all types of climatic hazards. In fact, the level of risk of a particular hazard varied even within a district. For example, communities closer to the shoreline faced higher risks of cyclones, storm surges, and saline water intrusion, while communities interior to the coast were at an increased risk of river flooding and waterlogging. My findings also suggest that not all livelihood activities were equally at risk from all types of hazards. Some livelihood activities faced a higher risk from a specific climatic hazard than others. For example, the level of risk from cyclones and storm surges was very high for households dependent on marine fishing, river fishing, and farming. Alternatively, households whose livelihoods were dependent on aquaculture and livestock faced a higher risk of flooding and waterlogging than other occupation groups. This result resonates with the findings of Brouwer et al.'s (2007) research in Bangladesh, where they show that the impact of flooding varied significantly across occupation groups as farmers and fishers were disproportionately impacted than other occupational groups. Another study in Nepal (Gentle et al., 2014) also demonstrated the differential impacts of climate change on different geographical locations and occupation groups.

Another noteworthy finding from the risk indices is that, unlike vulnerability, both low- and high-income households faced higher levels of risk. However, this results need to be interpreted carefully

in policy making since higher levels of risk faced by these two groups stemmed from different components of the indices. Higher levels of risk among poorer households were attributed to the higher levels of vulnerability, namely high sensitivity and low adaptive capacity, that they faced. In contrast, while non-poor households tended to own greater values of assets than poorer households, the potential and/or actual loss of these assets due to climatic hazards also exposed them to high levels of risk. The finding that upper-income households also faced an increased risk of climatic hazards was driven by the AR5's new definition of exposure, which considers the presence of assets in places and settings that could be adversely affected as 'high exposure'.

The second paper (Chapter 3) of the dissertation attempts to answer the following question: How have coastal households in Bangladesh used temporary migration as a risk management strategy in the context of climatic hazards and socio-ecological changes? While the literature on environmental migration mainly concentrates on permanent migration as a consequence of climatic hazards and change, this paper contributes to the discussion by highlighting temporary labour migration as a risk management strategy. Results of this paper show that the relationship between climatic hazards and temporary migration is not straightforward. Rather, the connections between these phenomena depend on the types of hazards experienced by households, the risk management options available to households, as well as other traditional socio-economic drivers of migration. For example, households affected by rapid-onset climatic hazards were less likely to send temporary migrants to work. In contrast, households affected by recurring and slow-onset climatic hazards were more likely to send temporary labour migrants. The differential impact of different types of climatic hazards on migration was also observed in Gray and Mueller's (2012) study in Bangladesh, although their study considered only permanent migration. Several studies in Bangladesh identified the temporary migration of agricultural labourers to urban informal sectors as a common strategy during the pre-harvest season to manage risks of seasonal poverty and hunger, particularly among individuals from seasonally hunger-prone northern districts (Chowdhury et al., 2009; Khandker and Mahmud, 2012; Mobarak et al., 2020). Research on migration from the southern coastal region has mainly highlighted permanent migration or temporary displacement (Islam and Shamsuddoha, 2017; Luetz, 2008; Alam et al., 2020; Hossain et al., 2020; Paul, 2022). This study confirms that coastal communities affected by climatic hazards and changes also adopted temporary labour migration as a risk management strategy.

The third paper (Chapter 4) investigates the following question: Have government-run social protection programs in Bangladesh been responding to the risks and vulnerabilities faced by coastal communities? Applying the adaptive social protection framework (Davies et al., 2008; Béné et al., 2018), this paper specifically assesses the effectiveness of social protection programs in terms of targeting efficiency, scalability, swiftness, and ability to foster adaptive capacity among affected households. This study revealed four major findings. First, social protection programs in Bangladesh's southern coastal zone failed to scale up (i.e., increase their coverage and support packages when needed). Second, programs performed poorly in targeting beneficiaries. This finding is consistent with the findings of a number of recent studies (Coirolo et al., 2013; Razzaque and Rahman, 2019; World Bank, 2021). Third, programs were slow in response to climatic and livelihood shocks. Fourth, notwithstanding these challenges, beneficiaries of food security-enhancing social protection programs were less likely to embrace adverse coping strategies and more likely to adopt adaptive livelihood strategies.

An earlier study by Arnall et al. (2010) applied the original framework of adaptive social protection (Davies et al., 2008) to assess the social protection programs of five countries in South Asia, including Bangladesh. Their study mainly examined the extent of overlap between social protection, disaster

risk reduction, and climate change adaptation features among the social protection programs of the studied countries. They found a very low level of overlap between these three concepts in these South Asian countries, implying that all of the studied countries, including Bangladesh, were far from implementing adaptive social protection programs. Béné et al.'s (2018) extension of the adaptive social protection framework, applied in the third paper, allows researchers to go beyond assessing the design features of such programs to explore the operational efficiency and impact of the programs on households' adaptive capacity. This paper also highlights the significant gaps that Bangladesh's social protection programs need to overcome to represent an adaptive social protection system.

While the three main papers found in this dissertation focus on three different research questions, the findings are interconnected and offer a comprehensive picture of coastal livelihoods. This dissertation contributes to the literature on coastal climatic risk and vulnerability by identifying sources of risk and vulnerability specific to climatic hazards and livelihoods, while also highlighting how migration and social protection interact with climatic risk and vulnerability. What follows are three interrelated findings drawn from the papers:

First, the three papers of this dissertation highlight the connections among types of climatic hazards, households' migration decisions, and the availability of social protection support. Chapter 3 highlights that household migration decisions were significantly impacted by the types of climatic hazards they experience, and the social protection support available to them. For example, these results suggest that although households affected by recurring, slow-onset, and multiple types of disasters were more likely to send temporary migrants, they were less likely to send temporary migrants if they could access social protection support.

Second, Chapters 2 and 4 together show that social protection programs in the coastal zone were not adequately addressing the needs of either poor or non-poor households, even though both groups faced high levels of risk due to climatic hazards and change. Beyond this broad finding, Chapter 4 further reveals a more nuanced relationship between the Bangladesh government's programs and coastal communities: although government-run social protection programs were likely to address the vulnerabilities of poor households, they were not well-targeted and excluded substantial proportions of the poor, despite the fact that these programs were specifically designed for low-income households.

Third, the findings of Chapters 3 and 4 illustrate that there was a lack of direct support for households seeking to adopt risk management or adaptive strategies, such as temporary labour migration. Regarding temporary labour migration, this research further revealed that the largest proportion of temporary migrants found low-paying wage labourer positions in their destinations. Focus group participants reported that most labour migrants lacked the necessary skills to take advantage of higher-wage jobs in urban areas. These participants also explained that the cost of migration represented a significant barrier to migration. The survey data showed that an overwhelming majority of labour migrants covered their migration costs using their household's common savings, while existing social protection programs did not offer opportunities to develop skills or cover migration costs. The only program that provided skill development training for participants was the Vulnerable Group Development program, which exclusively targets women and offers training that pertains more to rural labour markets than urban ones.

Theoretical applications

To assess the risk and vulnerability of coastal fisheries-based communities, this dissertation relied on the IPCC's AR5 risk and vulnerability framework. This framework represents a significant shift from the earlier vulnerability-based framework to a risk-based framework, where vulnerability is considered as a component of risk. While the previous framework considered vulnerability as a consequence of the occurrence of hazards, the AR5 framework draws upon the 'contextual vulnerability' or 'starting-point approach' to conceptualize vulnerability as the present inability of a system to cope with changing climate conditions, which is determined by both biophysical and socio-economic factors (IPCC, 2014). The differences between the AR4 and AR5 frameworks also imply a shift from a primarily biophysical approach to a approach that considers both biophysical and socio-economic factors in assessing risk and vulnerability (Gregor-Gaona et al., 2021). The transition towards a risk-based framework ensures greater consistency in approaches between climate change and disaster risk management research communities (IPCC, 2014). However, the revised definition of exposure in the AR5 framework may underestimate the risk faced by low-income households. The risk indices should be interpreted carefully by taking account of each component to locate the main reasons of risk faced by different groups. Although the framework was proposed in 2014, only a handful of studies have adopted this framework (Das et al., 2020; Dubois et al., 2021, Malakar et al., 2021), and none have applied this framework to assess household-level risk and vulnerability. This dissertation demonstrates the first household-level application of this framework.

The second paper developed an analytical framework combining Black et al.'s (2011) environmental migration framework and the NELM theory (Stark and Bloom, 1985; Stark and Lucas, 1988). Black et al. (2011) offer a particularly nuanced analysis of migration, arguing that it is difficult to distinguish environmental migrants from other types of migrants. They outline five drivers of migration: social, political, demographic, economic, and environmental, and propose a conceptual framework that incorporates environmental change as an external factor which directly influences migration through changes to environmental drivers and indirectly through interacting with the other drivers (social, political, demographic, and economic) of migration.

Initially articulated by Stark and Bloom (1985), the NELM model extended the neoclassical theories of migration by shifting agency from individuals to households and introducing a number of new considerations to migration decisions, most notably the idea of risk management to complement income maximization (Mincer, 1978; Stark and Bloom, 1985; Stark and Lucas, 1988). By positing that migration decisions are made by households, the NELM model assumes that a social contract exists between household members, with migrants sending remittances to their household in order to maintain access to the household's pooled resources (Williams and Baláž, 2012).

The results of the second paper support using these two theoretical frameworks together, as their combination corroborated NELM's hypothesis that an informal social contract connects households and their migrant members. The regression results in the second paper also highlight the significance of the traditional drivers of migration suggested by Black et al. (2011). These results also highlight the interaction between traditional drivers of migration and environmental shocks in shaping households' temporary labour migration decisions.

The third paper applies the adaptive social protection framework. This framework was first proposed by Davies et al. (2008) and was further elaborated by Béné et al. (2018). The original framework suggests that incorporating components of social protection, disaster risk reduction, and climate change adaptation into social protection programs can make a social protection system adaptive, address underlying causes of vulnerability, and increase households' adaptive capacity. Béné et al.

(2018) extend the original framework and identify five key principles that are necessary for a social protection system to become effectively adaptive: institutional coordination, scalability, targeting efficiency, swiftness of response, and fostering adaptive capacity. This dissertation applied Béné et al.'s (2018) framework with slight modifications to contextualize to the unit of analysis, i.e.; households, of this study (see Chapter 4 for details).

Overall, the three papers of this dissertation rely on three different, yet interconnected theoretical frameworks, as presented in the Chapter 1. The empirical chapters, 2 through 4, further validate these connections. As a notable example, the linkages between the types of climatic hazards, access to social protection, and labour migration decisions represent promising contributions for future theory development in the area of climatic risk, migration, and social protection.

Methodological contributions

The first paper proposes a replicable method to apply the IPCC's AR5 risk and vulnerability framework in constructing risk and vulnerability indices. One of the main reasons of low uptake of AR5 risk framework is the lack of clarity on operationalization of this framework (Estoque et al., 2022). This paper demonstrates a method to implement the AR5 framework. The indices can be replicated in other socio-ecological systems to locate households that are vulnerable and face high levels of risk of climatic hazards. The insights from the indices can be used for making policies and creating programs to address the risk and vulnerability of households living in ecologically vulnerable regions. This paper also highlights the importance of using both qualitative and quantitative methods in combination to assess risk and vulnerability. For example, the paper demonstrates an example of location-specific qualitative research in determining exposure indicators required for quantitative assessment. The method of developing indicators in this paper suggests that qualitative research should be carried out first to come up with context-specific quantitative indicators, particularly for the exposure component of the risk index.

The second paper applies a method to operationalize Black et al.'s (2011) environmental migration framework in combination with the NELM theory to understand the role of temporary labour migration in the context of climatic hazards and changes. Specifically, this paper applies an econometric approach to capture how environmental risks interact with social, political, demographic, economic, and environmental drivers in determining households' labour migration decisions. While a number of studies have quantitatively applied the NELM theory (Taylor, 1999; Taylor et al., 2003; Mannan and Fredericks, 2015), only a handful of studies have attempted to apply Black et al.'s (2011) framework quantitatively (Betcherman et al., 2019), and none have quantitatively combined and applied both frameworks.

The third paper demonstrates a method for applying the adaptive social protection framework (Davies et al., 2008) to assess the effectiveness of social protection programs in addressing climatic risk and vulnerability. This method is a quantitative application of Béné et al.'s (2018) analytical framework (Béné et al., 2018) to assess social protection programs through the adaptive social protection lens. The framework applied in this paper can be replicated in other country contexts to evaluate whether social protection programs address risk and vulnerability stemming from climatic hazards and changes.

Policy Implications

The findings of this dissertation have implications for policies related to risk and vulnerability reduction and adaptation planning. These policies may include:

Adaptation and mitigation programs: need to address specific needs

Effective climate change adaptation policies require vulnerability assessments using biophysical and socio-economic indicators. The governments of both developed and developing countries have widely used index-based vulnerability assessments in making adaptation policies (Zhang et al., 2018; Barankin, 2021). The risk and vulnerability indices developed in this dissertation can inform both adaptation and mitigation policymaking. The indices constructed at the intersection of specific hazards, locations, occupation groups, and income levels have the potential to inform more targeted adaptation and mitigation policies tailored to the needs of the communities in question. The indices show that the sources of risk of a specific hazard are different for high-income and low-income households. Therefore, they require different types of interventions. The indices can identify who needs what kind of adaptation or mitigation programs. Households that face a high level of vulnerability can be supported through programs targeted to increase adaptive capacity and reduce sensitivity. On the other hand, communities where households face higher levels of disaster risk will require risk-mitigating community infrastructure development programs.

Bangladesh's two major early climate change-related policy documents, the National Adaptation Plan of Action (NAPA) and Bangladesh Climate Change Strategy and Action Plan (BCCSAP), consider social protection as a key strategy to improve adaptive capacity (GoB, 2005; 2009). However, the synergy between climate change adaptation and social protection was largely missing in the programs run by the government. Moreover, the more recent Eighth Five Year Plan (GED, 2020) do not emphasize the role of social protection in developing adaptive capacity. This document highlights the role of social protection only in disaster response.

Social protection program delivery: ensuring targeting efficiency, scalability, and swiftness

Although Bangladesh's government-run social protection programs have had the potential to address the vulnerabilities of poor households, they were not well-targeted and have excluded substantial proportions of the poor, even though these programs were specifically designed for low-income households. In spite of the poor targeting, my findings suggest that these programs have had a positive and significant effect on factors of adaptive capacity among recipient poor households. Therefore, targeting efficiency is necessary to increase the effectiveness of these programs to increase the adaptive capacity of many poor households who were eligible but did not receive support from these programs. However, a strong political will is needed to reduce corruption in distributing social protection benefits. The third paper also demonstrates that updating and improving targeting criteria would increase targeting efficiency considerably. Recent studies on Bangladesh's social protection programs have also suggested measures for improving targeting efficiency, including the development of a single registry management information system for all social protection programs, the establishment of proxy mean test scores for selecting beneficiaries, and setting up a grievance redressing mechanism (Razzaque and Rahman, 2019; World Bank, 2021).

Recent research on climatic hazards and displacement has ranked Bangladesh among the leading countries globally in terms of disaster-related internal displacement; here, rapid-onset disasters displace 700,000 people per year on an average (Smith and Henly-Shepard, 2021). The focus group discussions conducted in this study also revealed that acute food insecurity and unlivable conditions following rapid-onset disasters were the main reasons for distressed short-term migration or displacement. Social protection programs, particularly food security programs, can address post-disaster acute food insecurity (Heltberg et al., 2008; GFDRR, 2020). My findings also show that social protection recipients were less likely to adopt negative coping strategies, such as reducing food consumption or selling assets for consumption smoothing. However, my findings also suggest that

social protection programs largely failed to scale up and respond promptly following rapid-onset disasters. The slow response time of social protection programs and their inability to scale up when needed left many acutely food insecure households in peril. While the national budget allocation for social protection programs has increased steadily over the last decade, more attention is needed to build the government's capacity to scale up these social protection programs and deliver them on time.

Social protection for migration

To support the potential migrants to cover the cost of migration and acquire necessary skills and information to exploit urban labour markets, a social protection program could be developed by providing financial assistance or lines of credit to cover migration costs, facilitate skill development training, and ensure access to information on distant job markets. Similar services are provided to migrants in India through an NGO-led labour support program. A randomized control trial conducted in the seasonally hunger-prone districts of Northern Bangladesh found that a subsidy to cover the cost of migration increased temporary migration significantly, and that migrant households recorded higher incomes and expenditures, higher caloric intake, and higher investments in children's education (Lagakos et al., 2018). To promote external or overseas migration, the Eighth Five Year Plan of Bangladesh outlines several enabling policies, such as migration cost support, dissemination of information on foreign labour markets, and skill development training (GED, 2020). Similar approaches are also needed for internal labour migration, as migrants often lack the financial resources needed for migration, internal labour market information, and skills.

Future research agenda

This dissertation has explored the risk and vulnerability of coastal fisheries-based communities and the role of temporary migration and government-run social protection in managing multiple risks faced by these communities. The findings of this research shed light on several issues that can be explored with future research. Some avenues of potential future research are:

***Climatic risks and livelihood transition*:** This dissertation clearly shows that different livelihood groups are disproportionately affected by different types of climatic hazards. Depending on the climatic hazards they frequently face, switching livelihoods could be an enticing and/or beneficial option for households. However, to date, no research has been done in Bangladesh's coastal context that examines whether coastal communities are going through a livelihood transition (i.e., in which households would switch from high-risk livelihood activities to low-risk livelihood activities or move towards multi-local livelihoods to manage their livelihood risks at their origin). A study on the Mekong delta found that environmental and economic changes caused a livelihood transition in Vietnam, where many households partly or completely exited livelihood activities that did not offer sufficient returns for activities that met their needs (Betcherman and Marschke, 2016). Similar research could be conducted in the context of Bangladesh.

Impact of temporary migration and social protection on creating long-term adaptive capacity: My research identifies temporary labour migration as an important risk management strategy for households affected by climatic hazards and change, particularly for those who cannot access social protection assistance. While the impact of temporary labour migration on reducing seasonal poverty and hunger has been well-researched, future research could explore whether temporary labour migration is capable of building long-term adaptive capacity among households. Similarly, the impact of social protection programs in creating long-term adaptive capacity among households is also

another avenue for future research. The availability of longitudinal household-level data can facilitate such studies.

Concluding remarks

Overall, the findings of the three papers of this dissertation contribute to our understanding of different aspects of climatic and environmental risks and the management of these risks, namely by identifying: 1) the dominant factors of risk across occupational groups, geographical locations, and income levels; 2) the ways households use temporary migration as a risk management strategy in the context of climatic hazards and change; and 3) how social protection programs can be improved to address the risks and vulnerabilities faced by coastal fisheries-based communities. This dissertation represents a significant contribution for international development scholarship because its findings can help inform climate-conscious development policies in the context of developing and least developed countries. In the absence of climate-informed development planning, climate change can potentially reverse the achievements of international development work and force an additional 100 million people into extreme poverty by 2030 (World Bank, 2017). Climate change impacts are projected to disproportionately affect developing and least developed countries by not only slowing their rates of economic growth and poverty reduction, but also by increasing livelihood and food insecurity (IPCC, 2014; 2022). Therefore, research on climate change-related risks and vulnerabilities, as well as on mitigation and adaptation strategies, has become more closely intertwined with international development research. This dissertation is an attempt to contribute to the intersectionality of risk and vulnerability and adaptation strategies.

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Appendix 1: Survey method

Sampling

The author drew the sample for this research using a random sampling technique. The sample size was determined using the standard formula for developing countries suggested by the UN (2005):

$$n_{hh} = (z^2)(r)(1-r)(f)(k)/(p)(n)(e^2)$$

where

n_{hh} is the sample size in terms of the number of households to be selected;

z is the statistic that defines the level of confidence desired;

r is an estimate of a key indicator to be measured by the survey;

f is the sample design effect;

k is a multiplier to account for the anticipated rate of non-response;

p is the proportion of the total population accounted for by the target population and upon which the parameter, r, is based;

n is the average household size (number of persons per household); and

e is the margin of error to be attained.

The z-statistics were set to 1.96, which denotes a 95% level of confidence. The value of r is usually obtained from a similar survey conducted in the same community. In absence of a similar survey in these same communities, the value for r is unknown. When r is unknown, it is suggested to set the value to 0.5 because the variance of indicators that are measured as proportions reach their maximum as they approach 0.5 (Islam, 2013; World Bank, 2019). Thus, setting r to 0.5 produces the most conservative or largest sample size, which was the approached used in this study. Since the survey is a simple random survey, no design effect was assumed, and therefore the value of *f* was set to 1. The UN (2005) has suggested assuming a non-response rate of 10%. Thus, the value for k should be assumed to 1.10. However, in this study, I decided to replace non-responding households with other households. Therefore, the value for k was set to 1. The population of interest in this study constitutes households that are exposed to climatic and environmental stressors, I sought to study the total population of interest. As a result, the value for p was set to 1 (UN, 2005). The average household size, n, was obtained for each sub-district from the latest population census (completed in 2011). The UN (2005) has recommended that the margin of error, e, be set to 10% of the value of r, which was followed in this study.

In each sub-district, the number of households required for inclusion in the survey ranged between 108 to 120. The sample size was rounded to 120 for each sub-district. Across the six-sub-districts, the sample size of this study totalled 720 households.

Training enumerators and pilot testing the questionnaire

I hired twelve experienced enumerators with the help of the DRI and ICCCAD. Both organizations are experienced in conducting complex surveys. The hired enumerators were graduates of social science or geography from local universities, experienced in conducting household surveys, and well-versed

in local dialects spoken in the study districts. I also conducted a two-week long training of the enumerators, which involved both a classroom component and practice fieldwork. I initiated the training session by briefing the enumerators on the objectives of the study, the structure of the survey, and the sampling design. I went through each module of the survey and conveyed how the enumerators should carry out the survey, explaining each question of the questionnaire, the definitions of terms, and skip logic. The enumerators were also briefed on possible situations when they would be required to contact me for assistance and/or for important decisions.

After training the enumerators, I led the team in a pilot test of the questionnaire in two rural locations. The pilot testing simulated the actual implementation of the survey and helped reveal shortcomings of the questionnaire, which I revised accordingly. The pilot testing exercise also allowed enumerators to gain practical experience in conducting this particular questionnaire.

Survey administration

The enumerators administered the survey face-to face with household heads (i.e., the main earning member of the household) and female co-heads, if the household head was not female. From each union, 120 households were surveyed. Depending on the unions, the survey covered up to nine villages to reach these 120 households. I divided each village into four quadrants and selected households from ach quadrant by following every fifth household rule. In case of non-response, the research team went to the next fifth household. The team continued this approach until 120 households were surveyed in each union.

A team of two enumerators required approximately 2 hours to interview one household. One of the enumerators asked and explained the questions to the respondents, while the other entered the responses into a form. I accompanied the team of enumerators and supervised them in each village, and often observed the interviews. At the end of each working day, I verified the completed questionnaires, and detected inconsistencies in responses. In the case of inconsistencies, we visited the households, usually on the next day, to explore the reason of inconsistencies and revised the responses if required.

Data cleaning

After collecting the data, the data were entered into the statistical package STATA. After data entry, I worked on cleaning the data and located identifiable errors, such as inconsistencies in household responses and out-of-range responses. I tried to resolve errors while still in the study districts, since some errors could only be resolved by revisiting a household. I resolved any errors before starting to analyze the data. For a small number of cases when errors could not be rectified, the I excluded these data points.

Appendix 2: Community infrastructure

Appendix table A 2.1: List of amenities used to construct the sub-district-level community infrastructure index

1	Weekly market
2	Local daily market
3	Union Council Office
4	Police Station
5	Telephone service (cell phone network)
6	e-service centre
7	Commercial banks
8	Recreation club
9	Bus stand
10	Fertilizer depot
11	Cold storage
12	Grain silo
13	Milk storage
14	Animal feed store
15	Veterinary

Appendix 3

Table A 3.1: Selected characteristics of surveyed districts

	Satkhira	Patuakhali	Noakhali
Population (2011)	1,985,959	1,535,854	3,108,000
Number of households (2011)	469,890	346,462	593,918
Aquaculture production (metric tons)	116,845	30,441	42,957
Fishing production (metric tons)	21,045	23,533	50,074
2016 Poverty headcount rate (%)	18.6	37.2	23.3
Distance to major Divisional city (km)	60	45	130
Distance to Dhaka (km)	275	282	173

Source: Bangladesh Population and Housing Census-2011 (BBS, 2013), Fisheries Statistics of Bangladesh-2016 (DoF, 2018), Household Income and Expenditure Survey-2016 (BBS, 2018)

Note: Bangladesh Population Census-2011 is the most recent population census in Bangladesh. The next census was due in 2021, but it has not been completed yet due to the Covid-19 pandemic.

Table A 3.2: Summary statistics of variables included in logistic regressions in chapter 3

Variables	Observation	Mean	Std. Dev.	Min	Max
Household had member/s who migrated for employment in 2016	720	0.22	0.41	0	1
Households perceived rainfall pattern change	720	0.71	0.51	0	2
Households experienced fish catch decline	720	0.13	0.36	0	1
Households affected by rapid-onset disasters	720	0.20	0.49	0	1
Households affected by recurring disasters	720	0.16	0.48	0	1
Households affected by multiple disasters	720	0.19	0.39	0	1
Households affected by slow-onset disasters	720	0.16	0.38	0	1
Time in minutes required to obtain drinkable water	720	5.31	7.45	0	60
Dummy for households affected by economic shocks	720	0.31	0.46	0	1
Dummy for households affected by demographic shocks	720	0.19	0.40	0	1
Household head's age	720	43.88	12.71	20	85
Household head's age squared	720	2086.55	1214.57	400	7225
Dummy for female household head	719	0.05	0.22	0	1
Dependency ratio	720	0.83	0.76	0	5
Household's maximum education: number of years	720	7.42	3.06	0	16
Household's land holding: landless or marginal	720	0.88	0.32	0	1
Household's land holding: small	720	0.09	0.28	0	1
Household's land holding: medium and large	720	0.03	0.179	0	1
Household had dispute/conflict over land or water	720	0.10	0.30	0	1
Household affected by fishing ban	720	0.20	0.40	0	1
Household affected by pirates	720	0.06	0.23	0	1
Household had access to microfinance	720	0.54	0.50	0	1
Household received social protection program benefits	719	0.43	0.50	0	1
Interaction variable: rapid-onset disaster and social protection	719	0.19	0.39	0	1
Interaction variable: recurring disaster and social protection	719	0.14	0.35	0	1
Interaction variable: slow-onset disaster and social protection	719	0.13	0.34	0	1
Household received support from NGOs	720	0.09	0.29	0	1
Household's previous experience of migration	720	0.22	0.42	0	1
Religious minority	719	0.23	0.42	0	1
Group membership	720	0.276	0.44	0	1
Primary occupation: river fishing	719	0.24	0.43	0	1
Primary occupation: marine fishing	719	0.10	0.30	0	1

Primary occupation: aquaculture	719	0.17	0.38	0	1
Primary occupation: small business	719	0.05	0.22	0	1
Primary occupation: livestock rearing	719	0.04	0.19	0	1
Primary occupation: wage labour	719	0.24	0.43	0	1
Primary occupation: formal employment	719	0.03	0.16	0	1
Primary occupation: other	719	0.09	0.29	0	1

Table A 3.3: Migrants' relationship with household heads

Relationship with the household head (%)				
Occupation in origin	Total number of migrants	Head	Son or daughter	Other family members
River fishing	21	47.6	42.9	9.5
Deep sea fishing	4	25.0	75.0	0.0
Shrimp post-larvae collection	16	78.6	14.3	7.1
Aquaculture	16	100.0	0.0	0.0
Farming	8	12.5	75.0	12.5
Wage labour	54	47.1	39.2	13.7
Livestock rearing	2	50.0	0.0	50.0
Small business	6	33.3	33.3	33.3
Other	10	11.1	77.8	11.1
Unemployed	45	2.2	86.7	11.1
Total	183	38.3	50.3	11.4

Table 3.4: Determinants of migration: Results of the logistic regression with dummy variables with alternative shock years

	Model 1	Model 2	Model 3
Household perceived change to rainfall patterns	0.491**	0.441	0.634**
	(0.219)	(0.274)	(0.286)
Household perceived fish catch decline	-0.0165	0.562	0.398
	(0.301)	(0.371)	(0.409)
Household affected by rapid-onset disasters only	0.110	0.170	0.0862
	(0.427)	(0.470)	(0.505)
Household affected by recurring disasters only	1.930***	1.719***	2.386***
	(0.400)	(0.643)	(0.813)
Household affected by slow-onset disasters only	2.110***	1.156	2.529**
	(0.405)	(0.737)	(1.018)
Household affected by multiple types of disasters	1.092***	0.837	2.224***
	(0.413)	(0.605)	(0.811)
Time in minutes required to obtain drinkable water	0.0384***	0.0364**	0.0473***
	(0.0127)	(0.0143)	(0.0144)
Household affected by demographic shocks		0.163	0.200
		(0.332)	(0.340)
Household head's age in years		0.107	0.120*
		(0.0754)	(0.0668)
Household head's age squared		-0.000879	-0.000956
Female household head		0.0140	0.0709
		(0.590)	(0.705)
Dependency ratio		0.145	0.105
		(0.151)	(0.157)
Household's previous experience of migration		1.990***	2.315***
		(0.259)	(0.298)
Religious minority household		-1.084***	-1.200***
		(0.307)	(0.318)
Group membership		0.628**	0.830***
		(0.296)	(0.304)
Household affected by economic shocks		-0.378	-0.308
		(0.332)	(0.340)
Years of education of highest educated individual		0.0445	0.0358
		(0.0415)	(0.0408)
Household's land ownership: marginal		-0.234	-0.506
		(0.459)	(0.482)
Household's land ownership: small		-0.161	-0.591
		(0.460)	(0.465)
Household's land ownership: medium and large		-1.144	-1.991**
		(0.759)	(0.901)
Household had dispute/conflict over land or water		0.493	0.679*
		(0.332)	(0.375)
Household affected by fishing ban		-0.359	-0.455

		(0.415)	(0.659)
Household affected by pirates		1.651***	1.637***
		(0.481)	(0.480)
Household received social protection program benefits			0.520
			(0.787)
Interaction variable: rapid-onset disaster and social protection			-2.182***
			(0.824)
Interaction variable: recurring disaster and social protection			-1.488
			(0.911)
Interaction variable: slow-onset disaster and social protection			-1.561
			(0.952)
Interaction variable: multiple shocks and social protection			-2.923***
			(0.874)
Interaction variable: fishing ban and social protection			0.467
			(0.866)
Household had access to microfinance			-0.347
			(0.358)
Household had access to informal support			-0.244
			(0.294)
Households received support from NGOs			-0.838*
			(0.462)
Primary occupation: aquaculture		-0.183	-0.0985
		(0.404)	(0.432)
Primary occupation: farming		0.725	0.746
		(0.685)	(0.694)
Primary occupation: small business		0.114	0.191
		(0.658)	(0.649)
Primary occupation: livestock rearing		-0.507	-0.447
		(0.546)	(0.583)
Primary occupation: wage labour		0.777**	0.756**
		(0.343)	(0.368)
Primary occupation: formal employment		0.290	0.362
		(0.701)	(0.698)
Primary occupation: other		-0.560	-0.656
		(0.627)	(0.657)
District dummy: Satkhira		0.109	-0.423
		(0.574)	(0.663)
District dummy: Patuakhali		-0.106	0.382
		(0.495)	(0.666)
Constant	-2.985***	-6.994***	-7.468***
	(0.406)	(1.665)	(1.581)
Observations	720	719	719
Pseudo R2	0.1354	0.3366	0.3824
Prob > chi2	0.000	0.000	0.000

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix 4

Table A 4.1: Definitions of the income groups

Income groups	Definition
Extremely poor	Monthly per capita income less than the lower poverty line
Poor	Monthly per capita income less than the poverty line, but above the lower poverty line
Near-poor	Monthly per capita income between the poverty line and 1.25 times the poverty line income (reflecting a higher risk of falling into poverty)
Vulnerable to poverty	Monthly per capita income between the near-poor line and 1.5 times the poverty line income
Non-poor	Monthly per capita income more than 1.5 times the poverty line income

Source: A World Bank Study (Gautam and Faruqe, 2016) divided rural households in Bangladesh in four groups: extremely poor, poor, vulnerable, and non-poor. This study further divided the 'vulnerable' group into two groups: near-poor and vulnerable.

Table A 4.2: Use of adaptive technologies and innovative strategies by households

Innovative strategy or adaptive technology	Number of households	Percentage of households
Consulting weather forecast when planning fishing voyage	63	8.8
Rainwater storage	41	5.7
Saline tolerant varieties of rice or other crops	34	4.7
Switching to shrimp/prawn aquaculture due to high salinity	20	2.8
Floating gardens during waterlogging	20	2.8
Waterlogged lands converted to fish-farming areas	10	1.4
Adjustments to irrigation systems	7	1.0
Draining out of congested water by a diesel pump	2	0.3
Switching to short duration crops	1	0.1
Crop diversification	1	0.1
Other	11	1.5

Table A 4.3: Summary statistics of regression variables

Variable	Description	Observation	Mean	Std. Dev.	Min	Max
d_spfoodsec	A dummy variable for households who received support from at least one food security program	719	0	0	0	1
d_spcashtrans	A dummy variable for households who received support from at least one cash transfer program	719	0	0	0	1
d_spdev	A dummy variable for households who received support from development sector programs, which are mainly school stipend and school feeding programs.	719	0	0	0	1
Frequency of shocks	An index indicating a household's frequency of experiencing environmental and climatic shocks.	719	0	0	0	1
head_age	Age of the head of the household	719	44	13	20	85
hhh_agesq	Age of the head of the household squared	719	2083	1212	400	7225
hhh_edu	Number of years of education of the household head	719	3	4	0	14
d_nomale	A dummy variable for households without any adult male member	719	0	0	0	1
dependency_ratio	The dependency ratio measured as the ratio of the number of children (0-14 years old) and older persons (65 years or over) to the working-age population (15-64 years old) of a household	719	2	2	0	6
d_landless	A dummy variable for functionally landless households,[27] i.e., land holdings below 50 decimal	719	0	1	0	1
d_nomfi	A dummy variable for households who could access microfinance from formal microfinance institutions	719	0	0	0	1
d_noprodasset	A dummy variable for households who possessed no productive assets	719	0	0	0	1
log_pcexp	Logarithm of household's per capita expenditure	719	8	1	6.7	11.8
Dummy variables for primary occupation categories	Dummy variables for the main livelihood categories, which could be considered as proxies for a household's dependence on ecosystem services, their capital tied to specific natural resource-based livelihood activities, and their preferences. We determined the main livelihood activities of the households by calculating a household's largest source of income (Betcherman and Marschke, 2016). Finally, the models include dummy variables for districts to control for spatial variation.					
d_mainriverfish	Reference variable: A dummy variable for households who mainly depend on farming Primary occupation: river fishing	719	0	0	0	1

[27] The definition of functionally landless household was drawn from the Bangladesh Bureau of Statistics (BBS, 2008)

d_mainseafish	Primary occupation: marine fishing	719	0	0	0	1
d_mainaqua16	Primary occupation: aquaculture	719	0	0	0	1
d_mainlvstock16	Primary occupation: livestock rearing	719	0	0	0	1
d_mainwage16	Primary occupation: wage labour	719	0	0	0	1
d_mainjob16	Primary occupation: formal job	719	0	0	0	1
d_mainothers16	Primary occupation: other	719	0	0	0	1
District dummy variables	Dummy variables for districts Reference district: Noakhali					
d_patuakhali	A dummy variable for Patuakhali district	719	0	0	0	1
d_sathkhira	A dummy variable for Satkhira district	719	0	0	0	1

Table A 4.4: Number of beneficiaries of social protection programs by district

Social protection programs	Satkhira	Patuakhali	Noakhali	Total
Cash transfer programs				
Old Age Allowance	12	14	6	32
Allowances for the Widowed, Deserted and Destitute women	4	9	8	21
Maternity Allowance Program for the Poor	2	1	0	3
Allowances for the Financially Insolvent Disabled	0	2	0	2
Number of **unique** beneficiary households of cash transfer programs	18	26	14	58
Food security programs				
Vulnerable Group Feeding (VGF)	85	144	7	236
VGF for fishers	0	91	0	91
Open Market Sales (OMS)	46	109	2	157
Vulnerable Group Development (VGD)	4	16	2	22
Gratuitous Relief (GR)- Food	4	2	0	6
Employment Generation Program for the Poor	8	0	0	8
Work for money (WFM)	1	2	0	3
Food for work (FFW)	0	2	0	2
Test relief (TR) Food	0	1	0	1
Number of **unique** beneficiary households of food security programs	106	194	12	312
Development sector programs				
Scholarship	69	122	46	237
School Feeding Program	93	124	0	217
Number of **unique** beneficiary households of development sector programs	104	143	46	293

Appendix 5: Focus Group Discussion Guide

Key themes:

What are the environmental changes you observed over the last two decades?

How are they affecting your livelihoods?

How fisheries related regulation impact your livelihoods?

Tell us about the on-going social protection programs? Is it easy to get included, if qualified?

Are you observing permanent and temporary migration from your community?

Share your experiences of adaptation strategies

Appendix 6: Key Informant Interview Guide

Key themes:

What socio-ecological changes did you observe in this region over last two decades?

How your organization/agency respond to these changes?

What are the social protection programs in place?

How do you select beneficiaries of Social protection programs?

Do migrants have any resources available for them before migration?

Are their specific programs/policies in place for fisheries and aquaculture-based households?

Are there any regulation (e.g. fishing ban) which might have impacted fishers' livelihood?

Appendix 7: Factor Analysis

Lack of Adaptive Capacity Index

Factor analysis/correlation
Method: principal factors
Rotation: orthogonal varimax

Number of obs	713
Retained factors	4

Factor	Variance	Difference	Proportion	Cumulative
Factor1	1.38279	0.36977	0.5417	0.5417
Factor2	1.01303	0.25528	0.3968	0.9385
Factor3	0.75774	0.56302	0.2968	1.2354
Factor4	0.19472	.	0.0763	1.3117

Rotated factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
level of education	0.49	0.19	0.14	0.08	0.70
share of employed individuals	-0.03	0.12	0.03	0.30	0.89
livelihood diversity indicator	-0.08	0.08	0.10	-0.24	0.92
household savings	0.11	0.67	0.06	-0.14	0.52
type of housing	0.44	0.02	0.14	0.00	0.78
Productive wealth index	0.32	0.02	0.20	0.02	0.85
Consumption wealth index	0.78	0.06	-0.07	-0.01	0.39
community infrastructure index	0.46	-0.10	-0.49	-0.03	0.54
Access to food or cash during hardship	0.04	0.01	0.52	-0.02	0.73
Membership in NGO/CBOs	0.00	0.70	-0.02	0.13	0.49
Community harmony	-0.03	0.04	-0.40	0.05	0.84

Note: Adaptive capacity is negatively correlated with vulnerability. To construct the vulnerability index, this paper inverted the value of adaptive capacity indicators by subtracting the standardized value from 1.

Sensitivity Index

Factor analysis/correlation
Method: principal factors
Rotation: orthogonal varimax

Number of obs	713
Retained factors	2

Factor	Variance	Difference	Proportion	Cumulative
Factor1	0.20	0.05	1.84	1.84
Factor2	0.15	.	1.34	3.18

Rotated factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Uniqueness
Time to get drinking water	0.18	0.08	0.96
Compromised food security	0.26	0.21	0.89
Chronic disease of any household member	0.02	0.29	0.91
Time required to reach a health facility	0.30	-0.02	0.91
Dependency ratio	0.10	-0.09	0.98

Exposure index: Cyclones and storm surges

Factor analysis/correlation		Number of obs	710
Method: principal factors		Retained factors	4
Rotation: orthogonal varimax			

Factor	Variance	Difference	Proportion	Cumulative
Factor1	2.45	1.33	0.45	0.45
Factor2	1.12	0.06	0.20	0.65
Factor3	1.06	0.12	0.19	0.85
Factor4	0.94	.	0.17	1.02

Rotated factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
Ownership of fishing boat	-0.19	0.05	-0.03	0.62	0.58
Ownership of fish pond	0.53	0.03	0.38	0.05	0.57
Ownership of shrimp farm	0.91	0.19	0.02	-0.21	0.09
Ownership of farm land	0.23	0.19	0.58	-0.11	0.56
Ownership of livestock	0.23	0.78	0.12	0.08	0.32
Proportion of income from shrimp aquaculture	0.71	0.00	-0.15	-0.03	0.48
Proportion of income from fishing	-0.43	-0.13	-0.32	0.61	0.32
Proportion of income from non-shrimp aquaculture	0.70	-0.07	0.22	-0.05	0.45
Proportion of income from farming	-0.13	0.02	0.62	-0.23	0.54
Proportion of income from livestock	-0.06	0.65	-0.05	-0.25	0.51

Exposure index: Floods and waterlogging

Number of obs	710
Retained factors	4

Factor analysis/correlation
Method: principal factors
Rotation: orthogonal varimax

Factor	Variance	Difference	Proportion	Cumulative
Factor1	2.05	0.82	0.40	0.40
Factor2	1.23	0.14	0.24	0.64
Factor3	1.09	0.21	0.21	0.86
Factor4	0.88	.	0.17	1.03

Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
Ownership of fish pond	0.41	0.41	-0.01	0.23	0.61
Ownership of shrimp farm	0.81	0.49	0.20	-0.06	0.06
Ownership of farm land	0.18	0.26	0.18	0.57	0.54
Ownership of livestock	0.20	0.08	0.77	0.11	0.35
Proportion of income from shrimp aquaculture	0.79	-0.07	0.04	-0.02	0.37
Proportion of income from fishing	-0.21	-0.82	-0.09	-0.14	0.25
Proportion of income from non-shrimp aquaculture	0.68	0.20	-0.07	0.22	0.45
Proportion of income from farming	-0.12	0.10	0.04	0.64	0.56
Proportion of income from livestock	-0.08	0.11	0.64	-0.03	0.57

Exposure index: Salinity

Factor analysis/correlation	Number of obs 710
Method: principal factors	Retained factors 4
Rotation: orthogonal varimax	

Factor	Variance	Difference	Proportion	Cumulative
Factor1	1.30	0.44	0.45	0.45
Factor2	0.86	0.02	0.30	0.75
Factor3	0.83	0.19	0.29	1.04
Factor4	0.64	.	0.22	1.26

Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
Ownership of fish pond	0.71	0.05	0.13	0.01	0.47
Ownership of farm land	0.34	0.18	0.59	-0.01	0.50
Ownership of livestock	0.12	0.61	0.13	0.02	0.59
Proportion of income from river fishing	-0.44	-0.15	-0.26	-0.53	0.44
Proportion of income from non-shrimp aquaculture	0.64	-0.01	0.10	-0.07	0.57
Proportion of income from farming	0.04	0.01	0.58	-0.02	0.66
Proportion of income from livestock	-0.02	0.65	0.04	0.01	0.58
Proportion of income from wage labour	-0.22	-0.06	-0.19	0.60	0.55

Hazard Index: Cyclones and storm surges

Factor analysis/correlation
Method: principal factors
Rotation: orthogonal varimax

Number of obs	713
Retained factors	4

Factor	Variance	Difference	Proportion	Cumulative
Factor1	1.99	0.63	0.43	0.43
Factor2	1.36	0.09	0.29	0.73
Factor3	1.27	1.26	0.28	1.00
Factor4	0.01	.	0.00	1.00

Rotated factor loadings (pattern matrix) and unique variances

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Uniqueness
Proportion of households affected by cyclones	0.79	0.32	0.51	-0.05	0.01
Proportion of households affected by storm surge	0.30	0.40	0.81	0.01	0.10
storm surge score	-0.10	0.92	0.32	0.00	0.03
(negative) elevation	0.94	-0.32	0.11	0.02	0.01
proportion of households in the village that experienced cyclones or storm surges	0.63	0.37	0.49	0.09	0.22

Hazard Index: Floods and waterlogging

Factor analysis/correlation
Method: principal factors
Rotation: orthogonal varimax

Number of obs 713

Retained factors 2

Factor	Variance	Difference	Proportion	Cumulative
Factor1	1.73987	0.00652	0.5161	0.5161
Factor2	1.73335	.	0.5142	1.0303

Variable	Factor1	Factor2	Uniqueness
Proportion of land area affected by soil salinity	0.64	0.65	0.16
Surface water salinity level	0.36	0.84	0.16
Groundwater salinity level	0.84	0.36	0.16
Proportion of households in a village experienced salinity	0.69	0.69	0.05

Appendix 8: Household Questionnaire

Socio-ecological Vulnerability, Social Protection and Migration: An examination of fisheries livelihoods in coastal Bangladesh

This questionnaire draws on Bangladesh's Household Income and Expenditure Survey-2016 (BBS, 2016), the Resilience Focused Baseline Survey: ECOFISH^{BD} Project, and the fisheries and aquaculture modules used in the Vietnam Fisheries Transition Survey (Marschke and Betcherman, 2016).

Name of interviewer:
Date of interview:
Village/Union/District:

HOUSEHOLD ROSTER:

	1001	**1002**	**1003**	**1004**	**1005**	**1005**	**1006**
Line no. of HH members	Name of household member*	Age (full years)	Gender	Relationship with household head (HHH)	Education (if 5 years or older)	Marital status (if 16 years or older)	In the last 12 months, in which income generating activities has this member been involved (if 16 years or older)
01							
02							
03							
04							
05							
06							

07							
08							
09							
10							

1002. Gender:

1. Male
2. Female
88. 'I don't know'

1003. Relationship with HH head:

1. Household head
2. Husband/wife
3. Son/daughter
4. Father/mother
5. Father/mother-in-law
6. Brother/sister
7. Brother/sister-in-law
8. Son/daughter-in-law
9. Grandson/grand-daughter
10. Grandfather/grandmother
11. Grandfather/grandmother-in-law
12. Uncle/Aunt
13. Uncle/Aunt-in-law
14. Cousin
15. Cousin-in-law
16. Nephew/niece
17. Nephew/niece-in-law
18. Co-wife
19. Friend
20. Any other
88. 'I don't know'

1004. Education:

0. No schooling
1. 1st Grade
2. 2nd Grade
3. 3rd Grade
4. 4th Grade
5. 5th Grade
6. 6th Grade
7. 7th Grade
8. 8th Grade
9. 9th Grade
10. Only religious study
11. S.S.C or equivalent

1005. Marital status:

1. Unmarried
2. Married
3. Divorced
4. Widow/widower
5. Separated/Left behind
88. 'I don't know'

1006. Income generating activities:

1. River fishing
2. Deep sea fishing
3. Farming/Agriculture
4. Shrimp larvae collector
5. Agro based day labor (to others' land)
6. Non agro based day labor (e.g.: road repairing, construction worker)
7. Fish cultivation / aquaculture
8. Industrial labor (e.g. garments worker)
9. Vegetable growing and selling
10. Goat rearing
11. Restaurant/Shop worker
12. Maid/Servant/work in other peoples' house
13. Food processing for sale (e.g. Muri, corn made, paddy grind)
14. Sewing/ Handy craft/ cottage industry (with payment)
15. Hawker/Mobile hawker
16. Micro enterprise in own house
17. Restaurant/Shop owner
18. Community health staff (Midwife, Nurse)
19. Teacher/house tutor
20. Non-government service/NGO worker
21. Governmental organization worker
22. Whole sale retail/trade
23. Other small business (outside house, e.g. in the street)
24. Other, specify

Income & employment of Households

2.1 Please provide information on approximate Annual Income of your household in 2016

Sl. No.	Source of Income HH	Annual Income of HH (BDT) (2006)	Annual Income of HH (BDT) (2016)
1	River fishing		
2	Deep sea fishing		
3	Farming/Agriculture		
4	Shrimp larvae collector		
5	Agro based day labor (to others' land)		
6	Non agro based day labor (e.g.: road repairing, construction worker)		
7	Fish cultivation / aquaculture		
8	Industrial labor (e.g. garments worker)		
9	Vegetable growing and selling		
10	Goat rearing		

Sl. No.	Source of Income HH	Annual Income of HH (BDT.) (2006)	Annual Income of HH (BDT.) (2016)
11	Drying/processing fish		
12	Wood business		
13	Rearing ducks/Chicken		
14	Rearing domestic animals		
15	Agricultural labour		
16	Non-farm labour		
17	Rickshaw/rickshaw-van push cart pulling		
18	Others		

2.2 Others income

Sl. No.	Source of Income HH	Annual Income of HH 2006	Annual Income of HH 2016
2	Pension		
3	Driver, Factories Labor, etc.		
4	Fruits seller		
5	Handicrafts (Sewing/ Handy craft/ cottage industry (with payment)		
6	Food processing for sale (e.g. Muri, corn made, paddy grind)		
7	Remittance		

Sl. No.	Source of Income HH	Annual Income of HH 2006	Annual Income of HH 2016
11	Hawker/Mobile hawker		
12	Micro enterprise in own house/Small business owner		
13	Maid/Servant		
14	Adult allowance		
15	Widows allowance		
16	Selling housekeeping assets		

8	Mortgaged in /leased in land		17	Mortgaged housekeeping assets	
9	Received Investments & Bank Interest		18	Govement Service	
10	Restaurant/Shop owner		19	Non Govement Service	
			20	Others	

Household expenditure

Please provide information on approximate Annual expenditure of your Household in 2016

Period	Expenditures	Approx. Expenditure in BDT
Weekly Expenditure	1. Food items	
Monthly Expenditure	1. Expenditure on energy (Kerosine/electricity etc)	
	2. Monthly Educational expenses	
	3. Medical expenses (Doctor and medicine)	
	4. Commuting	
	5. Others	
Yearly Expenditure	6. Expenses on purchase/construction of fish-net, boat, other appliances of fishing	
	7. Expenses on repair of fish-net, boat, other appliances of fishing	
	8. Repair/renovation of house	
	9. Clothing	
	10. Occasional major treatment	
	11. Annual expense for education	
	12. Expenses during religious festivals	
	13. Expenses during social festivals, family occasions (marriage. Dowry etc.)	
	14. Expenses on litigation	
	15. Expenses on household utensils/other items	
	16. Payment of bribe for authorities	
	17. Other expenses (mention)	

FISHING

Only for hh that mentioned fishing income in Q.2.1

Fisheries

Q.4.1 Why is this hh engaged in fishing?

1.	Traditional fishing family	5.	Not enough land to farm or do aquauculture
2.	Fishing brings more money than other activities	6.	Fishing is a good source of food for the hh
3.	Fishing supplements main hh activity	7.	Like being a fisher
4.	There are no other jobs	8.	Less investment than other activities

Fish capture

	How much did your HH catch in…?		How much did your HH sell in …?		How much did your HH consume in…..?	
	2016	2006	2016	2006	2016	2006
Marine/offshore fishing						
Canal/River fishing						
Dry fish						

Q.4.2. Please provide information about the following:

Main species caught in past year?	How many kg catch in past year?	Did you catch this species in 2006? *If yes, continue; if no, go to Q.4.4*	If yes, how has the quantity changed?	Main reason for the larger (smaller) catch than 10 years ago?

Fish species codes

Silver carp 1
Grass carp 2
Miror carp 3
Common carp..... 4
Karfu 5
Rui 6
Katla 7
Mrigel 8
Kalibaus 9
Telapia/Nailotica 10
Pona 11
Koi 12
Magur 13
Shingi 14
Khalse 15
Shol/Gajar/Taki 16
Puti/Swarputi 17
Prawn (Golda Chingri) 18
Shirmp (Bagda Chingri) 19
Tengra/Baim 20
Mola/Dhela/Kachki/Chapila 21
Ilish/hilsha 22
Other Large fish 23
Other Small fish 24
Sea fish 25
Pangash 26
Others.....27

Did you catch this species in 2006? 1 = Yes 2 = No

Change in caught quantity compared to 2006

1.	More now	3.	Less now
2.	About the same	4.	Not sure

Causes for change in quantity

1.	Change in quantity or quality of gear	4.	Change in market price of species
2.	Change in time spent fishing	5.	Change in access to buyers
3.	Change in amount of competition	6.	Natural fluctuations
		7.	Not sure

Q.4.4. Did you own any boats; at what capacity?

2006		2016	
# boats	Capacity (HP)	# boats	Capacity (HP)

NB: O means a row boat (no motor)

Q.4.5 a) Has fishing always been your main livelihood? 1 = Yes 2 = No

Q.4.5. b) If no, what was your main livelihood activity?

1. Aquaculture
2. Wage worker
3. Farmer
4. Self-employed
5. Near-shore fishing

Q.4.5. c) In what year did you begin fishing as your main livelihood activity?

AQUACULTURE

For those hhs that reported aquaculture income in Q. 2.1

Q.5.1. Why is this hh engaged in aquaculture?

1.	Aquaculture brings more money than other activities	4.	Wanted to try something new
2.	Aquaculture supplements the main activity of the hh	5.	Following government policies on land use conversion
3.	There are no other jobs available	6.	Family did aquaculture before

Q.5.2. What type of aquaculture do you practice?

Aqua tech	Aqua form	Aquatic species (general)
Intensive	1. Mono 2. Poly	1. shrimp 2. prawn 3. Fish 4. Crab
Improved extensive	1. Mono, pond 2. Poly, pond 3. Mono, mangrove 4. Poly, mangrove 5. Mono, rice 6. Poly, rice 7. Net enclosure 8. Cage	1. shrimp 2. prawn 3. Fish 4. Crab
Extensive	1. Mono, pond 2. Poly, pond 3. Mono, mangrove 4. Poly, mangrove 5. Mono, rice 6. Poly, rice 7. Net enclosure 8. Cage	1. shrimp 2. prawn 3. Fish 4. Crab
Semi-intensive	1. Mono, pond 2. Poly, pond 3. Mono, mangrove 4. Poly, mangrove 5. Mono, rice 6. Poly, rice	1. shrimp 2. prawn 3. Fish 4. Crab

Fish Production

Q5.3. Provide the following info about your hh aquaculture activities

Main species farmed in past year?	How many kg grown in past year?	Did you grow this species in 2006? *If yes, continue; if no, go to Q.5.4*	If yes, how has the quantity changed?	Main reason for the larger (smaller) growth rates than 10 years ago?

Aquaculture species codes

Silver carp 1
Grass carp 2
Miror carp 3
Common carp..... 4
Karfu 5
Rui 6
Katla 7
Mrigel 8
Kalibaus 9
Telapia/Nailotica 10
Pona 11
Koi 12
Magur 13
Shingi 14
Khalse 15
Shol/Gajar/Taki 16
Puti/Swarputi 17
Prawn (Golda Chingri) 18
Shirmp (Bagda Chingri) 19
Tengra/Baim 20
Mola/Dhela/Kachki/Chapila 21
Ilish/hilsha 22
Other Large fish 23
Other Small fish 24
Sea fish 25
Pangash 26

5.4 Did you cultivate each of these species 10 years ago? 1 = yes 2 = no

How has the quantity changed compared to 10 years ago?

1. More now
2. About the same
3. Less now
4. Not sure

Main reason for the change in catch?

1.	Better techniques/knowledge	7.	Higher price for species	13.	Poorer water quality
2.	More ponds/cages	8.	More available breed	14.	Cannot afford medicine
3.	More reliable stocking source	9.	Not sure	15.	Spread of disease
4.	Better water quality	10.	Cannot afford latest techniques	16.	More competition
5.	Better access to buyers	11.	Fewer ponds/cages	17.	Lower price for species
6.	Less competition	12.	Less reliable stocking source	18.	Worse access to buyers

Q. 5.4. a) Has aquaculture always been your main livelihood activity? 1 = yes; 2 = no

Q.5.4. b) If no, what was your main livelihood activity before?

1. Agriculture
2. Home business
3. At school
4. Worked for wage
5. Fishing

Q.5.4. c) In what year did you begin aquaculture as your main livelihood activity?

Asset and housing

Item	2016 (Number and value)	2006 (Number and value)	Item	2016 (Number and value)	2006 (Number and value)
Car			Computer		
Motorbike			Fridge		
Motorboat			Freezer		
Rowboat			Air conditioner		
Cell phone			Washing machine		
T.V.			Electric cooker		
Stereo			Gas cooker		
Machine pump			Water heater		
Livestock			Agricultural tools		
Other Asset (Specify)					

What type of structure best describes the main residence where your hh is living?

1. Permanent – concrete
2. Semi-permanent – brick, tin roof
3. Temporary – thatch

Nearest drinking water source: Time required to fetch drinking water?

LAND OWNERSHIP in 2016

Please tell us about each plot of land owned:

Plot	Area (in decimal)	Type of land	Use status	Ownership status

LAND OWNERSHIP in 2006

Plot	Area (in decimal)	Type of land	Use status	Ownership status

Codes for land type:	Code for use status:	Code for ownership status:
1. Resident land 2. Agricultural land 3. Aquaculture land 4. Forestry land 5. Barren land	1. Used by hh members 2. Unused 3. Rented out 4. On loan (no fee)	1. Own land, w certificate 2. Long term lease, w certificate 3. Short term lease, w certificate 4. Long term lease, no certificate 5. Short term lease, no certificate 6. Borrowed 7. Rented from others

Shocks

	9101	9102	9103				
	List the main shocks/stressors the household experienced in last 5 years?	When did it happen? (month/year)	How often does this shock usually occur?	Ask the following questions only for the 5 most severe events following the response to 9104			
				9105	**9106**	**9107**	**9108**
				Last time you faced this EVENT tell us how 'severe' this was/is for your family	Last time you faced this EVENT did you lose some assets?	If Yes to 9106 how much of your total assets did you lose?	Last time you faced this shock did you experience some disruptions in your regular income?
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

9101. Adverse events: Shocks/ Stressors:

Covariant:

1. Cyclone and tidal surge
2. Flooding/water logging following cyclone
3. Flashflood
4. Flooding from excessive rainfall
5. Water logging
6. Two-month fishing ban
7. River erosion immediate impact (loss of land)
8. Drought
9. Pest attack (leading to crop failure)
10. Loss of small livestock (due to diseases)
11. Poor access to services
12. Hailstorm
13. Saline flood following high tide (moon)
14. Increasing ground water salinity during dry season
15. Water contaminated (arsenic)
16. Fish catch slow decline
17. High food price
18. High agriculture input price; e.g. fuel, fertilizer etc.
19. Low market price of agriculture production

Idiosyncratic:

20. Sudden death/disability of main earner
21. Death of HH member (not main earner)
22. Accident (physical injury)
23. Eviction (Illegal grabbing)
24. Serious Illnesses including diarrhea and/or malaria
25. Loss of job
26. Dowry
27. Pregnancy
28. Increasing indebtedness
29. Family split (divorce/abandonment)
30. Loss of assets (destruction/stolen)
31. Abduction at sea

9103. How often:

1. On a continuous (daily) basis
2. Once every week
3. Once every month
4. Once every 3 month
5. Once every 6 month
6. Once every year
7. Once every two-year
8. Once every 5 year
9. Once every 10 year
10. Once every 20 Year or more

88. 'I don't know'

9105. Serious or bad:

1. Very bad
2. Quite bad
3. A little concerning
4. we handled it with no problem
5. Eventually it brought some positive outcomes

88. 'I don't know'

9106 Lose of assets

1. Yes
2. No

88. 'I don't know'

89. No answer

9107. Lose (How much):

1. Very little
2. Some of it
3. About half of all my assets
4. Almost everything
5. Everything

88. 'I don't know'

89. No answer

9108. Disruptions (Income):

1. Yes
2. No

88. 'I don't know'

RESPONSE TO SHOCK: Coping Mechanism (Immediate)

For each of the severe shock events listed in the previous section, ask the following questions:

	9301	9302	9303	9304	9305
List five most severe shocks experienced by the household	how did you feel you could handle it	Last time you faced, did you reduce the level of food consumption of the family? If yes, for how long in days?	When facing, did you change the type of food consumed by the family? If yes, what did you change?	When facing , did you sell household asset? (Yes/No)	Last time you faced, did you reduce the level of expense of the family? If yes, what expenses you reduce?
1					
2					
3					
4					
5					

9301

1. Very easily
2. somewhat easily
3. with a bit of difficulty
4. with a lot of difficulty
5. could not handle it at all

88. I don't know

Response: Migration

List the most severe 5 shocks experienced by households reported in the previous section	10005.1: did you or anyone in your household have to leave to migrate in response to this shock? (Yes/No)	10005.2: Did anyone from your household temporarily migrate for other reasons? (Yes/No) If ye, write down the reason	10005.3: If yes in 10005.1 and 10005.2, for how long the hh member migrate? (Years and Months)	10005.4: Migrant member/s relationship with the household head?	10005.4: Where did they migrate?	10005.5: Did the migrant engage in a new activity after migration?	10005.6: If yes in 10005.5, what activity?	10005.7: How was the migration expense paid?

Adaptive Capacity: Preparedness

For each of the severe shock events listed in the previous section, ask the following questions:

10401: Did you anticipate this shock and made some preparedness plan for your household? (Yes/No)
10402: If yes, please list the preparedness plans.
10403: List any innovative strategy or adaptive technology you adopted?

Adaptive Capacity: Recovery

For each of the severe shock events listed in the previous section, ask the following questions:

10404: how do you consider you managed to recover after the event?

10405: how do you consider you recover in comparison to the rest of the community:

10406: if it was to happen again in the near future how do you consider you would be able to recover?

10404:	10405:	10406:
1. Did not recover at all and I don't think I will be able to recover 2. Not yet fully recovered and it will be difficult / long 3. Not yet but I think we will 4. Have fully recovered -but it was long and painful 5. Have fully recovered -and it was not too difficult 6. Have fully recovered and I am better off now	1. I think I did worse than most of the others in the community 2. I think I did as bad as some people but better than others 3. I think I did like most of the others 4. I think I did better than most of the others 5. I think I did better than anyone else	1. I would do worse than last time 2. I would do as bad as last time 3. I would do more or less the same than last time 4. I would do as well as last time 5. I will do better than last time

External support and services: Government and Non-government services in time of shocks

100501: List 5 most severe shock events as listed in 10004	100502: List the government agencies that helped you during/after this shock event?	100503:List the non-government agencies that helped you during/after this shock event?
1		
2		
3		
4		
5		

Households' social network during crisis

10603: How many people or friends in your community can help you with good suggestions when needed?

10602: How many people or friends in your community can help you when you need money/cash?

10603: How many people or friends in your community can help you with food?

10604: How many people or friends in your community can help you in finding paid work?

10605: Do you feel socially included (e,g,; do you receive invitations to social gathering?)

Community harmony

10701: Among the members of your village, how often are there tensions or conflicts/disagreement?

10702**:** If yes to 10701, how would you categorize these tensions/conflicts?

10703: Among the members of your village, how many are excluded / marginalized from the rest of the community?

10704: Do you consider yourself / your family to be excluded / marginalized?

10705: How would you describe the relationship in your community?

10706: How would you describe our relationship with your neighbours?

10701:

Never

1. It does happen but very rarely
2. It does happen from time to time
3. It does happen relatively frequently
4. It does happen very frequently
5. It happen almost every day

88. I don't know'

10702.

1. Always easily resolved/settled
2. Resolved/settled easily most of the time
3. Sometimes a bit difficult to resolve/settle
4. Often very difficult to resolve/settle
5. Often evolved in fight

88. I don't know'

10703.

1. No one individual/ family is excluded
2. Only one or two individuals / families are excluded but it is their own choices
3. Only one or two individuals are excluded but it is not their own choices
4. Quite a few people/families are excluded
5. Quite a large number of people are totally excluded

88. 'I don't know'

10704:

1. Not at all
2. Yes sometimes
3. Yes completely

88. I don't know

89. No answer

10705:

1. Everyone is trying to help and support each other
2. A large part of people try to help each other
3. Some people try to help, but the majority is just doing their own business
4. You may have to be careful as sometimes some people may try to take advantage
5. Most people try to take advantage of you if they can

88. 'I don't know'

89. No answer

10706. When they ask for help I don't hesitate one minute to help any of my neighbours as I know that they all would do the same for me

1. When they ask for help I help most of my neighbours as I know that most of them would do the same for me
2. I usually try to help most of my neighbours and I hope I would get the same
3. Sometimes I hesitate to help as I am not sure I would be helped in return
4. I try not to help as I know I will rarely get any help if I ask
5. I never help because I know I will not get any help in return

88. 'I don't know'

89. No answer

Household debts and savings

1101: Savings

	Household savings in Taka
Cash	
Bank	
NGOs/	
Co-operatives	
Other	
Total	

1102: Do you and/or your HH have any outstanding loans?

1103: Where did you borrow the money from? (List the source of borrowing and amount)

Source of borrowing	**Amount borrowed (in Taka)**	**Outstanding loan (in taka)**

Perception of environmental change

12.1 Do you think the average temperature over the last 10 years have changed? If yes, has it increased or decreased?

12.2: Do you think the average rainfall over the last 10 years has changed? If yes, has it increased or decreased?

12.3: Have you observed any change in rainfall pattern over the last 10 years? If yes, choose all that apply from the options below: 1) became more erratic, 2) monsoon comes earlier, 3) monsoon comes later, 4) more torrent rains, 5) Longer period of drought season

12.4: Are you worried about the changing climate? *(such as occurrence of drought or floods, erratic rain).*

12.5: If yes to above, what are the reasons for the worrying?

12.1 and 12.2: 1. Increased, 2. Decreased, 3. Stayed the same, 4. Don't know
12.5: Reduced fisheries /agriculture productivity More river erosion Increase poverty levels Increase salinity (water & soil) Decrease fish stocks Food security Decrease in Livestock fodder Affect income sources

Household food security

1301: In the past four weeks, did you worry that your household would not have enough food? If yes, how many times?

1302: In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?

1303: In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources? If yes, how many times?

1304: In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food? If yes, how many times?

1305: In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food? If yes, how many times? Which members of the households?

1306: In the past four weeks, did you or any household member have to eat fewer meals in a day because there was not enough food? If yes, how many times? If yes, how many times and which member?

1307: In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food? If yes, how many times and which member of the household?

1. Never
2. Rarely (one or twice only)
3. Sometimes (3 to 10 times)
4. Often (more than 10 times)
5. Almost every day

88. 'I don't know'

89. No answer

Which member?

1. Male adults only
2. Female adults only
3. Male and Female adults
4. Young male adults
5. Young female adults
6. All adults (young and older)
7. All female adults (young and older)
8. Adults and children
9. All female adults and children
10. This does not happen

88. 'I don't know'

Participation in Social protection Programs

Collect data for last 5 years (2012-2016). Applicable for all household members. In case of participation in multiple programs report MID of all participants.

		Entitled								
Family Member ID	Programs	Cash (Tk)	Rice (KG)	Wheat (KG)	Other Food (KG)	Other in-kind Value (Tk)	Did you receive the entitled amount?	When? Years and months	Did you have to pay for admitting into the programs?	If yes, how much you paid?

1. School Feeding Program 2. Old Age Allowance 3. Allowances for Distressed Cultural Personalities/ Activitists 4. Allowances for beneficiaries in Ctg. Hill Tract area. 5. Allowances for the Widowed, Deserted and Destitute Women 6. Allowances for the Financially Insolvent Disabled 7. Maternity allowance program for the Poor Lactating Mothers 8. Maternal Health Voucher Scheme 9. Honorarium for Insolvent Freedom Fighters 10. Honorarium for Injured Freedom Fighters 11. Gratuitous Relief (Cash) 12. Gratuitious Relief (GR)- Food 13. General Relief Activities 14. Cash For Work 15. Agriculture Rehabilitation 16. Subsidy for Open Market Sales 17. Vulnerable Group Development (VGD) 18. Vulnerable Group Feeding (VGF) 19. Test Relief (TR) Food 20. Food Assistance in CTG-Hill tracts Area	21. Food For Work (FFW) 22. Special fund for Employment Generation for Hard-core Poor in SIDR Area 23. Fund for the Welfare of Acid Burnt and Disables 24. 100 days Employment Scheme 25. Rural Employment Opportunities for Protection of Public Property (REOPA) 26. Rural Employment and Rural Maintenance Program 27. Community Nutrition Program 28. Char Livelihood 29. Shouhardo Program 30. Accommodation (Poverty Alleviation & Rehabilitation) Project (Chief Advisors Office) 31. Housing Support 32. TUP (BRAC) 33. One House one farm 34. Improving maternal and child nutrition (IMCN) 35. Enhancing resilience to disasters and the effects of climate change (ER) 36. Other (specify)